# A Sustainable Approach to Advanced Energy and Vehicular Technologies at the University of Kansas

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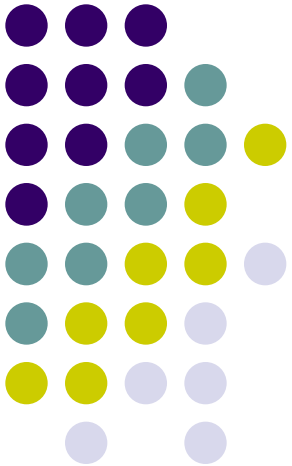

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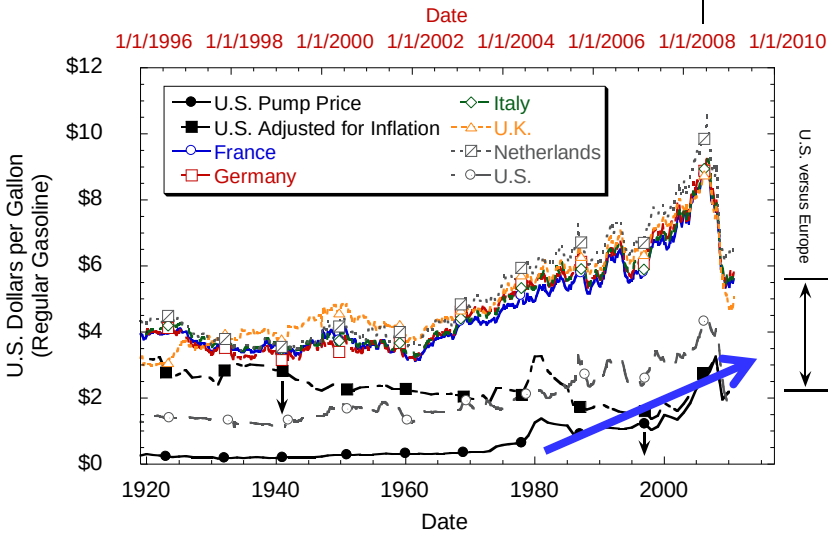
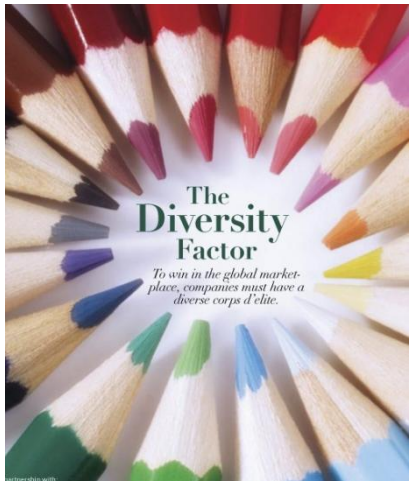
# Introduction

- Shift in Priorities
- Initial Efforts
- Sustainability
- First Year Accomplishments
- Future Efforts
- Incorporating K-12 Education
- Special Thanks

# Shift in Priorities

- Mindset of consumer shifted
- Automotive industry caught off guard
- Mostly touted power over fuel economy
- Change in priorities must occur within a university curriculum
- Traditional view of “gearhead” students must be replaced with a reflection of the diversity of modern society
- Adaptive vehicle design course required



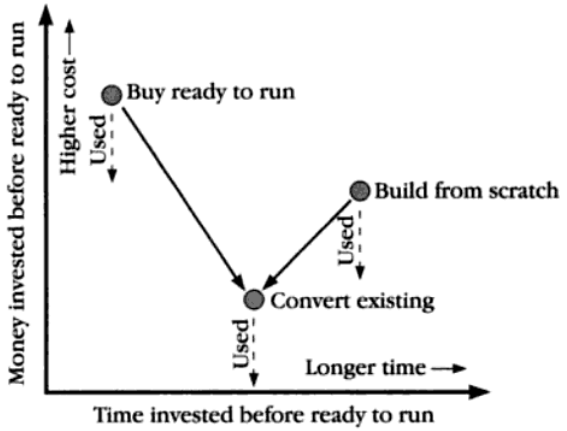

Society of Women Engineers

# Initial Efforts

- Students involved in discussion and formation of KU EcoHawks (May 2008)
- Course added to curriculum (ME 645) with vehicle target of a 500 mpg vehicle
- Initial goal was Shell Eco-Marathon Urban Concept challenge (others, like EcoCAR considered)
- Starting August 2008 only had vision and seed money
- No tools, no infrastructure, no place for the vehicle and little background knowledge in building passenger style car from scratch

# Conservative Approach

- Recycle a vehicle
  - Eliminates time to build chassis
  - Saves 3 to 12 tons of $CO_2$
- No challenge selected
  - First year, limited resources
  - Flexibility to adapt to student backgrounds
  - Freedom to lead the program in any direction
  - Issues with student time commitments alleviated
- Great opportunity for students to tear “simple” car apart and learn how it comes together

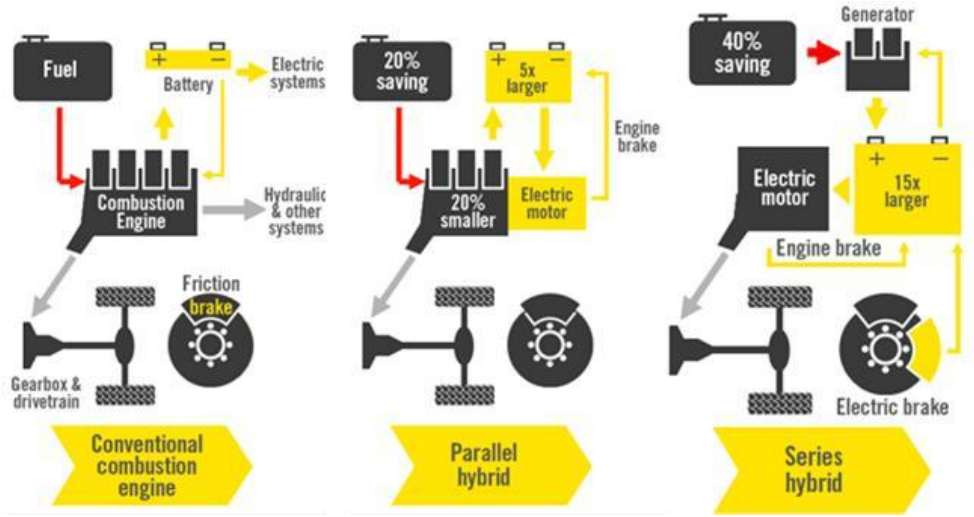



Build Your Own Electric Vehicle by Bob Brant

1974 VW Super Beetle donated to the class
(sat on car lot for 2+ years)

# Fuel Neutrality

- Decision made with students to convert Beetle into a fuel neutral, series hybrid vehicle
  - Most efficient power plant system
  - Operate on any fuel through swapping generators or fuel cells
- Idea formulated from focus on sustainability
  - Presenter part of university wide sustainability working group



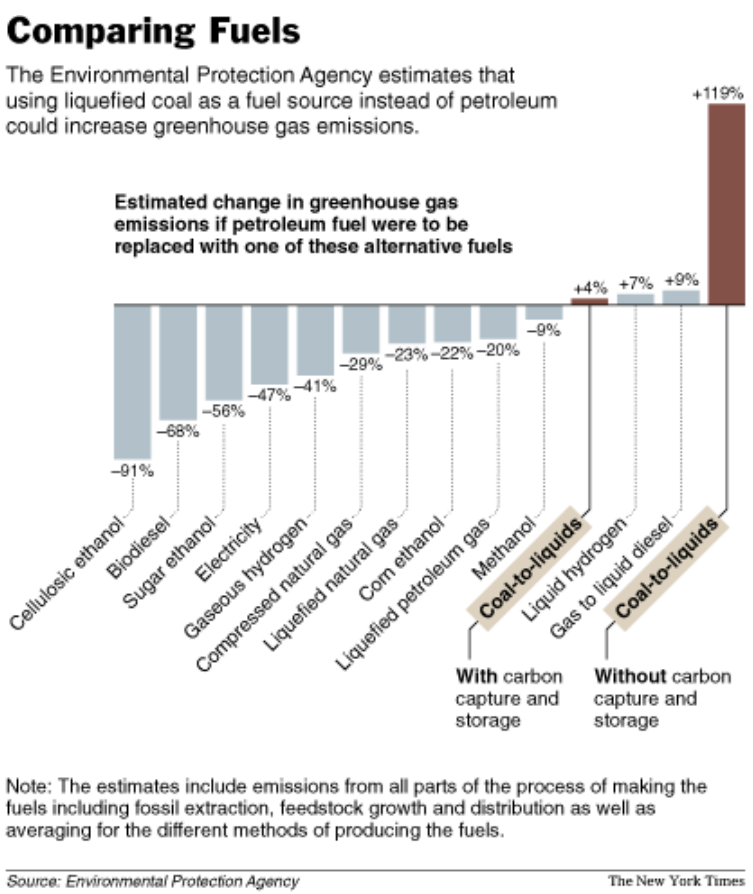

Different Engine Platforms

# Sustainability

- Classic definition - “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (Bruntland Commission, 1992)
- KU EcoHawks: the application of engineering principles to solving a real-world problem by focusing upon the connection between the *environment*, *energy*, *economy*, *education* and *ethics*
- Give students a conceptual picture of how to make correct decisions that are long lasting

# Environmental Sustainability

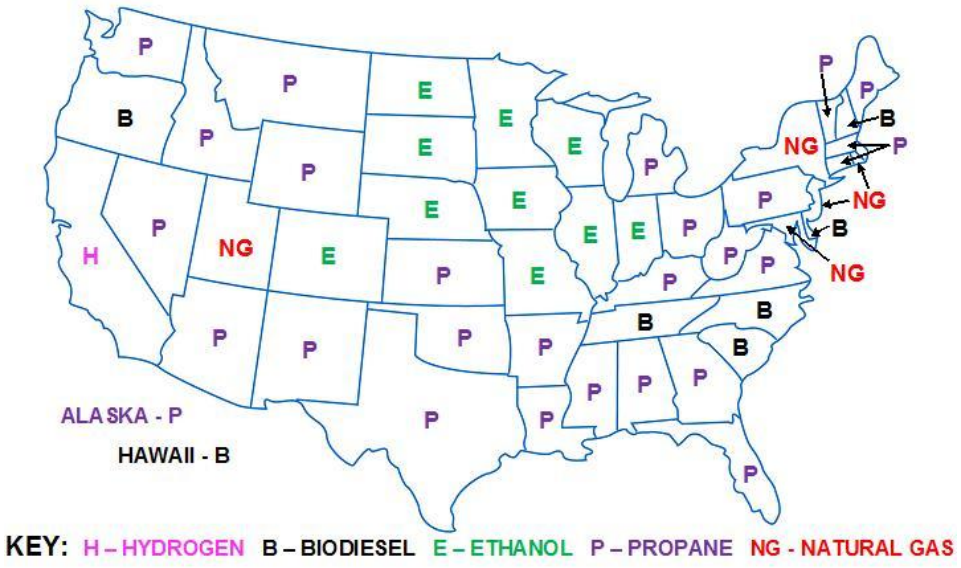
- Reduction in emissions through:
  - Recycling of older vehicle
  - Conversion to more efficient power plant
  - Utilize biofuels (100% biodiesel from used cooking oil)
- Future efforts
  - New vehicle designs
  - Different materials
  - Renewable energy




Fuels and Greenhouse Gases

# Energy Sustainability

- Design around fuel and energy neutrality
- Framework of series hybrid allows iPod app approach
  - Change generator depending on region and availability
  - Enhances local infrastructure
  - Maintains freedom of movement for customer
- Reinforces national security as supported by the Department of Energy's "Strategic Approach to Transportation Energy Security"




Map represents largest number of alternative fueling stations as of 2007

# Economic Sustainability

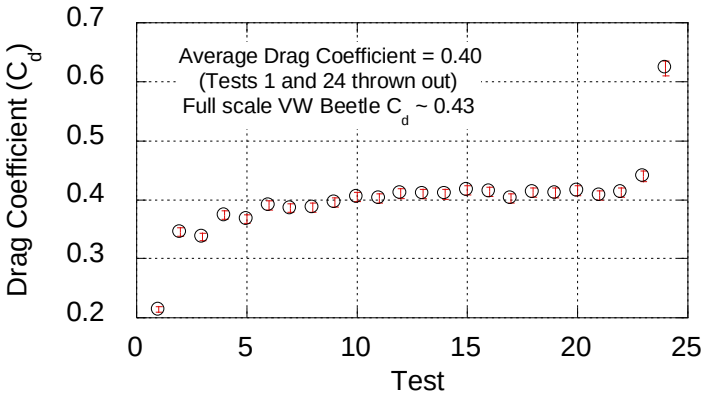
- Need to train students in innovative technology
- Keep costs moderate
- Recycling vehicles and incorporating advanced concepts wisely keeps costs moderate
- Approximately $25,000 spent in starting program with biodiesel components around $15,000
- In-kind donations can reduce costs further
- Large aftermarket automotive industry


The SAHMO fuel cell concept won third most efficient vehicle in Europe's 26th Shell Eco Marathon and cost **$170,000**

# Educational Sustainability

- Get students working on right technology
- Foster interdisciplinary relationships
  - Chemical Engineering provided fuel
  - Aerospace Engineering provided space and wind tunnel time
  - Electrical Engineering working on regenerative braking
  - Environmental Engineering analyzing exhaust emissions
- Grant written for program with multiple faculty

Wind tunnel test of Beetle design



# Ethical Sustainability

- While researching fuels and power plant choices, it is important to consider the societal impact of decisions (ex: food vs. fuel)
- Vehicle cost should be realistic as a car that the general public can afford would make the largest sustainable impact

**FUEL SOURCES**

| CROP | USED TO PRODUCE | GREENHOUSE GAS EMISSIONS* Kilograms of carbon dioxide created per mega joule of energy produced | USE OF RESOURCES DURING GROWING, HARVESTING AND REFINING OF FUEL: WATER | FERTILIZER | PESTICIDE | ENERGY | PERCENT OF EXISTING U.S. CROP LAND NEEDED TO PRODUCE ENOUGH FUEL TO MEET HALF OF U.S. DEMAND | PROS AND CONS |
|---|---|---|---|---|---|---|---|---|
| Corn | Ethanol | 81-85 | high | high | high | high | 157%-262% | Technology ready and relatively cheap, reduces food supply |
| Sugar cane | Ethanol | 4-12 | high | high | med | med | 46-57 | Technology ready, limited as to where will grow |
| Switch grass | Ethanol | -24 | med-low | low | low | low | 60-108 | Won't compete with food crops, technology not ready |
| Wood residue | Ethanol, biodiesel | N/A | med | low | low | low | 150-250 | Uses timber waste and other debris, technology not fully ready |
| Soybeans | Biodiesel | 49 | high | low-med | med | med-low | 180-240 | Technology ready, reduces food supply |
| Rapeseed, canola | Biodiesel | 37 | high | med | med | med-low | 30 | Technology ready, reduces food supply |
| Algae | Biodiesel | -183 | med | low | low | high | 1-2 | Potential for huge production levels, technology not ready |

* Emissions produced during the growing, harvesting, refining and burning of fuel. Gasoline is 94, diesel is 83.

Source: Martha Groom, University of Washington; Elizabeth Gray, The Nature Conservancy; Patricia Townsend, University of Washington; as published in Conservation Biology

SEATTLE P-I

"Bio-debatable: Food vs. Fuel", Seattle Post-Intelligencer

# First Year Accomplishments

- Eleven students maintained 3.14 GPA
- Series hybrid platform created with estimated 50 mpg fuel economy
- Garnered significant press for university
- Two students staying for graduate school
- Program just won university wide award for sustainability

100% biodiesel generator in area of original trunk

→ fills

10 Advanced Glass Mat (AGM) lead-acid batteries

→ powers

NetGain Warp 9 motor connected to original transmission

# Future Efforts – VW Beetle

- Students tearing apart car and rebuilding for vehicle inspection
- Get on the road for data collection
- Make plug-in hybrid vehicle
- Incorporate energy neutrality through solar energy filling station
  - Beginnings of smart grid goal
  - 2011 Solar Decathlon possibility
  - Refurbishment of old barn
- Incorporate more disciplines

Rebuilding of VW interior for aesthetics and safety

Solar panel install on “new” EcoHawks facility

# Future Efforts – R/C Cars

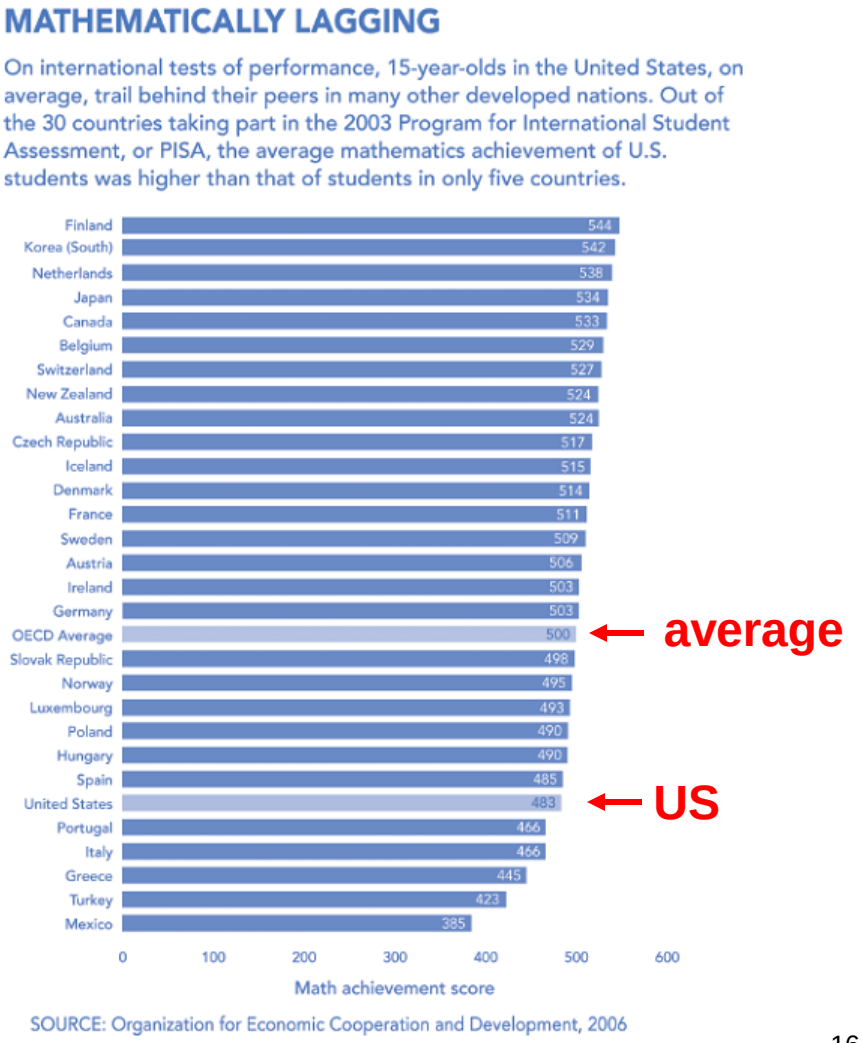
- Fun way of incorporating advanced technology
- Significant reduction in cost because of the relative scale of components (1:8/1:10)
- Increases the level of technology of the program
- Easier to shift focus and target trends and opportunities
- Students get unlimited freedom to design their car of the future
- Proposal written by them must incorporate all five facets of sustainability
- Other disciplines easier to incorporate
- Phasing of technology

PEM Fuel Cell for R/C applications - $700

Brushless motor and electronic speed controller - $150

# Incorporating K-12 Education

- Current state of US illustrates STEM shortage
- KU EcoHawks students fostering development on K-12 level
- Presented recently at Kansas environmental conference geared towards K-16 teachers
- Running gravity powered vehicle competition for students at KU Engineering Exposition



# Conclusion

- New, innovative program started at the University of Kansas
- Follows tenets of sustainability to ensure decisions being put in correct focus
- Students having fun, maintaining grades and learning new expertise
- Enrollment tripled in one year (32 students for 2009-2010)
- Future technologies incorporated now

# Special Thanks

KU TRANSPORTATION RESEARCH INSTITUTE
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KU eco HAWKS

# *Any Questions?*

http://www.ecohawks.org

# Six EcoHawk Teams

- Team CellMates
  - Hydrogen fuel cell powered vehicle using metal hydride storage
- Team Slayer
  - Parallel hybrid using E-85 or biodiesel fuel in IC engine
- Team AMP
  - $LiFePO_4$ batteries and on-board battery charger
- Team Redline
  - High efficiency batteries and motor into low drag design
- Team CranoFran
  - Incorporating recycled materials into highly efficient daily driver
- Team Electric Slide
  - Inexpensive plug-in electric vehicle

# Gravity Derby

- Ramp race
  - Gravity based power
  - Make from recyclable materials
- Easily constructed
  - Scalable difficulty for any grade level
- Concepts taught:
  - Potential and kinetic energy, rolling resistance, wheel inertia, others?