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It's Not Easy Being Green—

Transportation Challenges With A Global Perspective

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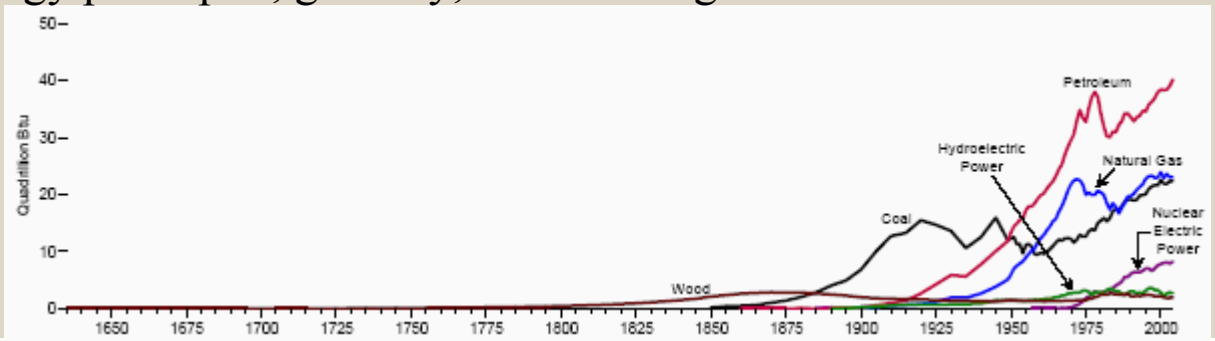
Energy Trends

- Good News:
  - From 1850 to 1970: population tripled, energy 12-fold.
  - From 1970 to present: population up 68%, energy use up 73%.
    - (State of the World Report, Worldwatch Institute 2004)
- Bad News:
  - Population, and therefore total energy use, continues to rise.
    - In the production of food, only 10-20% of the input energy is in production; 80-90% is in transportation, processing, and consumption (Heller and Kaoleian)
  - The energy per capita, globally, is increasing

Total Energy Use (1650-present)

Source: Energy Information Administration, Annual Energy Review 2004



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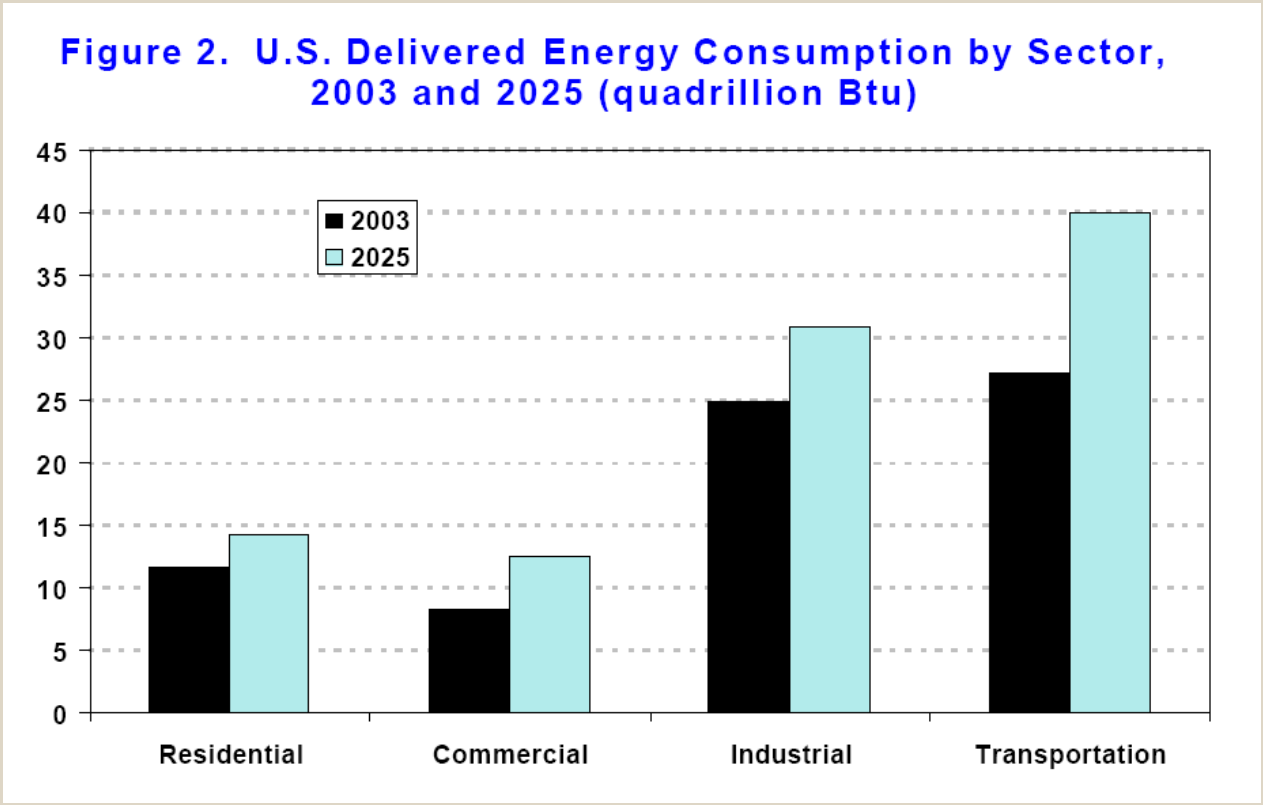
Why Transportation? (Total Energy)



Source: US Department of Energy

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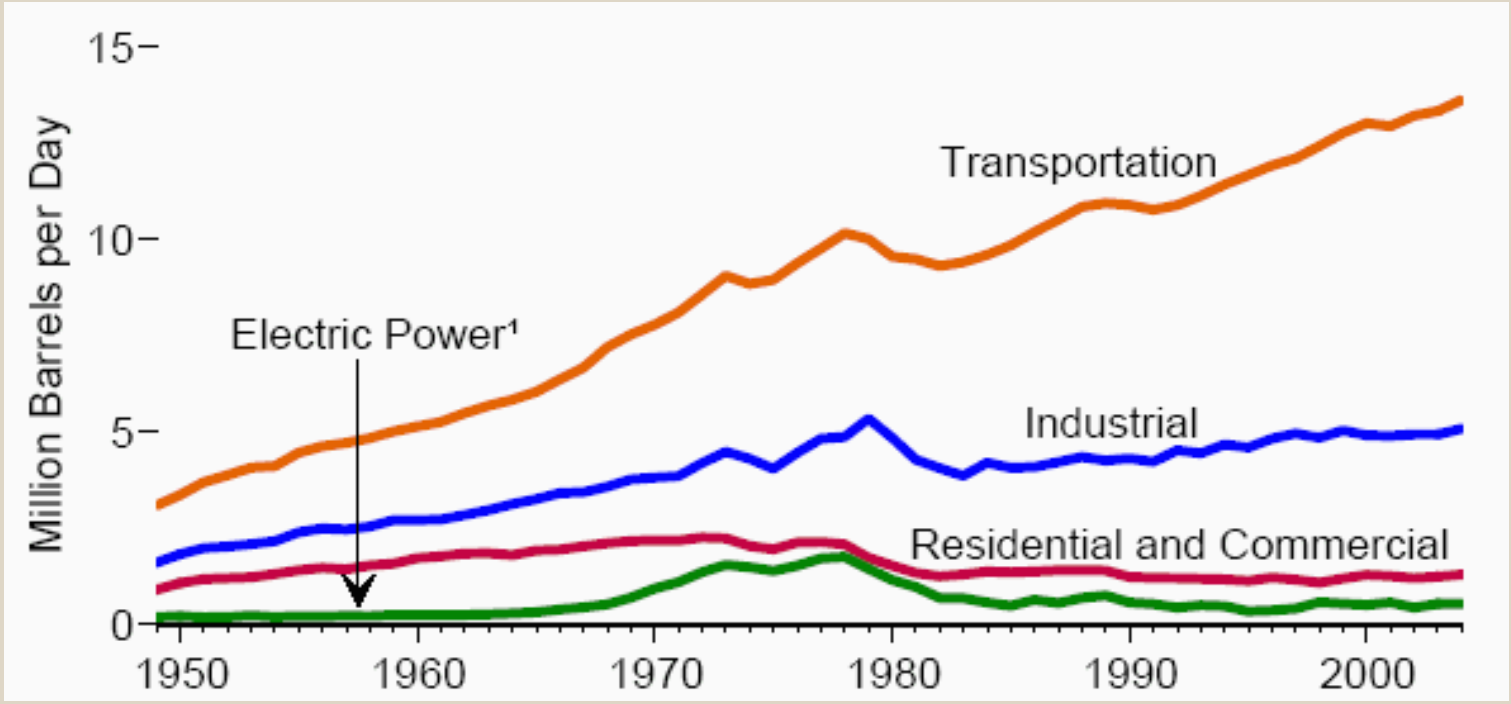
Why Transportation? (US Petroleum Based Energy)



Source: Energy Information Administration, Annual Energy Review 2004

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Questions for Today?

- Is our current path going to result in sustainable transportation?
- Are we able to achieve sustainable transportation?
  - Do we have a choice?
- The Big Question?
  - Is it enough to find a technical solution(s)?

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Recent Trends…Mobility

- Resurgence of Hybrid Vehicles
  - Prius, Insight, Escape, HLA, Cumulo
- Emphasis on Fuel Cells
- Clean Diesel Technologies
- New Engine Technologies
- Increased Emphasis on Biofuels

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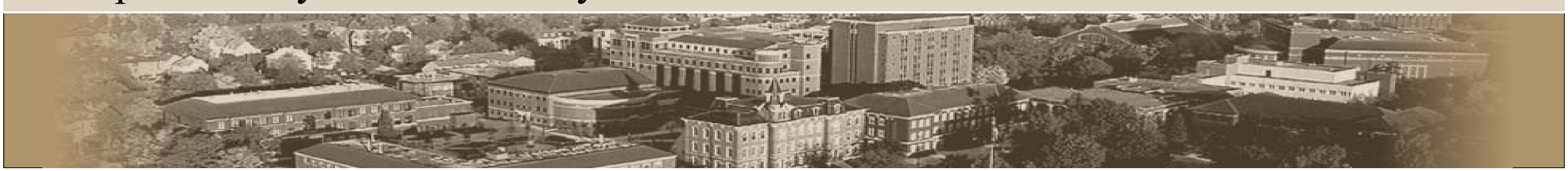
Fuel Efficient Vehicles Current Activity

- In production, targeted for, and concept hybrid vehicles…
- Hybrid, EV, PHEV, diesel, E85
- 54.5MPG by 2025

http://www.hybridcars.com/hybrid-cars-list

OUR COMPLETE LIST OF ALTERNATIVE FUEL-EFFICIENT VEHICLES
IT'S A LONG LIST, SO YOU CAN SORT BY VEHICLE NAME, MPG, TECHNOLOGY, TYPE, AND PRICE. JUST CLICK ON THE COLUMN HEADER OF YOUR CHOICE.
SORT BY: NAME COMBINED
MPG TECHNOLOGY TYPE MSRP AVAILABLE TOYOTA PRIUS THE NUMBER-ONE SELLING HYBRID CAR. THE PRIUS IS NEARLY SYNONYMOUS WITH "HYBRID."
50 MPG HYBRID SEDAN $22,000 NOW HONDA CIVIC HYBRID FUEL EFFICIENCY, FULL-HYBRID SYSTEM, AND A SLEEK DESIGN.
42 MPG HYBRID SEDAN $22,600 NOW HONDA INSIGHT THE NEW HONDA INSIGHT COMBINES PRACTICALITY, AFFORDABILITY AND TOP-OF-THE-CHARTS FUEL ECONOMY.
41 MPG HYBRID SEDAN $19,800 NOW FORD FUSION HYBRID A FULL-SIZE SEDAN THAT ACHIEVES 41 MPG IN THE CITY.
39 MPG HYBRID SEDAN $27,300 NOW MERCURY MILAN HYBRID THE MILAN HYBRID, CLOSE COUSIN TO THE FUSION, ALMOST DOUBLES THE CITY EFFICIENCY OF THE NON-HYBRID MILAN.
39 MPG HYBRID SEDAN $27,500 NOW SMART FORTWO THE SMART FORTWO IS CUTE AND RELATIVELY FUEL EFFICIENT, BUT UNDERPOWERED.
36 MPG SMALL CAR COUPE $15,000 NOW MINI COOPER MATCHES OR BEATS EFFICIENCY OF OTHER SUBCOMPACTS, BUT WITH TONS MORE STYLE.
35 MPG SMALL CAR COUPE $18,700 NOW VOLKSWAGEN JETTA TDI THE VOLKSWAGEN JETTA TDI OFFERS 140 HORSEPOWER, 40-MPG ON THE HIGHWAY, AND A WAGON OPTION.
35 MPG DIESEL SEDAN $21,900 NOW NISSAN ALTIMA HYBRID THE ALTIMA HYBRID IS BASICALLY A TOYOTA HYBRID WRAPPED IN NISSAN'S ATTRACTIVE PACKAGING.
34 MPG HYBRID SEDAN $25,100 NOW LEXUS HS 250H THINK OF IT AS A LUXURY PRIUS WITH A TRUNK.
34 MPG HYBRID SEDAN $34,200 NOW TOYOTA CAMRY HYBRID THE HYBRID VERSION OF THE CAMRY BEATS THE FUEL EFFICIENCY OF THE V6 VERSION BY 10 MPG.
33 MPG HYBRID SEDAN $25,500 NOW FORD ESCAPE HYBRID THE OVERALL MOST FUEL EFFICIENT SUV.
32 MPG HYBRID SUV $29,300 NOW MERCURY MARINER HYBRID SLIGHTLY UPSCALE VERSION OF THE FORD ESCAPE HYBRID.
32 MPG HYBRID SUV $29,800 NOW TOYOTA YARIS THE YARIS IS THE LEADER OF THE SUBCOMPACT TRIUMVIRATE, WHICH INCLUDES THE HONDA FIT AND THE NISSAN VERSA.
32 MPG SMALL CAR SEDAN $12,400 NOW MAZDA TRIBUTE HYBRID THE MAZDA TRIBUTE HYBRID IS BASICALLY A RE-SKINNED FORD ESCAPE HYBRID, USING THE SAME POWERTRAIN AND MANY OF THE SAME INTERIOR BITS.
32 MPG HYBRID SUV N/A NOW MINI COOPER CLUBMAN THE SAME HIP AND EFFICIENT MINI COOPER, BUT WITH A LONGER BODY AND WHEELBASE.
32 MPG SMALL CAR COUPE $19,900 NOW HONDA FIT THE FIT HAS A SMART, BUT PLAYFUL APPEARANCE, AND A DECEIVINGLY LARGE AND VERSATILE FIVE-PASSENGER INTERIOR.
31 MPG SMALL CAR SEDAN $14,600 NOW TOYOTA COROLLA POPULAR AND PRACTICAL MODEL WITH FUEL EFFICIENCY APPROACHING THE HYBRID REALM.
30 MPG SMALL CAR SEDAN $14,200 NOW SCION XD SMALL AND EFFICIENT LIKE THE XA, BUT EDGIER AND MORE POWERFUL.
30 MPG SMALL CAR SEDAN $14,500 NOW HONDA CIVIC THE BEST-SELLING COMPACT IS AFFORDABLE, AND GETS GOOD MILEAGE.
30 MPG SMALL CAR SEDAN $15,500 NOW CHEVROLET MALIBU HYBRID THE FAMILIAR FAMILY SEDAN NOW WITH DRAMATIC CHANGES IN STYLE, REFINEMENT, AND PERFORMANCE. AND A HYBRID DRIVE.
29 MPG STOP-START SEDAN $22,800 NOW BMW 335D THE 3-SERIES WITH A 3.0-LITER BITURBO INLINE-SIX DIESEL POWERPLANT.
29 MPG DIESEL SEDAN $44,700 NOW KIA RIO PLAIN-JANE FROM FROM FRONT TO BACK. THE KIA RIO MAKES NO FALSE PROMISES. IT'S AFFORDABLE AND EFFICIENT.
29 MPG SMALL CAR SEDAN $10,900 NOW FORD FOCUS COMFORTABLE, CONTROLLABLE, EFFICIENT, AND AFFORDABLE.
29 MPG SMALL CAR SEDAN $14,700 NOW TOYOTA MATRIX A SEGMENT BUSTER: PART COMPACT CAR, PART SPORT WAGON, AND PART SMALL CROSSOVER UTILITY.
29 MPG SMALL CAR SUV $16,200 NOW PONTIAC VIBE ONE OF THE PREMIER "COMPACT CROSSOVER" VEHICLES IN THE NEW SEGMENT.
29 MPG SMALL CAR SUV $17,400 NOW CHEVROLET AVEO ONE OF THE CHEAPEST CARS ON THE MARKET. YOU GET WHAT YOU PAY FOR.
29 MPG SMALL CAR SEDAN $12,000 NOW NISSAN CUBE A WHIMSICAL AND QUIRKY OPTION IN THE SMALL ECONOMY CLASS.
29 MPG SMALL CAR SEDAN $14,000 NOW NISSAN VERSA OFFERED IN TWO BODY STYLES, A SPORTY 5-DOOR HATCHBACK AND A 4-DOOR SEDAN, THE VERSA IS THE LARGEST AND MOST POWERFUL ENTRY-LEVEL CITY CAR.
28 MPG SMALL CAR SEDAN $13,600 NOW LEXUS RX 450H UPDATED VERSION OF THE LUXURY SUV WITH GREEN STRIPES.
28 MPG HYBRID SUV $41,700 NOW KIA SOUL HIP, AFFORDABLE, BOXY URBAN CRUISER, WITH LOTS OF ACCESSORIES.
28 MPG SMALL CAR SEDAN $13,300 NOW SATURN VUE HYBRID THE VUE GREEN LINE IS THE LOW-COST LOW-BENEFIT HYBRID SUV.
27 MPG STOP-START SUV $24,200 NOW SATURN AURA GREEN LINE SATURN AIMS FOR HYBRID AFFORDABILITY.
27 MPG STOP-START SEDAN $22,100 NOW MERCEDES E320 BLUETEC THE E320 BLUETEC LUXURY SEDAN USES A MODERN DIESEL SYSTEM TO DELIVER EFFICIENCY AND ECO-FRIENDLINESS.
27 MPG DIESEL SEDAN $52,300 NOW TOYOTA HIGHLANDER HYBRID MORE AFFORDABLE THAN THE LEXUS RX400H, MORE POWERFUL THAN FORD'S HYBRID SUVS, AND MORE EFFICIENT THAN GM'S FULL-SIZE SUV HYBRIDS.
26 MPG HYBRID SUV $33,700 NOW CHEVROLET EQUINOX SMALL GAS-POWERED SUV WITH THE HIGHEST HIGHWAY FUEL ECONOMY RATING.
26 MPG SUV $23,200 NOW LEXUS RX 400H EVERYTHING A LUXURY SUV BUYER SEEKS—IN A GREENER PACKAGE.
25 MPG HYBRID SUV $42,000 NOW SCION XB GOOD FUEL EFFICIENCY FOR THE LITTLE WAGON. URBAN AND YOUTHFUL.
25 MPG SMALL CAR VAN $15,700 NOW MAZDA5 NUMBER ONE MOST FUEL-EFFICIENT MINIVAN ON THE MARKET. SMALLER THAN MOST.
25 MPG SMALL CAR VAN $18,000 NOW SUZUKI SX4 THE MOST AFFORDABLE ALL-WHEEL-DRIVE VEHICLE ON THE ROAD TODAY.
24 MPG SMALL CAR SEDAN $15,300 NOW LEXUS GS 450H RACE-CAR-LIKE ACCELERATION, LUXURIOUS APPOINTMENTS, AND HALF-WAY DECENT FUEL EFFICIENCY.
23 MPG HYBRID SEDAN $54,900 NOW BMW X5 XDRIVE35D HIGH-PERFORMANCE, LUXURY SUV. NOW MORE EFFICIENT AS A DIESEL.
23 MPG DIESEL SUV $52,000 NOW JEEP GRAND CHEROKEE CRD FOLLOWING THE SUCCESS OF THE DIESEL VERSION OF THE JEEP LIBERTY IN 2005, JEEP NOW OFFERS THEIR NEWEST DIESEL POWERTRAIN MATED TO THE GRAND CHEROKEE.
22 MPG DIESEL SUV $34,400 NOW CHEVROLET TAHOE HYBRID A NEW BREED OF FULL-SIZE SUV THAT IS SIGNIFICANTLY GREENER THAN ITS GAS-POWERED COUNTERPARTS
21 MPG HYBRID SUV $50,500 NOW CHEVROLET SILVERADO HYBRID GM PHASED OUT THE ULTRA-LIGHT HYBRID PICKUPS THAT PRODUCED A 10-15 PERCENT INCREASE IN FUEL ECONOMY TO MAKE ROOM FOR A FULL-HYBRID VERSION OF THE SILVERADO.
21 MPG HYBRID PICKUP $39,000 NOW LEXUS LS 600H L LEXUS'S 5-LITER, V8, 430-HORSEPOWER LUXURY SEDAN HYBRID.
21 MPG HYBRID SEDAN $104,000 NOW MERCEDES ML 320 BLUETEC THE MOST POPULAR MERCEDES SUV, AVAILABLE IN FUEL-EFFICIENT CLEAN DIESEL VERSION.
21 MPG DIESEL SUV $48,600 NOW VOLKSWAGEN TOUAREG TDI VW DITCHED V10. NOW, THE TOUAREG TDI COMES REASONABLY PRICED AND REASONABLY POWERED BY A 3.0-LITER V6 TURBO DIESEL ENGINE.
21 MPG DIESEL SUV $42,800 NOW GMC SIERRA HYBRID BREAKS THE 20-MPG MARK TO BECOME THE MOST EFFICIENT FULL-SIZE PICKUP.
21 MPG HYBRID PICKUP $39,400 NOW GMC YUKON HYBRID THE SISTER VEHICLE OF THE CHEVY TAHOE HYBRID. SAME GAS-SAVING IMPROVEMENTS TO THE XXL PLATFORM.
21 MPG HYBRID SUV $50,500 NOW MERCEDES R320 BLUETEC A BIG AND HEAVY LUXURY STATION WAGON WITH A CLEAN DIESEL ENGINE.
21 MPG DIESEL SUV $49,100 NOW AUDI Q7 TDI LUXURY SEVEN-PASSENGER CLEAN DIESEL SUV WITH ULTRA-LOW EMISSIONS.
21 MPG DIESEL SUV $50,900 NOW CADILLAC ESCALADE HYBRID THE FIRST EIGHT-PASSENGER LUXURY SUV HYBRID. AN ODD MIX OF SELF-INDULGENCE AND GREEN.
20 MPG HYBRID SUV $70,000 NOW MERCEDES GL320 BLUETEC THE BIGGEST, BLUNTEST, AND HEAVIEST CLEAN DIESEL SUV FROM MERCEDES-BENZ.
20 MPG DIESEL SUV $59,200 NOW DODGE CARAVAN E85 ONE OF THE TRUE WORKHORSE E85 VEHICLES.
18 MPG E85 ETHANOL VAN $22,400 NOW CHEVROLET IMPALA E85 THE POPULAR SEDAN IS ONE OF THE FRONT-RUNNING FLAGSHIPS OF THE E85 MOVEMENT.
17 MPG E85 ETHANOL SEDAN $22,400 NOW CHRYSLER SEBRING E85 AMERICA'S TOP-SELLING CONVERTIBLE BOASTS A NEW HARDTOP AND E85 CAPABILITY.
16 MPG E85 ETHANOL SEDAN $29,300 NOW CHEVROLET SILVERADO E85 AMERICA'S PROTOTYPICAL PICKUP IS A NATURAL FIT FOR E85.
13 MPG E85 ETHANOL PICKUP $29,400 NOW FORD F-150 E85 FORD'S BEST-SELLING PICKUP TRUCK OFFERS FLEX-FUEL CAPABILITIES.
11 MPG E85 ETHANOL PICKUP $22,100 NOW THE EBOX THE EBOX IS AN ELECTRIC VEHICLE CONVERSION OF THE SCION XB.
N/A ELECTRIC VAN $70,000 NOW TANGO T600 FIRST, THROW AWAY ALL THE EXPECTED CONVENTIONS ABOUT THE APPROPRIATE SIZE OF YOUR DAILY CAR. THIS ALL-ELECTRIC VEHICLE IS HALF THE SIZE, FROM SIDE TO SIDE, OF MOST CARS.
N/A ELECTRIC LUXURY $108,000 NOW MYERS NMG THE MYERS NMG IS A FUNKY, SINGLE-OCCUPANT THREE-WHEELED ELECTRIC VEHICLE. THAT'S RIGHT, THERE'S JUST ENOUGH ROOM FOR YOU AND A CART'S WORTH OF GROCERIES.
N/A ELECTRIC COUPE $36,000 NOW TESLA ROADSTER THE TESLA ROADSTER IS A SCREAMING-FAST, ALL-ELECTRIC TWO-SEATER SPORTS CAR BUILT ON THE FRAME OF THE LOTUS ELISE.
N/A ELECTRIC LUXURY $109,000 NOW VENTURI FETISH THE VENTURI FETISH, DESCRIBED BY ITS MAKER AS "THE FIRST PRODUCTION ELECTRIC SPORTS CAR IN AUTOMOBILE HISTORY," WILL SET YOU BACK $400,000.
N/A ELECTRIC LUXURY $400,000 NOW ZAP XEBRA CHINESE-BUILT THREE-WHEEL ROAD-READY ELECTRIC VEHICLE.
N/A ELECTRIC COUPE $12,000 NOW FISKER KARMA THE REAR-WHEEL DRIVE SPORTY PLUG-IN HYBRID FROM DESIGNER HENRIK FISKER.
100 MPG PLUG-IN HYBRID LUXURY $87,000 2009 MERCEDES ML 450 HYBRID THE MERCEDES-BENZ VERSION OF THE TWO-MODE SYSTEM COMBINES A 275-HORSEPOWER, 3.5-LITER V6 GASOLINE ENGINE AND TWO ELECTRIC MOTORS.
22 MPG HYBRID SUV 2009 VENTUREONE THE EXHILARATION OF A FAST MOTORCYCLE, THE SAFETY AND COMFORT OF A COMMUTER CAR, AND THE FUEL EFFICIENCY OF ADVANCED AUTOMOTIVE TECHNOLOGIES.
N/A PLUG-IN HYBRID COUPE $18,000 2009 HONDA GLOBAL SUBCOMPACT HYBRID A SMALL, PRACTICAL, AFFORDABLE AND ENTIRELY NEW HYBRID-ONLY MODEL FROM HONDA.
N/A N/A 2009 AUDI A3 TDI A STEP UP FROM THE JETTA TDI SPORTWAGEN, WITHOUT GOING AS FAR AS EXPENSIVE CLEAN DIESELS FROM MERCEDES AND BMW.
35 MPG DIESEL SEDAN $30,800 2010 HYUNDAI SONATA HYBRID HYUNDAI'S FIRST HYBRID COULD OFFER EFFICIENCY ABOVE 30 MPG, FOR THOUSANDS BELOW THE COMPETITION.
31 MPG HYBRID SEDAN N/A 2010 SATURN VUE GREEN LINE TWO-MODE THE TWO-MODE HYBRID VERSION OF THE SATURN VUE IS A SOLID HIGH-EFFICIENCY V6 SUV.
30 MPG HYBRID SUV $33,000 2010 HYUNDAI ACCENT HYBRID HYUNDAI DELAYED DEVELOPMENT OF ITS $15,000 45-MPG SUBCOMPACT UNTIL 2009, AT THE EARLIEST.
N/A HYBRID SEDAN N/A 2010 CHEVROLET VOLT ALL-ELECTRIC GAS-FREE DRIVING FOR 40-MILE STRETCHES.
N/A PLUG-IN HYBRID SEDAN $40,000 2010 BMW X6 HYBRID AN SUV THAT HAS CROSSED OVER INTO SPORTS CAR TERRITORY.
N/A HYBRID SUV N/A 2010 PORSCHE CAYENNE S HYBRID THE PORSCHE CAYENNE HYBRID ACHIEVES BETTER THAN 24 MILES PER GALLON COMPARED WITH LESS THAN 18 MPG FOR THE CONVENTIONAL MODEL.
N/A HYBRID SUV N/A 2010 MITSUBISHI IMIEV MITSUBISHI PLANS TO MASS-MARKET A SMALL ELECTRIC VEHICLE BY 2010.
N/A ELECTRIC COUPE N/A 2010 HONDA FIT HYBRID THE HYBRID VERSION OF THE HONDA SUBCOMPACT COULD BECOME THE LEADER OF THE PACK ON FUEL EFFICIENCY.
N/A HYBRID SEDAN N/A 2010 MERCEDES S400 BLUEHYBRID THIS ECO-CHIC LUXURY SEDAN COULD BE THE FIRST PRODUCTION VEHICLE WITH A LITHIUM ION BATTERY.
N/A HYBRID SEDAN N/A 2010 DODGE RAM HYBRID CHRYSLER'S HEMI-POWERED HYBRID SYSTEM APPLIED TO THE RAM PICKUP.
N/A HYBRID PICKUP N/A 2010 TH!NK CITY A VIABLE HIGHWAY-CAPABLE ALL-ELECTRIC TWO-SEATER FROM AN INDUSTRY VETERAN.
N/A ELECTRIC COUPE $28,000 2010 CHEVROLET CRUZE NEW STYLISH SUBCOMPACT, DUE IN 2010, COULD BE CHEVY'S HIGH-MPG HIT.
N/A SMALL CAR SEDAN N/A 2010 NISSAN LEAF THE TOP CONTENDER FOR FIRST AFFORDABLE MAINSTREAM ALL-ELECTRIC CAR.
N/A ELECTRIC SEDAN N/A 2010 BMW ACTIVEHYBRID 7 THE FASTEST-ACCELERATING HYBRID SEDAN IN THE WORLD
N/A HYBRID SEDAN N/A 2010 TOYOTA IQ THE IQ WILL COMPETE WITH SMART BY OFFERING FOUR SEATS, AND TOYOTA QUALITY.
SMALL CAR COUPE 2010 GM PLUG-IN CROSSOVER SUV GM'S PLUG-IN HYBRID SUV WAS A SATURN, THEN A BUICK, NOW PROBABLY A CHEVY.
N/A PLUG-IN HYBRID SUV N/A 2011 HONDA CR-Z HYBRID CAN A HYBRID COMPACT CAR BE SPORTY AND SPEEDY? HONDA WILL TRY.
N/A HYBRID COUPE N/A 2011 VOLKSWAGEN TOUAREG HYBRID COMBINES A DIRECT INJECTION ENGINE AND HYBRID GAS-ELECTRIC SYSTEM FOR MAXIMUM BENEFIT.
N/A HYBRID SUV 2011 DODGE CIRCUIT .
N/A ELECTRIC COUPE 2011 FORD FOCUS EV AN ALL-ELECTRIC VERSION OF THE FORD FOCUS, WITH 100 MILES OF RANGE.
N/A ELECTRIC SEDAN N/A 2011 TESLA MODEL S A BRIGHT VISION OF WHAT A PRACTICAL AND DESIRABLE ALL-ELECTRIC SEDAN COULD BE.
N/A ELECTRIC SEDAN $57,900 2011 FORD ESCAPE PLUG-IN HYBRID THE PROVEN FUEL-EFFICIENT SUV HYBRID WILL COME WITH A PLUG IN 2012.
N/A PLUG-IN HYBRID SUV N/A 2012 VOLVO V70 PLUG-IN HYBRID VOLVO APPEARS SERIOUS ABOUT PRODUCING A PLUG-IN HYBRID WAGON WITH 30 OR MILES OF ELECTRIC RANGE.
N/A PLUG-IN HYBRID VAN N/A 2012 HONDA FCX CLARITY A LIMITED NUMBER OF SOUTHERN CALIFORNIANS WILL HAVE THE OPPORTUNITY TO LEASE A HONDA FCX CLARITY IN THE NEXT FEW YEARS. THIS IS THE FIRST TIME A CUSTOMER CAN OBTAIN A FUEL CELL CAR DIRECTLY FROM A RETAIL DEALER.
74 MPG HYDROGEN SEDAN N/A CONCEPT CHEVROLET EQUINOX FUEL CELL A FLEET OF 100 CHEVY EQUINOXES RUNNING ON HYDROGEN HAVE BEEN TESTED BY MORE THAN 3,000 THOUSAND REAL-WORLD DRIVERS.
43 MPG HYDROGEN SUV N/A CONCEPT FORD REFLEX CONCEPT SPORTS COUPE MARRIES 1.4-LITER TURBO-DIESEL ENGINE WITH FORD'S HYBRID DRIVE.
N/A DIESEL COUPE N/A CONCEPT MERCURY META ONE A HYBRID TRANSMISSION WITH A TWIN-TURBOCHARGED V-6 DIESEL ENGINE CALIBRATED TO RUN ON BIODIESEL.
N/A DIESEL VAN N/A CONCEPT SUBARU B5-TPH A SPORTY TWO-SEAT, ALL-WHEEL-DRIVE GRAND TOURER THAT BLENDS ELEMENTS OF COUPE, SPORTY HATCHBACK, AND OUTBACK SPORT-UTILITY.
N/A ELECTRIC COUPE N/A CONCEPT TOYOTA VOLTA BEFORE THE CHEVY VOLT, THERE WAS THE TOYOTA VOLTA—A SUPER-HIP AND SPEEDY CONCEPT HYBRID FROM TOYOTA.
N/A HYBRID COUPE N/A CONCEPT TOYOTA SIENNA HYBRID TOYOTA OFFERS A HYBRID MINIVAN IN JAPAN. THOUSANDS OF FAMILIES ARE WAITING FOR THAT OPTION IN THE UNITED STATES.
N/A HYBRID VAN N/A CONCEPT TOYOTA HYBRID X THE HYBRID X IS A DESIGN EXERCISE INDICATING THE GENERAL VISUAL DIRECTION OF TOYOTA'S HYBRIDS.
N/A HYBRID SEDAN N/A CONCEPT SAAB BIOPOWER HYBRID SAAB'S KITCHEN SINK APPROACH TO SOLVING ENVIRONMENTAL PROBLEMS IN CARS.
N/A E85 ETHANOL SEDAN N/A CONCEPT VOLVO 3CCC ROCKET-SHAPED THREE-SEATER CAN ACCOMMODATE THE FULL RANGE OF POWER SYSTEMS AND FUELS.
N/A ELECTRIC COUPE N/A CONCEPT TOYOTA A-BAT CONCEPT HYBRID PICKUP TRUCK A KINDER, GENTLER, AND WEIRDER VISION FOR A PICKUP TRUCK. AND IT'S A HYBRID.
N/A HYBRID PICKUP N/A CONCEPT BMW HYDROGEN 7 THE BMW HYDROGEN 7— ESSENTIALLY A 7 SERIES SEDAN—BURNS SUB-ZERO LIQUID HYDROGEN IN ITS CONVENTIONAL V-12 ENGINE.
N/A HYDROGEN SEDAN N/A CONCEPT AUDI Q7 HYBRID REFINED AND OPULENT, AND NOW THE HYBRID VERSION OFFERS SLIGHTLY BETTER FUEL EFFICIENCY.
N/A HYBRID SUV N/A CONCEPT CADILLAC PROVOQ OVER-THE-TOP PLUG-IN HYDROGEN-ELECTRIC FUEL-CELL LUXURY HYBRID CONCEPT SUV.
N/A HYDROGEN SUV N/A CONCEPT SUBARU R1E SUBARU'S CONCEPT VEHICLE TO WORK ON GETTING CHARGE TIMES DOWN TO FIVE MINUTES OR SO.
N/A ELECTRIC COUPE N/A CONCEPT VOLKSWAGEN UP! VOLKSWAGEN'S PLAY INTO THE HIGH-MPG MINICAR MARKET.
N/A SMALL CAR COUPE N/A CONCEPT DODGE GRAND CARAVAN HYBRID AT THIS STAGE, IT'S MORE OF A RUMOR THAN A DEFINITE RELEASE. BUT IT MAKES SENSE FOR CHRYSLER.
N/A HYBRID VAN N/A CONCEPT MINI E LIMITED RUN OF 500 UNITS OF ALL-ELECTRIC VERSION OF MINI COOPER.
N/A ELECTRIC COUPE N/A CONCEPT TOYOTA FT-EV TOYOTA FT-EV CONCEPT, AN ALL-ELECTRIC CAR BASED ON THE TOYOTA IQ, OFFERS A DRIVING RANGE OF 50 MILES.
N/A ELECTRIC COUPE N/A CONCEPT CADILLAC CONVERJ AN ANGULAR, SLEEK, LUXURY CONCEPT VERSION OF THE CHEVROLET VOLT.
N/A PLUG-IN HYBRID SEDAN N/A CONCEPT



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What about the hybrid vehicles?

- Well-to-Wheel Comparison of 11 powertrains assuming standard rolling chassis.
  - SAE Paper 2003-01-0081

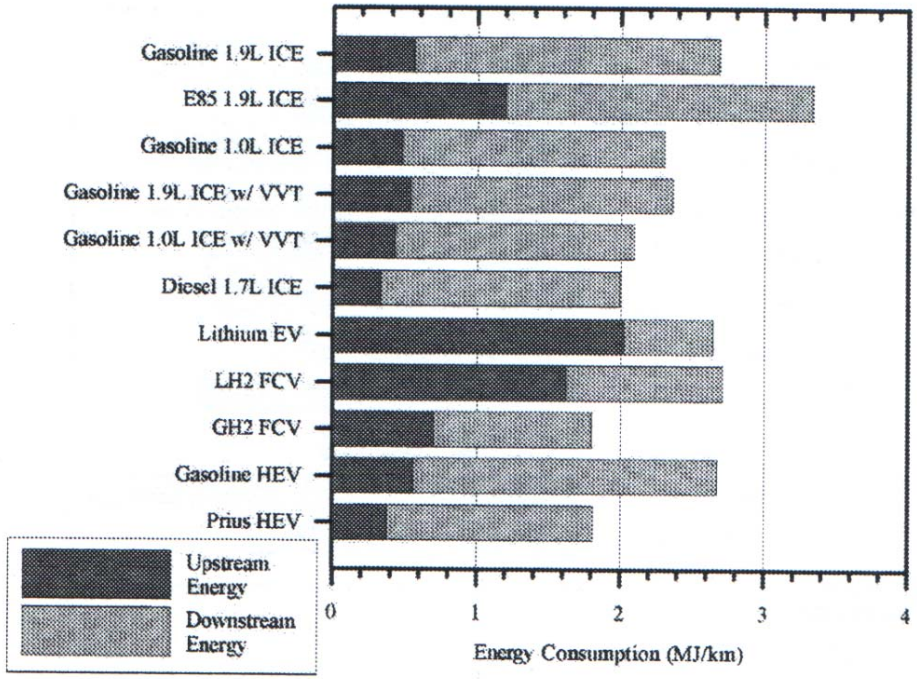

Figure 7 - Total Energy Consumption

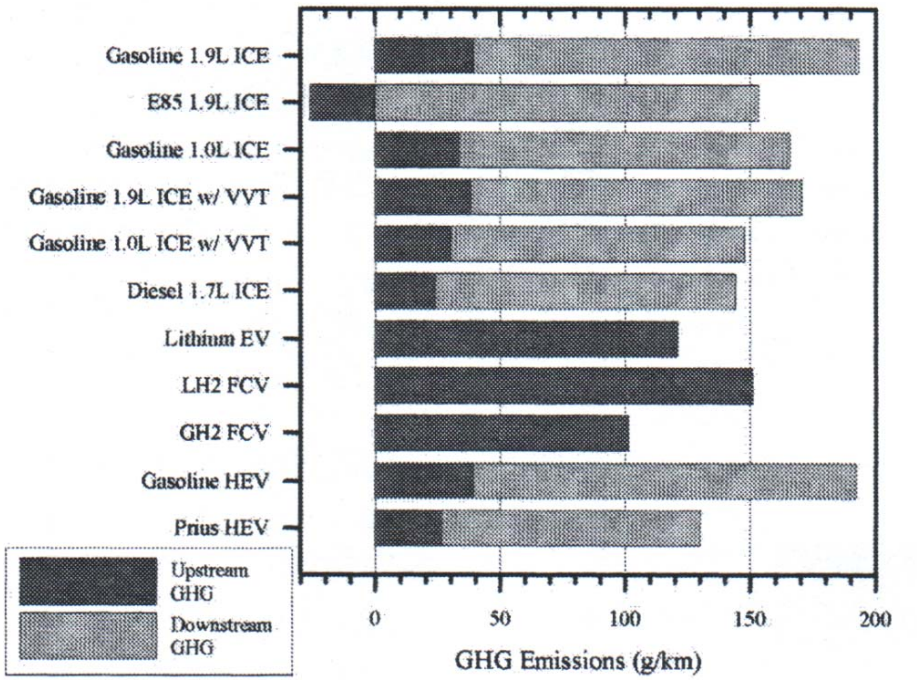

Figure 8 - Total GHG Emissions

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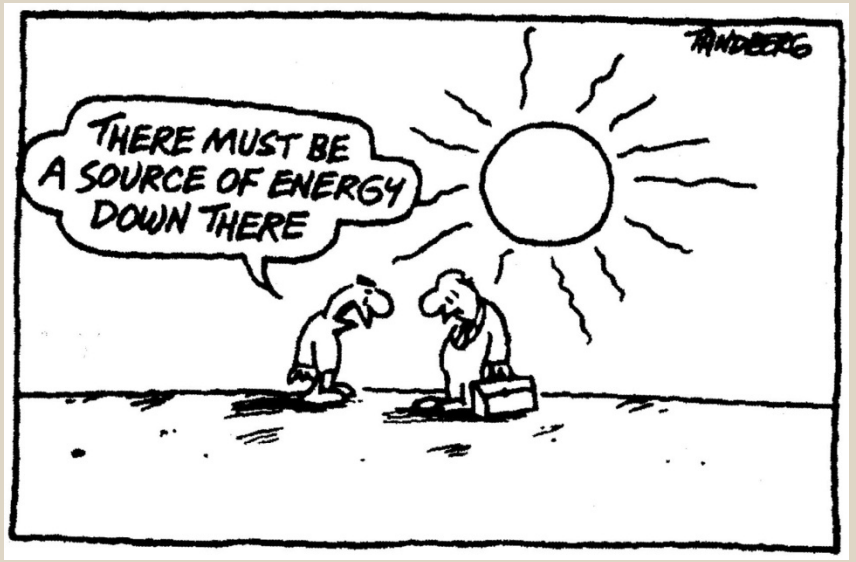
What are the Options for Carbon Neutral Energy?

- Fossil fuels + carbon sequestration
- Nuclear Power
- Renewable Sources
  - Biomass
  - Hydroelectric
  - Geothermal
  - Wind
  - Solar (Electricity, Fuels, and Thermal)



http://thebreakthrough.org/blog//2007/08/in_love_with_the_sun-print.html

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What About Hydrogen?

- “The two most common elements in the Universe are hydrogen and stupidity”
  - Harlan Ellison
- "I believe that one day hydrogen and oxygen, which together form water, will be used either alone or together as an inexhaustible source of heat and light"
  - *The Mysterious Island* by Jules Verne, 1874

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Why I (now) Think a Global Perspective is Necessary?

- United States
- China
- Cameroon

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United States

- Recently…
  - EPA updates CAFÉ standards, including 54.5mpg by 2025
    - *Estimated to add an average of $1300 cost/car (36.5mpg)
    - *$60 billion for the car makers to comply
    - *Average payback in 3 years, $3000 over life of vehicle
- What does this mean for China?
- For Cameroon? …for others?

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China

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Recent Headlines

- China growth path could exceed planet's resources (Henry Sanderson, AP, 9/16/09)
  - "If unchanged…GHG emissions could reach 17 billions tons by 2050" (60% of world's GHG)
- UN climate summit puts China, India in spotlight (John Heilprin, AP, 9/22/09)
  - China and U.S. each account for ~20% of current GHG. China and India say 'why should we scale back when the U.S. will not join other rich nations in scaling back…'
- A total of 16 out of the top 20 most polluted cities are in China. #1 on the list is Linfen City in Shanxi Province, China. "The whole city smells and is covered in smoke." (WorldWatch Institute, 2006)
- China could meet future energy needs with wind alone (R&D Magazine, 9/11/2009)
  - Currently only 0.4%, but could be wind alone by 2030 at a cost of $900 billion USD over the 20 years.

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Who Leads the Way?

http://www.seattlepi.com/horsey/

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Quiz: Global Impact and Trends

- Beijing, with a population of 17 million (about 1.7% of China), added an average of ____ cars/day to the streets during the first 7 months of 2009?

A. 310
B. 620
C. 1240
D. 2480

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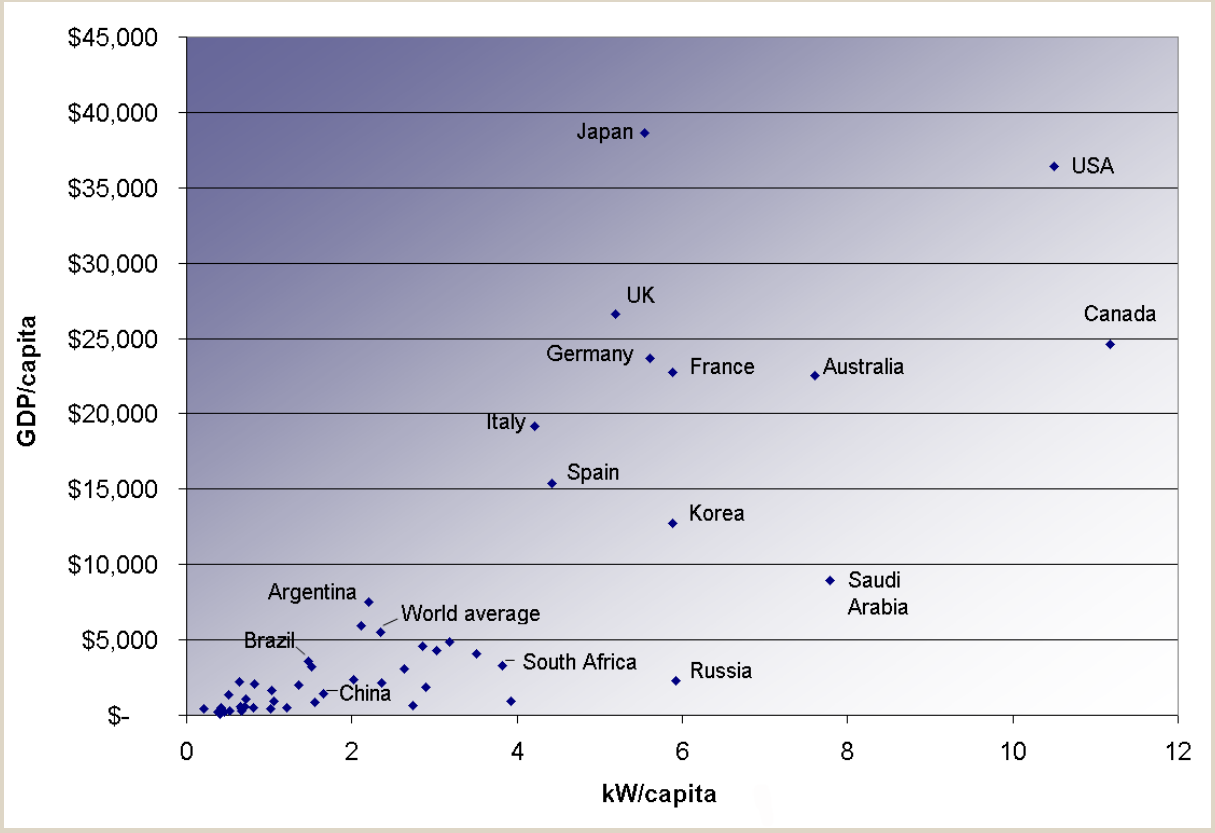
Energy consumption per capita versus the GDP per capita (2006)



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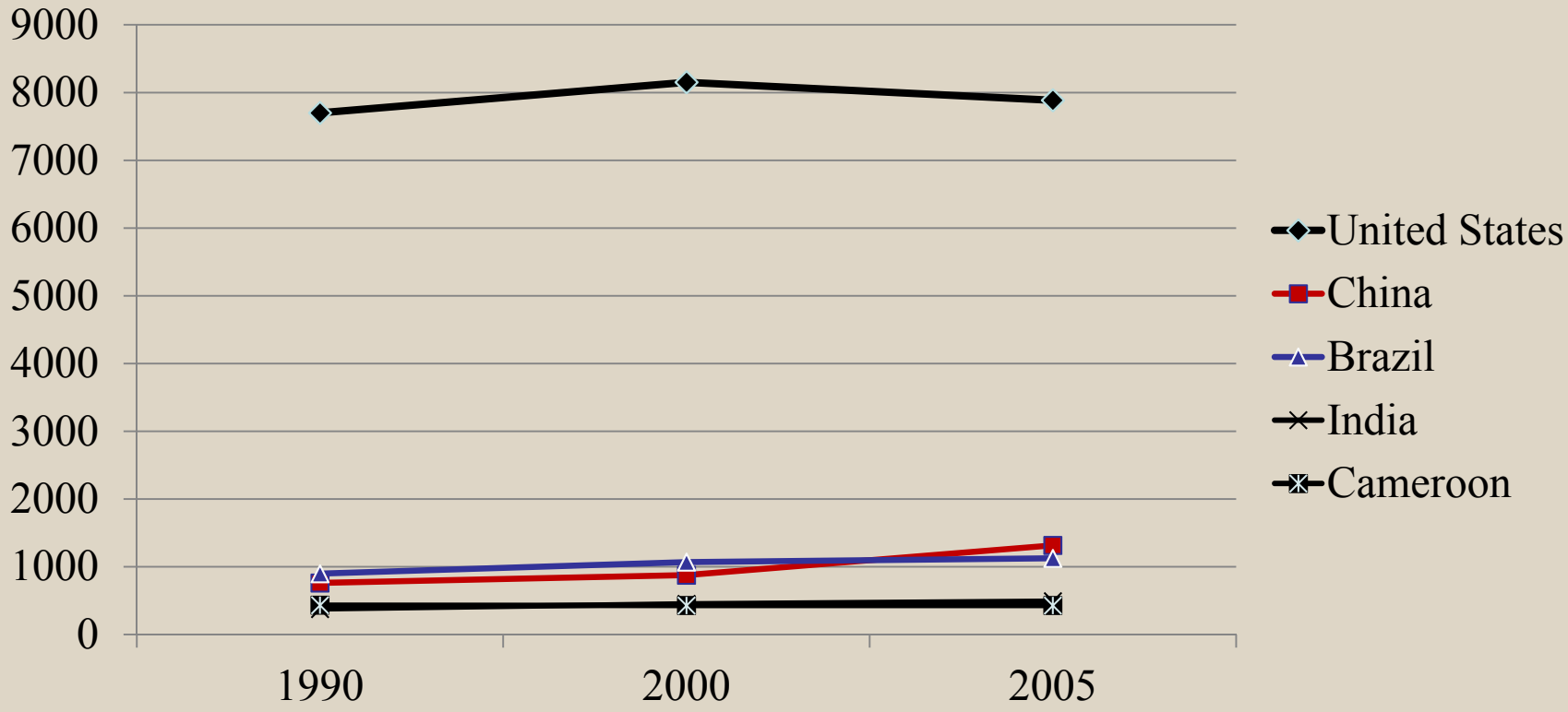
Kilograms of oil equivalent (kgoe) per person



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You Decide…

- If you had to choose between _____ or _____, what would you choose?
  - Enough Food or Pollution?
  - Access to Health or Pollution?
  - Education or Pollution?
  - More Income or Pollution?
  - "Quality" of Transportation or Pollution?

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The Need

- Each day, about 1 Billion people go to bed hungry
- 1.4 billion people live on less than $1.25/day
  - 70% of them are rural, and most of these depend on farming
- 2.6 billion (40% of the world's population) live on less than $2/day
- By 2030—demand for food up 35%, up 50% for energy, and nearly half the world's population will live in areas with severe water stress
- Venture capital in developing areas is non-existent outside of South Africa

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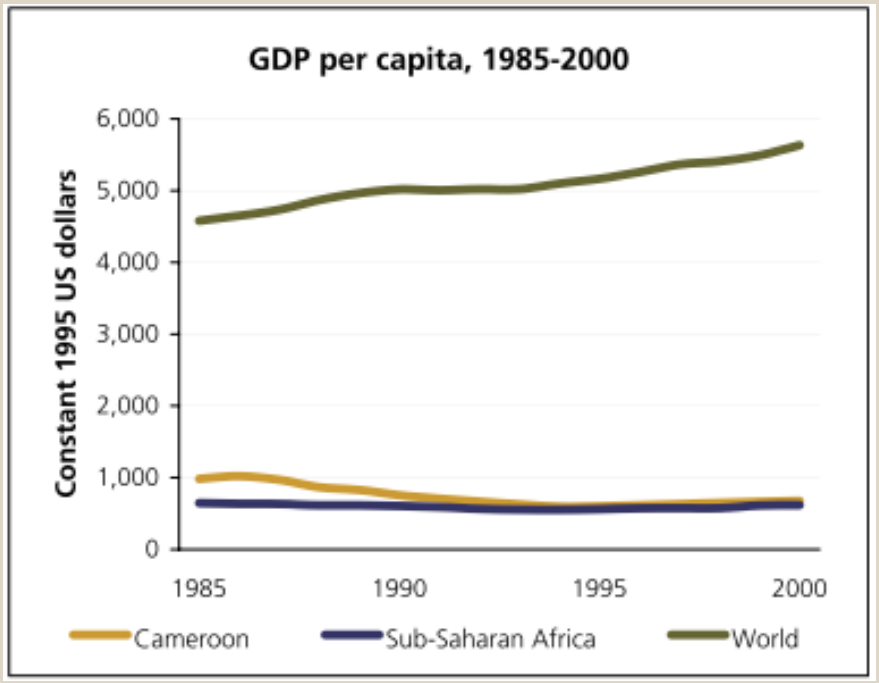
Cameroon

- Sixty-four percent of the population lives on less than $2/day
- Up to 40% of the food goes to waste
- No irrigation during the dry season
- http://earthtrends.wri.org



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Agricultural & Biological ENGINEERING

Purdue Utility Project

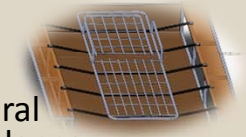
Maize grinding

Planting

Water pumping

Tillage

Rural ambulance



People transport

3-pt hitch implements

Material transport

Potential Users:

- Smallholder farmers
- Community Based Organizations (CBO/NGOs)
- Cooperatives
- Individual entrepreneurs & small business owners
- Municipalities

Additional Applications:

- Crop Harvesting
- Urban waste collection
- Delivery & taxi services
- Portable electricity generation/welding
- Hydraulic press for clay bricks & biomass briquettes
- Refrigeration transport box
- Emptying pit latrines & sewage pumping in urban areas

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PURDUE ENGINEERING
Think Impact.

Planter

- Design
  - Constructed using locally available resources
  - Two-row seeder, expandable design
  - Interchangeable seeder plates for different seeds
- Key Parts/Components:
  - Soil Opening and Closing
  - Frame and Axle Assembly
  - Drive Mechanism
  - Seed Metering

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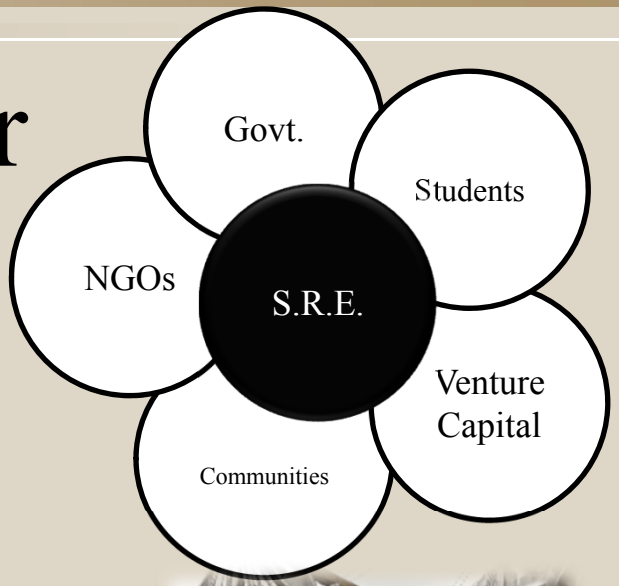
The Entrepreneurial Factor

- If innovation is market driven, how can it be initiated in developing countries?
- Where is the sustainable, resilient, intersection (SRE)?



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Final Approach…

- It will not be easy to achieve "sustainable transportation"
  - Especially in the global sense
- There are challenging growth trends in China and India, among others.
- What is the "right thing to do" in developing countries, where transportation is still evolving…
  - Walking, bicycles, rickshaws, motorcycles, cars, trucks, planes. Transportation impacts standard of living….

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My Speculation? (only worth the price of admission today)

- It will be difficult to find a "silver bullet"
- Energy sources will include:
  - Biomass, solar, nuclear, geothermal, etc. (coal?)
- Transportation will include:
  - "Greener Energy" + incremental breakthroughs in batteries, hydrogen source and fuel cells, hybrid drivelines, engine technologies, friction losses, etc.
- It is a great time for Purdue (and the U.S.) to be a leader
- We need to ask: are technical solutions enough?

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A Solar Powered Prius?

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Electric Powered Airplane

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Opportunities for you…

- Access to and protection of water resources (e.g. sanitation, purification, pumping, transport)
- Sustainable renewable energy (e.g. bio-digesters, wind, hydro, solar, biomass)
- Sustainable food production, bio-technologies
- Reduction of post-harvest losses (e.g. food processing, crop handling, markets, transportation)
- Supply chain management (e.g. improved transportation, project management, education)
- Entrepreneurial activities (e.g. micro-financing, multi village cooperatives, business plans)
- Development and implementation of education and technical program models that can be extended to new locations and partnerships
- Public health (e.g. access, food security, education)

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Get involved…

- Design teams/Clubs
  - Affordable mechanization
  - Fuel briquettes from waste biomass
  - Health and hygiene education
  - Food processing (processing and preservation)
  - Biologically based water purification systems
  - Environmental (water and land issues)
- Study Abroad/Exchange (China, Brazil, Africa)

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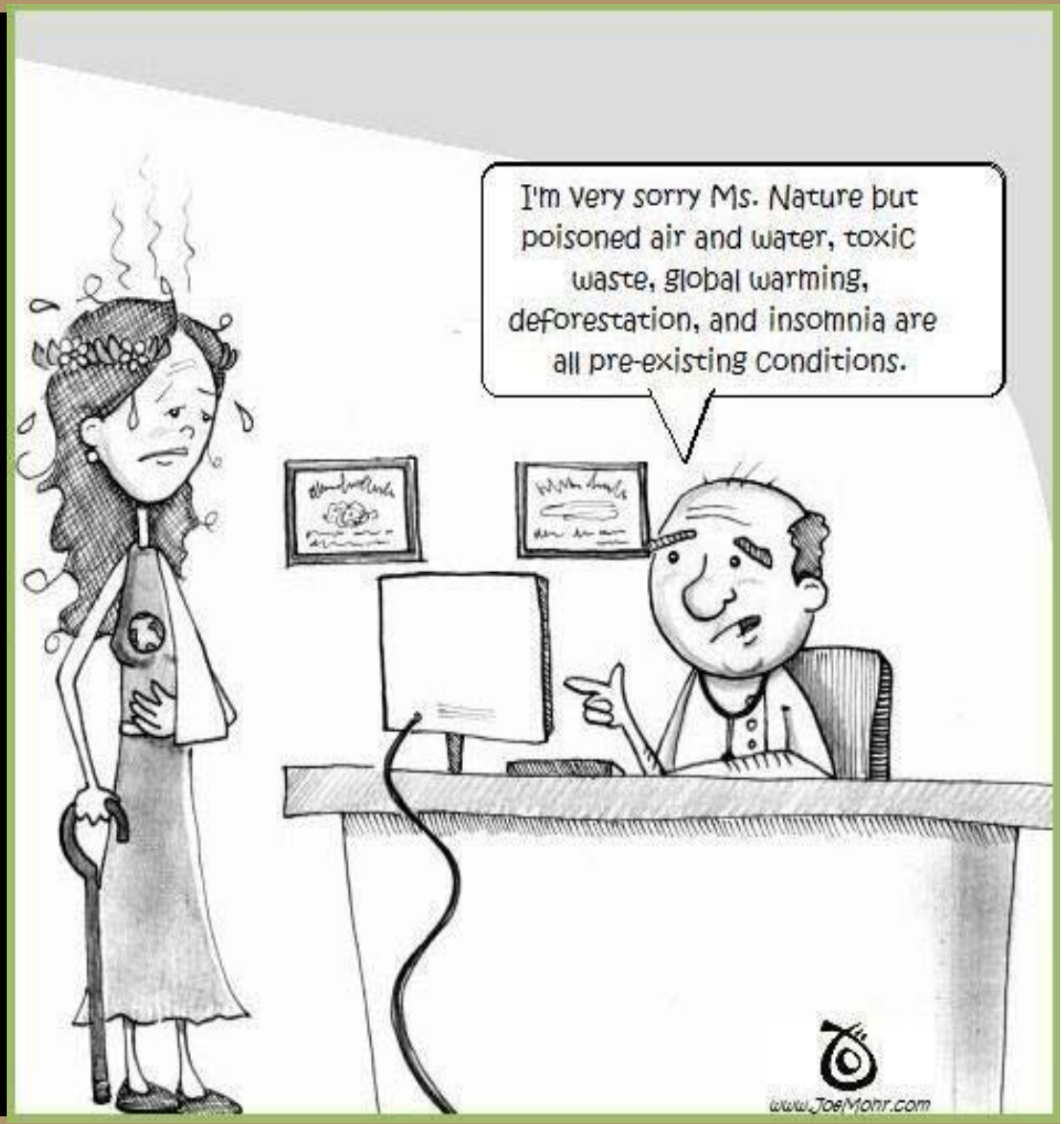
Questions?



http://redgreenandblue.org/category/topics/cartoons-topics/