Alternative Energy – What's developing in the Wings?

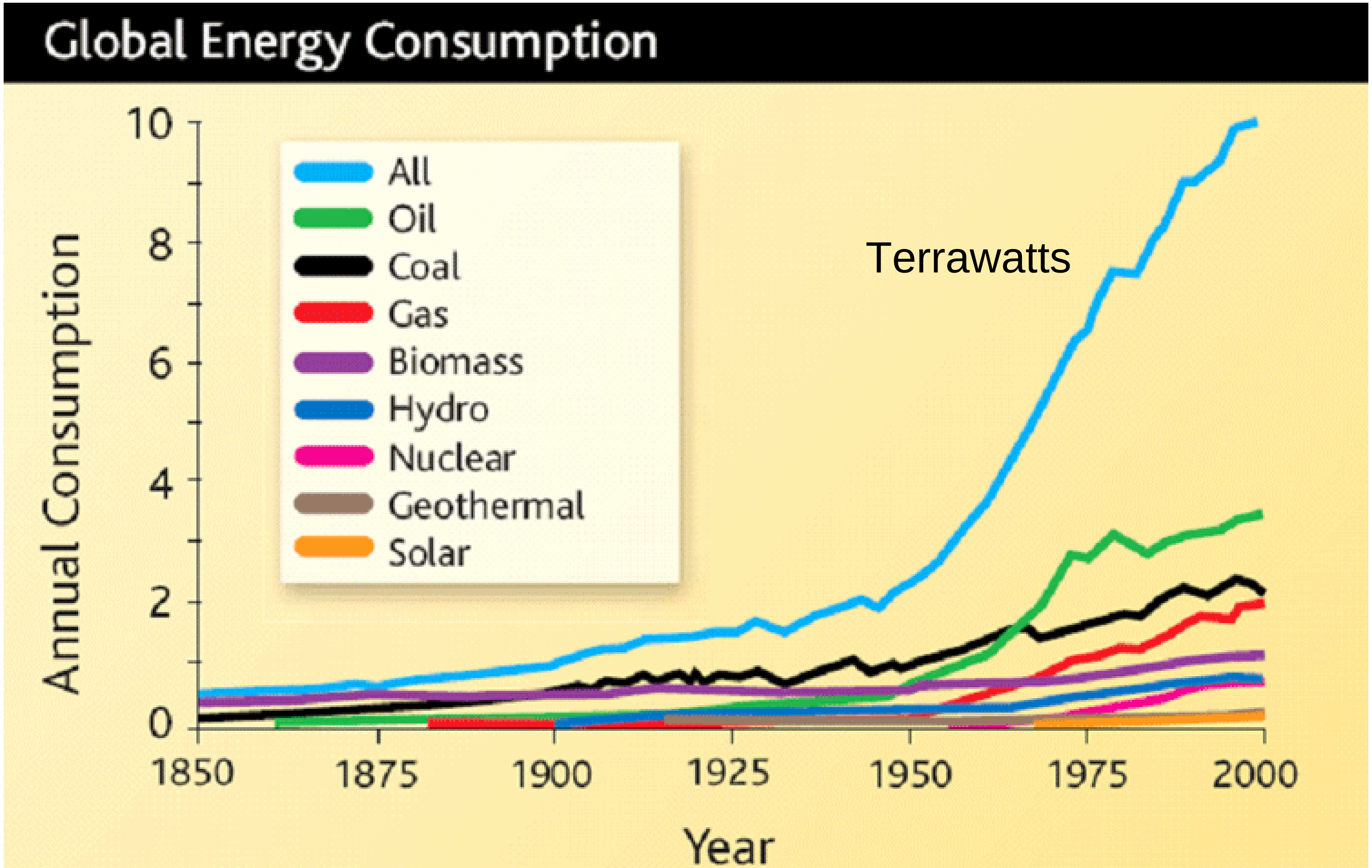
W. Lynn Watney

Kansas Geological Survey

KU Energy Research Center

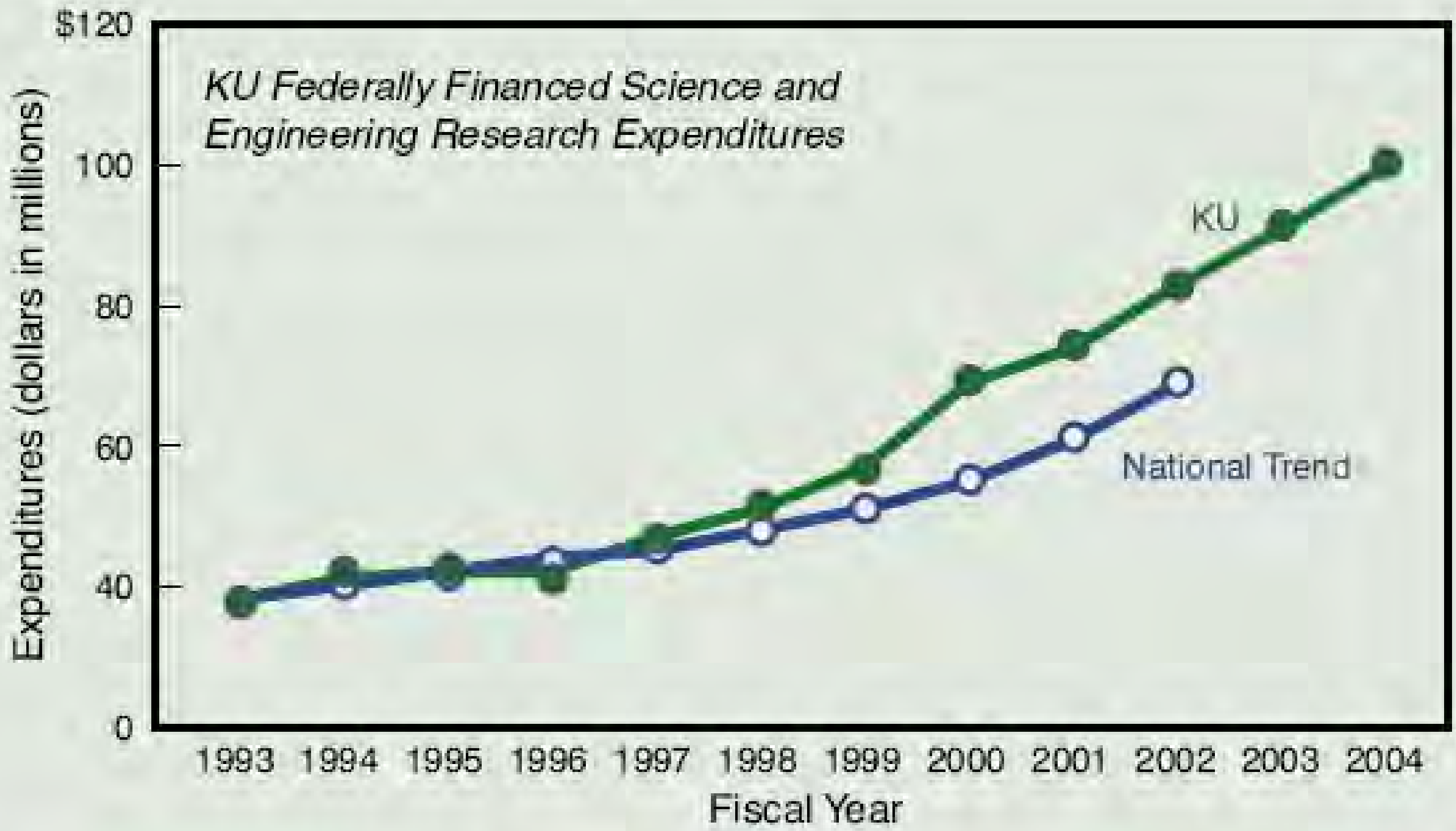
Outline

- Energy Research in Kansas/KU
- Status of energy use and fuels
- Policy changes to support alternative forms of energy
- Changing views on fossil energy dependence
- Are high oil and gas prices good?
- Biomass, ethanol, synfuels, land-fill gas, carbon sequestration
- Fuels Cells
- Electric Vehicles
- Wind Power
- Conservative, efficient use of energy
- Conclusions



http://www.sciencemag.org/cgi/reprint/309/5734/548.pdf

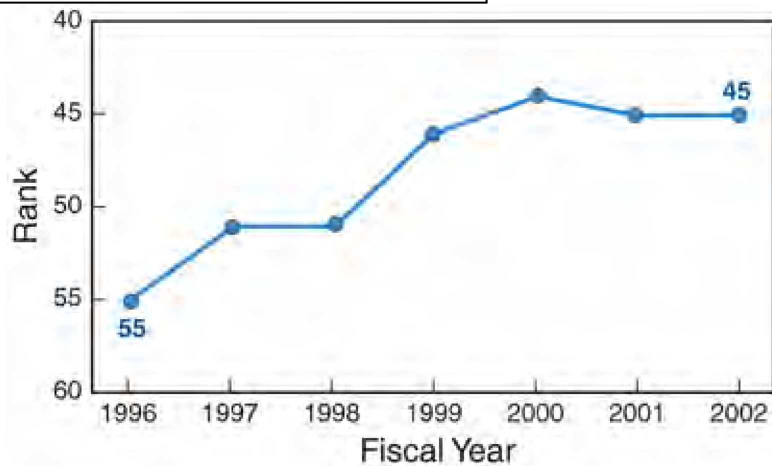
Science v. 309, 22 July 2005, p. 548-549.



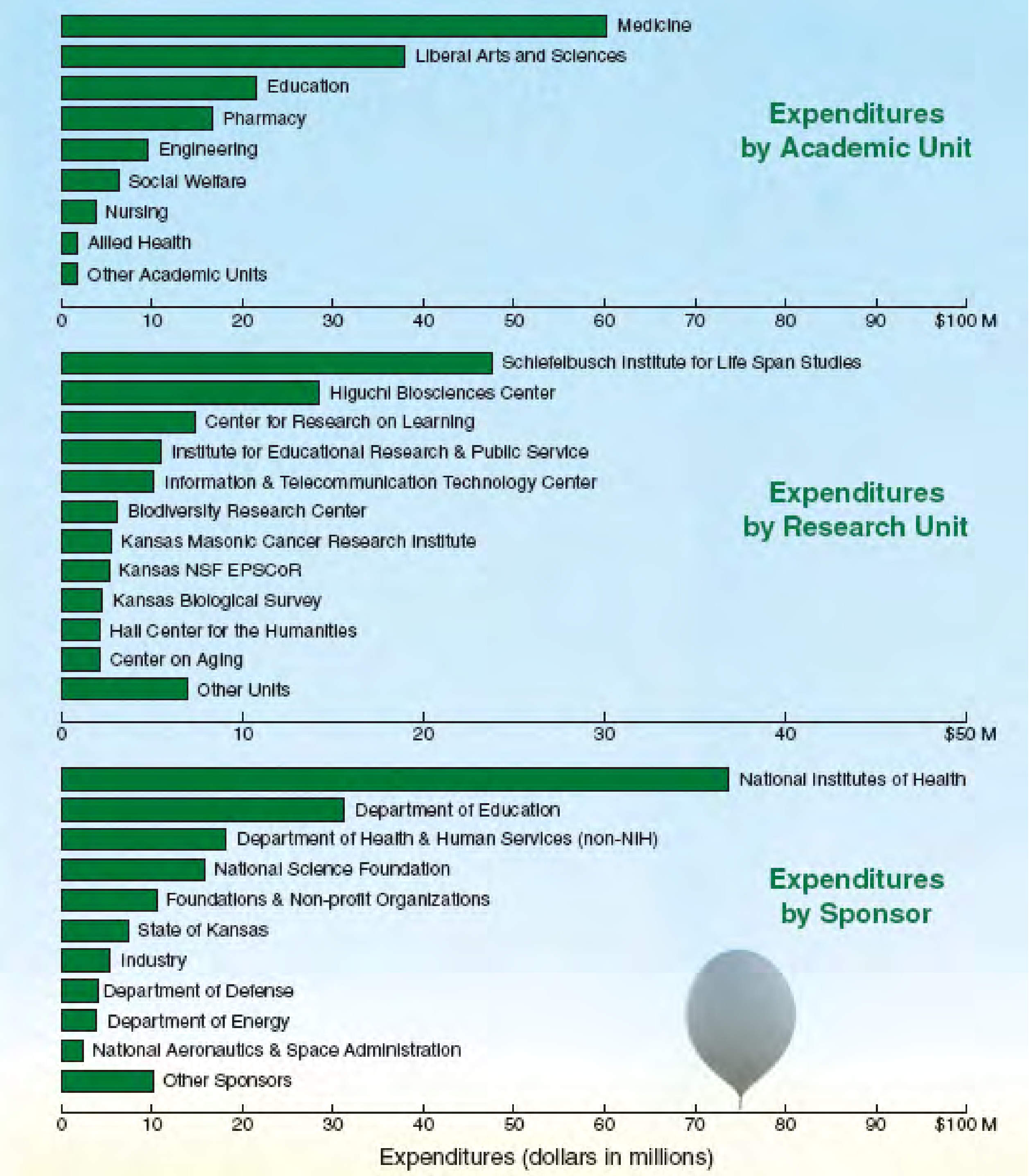
Source of Funds	Science and Engineering Research	Training and Other Research	Total
Grants and Contracts	**$118,012,550**	**$64,060,395**	**$182,072,945**
Federal Government	101,920,140	53,238,771	155,158,911
State and Local Governments	4,849,737	3,047,237	7,896,974
Industry	2,294,733	3,047,606	5,342,339
Nonprofit and Other	8,947,940	4,726,781	13,674,730
Institutional Funds	**$63,179,700**	**$28,598,970**	**$91,778,670**
TOTAL	**$181,192,250**	**$92,659,365**	**$273,851,615**

KU 2002 Federal Science and Engineering Expenditures
(select disciplines):

Sociology	15th
Political Science	23rd
Earth Sciences	30th
Life Sciences (combined)	29th
Life Sciences - Biological Science	30th
Life Sciences - Medical Sciences	32nd
Life Sciences - Other	8th



KU
Fiscal Year 2004



KU Energy Research Center Seed Fund Program

- Development of a Predictive Geomechanical Model for Recovery of Coalbed Methane
- Non-Invasive Collider Beam Monitoring
- Novel Au Catalysts for the Preferential Oxidation of CO
- Characterization of surface ionic activity of proton conducting membrane by conductive atomic force (CAFM)
- Gas Content, Chemical Composition, and Isotopic Analyses of Eastern Kansas Coals and Organic – Rich Shales
- Collaborative Research in Energy Policy: Grid Access
- **Next-Generation Building Energy Systems Design Software**

30 seed projects similar to above have been funded since 1991
$2.8 million awarded in external funds resulting from seed funds

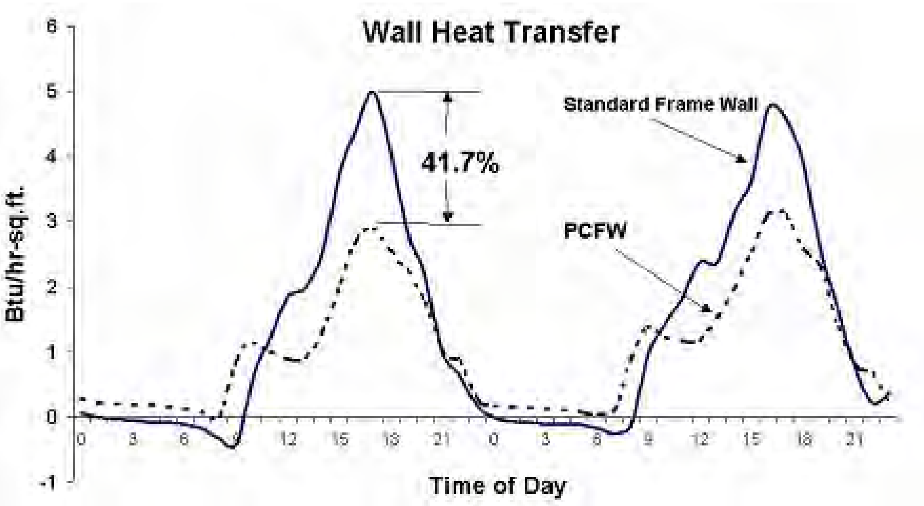
Featured Energy Research at KU

- Fuel Cells – Trung Van Nguyen
- Biofuels – Ethanol, syngas – Susan Williams
- Building Insulation – Mario Medina
- Carbon Sequestration -- Tim Carr
- Energy Information Network – Scott White

Sponsored by the KU Energy Research Center
http://www.kgs.ku.edu/ERC

Building Insulation

41% drop in heat loss



http://www.kgs.ku.edu/ERC/current.html

KU ENERGY RESEARCH CENTER'S SPONSORED PROJECT ON BUILDING INSULATION:

Little Houses on the Prairie
Phase-change materials help take the bite out of heating and cooling in test houses.
http://www.engr.ku.edu/publications/Oread_Engineer/2002/articles/tinyhouses.htm

KU professor studies unique substance that could help improve home efficiency
http://www.ku.edu/~kunews/2002/02N/SeptNews/Sept17/pcm.html

New Invention
"Phase Change Structural Insulated Panels and Walls." Filed in July 2003 with U.S. Patent and Trademark Office. Status: Pending.
http://www.research.ku.edu/techtran/news/newsletter/news_v3_n03.pdf

2004 Technology Showcase Draws a Crowd
http://www.research.ku.edu/techtran/news/newsletter/kutt-0105.pdf

THE UNIVERSITY OF KANSAS

Energy Research Center

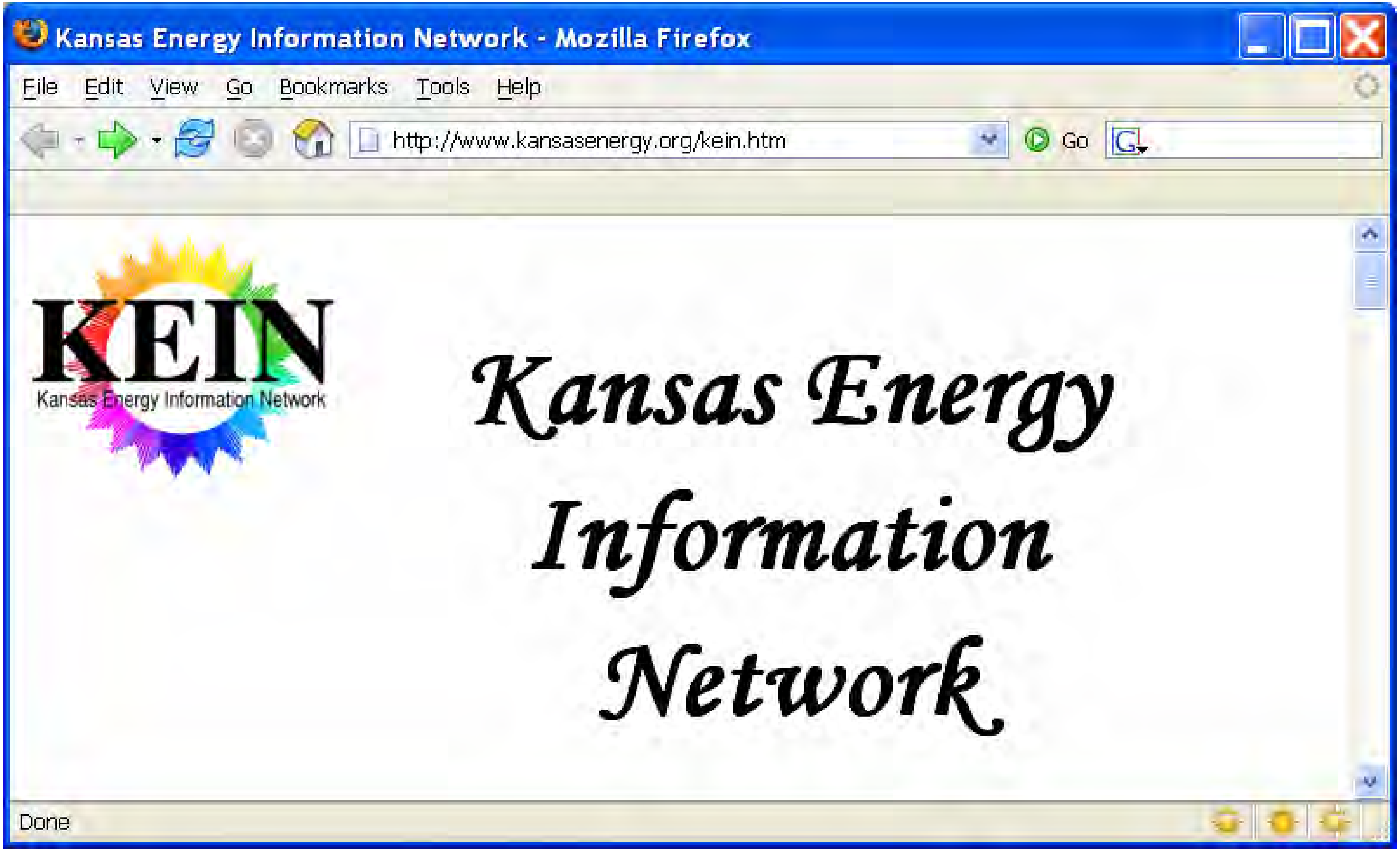
Home | Background | Tech Xfer | Organization | Capabilities | Updates | How to Apply | Awards

Capabilities

Building Efficiency	Energy Analysis, non-renewable resources, Energy Analysis & Diagnostic Center, phase-change insulation, off-the-grid housing
Basic Research in Energy Systems	Physics, chemistry, semiconductors, superconductors
Microbiology	Remediation, enhanced petroleum recovery
Alternative Energy	Solar, wind, fuel cells, catalysts for gasification and gas-to-liquid thermal energy storage, biofuels, transportation alternatives, turbines
Electrical Transmission	Utility regulations, energy storage systems, structures in energy generation, cogeneration, incineration, VOC conversion, biomass, atmospheric deposition, particulates, consumer incentives
Energy Policy	Energy Environmental Policy, International Energy Policy, Law Administration, Natural resources, Economics, History, Geography
Environmental / Conservation	Water resources, aqueous geochemistry, hydrology, wetlands, brine correlation, groundwater pollution, fly ash utilization, remediation, soils, climate, geophysical data acquisition, GIS technology, petroleum exploration
Fossil Fuels: Petroleum Geology	Oil & gas reservoirs, production statistics, well logging, geochemistry, fluid flow, probability methods in petroleum exploration, digital petroleum atlas, GIS, technology transfer, stratigraphy, sedimentology
Fossil Fuels: Petroleum Engineering	Petroleum reservoir engineering, gelation rheology utilization, reservoir simulation
Coal Supply	Coal resources, mining, liquification, coal bed methane, NOX removal from flue gas
Natural Gas Utilization	Natural gas engines, exhaust emissions

Done 0.110s

http://www.kgs.ku.edu/ERC/capabilities.html



www.kansasenergy.org/kein.htm

Kansas Energy Information Network

http://www.kansasenergy.org/kein.htm

Wind energy back on county's agenda

By KERRI SNELL, Sentinel Staff Writer
Wednesday, February 8, 2006 12:30 PM CST

Posted on Mon, Feb. 13, 2006
Biodiesel plant coming to northwest Missouri

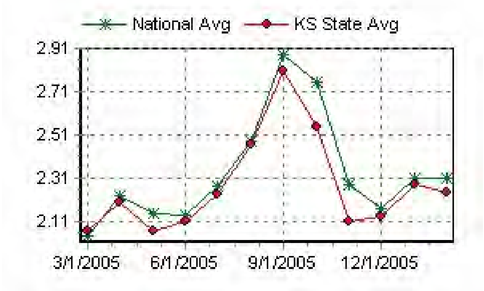
Associated Press

Posted on Sun, Feb. 12, 2006
Using bugs to gin up ethanol

PAUL ELIAS

Associated Press

Proposed ethanol plant to fuel job growth
By LeROY WILSON
lwilson@gctelegram.com
Posted on Monday, February 13, 2006 2:05:04 PM



Kansas Energy Report 2006

Kansas Energy Council

www.kansasenergy.org

December 22, 2005

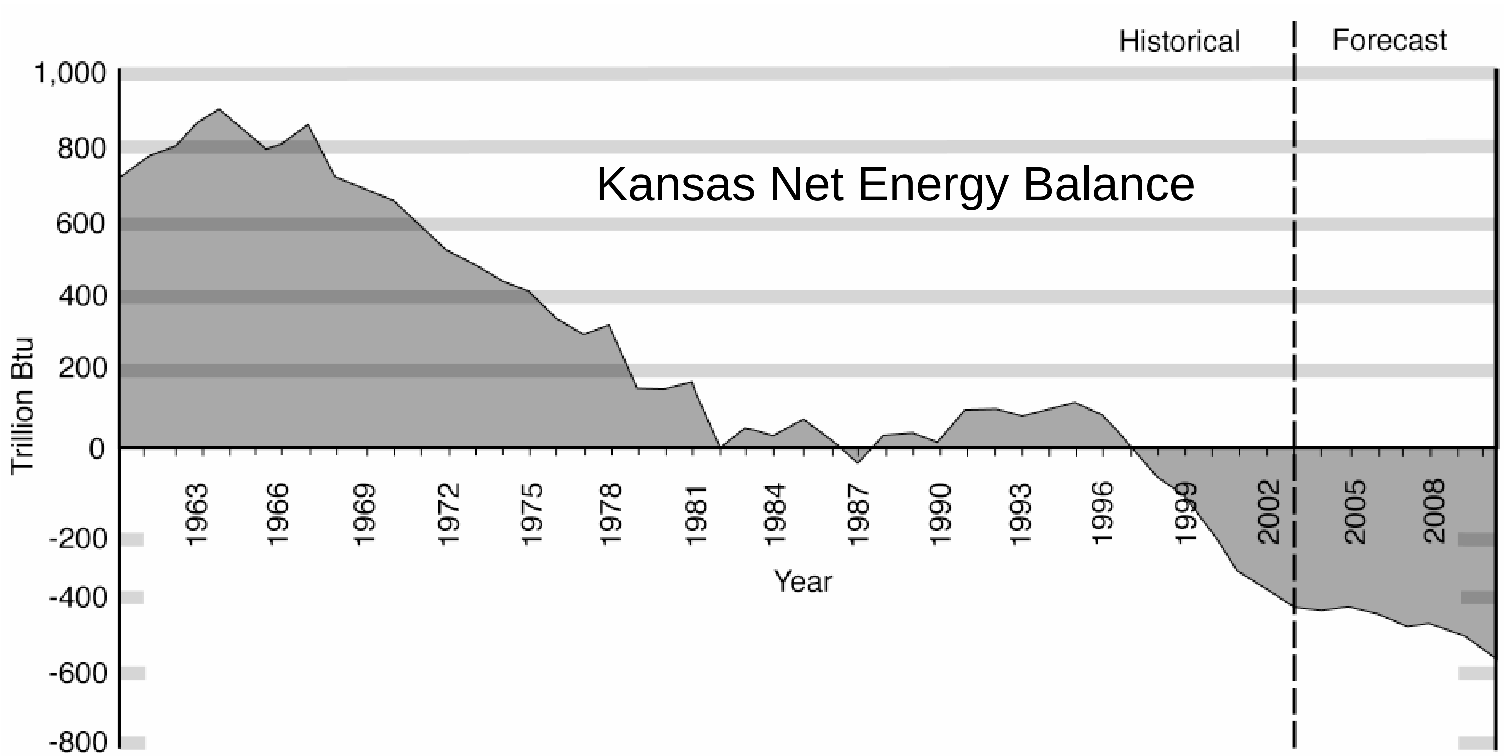


Figure 1—Kansas net energy balance, 1960 to 2003, with projections to 2010. Positive numbers show energy produced in excess of consumption (exports), while negative numbers show energy consumed in excess of production (imports).

KEC

Kansas Energy Council

The Council identified the following core priorities:

- To ensure a low-cost, reliable and secure energy supply,
- To increase energy conservation and efficiency,
- To extend the life of existing energy resources, and
- To develop a balanced renewable energy policy.

http://www.kansasenergy.org/KEC/reports/KEC_EnergyReport2006.pdf

General Overview

Kansas Oil and Gas

Population: 2,735,502 (2004) ranked 33rd

Per Capita Income: $30,811 (2004) ranked 29th

Total Energy Consumption: 1.0 quadrillion Btu (2001), ranked 32nd

Per Capita Energy Consumption: 386 million Btu (2001), ranked 15th

Total Petroleum Consumption: 8.2 million gallons per day (2002), ranked 31st

Gasoline Consumption: 3.3 million gallons per day (2002), ranked 33rd

Distillate Fuel Consumption: 1.9 million gallons per day (2002), ranked 33rd

Liquefied Petroleum Gas Consumption: 1.2 million gallons per day (2002), ranked 13th

Jet Fuel Consumption: 0.2 million gallons per day (2002), ranked 34th

Petroleum Supply (Upstream)

Crude Oil Proved Reserves: 245 million barrels (2004), ranked 10th (11th including Federal Offshore). Accounts for 1 percent of U.S. crude oil proved reserves.

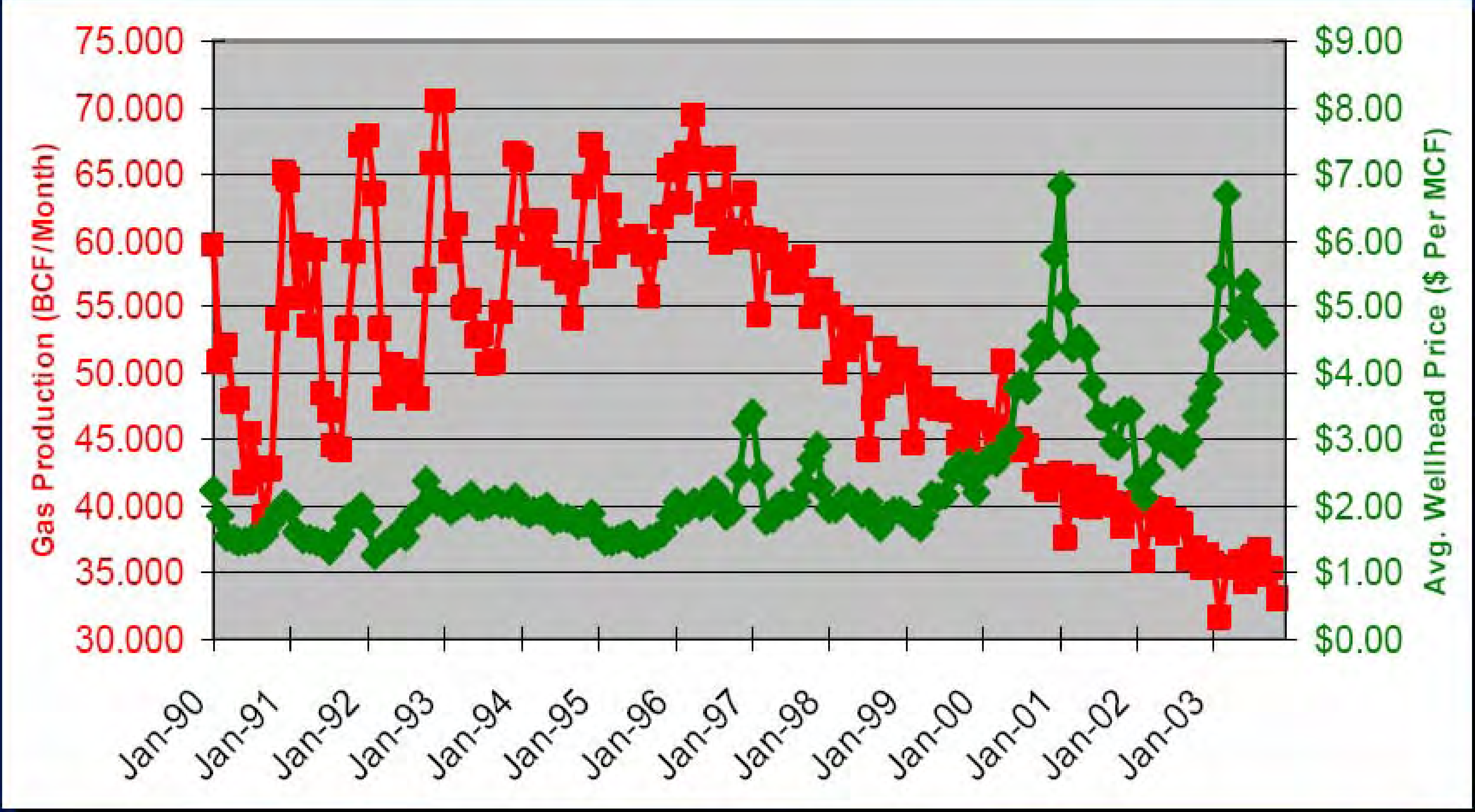
Crude Oil Production: 92,000 barrels per day (2004), ranked 8th (9th including Federal Offshore). Accounts for 2 percent of U.S. crude oil production.

Total Producing Oil Wells: 40,474 (2004)

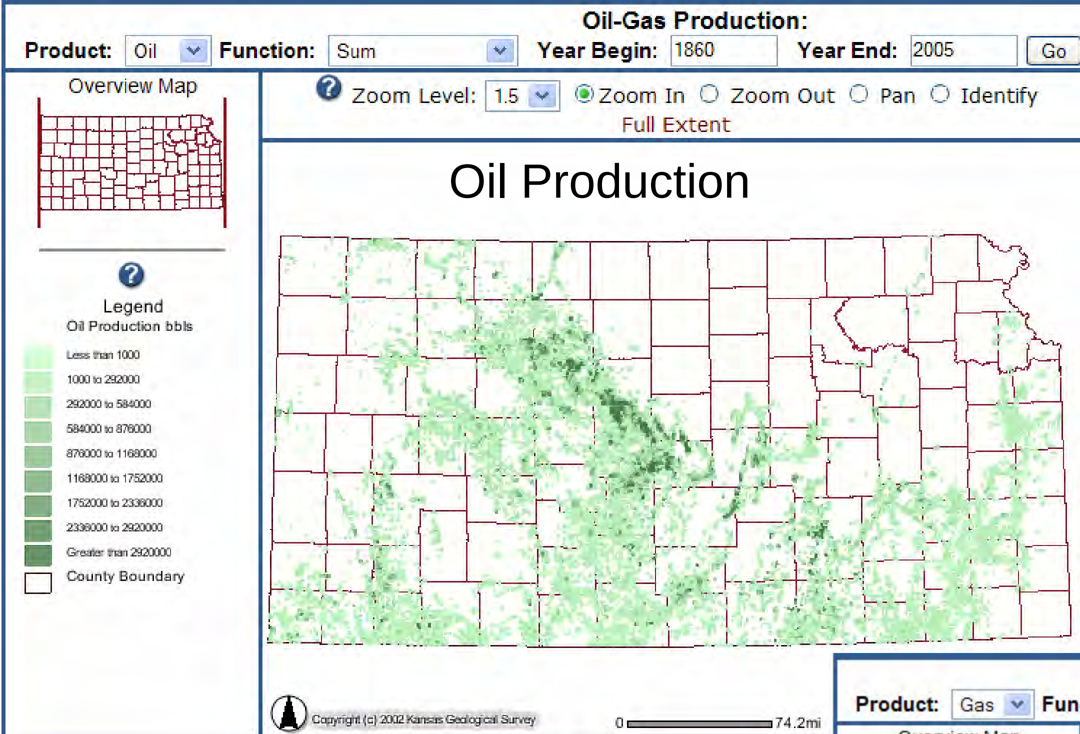
Refineries: Distillation capacity of 296,200 Barrels Per Calendar Day (BCD) (2005)
Coffeyville Resources Refining & Mkg (Coffeyville @ 112,000 BCD)
Frontier Refining & Marketing Inc. (El Dorado @ 103,000 BCD)
NCRA (McPherson @ 81,200 BCD)

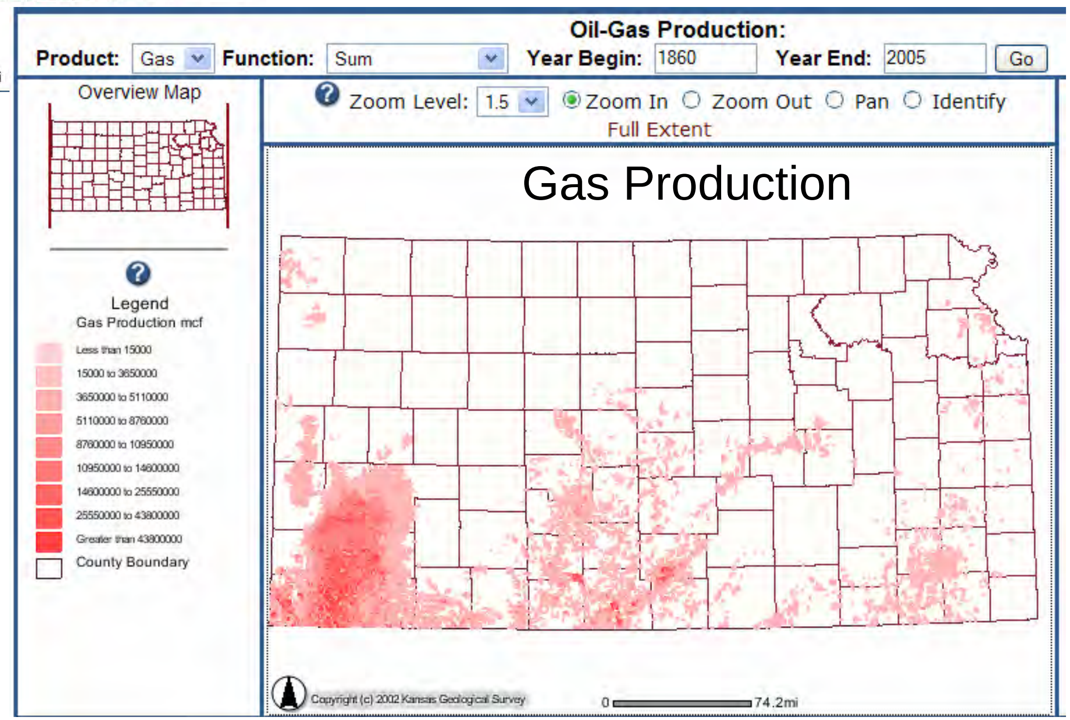
Gasoline Stations: 2,500 outlets (2005), or about 1.5 percent of U.S. total.

Kansas Gas Production



Production Through November 2003
Wellhead Prices through September 2003





http://hercules.kgs.ku.edu/kgs/oilgas/production/imageviewertest.cfm

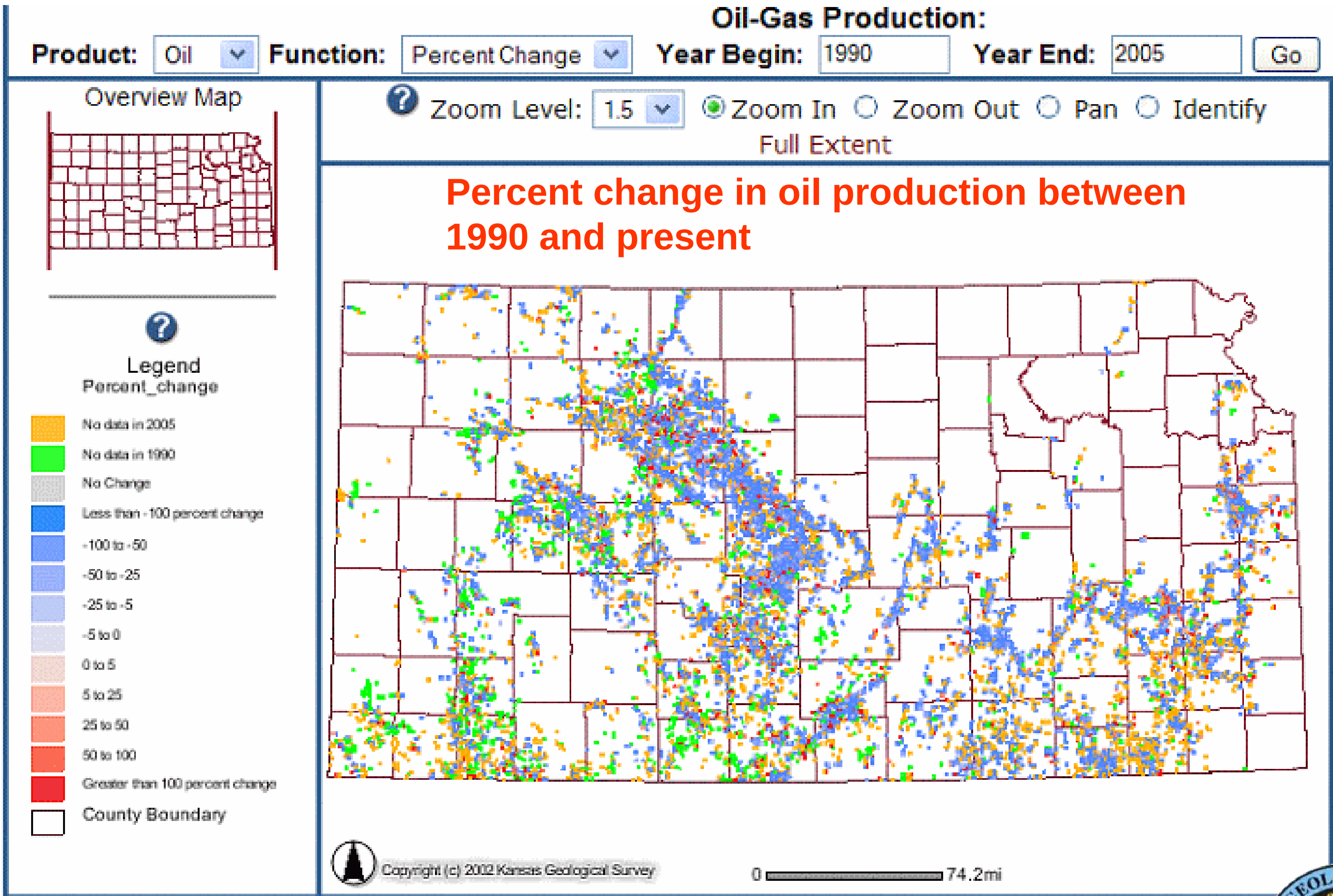
Oil and Gas Production by Operator

Table 1

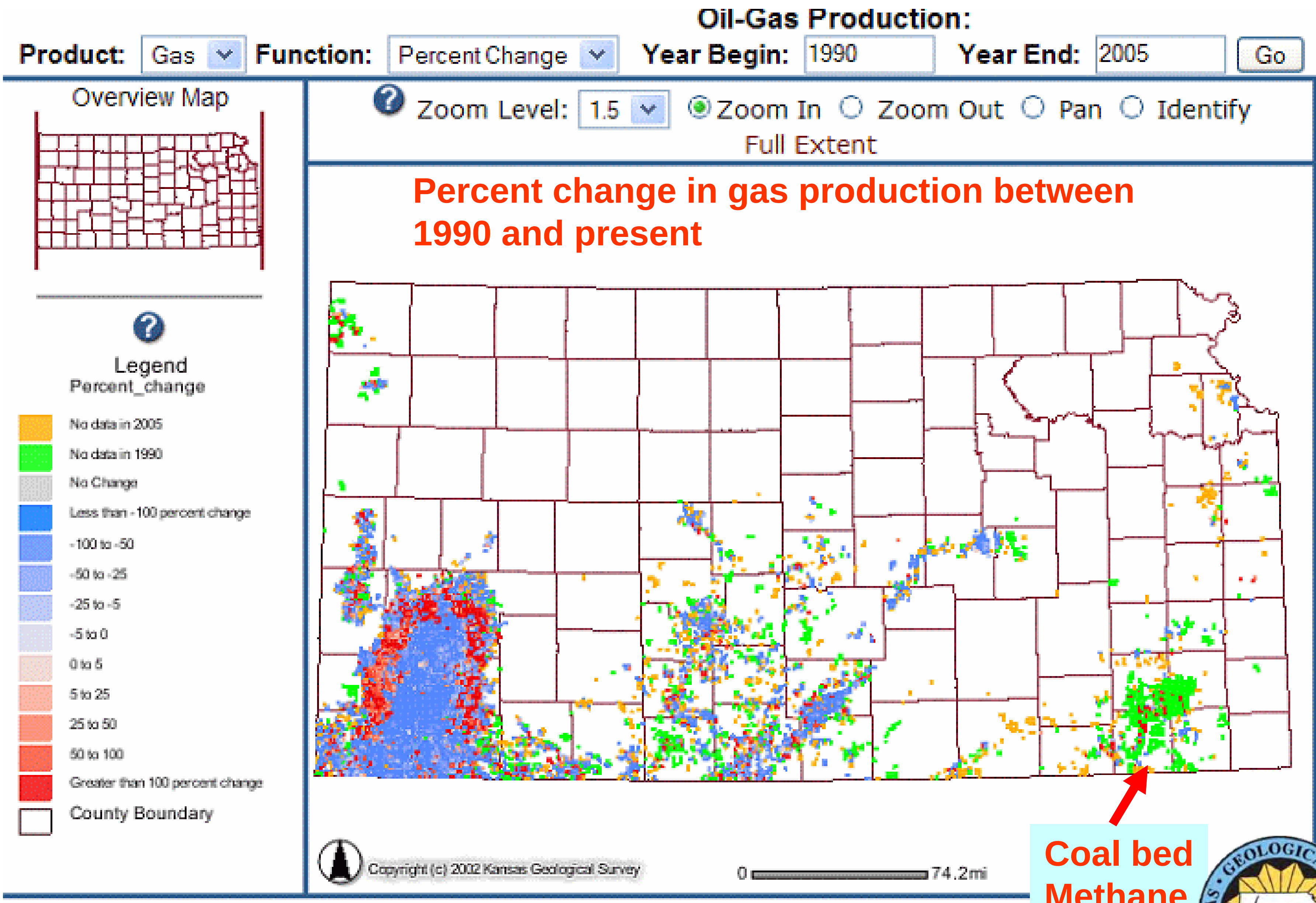
Oil Production from July 1, 2004 through June 30, 2005		
Ranking	**Operator Name**	**Production (bo)**
1	Berexco, Inc.	1,546,728
2	Vess Oil Corporation	1,471,096
3	Murfin Drilling Co., Inc.	1,260,885
4	Oxy USA, Inc.	1,186,353
5	American Warrior, Inc.	729,542
6	Merit Energy Company	683,356
7	Cimarex Energy Co.	587,857
8	McCoy Petroleum Corporation	525,824
9	Elysium Energy, L.L.C.	469,468
10	Ritchie Exploration, Inc.	469,214
11	PetroSantander (USA) Inc.	466,113
12	Loeb, Herman L.	411,820
13	Hartman Oil Co., Inc.	397,181
14	White Eagle Resources Corp.	349,212
15	Oil Producers, Inc. of Kansas	323,062
16	Farmer, John O., Inc.	317,366
17	Mull Drilling Company, Inc.	306,147
18	Trans Pacific Oil Corporation	304,089
19	Abercrombie Energy, LLC	285,393
20	Schmitt, Carmen, Inc.	267,061

Table 2

Gas Production from July 1, 2004 through June 30, 2005		
Ranking	**Operator Name**	**Production (mcf)**
1	BP America Production Company	63,852,573
2	EXXONMOBIL Oil Corp	53,445,319
3	Oxy USA, Inc.	42,432,884
4	Anadarko Petroleum Corporation	31,674,258
5	Pioneer Natural Resources USA, Inc.	27,446,942
6	Cimarex Energy Co.	11,803,937
7	XTO Energy Inc.	11,445,796
8	Merit Energy Company	10,497,582
9	Chesapeake Operating, Inc.	7,223,242
10	Quest Cherokee, LLC	6,361,021
11	Kansas Natural Gas, Inc.	4,650,464
12	Osborn Heirs Company, LTD	4,138,505
13	Dart Cherokee Basin Operating Co. , LLC	3,896,081
14	Oil Producers, Inc. of Kansas	3,505,031
15	Berexco, Inc.	3,122,163
16	Woolsey Operating Company, LLC	3,055,935
17	Horseshoe Operating, Inc.	2,869,958
18	McCoy Petroleum Corporation	2,352,013
19	Dominion Oklahoma Texas Expl & Prod, Inc.	2,345,844
20	Chevron USA, Inc.	2,199,923



http://hercules.kgs.ku.edu/kgs/oilgas/production/imageviewertest.cfm



http://hercules.kgs.ku.edu/kgs/oilgas/production/imageviewertest.cfm

Dependability of natural gas availabilty and its price is a function of supply including storage.

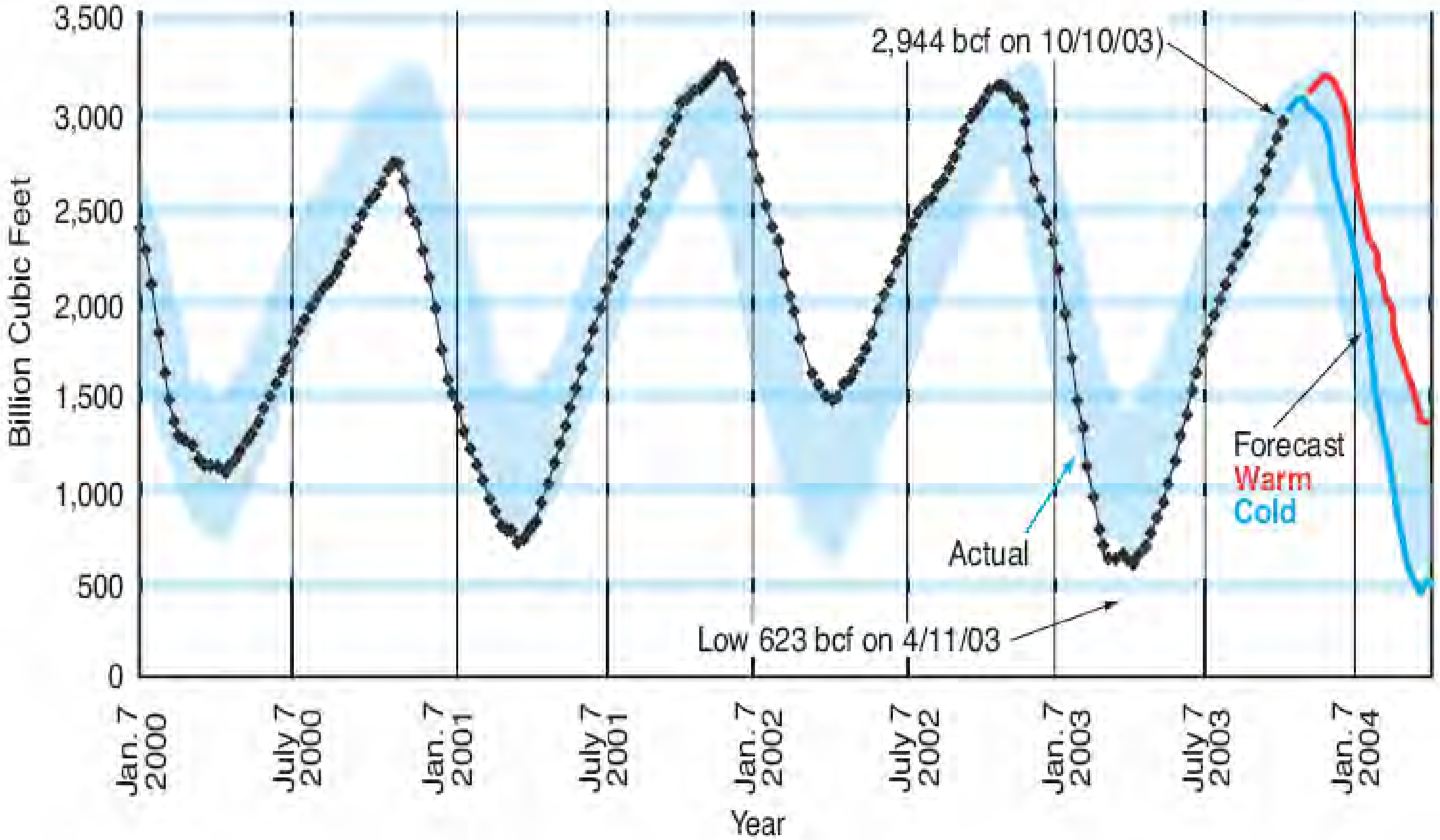
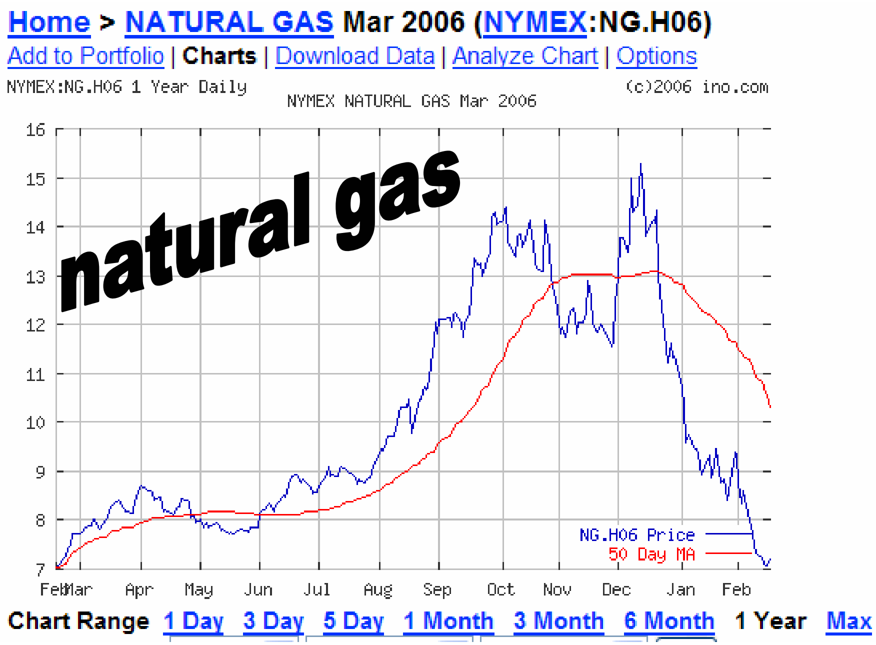
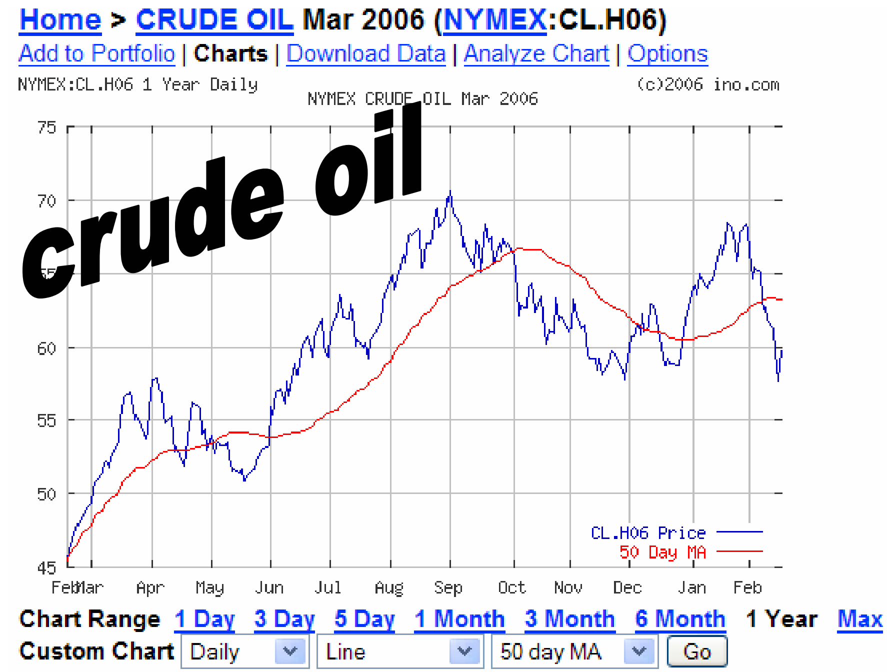
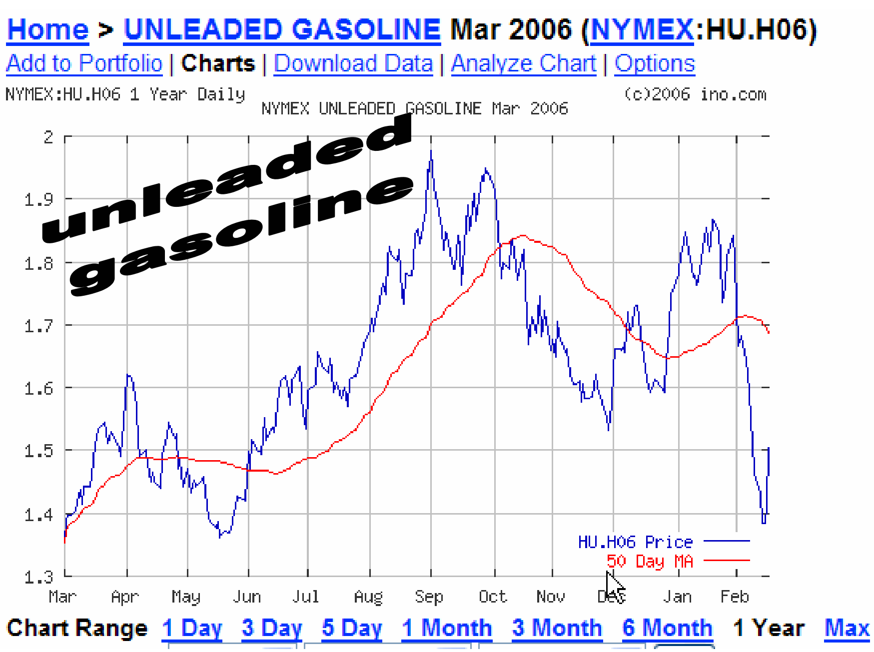
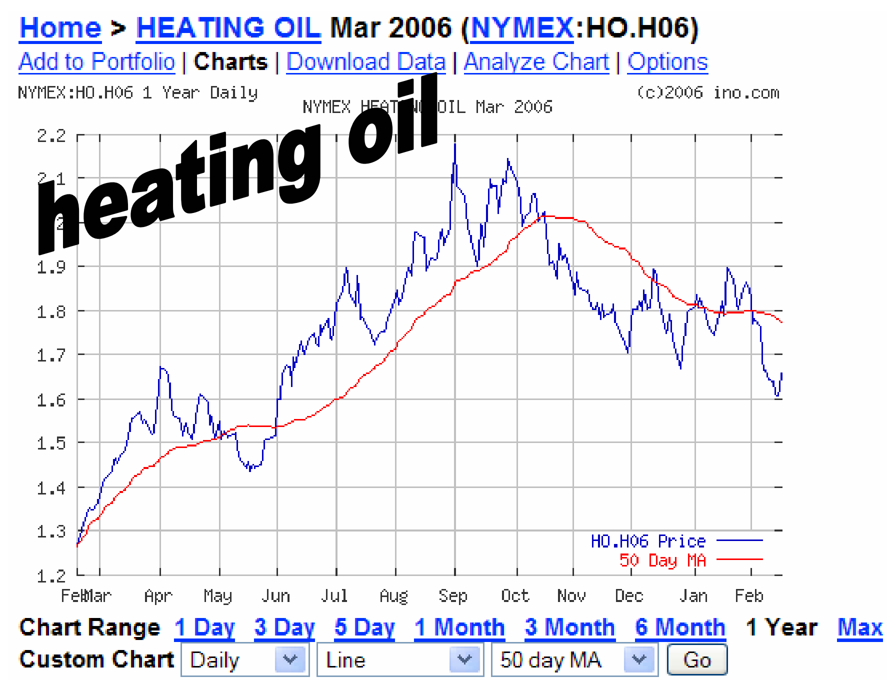


Figure 1—Monthly U.S. natural gas storage, 2000–2003, with projections for the first half of 2004. Colored band shows the normal storage range from previous four years. Projected withdrawal rates for the 2003–2004 heating season are based on withdrawals during the colder than normal 2002–2003 (blue line) and warmer than normal 2001–2002 (red line) heating seasons (Tim Carr, Kansas Geological Survey, personal communication, October 17, 2003).





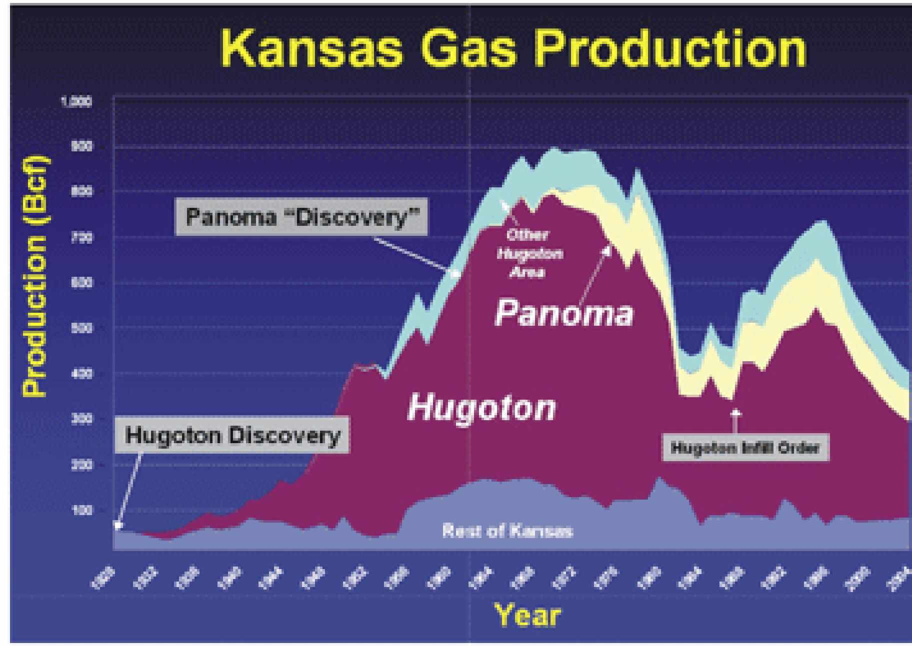




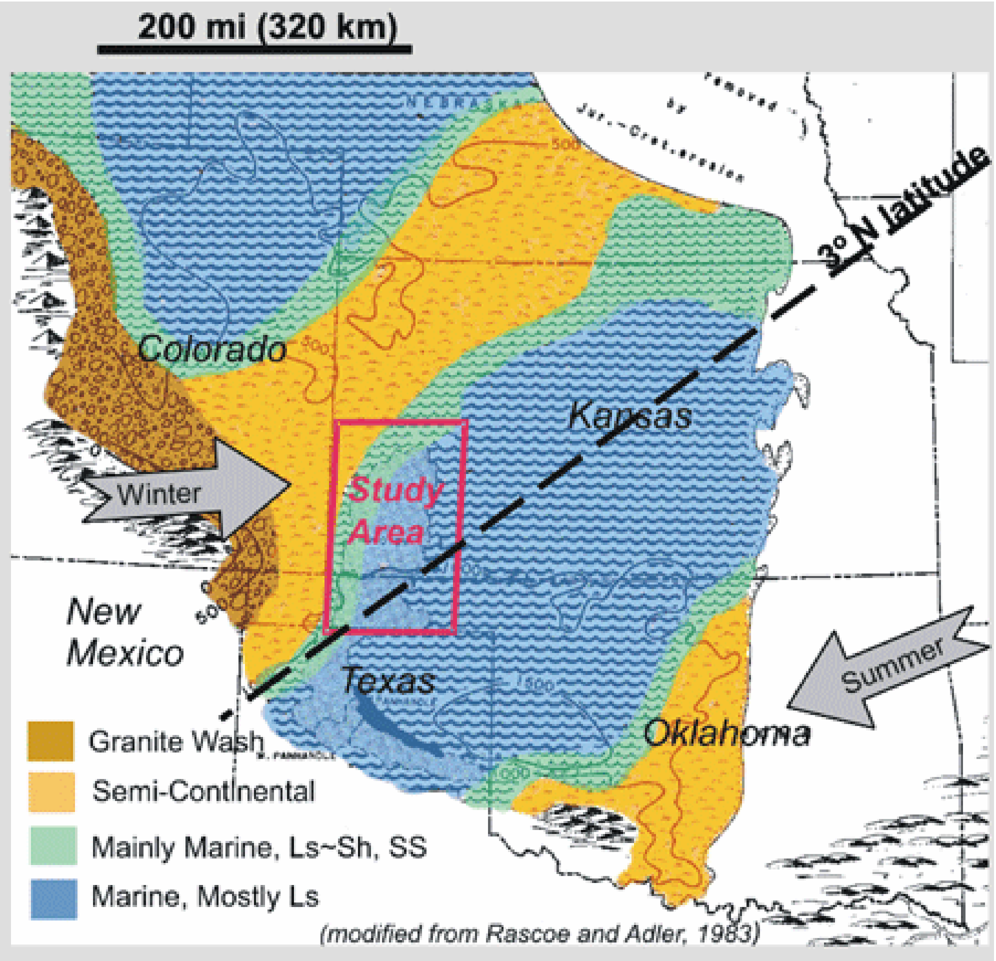
http://quotes.ino.com/chart/?s=NYMEX_NG.H06

KANSAS

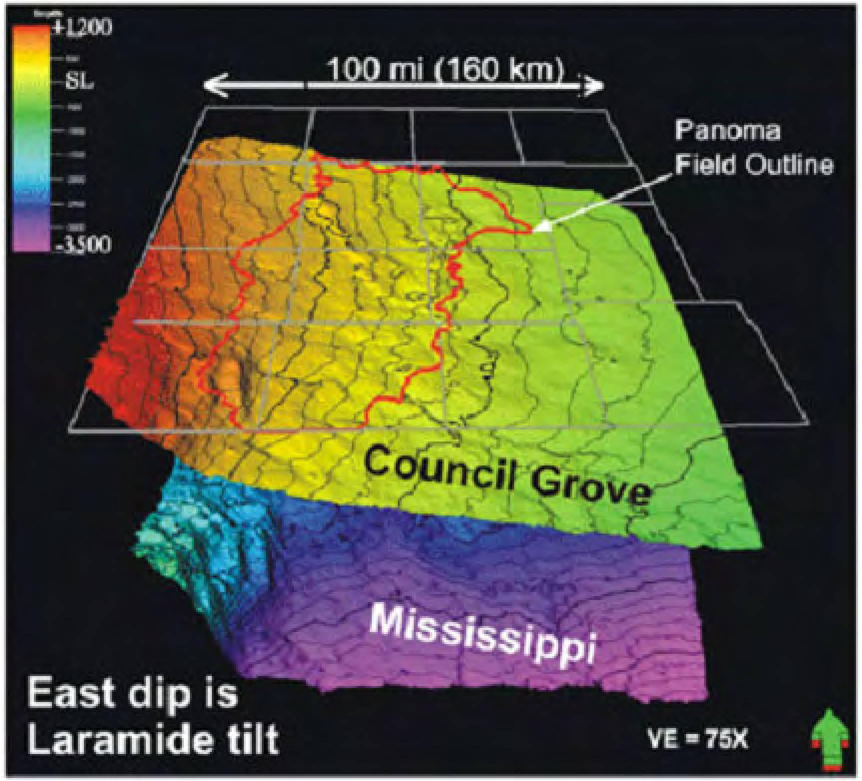
	Hugoton	Panoma	Combined
Discovery	1928	1958	
Development	1948	1970	
Infill Drilling	1990	?	
Depth	2,500	2,750	
Wells	7,536	2,345	9,881
Cum. Gas (TCF)	24.7	3.0	27.7
BCF/well	3.3	1.3	2.8
Annual (BCF-2003)	239.9	62.5	302.4
MMCF/Well	31.8	26.7	30.6

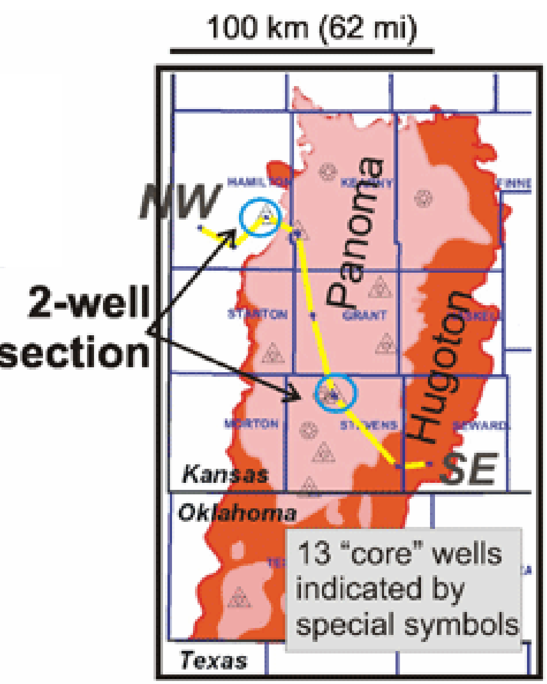


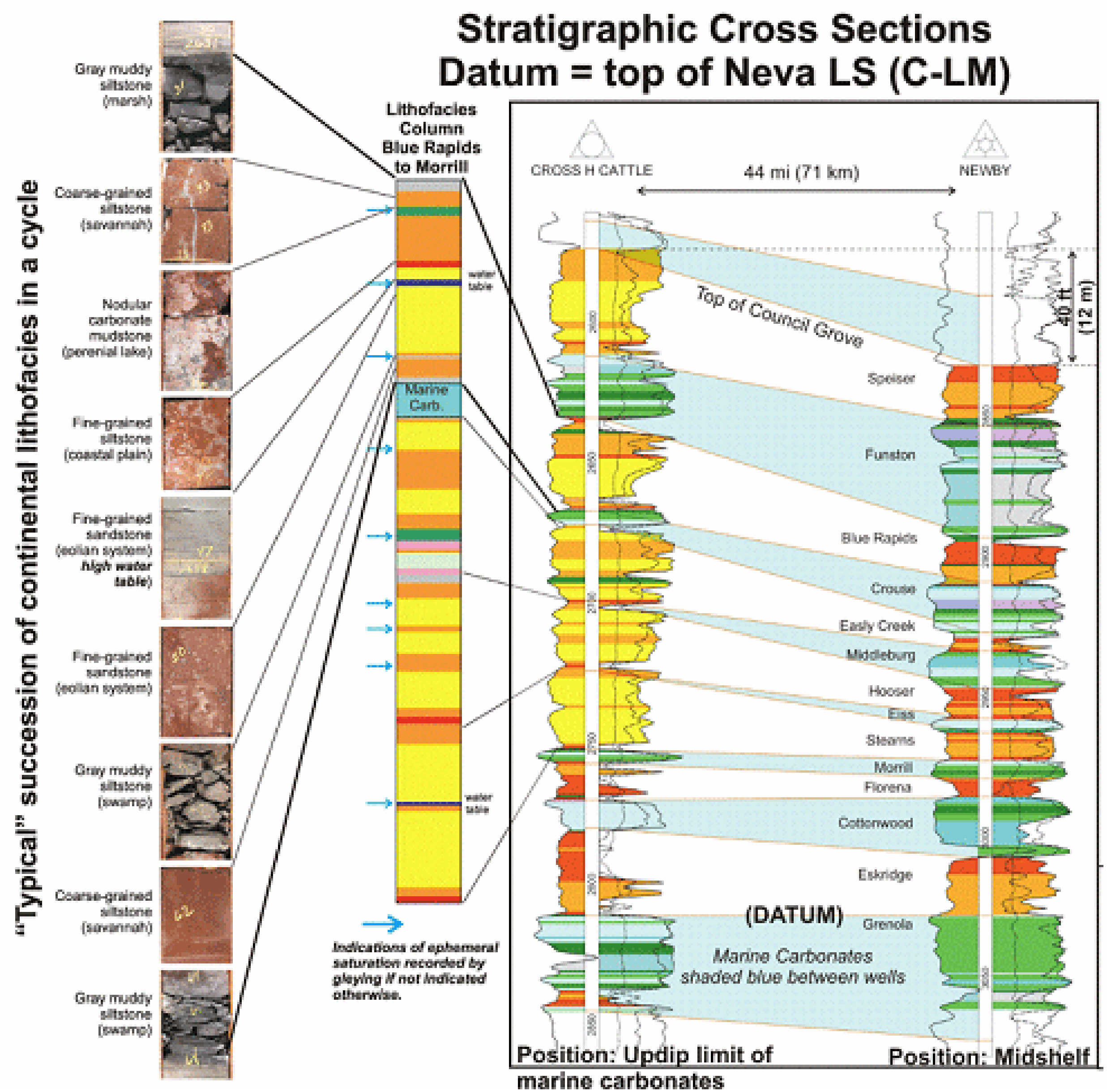
http://www.kgs.ku.edu/PRS/AAPG2005/2005-25/p1-01.html



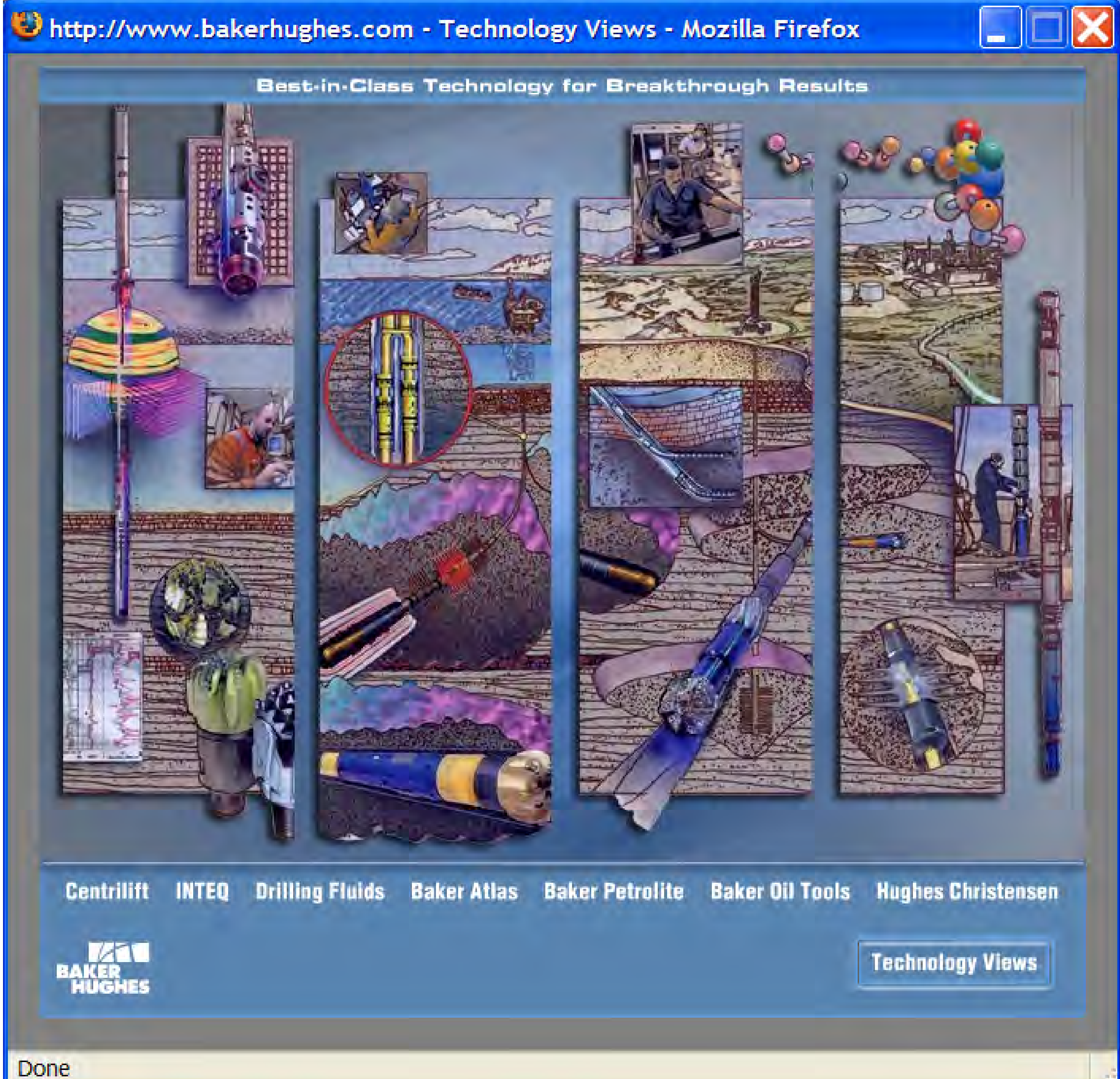
Late Wolfcamp Paleogeography
(Rascoe and Adler, 1983)
Prevailing winds from Parish and Peterson, 1988
Wolfcamp latitude from Scotese, 2001




100 km (62 mi)
NW
2-well section
Panoma
Hugoton
SE
STANTON
GRANT
MORTON
SEWARD
Kansas
Oklahoma
Texas
13 “core” wells indicated by special symbols


Stratigraphic Cross Sections
Datum = top of Neva LS (C-LM)
“Typical” succession of continental lithofacies in a cycle
Gray muddy siltstone (marsh)
Coarse-grained siltstone (savannah)
Nodular carbonate mudstone (perenial lake)
Fine-grained siltstone (coastal plain)
Fine-grained sandstone (eolian system) high water table)
Fine-grained sandstone (eolian system)
Gray muddy siltstone (swamp)
Coarse-grained siltstone (savannah)
Gray muddy siltstone (swamp)
Lithofacies Column Blue Rapids to Morrill
water table
Marine Carb.
water table
Indications of ephemeral saturation recorded by gleying if not indicated otherwise.
CROSS H CATTLE
44 mi (71 km)
NEWBY
40 ft (12 m)
Top of Council Grove
Speiser
Funston
Blue Rapids
Crouse
Easly Creek
Middleburg
Hooser
Eiss
Stearns
Morrill
Florena
Cottonwood
Eskridge
(DATUM)
Grenola
Marine Carbonates shaded blue between wells
Position: Updip limit of marine carbonates
Position: Midshelf

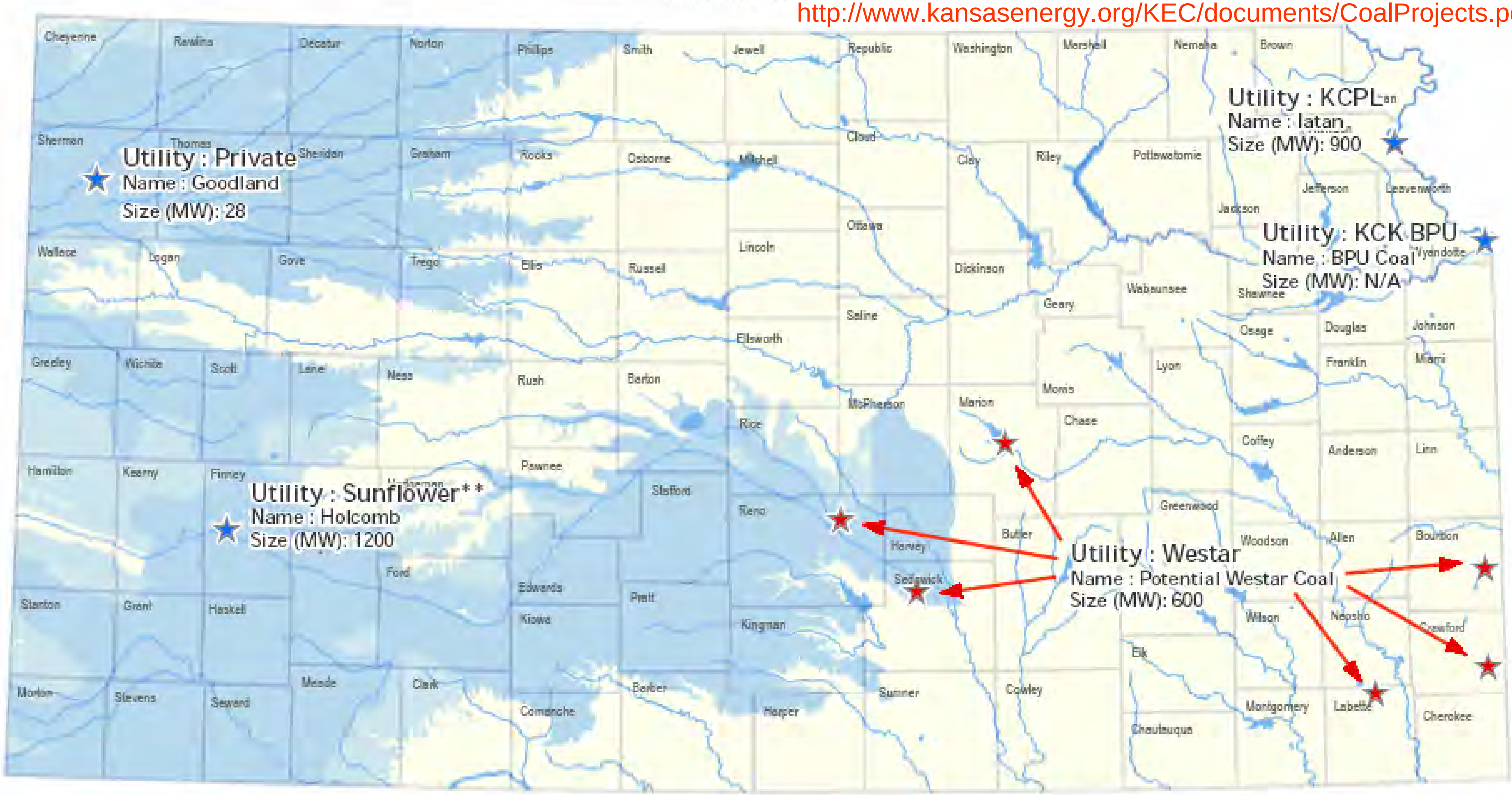
New Drilling Technology



PROPOSED LOCATIONS for NEW COAL-FIRED POWER PLANTS in KANSAS

September 2005

http://www.kansasenergy.org/KEC/documents/CoalProjects.pdf



Projection Information:
Name: Lambert Conformal Conic
Datum: NAD83 Spheroid GRS 1980
Distance Units: meters

★ Westar is only building one plant, but has several potential locations

** Sunflower is building two plants - Total output shown

Surficial Hydrography and Ogallala Aquifer shown in Blue

Compiled and edited by DASC (Data Access and Support Center), Kansas Geological Survey (KGS) at the University of Kansas, in Lawrence, Kansas. 08/05

All data except for the Proposed Coal sites can be downloaded from Kansas Geospatial Community Commons http://gisdasc.kgs.ku.edu

www.KansasEnergy.org

KEC Kansas Energy Council

Wyoming Coal Mines
Source of fuel for coal fired electricity
in Kansas and much of nation

Why $5 Gas Is Good for America

The skyrocketing cost of oil is sending pump prices soaring. But it's also subsidizing *research into new technologies that can change the energy game.*

By Spencer Reiss
December 2005 Issue of Wired Magazine

***As Prices Rise*:**

- **Technologies emerge**
- **New resources of energy become economic**
- **Environmental mitigation is more economically feasible**
- **Untapped, potential energy conservation becomes economic & compelling**

Ultradeep offshore Wells
Futuristic gear for tapping formerly inaccessible deposits
Gas to Liquid
Natural gas converted into diesel fuel
Tar sands
A sludgy mélange of petroleum and gravel
Digital oil fields
Networked drilling rigs and remote-controlled wells

Energy Sources Unleashed

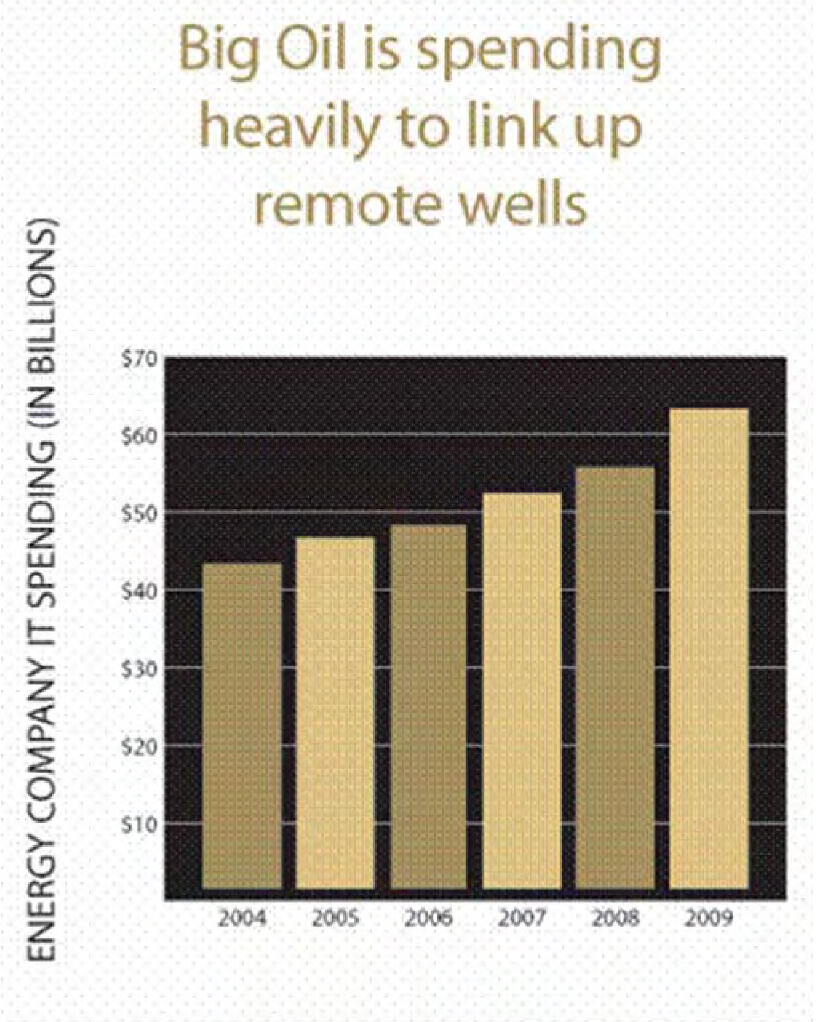
Given Long-term price per barrel: $30-$70

Natural Gas
Conventional compressed methane - clean, efficient, and explosive
Coal to Liquid
An abundant energy resource transformed into diesel
Biodiesel
Vegetable oil pressed from soybeans and palm
Ethanol
Gasoline-compatible alcohol fermented from corn, sugar, and cellulose

Given Long-term price per barrel: $70 & up

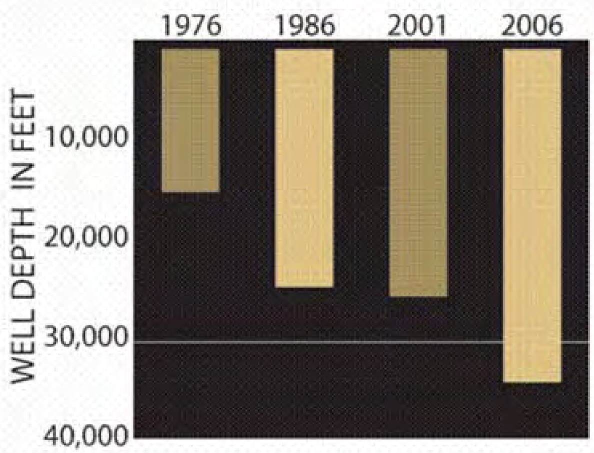
Energy Sources Unleashed:
Methane hydrates
A crystalline amalgam of methane and frozen water
Hydrogen
The most common element in the universe, and a superclean energy source
Plug-in Hybrids
Grid electrons propelling cars for short trips
Oil shale
High-grade petroleum distilled from sedimentary rock

December 2005 Issue of Wired Magazine

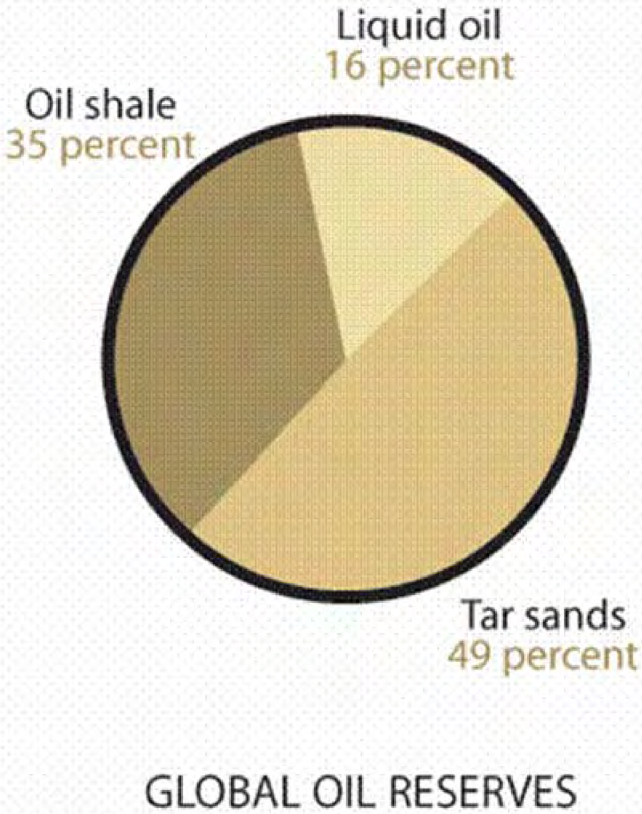


December 2005 Issue of Wired Magazine

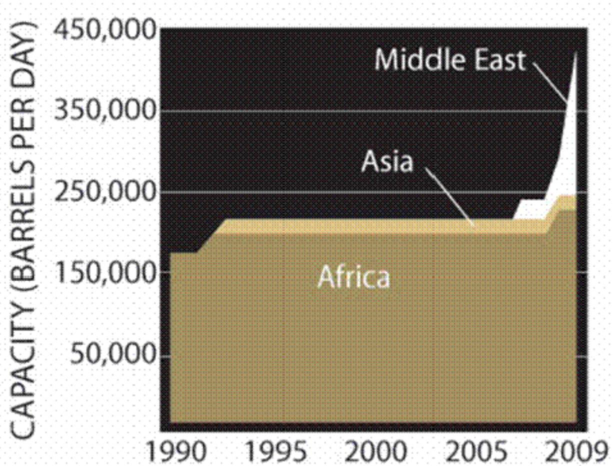
Offshore wells are twice as deep as 30 years ago



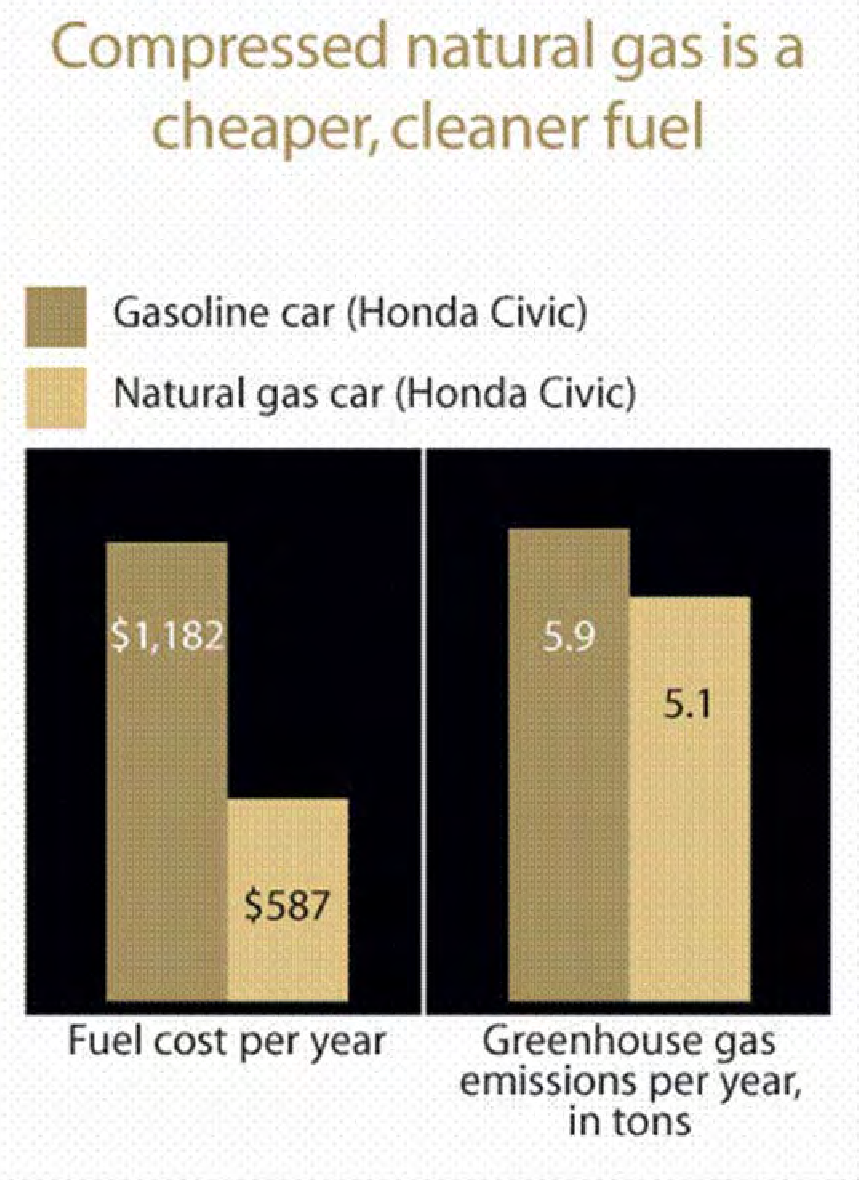
Nearly half the world's oil reserves are in tar sands

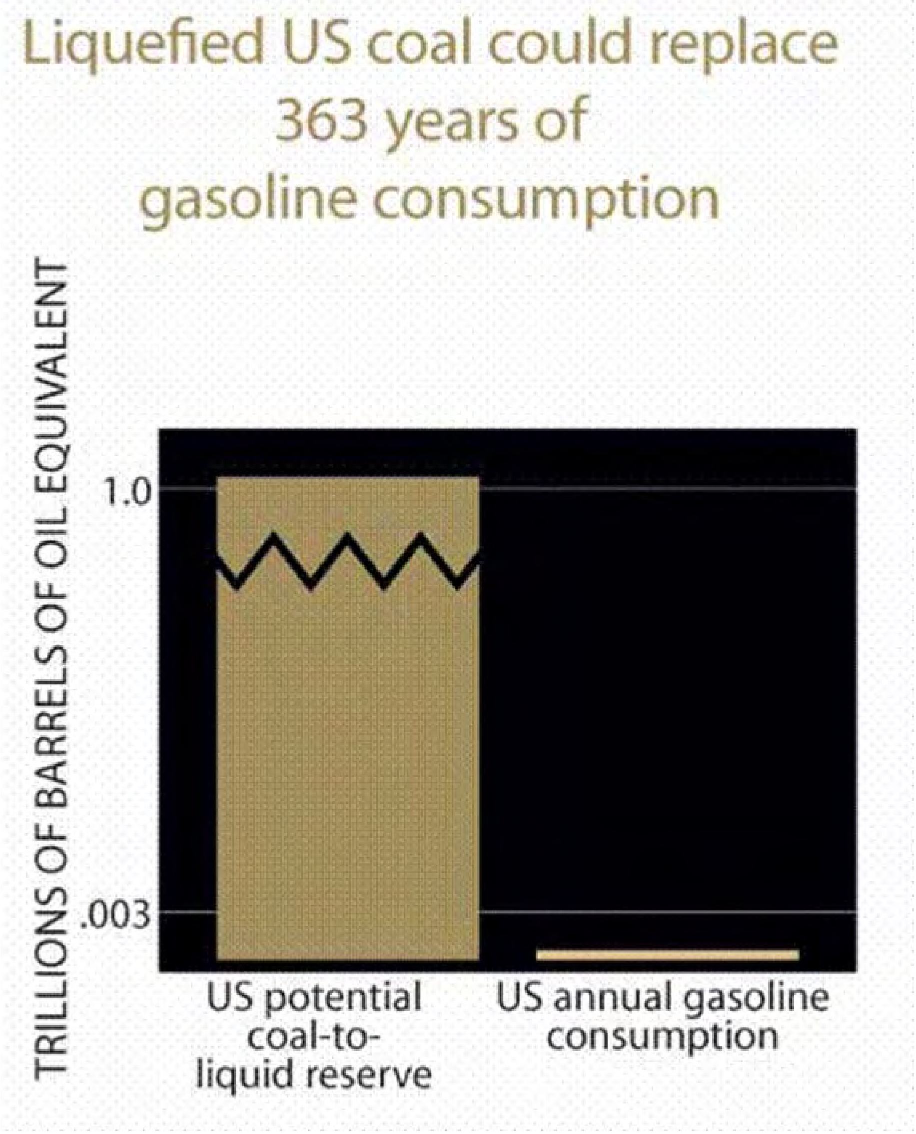


Africa is the chief source of gas-based synfuel

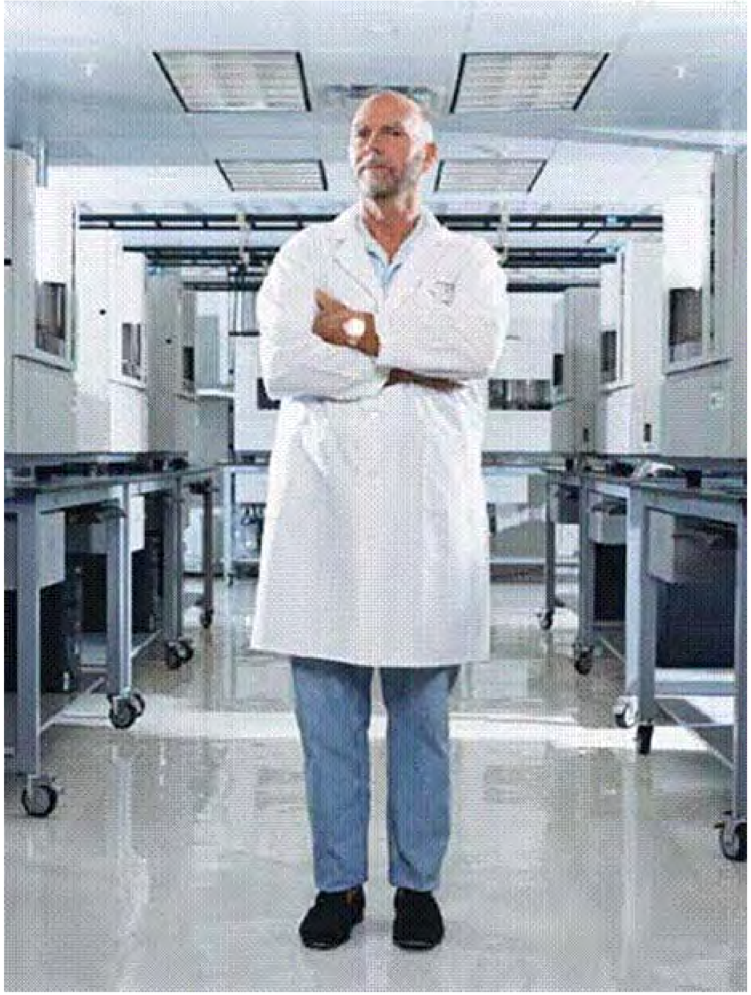


December 2005 Issue of Wired Magazine

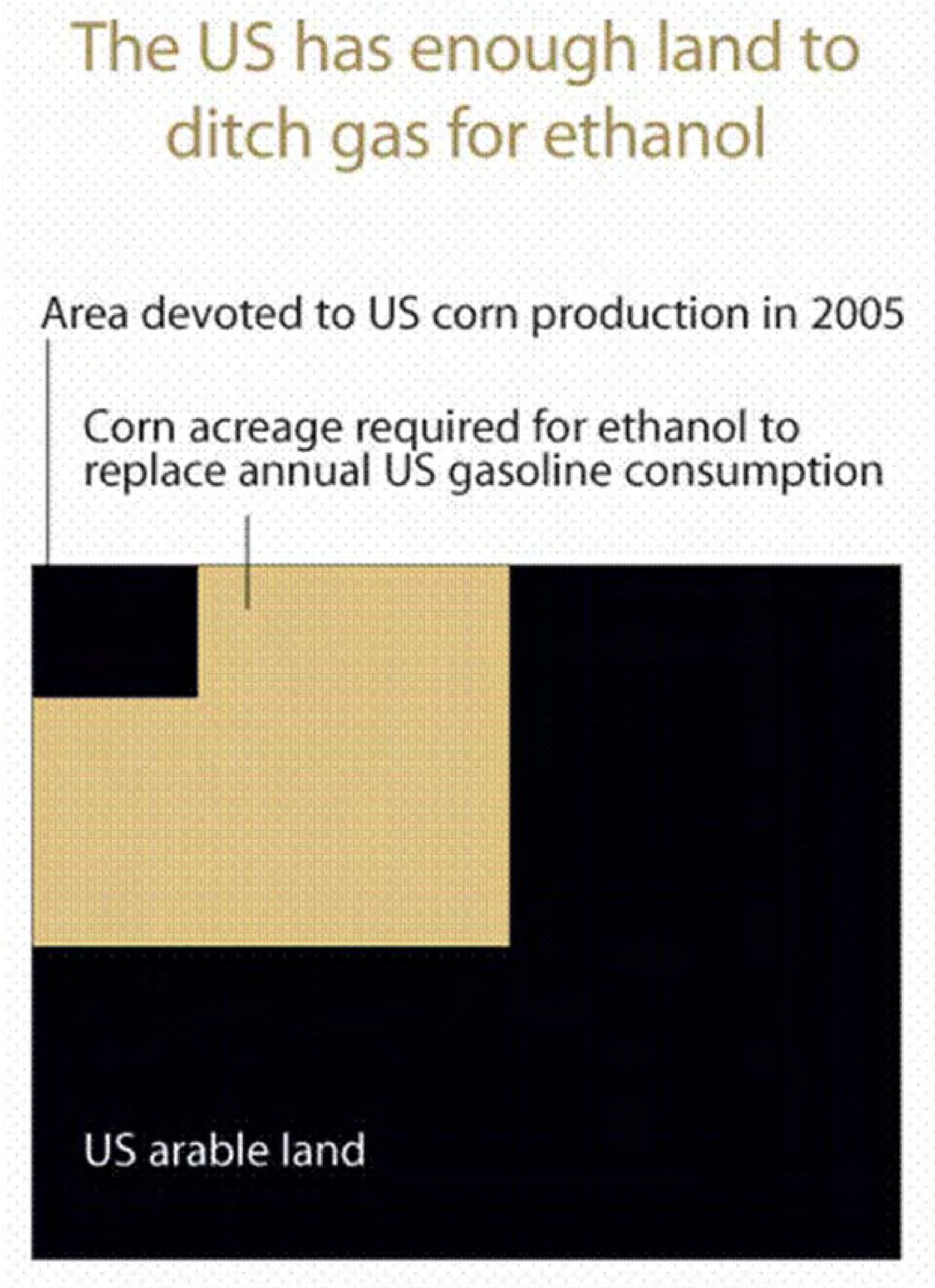




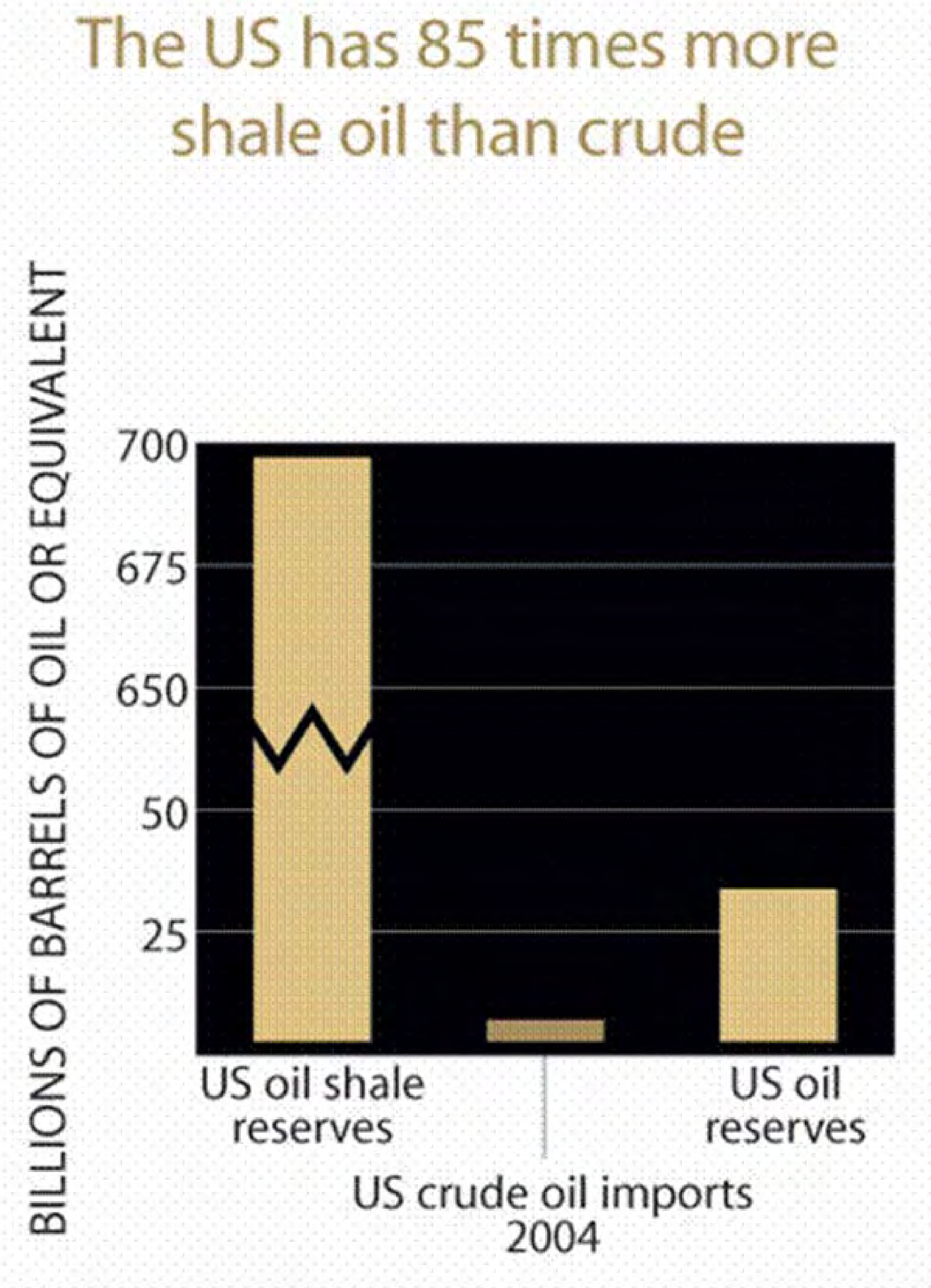
December 2005 Issue of Wired Magazine



December 2005 Issue of Wired Magazine



December 2005 Issue of Wired Magazine



- Electric heating of oil shale to distill oil
- Cyrogenic cooling of surrounding area to contain oil that is released.

December 2005 Issue of Wired Magazine

China's Next Cultural Revolution
The People's Republic is on the fast track to become the car capital of the world. And the first alt-fuel superpower.

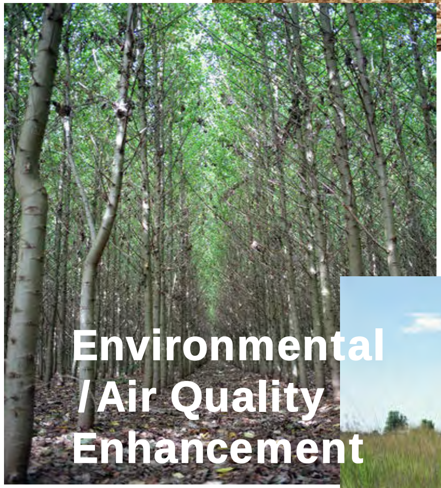
By Lisa Margonelli (Wired Magazine)

Lisa Margonelli (margonelli@yahoo.com) *is the author of* Oil on the Brain: Travels in the World of Petroleum.

Biomass organic matter derived from plant and animal matter

Kansas and National Resources

Switchgrass and big bluestem	Bioethanol, heat and electricity
Corn stover and wheat straw	Bioethanol
Oilseed crops - edible and inedible tallow and waste grasses	Biodiesel
Landfill gas	Heat and electricity
Livestock manures	Heat and electricity
Wood wastes	Heat and electricity



All of the above can be used to produce alternative liquid fuels, electricity, heat, and/or hydrogen

Source: Richard Nelson
K-State Engineering Extension

Biodiesel Production

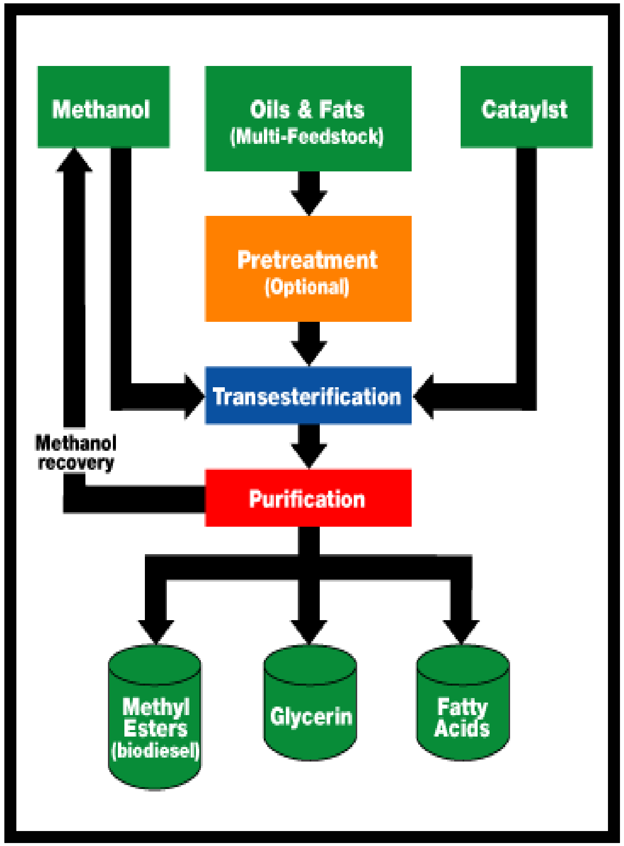
Transesterfication (the biodiesel refining process)

Combining

Vegetable Oil or
Animal Fat
(100 lbs.)
+
Methanol or
Ethanol

(10 lbs.)

In the presence of a catalyst



Yields

Biodiesel
(100 lbs.)
+
Glycerine
(10 lbs.)

Soy, Tallow, Waste Grease, Sunflower, Cottonseed, Canola

Critical Quality Parameters

- **Complete Reaction**
- **Removal of Glycerin**
- **Removal of Catalyst**
- **Removal of Alcohol**
- **Absence of free fatty acids**

Source: Richard Nelson
K-State Engineering Extension

National Renewable Fuels Standard (RFS)

Provision in the Energy Policy Act of 2005

General Objective

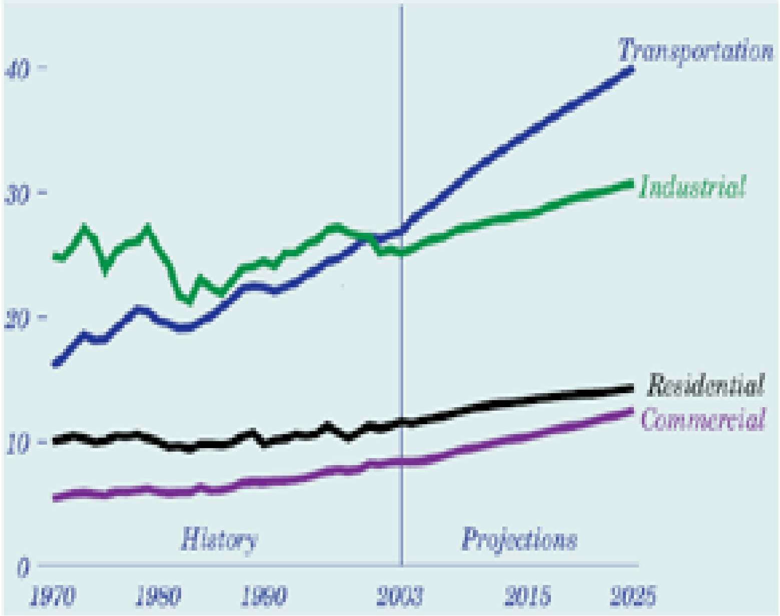
- Idea is to double the amount of renewable fuels (ethanol and biodiesel) by 2012 to 7.5 billion gallons from current levels of about 3.25 billion gallons

- No set "split" between ethanol and biodiesel

Renewable Fuels Standard Projections

2006	4.6 billion gallons
2010	6.8 billion gallons
2012	7.5 billion gallons

Figure 2. Delivered energy consumption by sector, 1970-2025 (quadrillion Btu)



Projected Increase in Petroleum Consumption for Transportation to 2025

Source: Richard Nelson
K-State Engineering Extension

Possible Cellulosic Feedstock Sources

- Agricultural residues
  - Stover, straws, bagasse, alfalfa
- Forestry waste
  - Mill residue, bark, wood chips, thinnings
- Dedicated energy crops
  - Switchgrass, willows, poplars, sorghum, eucalyptus
- Municipal solid waste
  - Yard wastes, paper, packaging, organic wastes

Difference between Quantity and Supply !

Source: Richard Nelson
K-State Engineering Extension

U.S. Biodiesel Production Expected to Triple in 2005
November 15, 2005
Reporting by Roddy Scheer

http://www.emagazine.com/view/?2958

State helps finance study on biodiesel plant
By Mark Fagan (Contact)
Thursday, July 7, 2005

http://www2.ljworld.com/news/2005/jul/07/state_helps_finance_study_biodiesel_plant/?business

Goodland project to produce power, ethanol, biodiesel
The Associated Press
Thursday, July 7, 2005

Biodiesel bus test at KU goes 'well'
By Terry Rombeck (Contact), Brooke Wehner (Contact)
Friday, June 3, 2005

The total cost of growing, harvesting, transporting, and co-firing must be at a cost reflecting a slight premium above the cost of coal.

Estimated Cost Per MMBTU For Energy Crops

Cost Component:	Base Case	Improved Case
Establishment	$0.37	$0.19
Harvesting	$1.88	$1.16
Transportation	$0.41	$0.41
Total	$2.66	$1.76

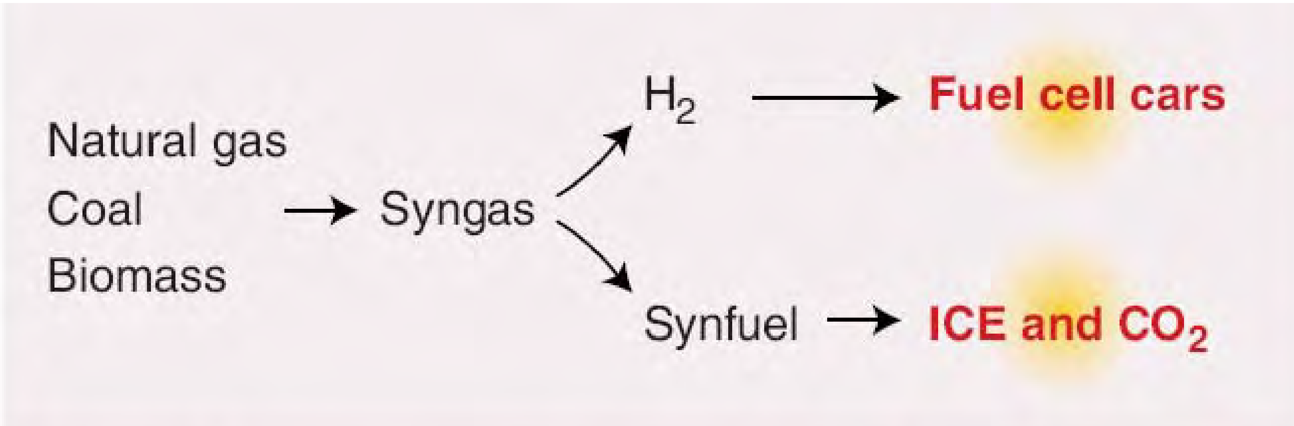
65% cost for harvesting
Coal: $1.5 to 1.75 per MMBTU

Base case: crop yields 32 green tons per acre
Improved case: 55 tons per acre

http://www.treepower.org/economics/main.html

Making Fuels from Biomass

Jens R. Rostrup-Nielsen

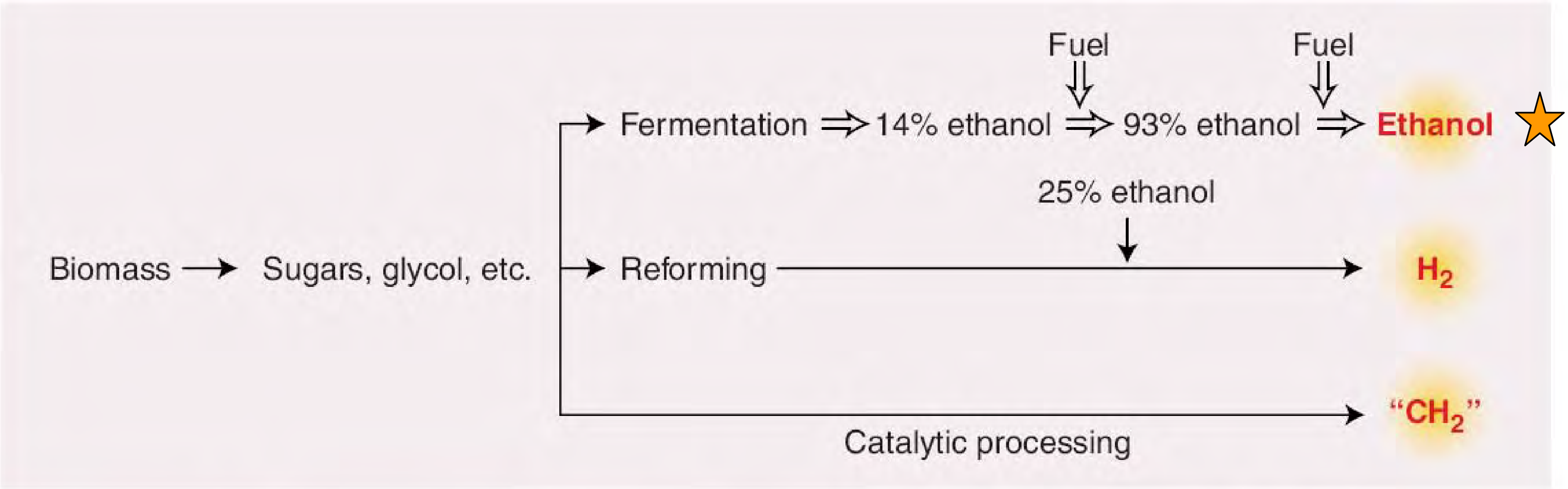


Fuels via synthesis gas. One can use synthesis gas to make hydrogen for fuel cell driven cars or convert it into synthetic diesel or gasoline (synfuel) to be used in conventional internal combustion engines (ICE). The conversion of fossil fuels to synfuels does not solve the CO_2 problem. This is achieved by using biomass or by coupling centralized production of hydrogen from fossil fuels with CO_2 sequestration.

http://www.sciencemag.org/cgi/reprint/308/5727/1421.pdf
Science, vo. 308, p. 1421-22, 3 June 2005

Making Fuels from Biomass

Jens R. Rostrup-Nielsen

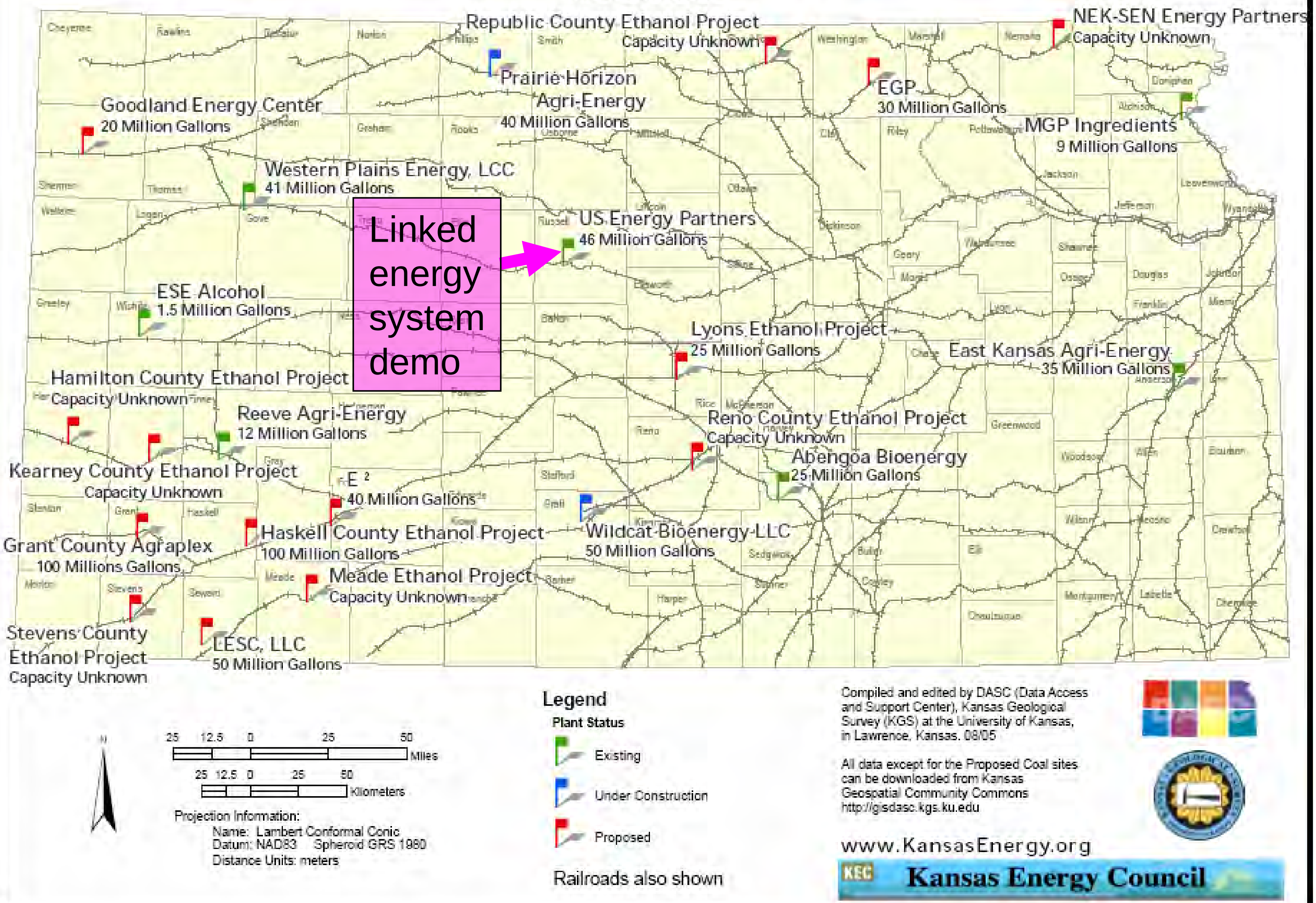


Process routes for conversion of carbohydrates to fuels. These routes include ethanol via fermentation and distillation (**top**), hydrogen via ethanol or directly by liquid-phase steam reforming (**middle**), and hydrocarbons ("CH_2") by the process described by Huber *et al.* (*1*) (**bottom**).

http://www.sciencemag.org/cgi/reprint/308/5727/1421.pdf
Science, vo. 308, p. 1421-22, 3 June 2005

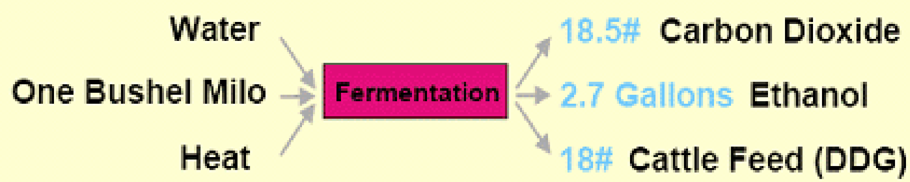
PROPOSED and EXISTING ETHANOL PLANTS in KANSAS

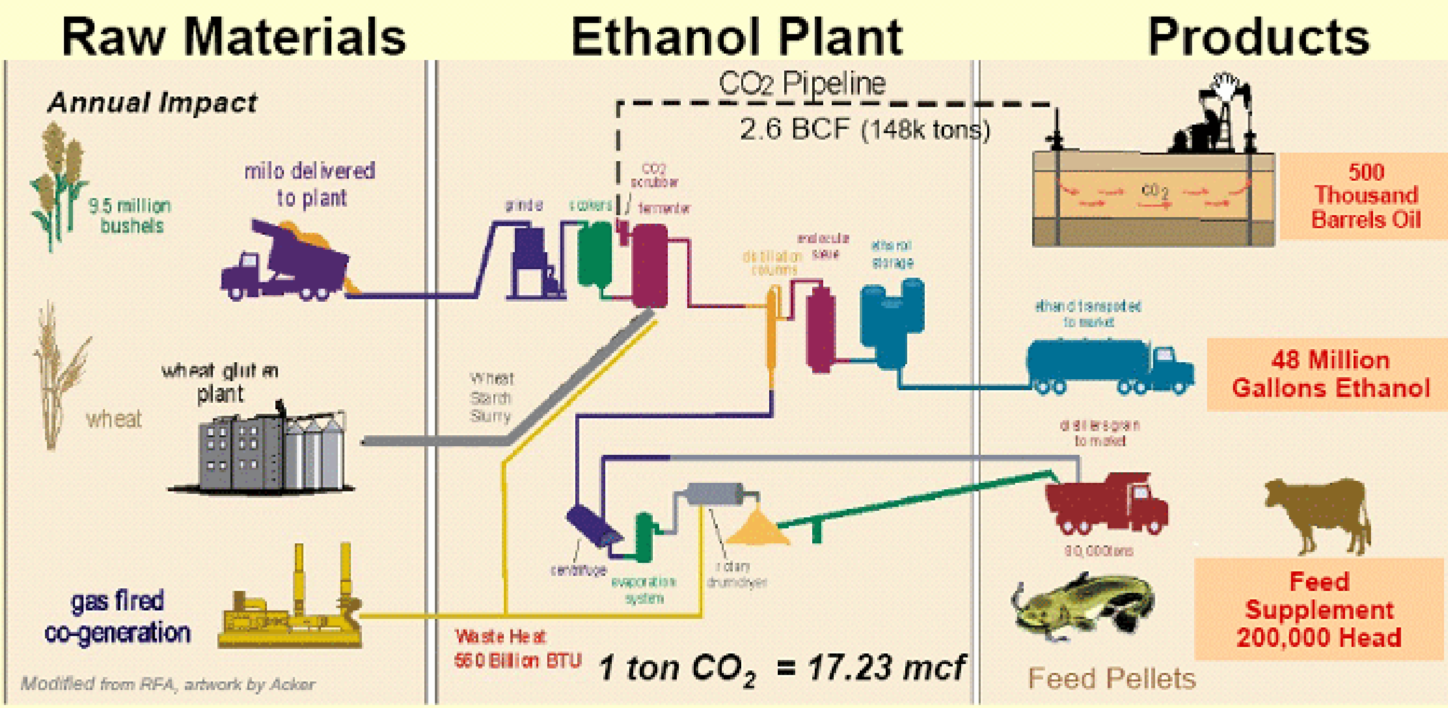
October 2005



http://www.kansasenergy.org/KEC/documents/EthanolProjects.pdf

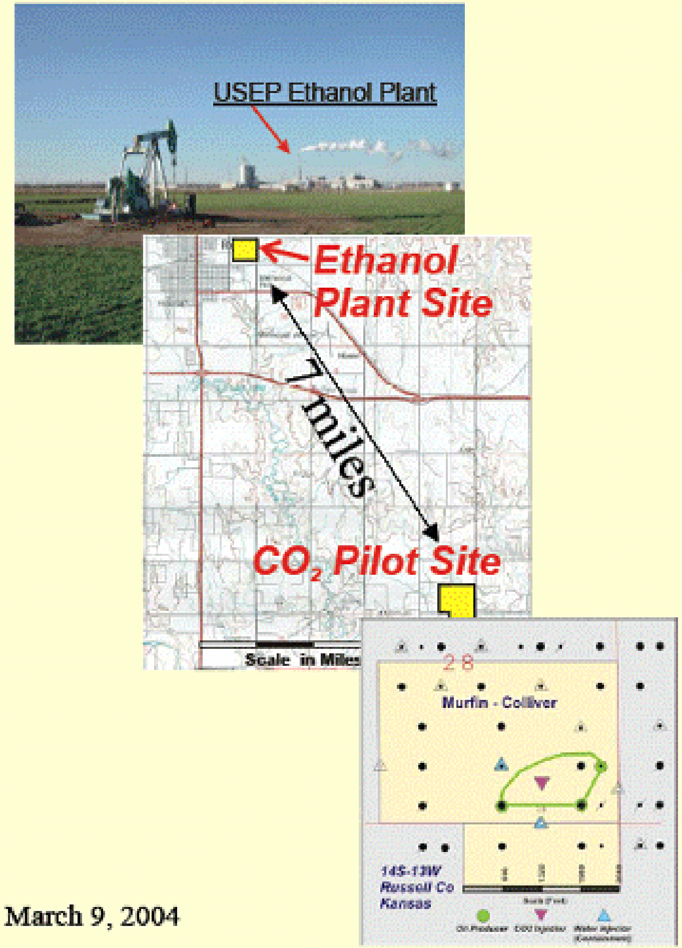
Russell Linked Energy System

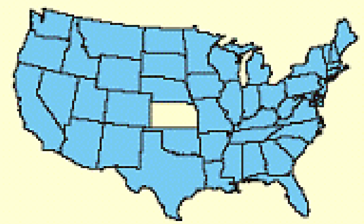


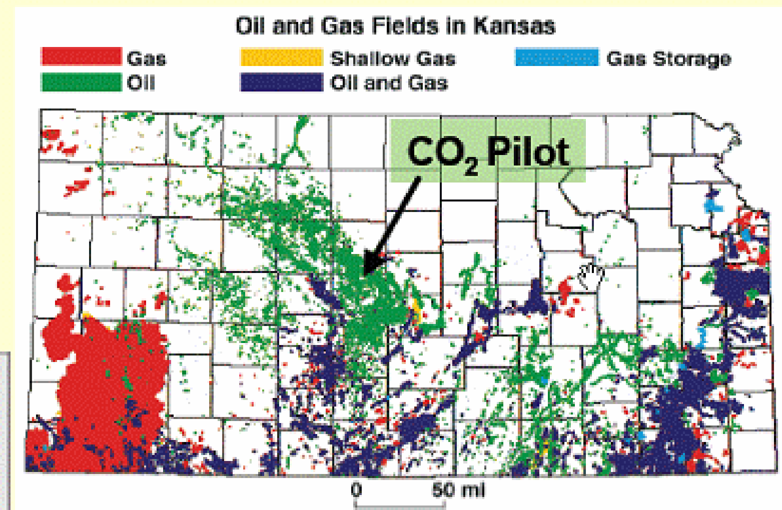


March 9, 2004

Russell, Kansas Project



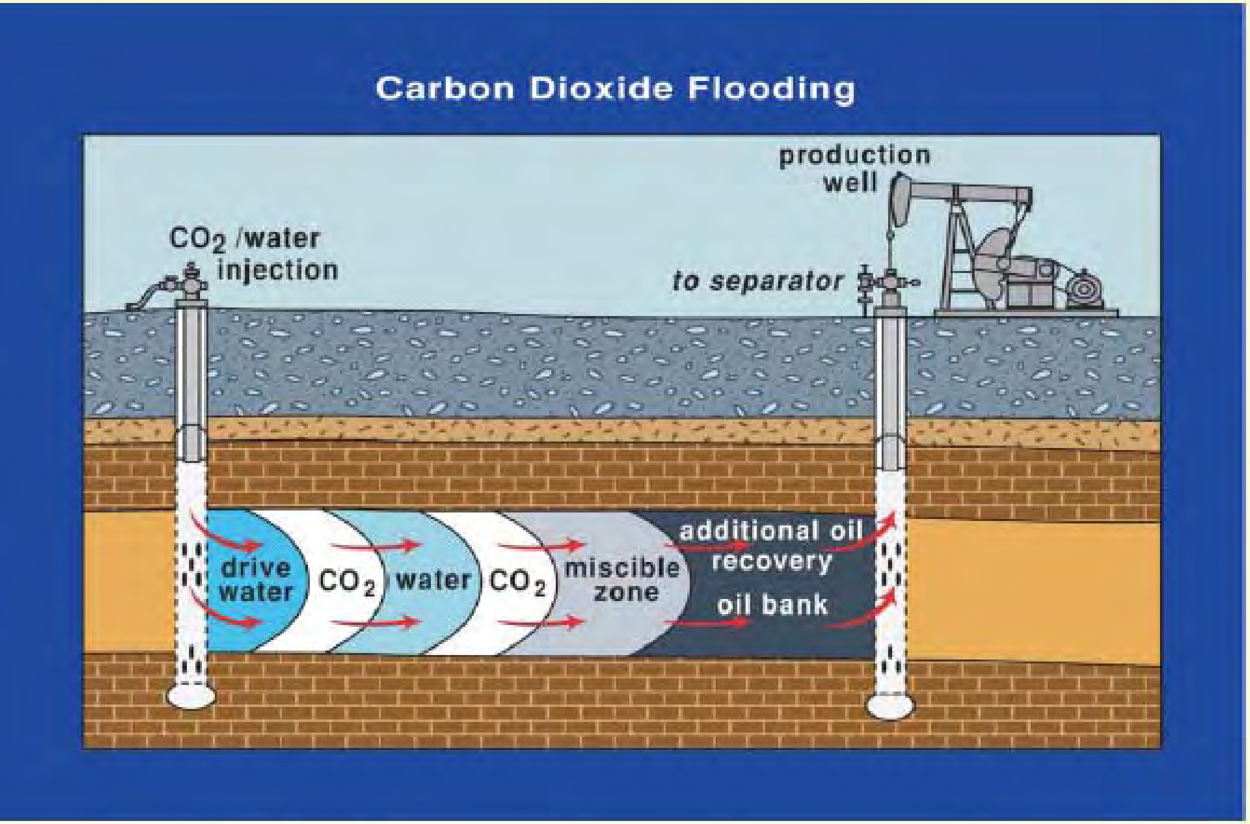


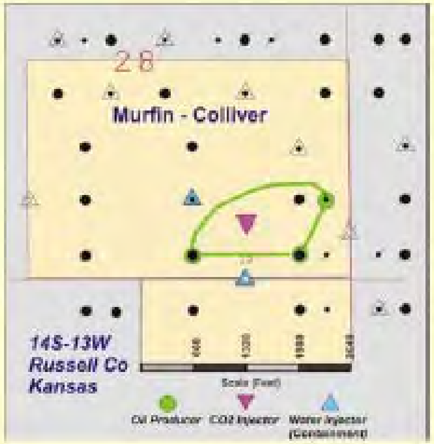


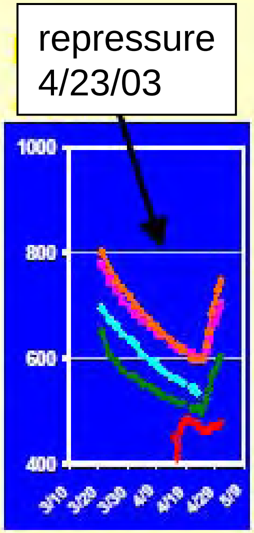
Russell is centered in oil, grain and cattle region

March 9, 2004

The CO_2 EOR Oil Resource

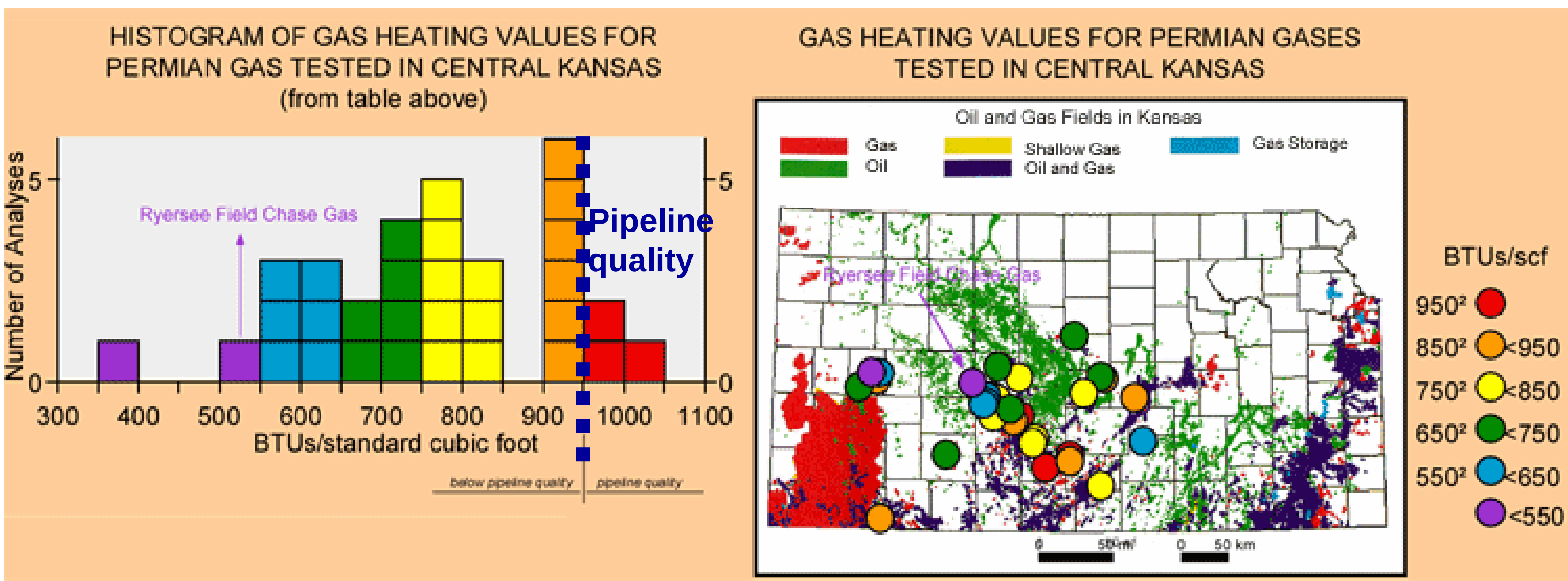






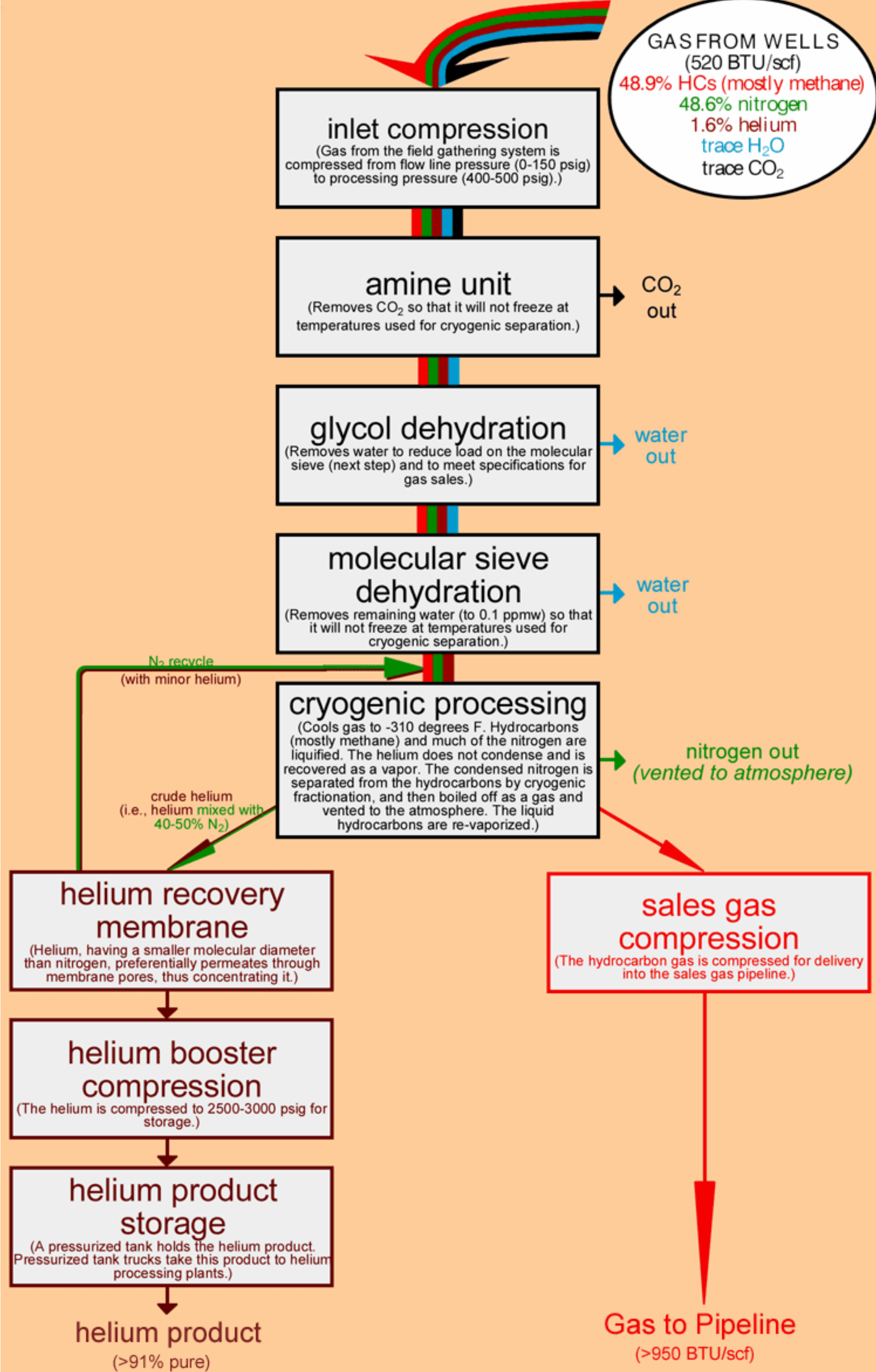
Low-BTU Gas in the Permian Chase Group in the Ryersee Field in Western Kansas: A Case History where Technology Creates a Marketable Commodity

K. David Newell, Kansas Geological Survey, University of Kansas, Lawrence, Kansas
Scott Corsair, American Warrior, Inc., Garden City, Kansas
Steve Chafin and Kent Pennybaker, River City Engineering, Inc., Lawrence, Kansas



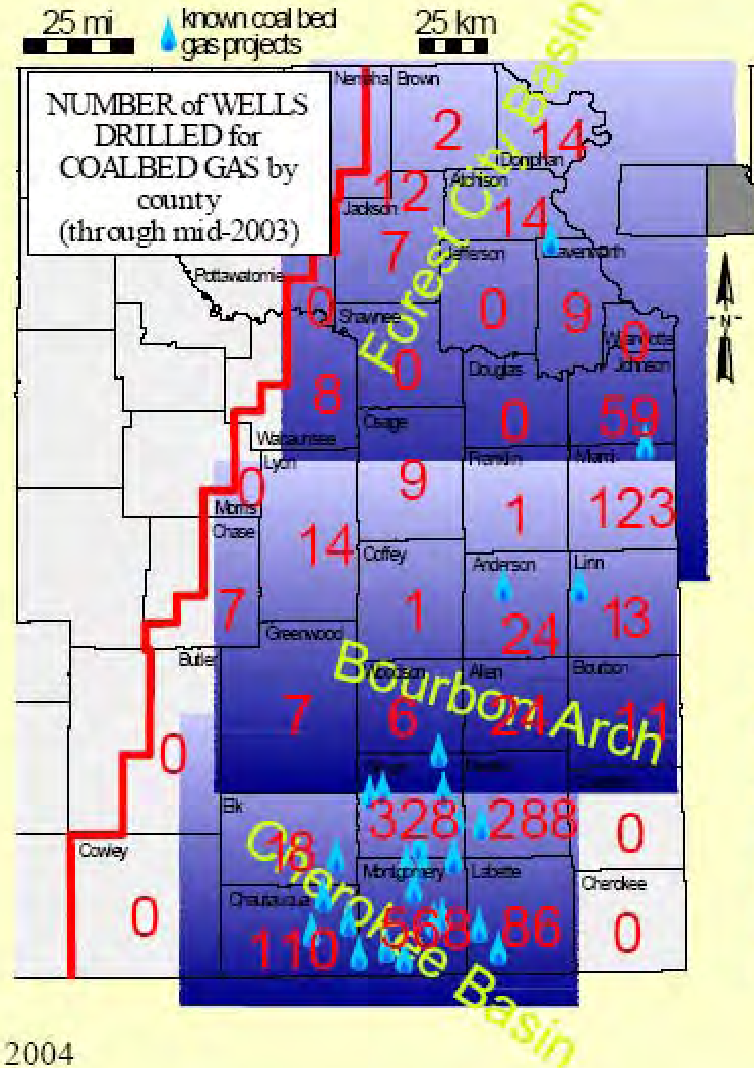
http://www.kgs.ku.edu/PRS/publication/2003/ofr2003-57/P2-03.html

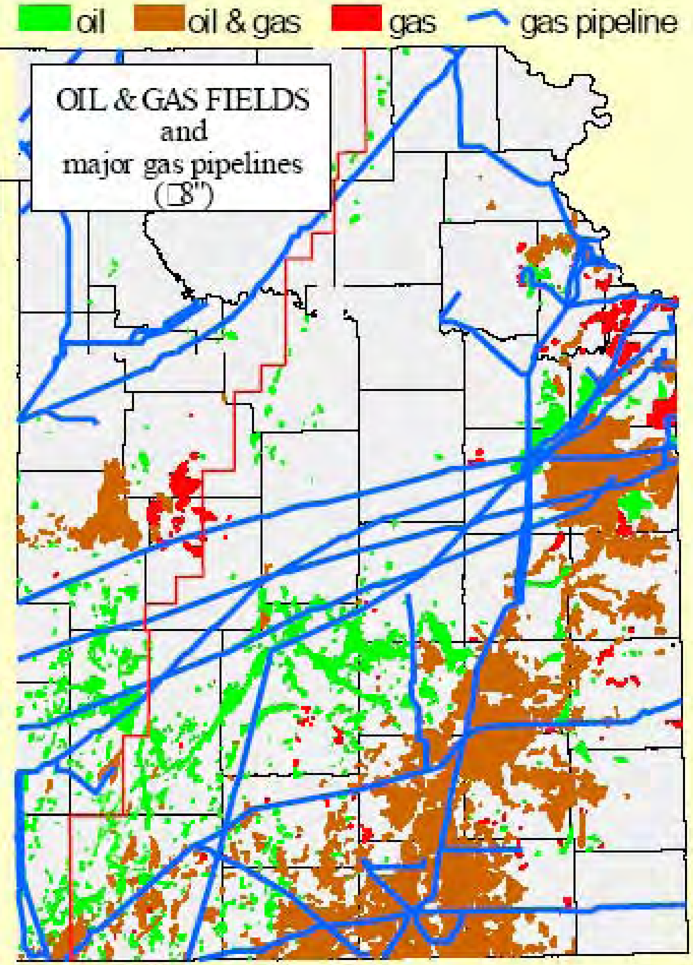
Separation of Methane and Helium from Raw, low-BTU gas



http://www.kgs.ku.edu/PRS/publication/2003/ofr2003-57/P2-03.html

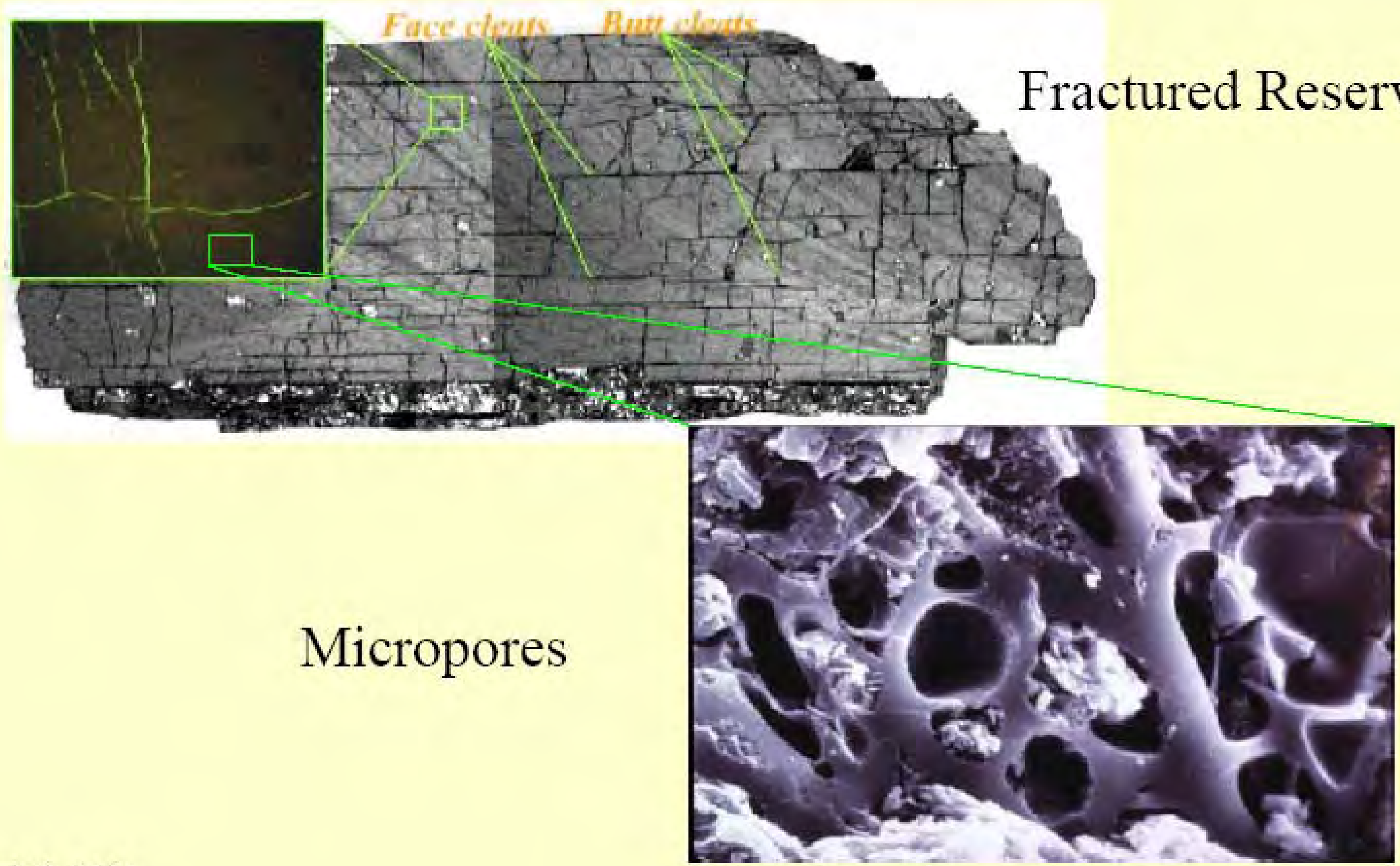
Kansas Coalbed Methane Activity





March 9, 2004

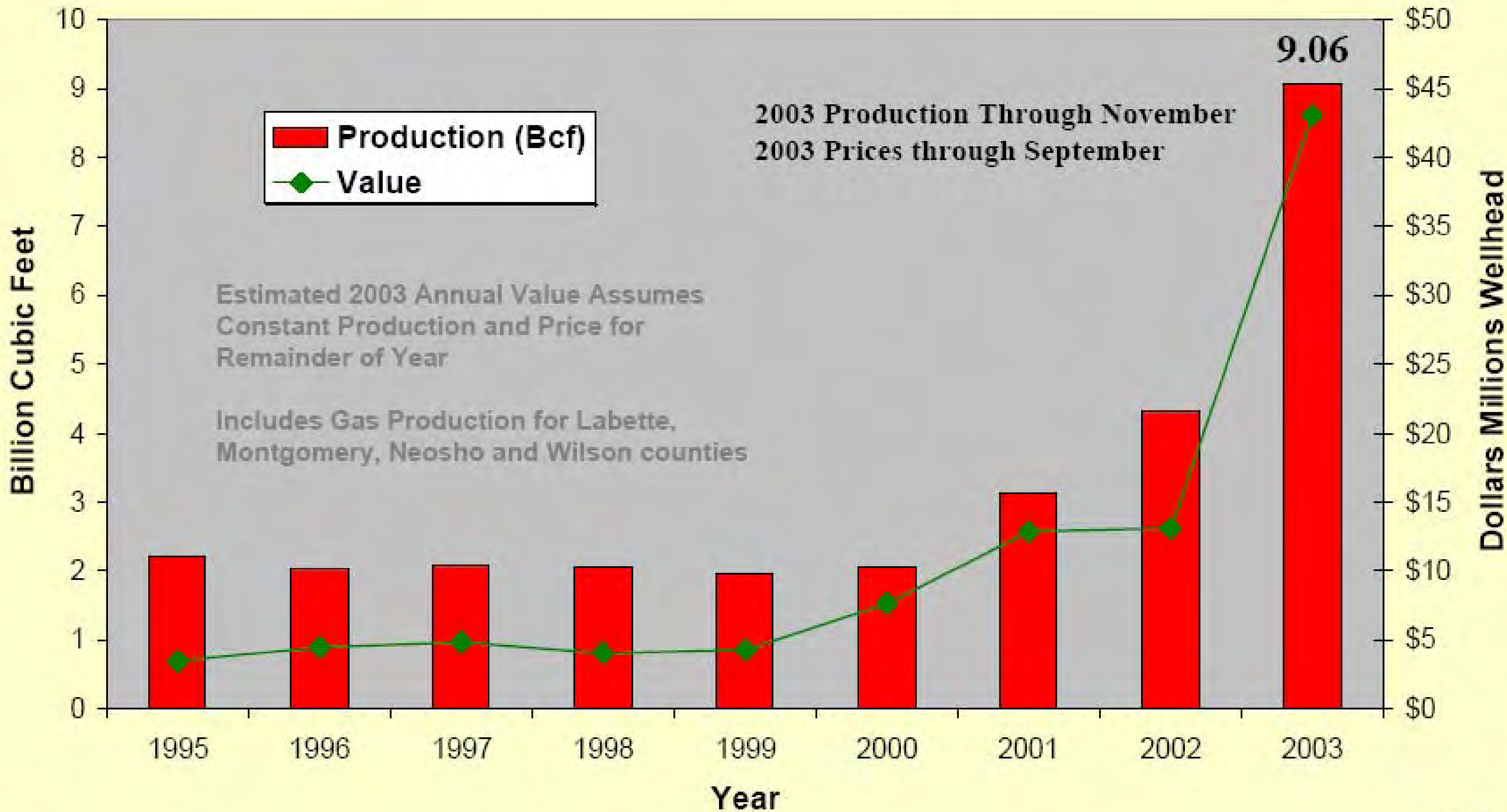
Coal, an Unconventional Reservoir



Fractured Reservoir

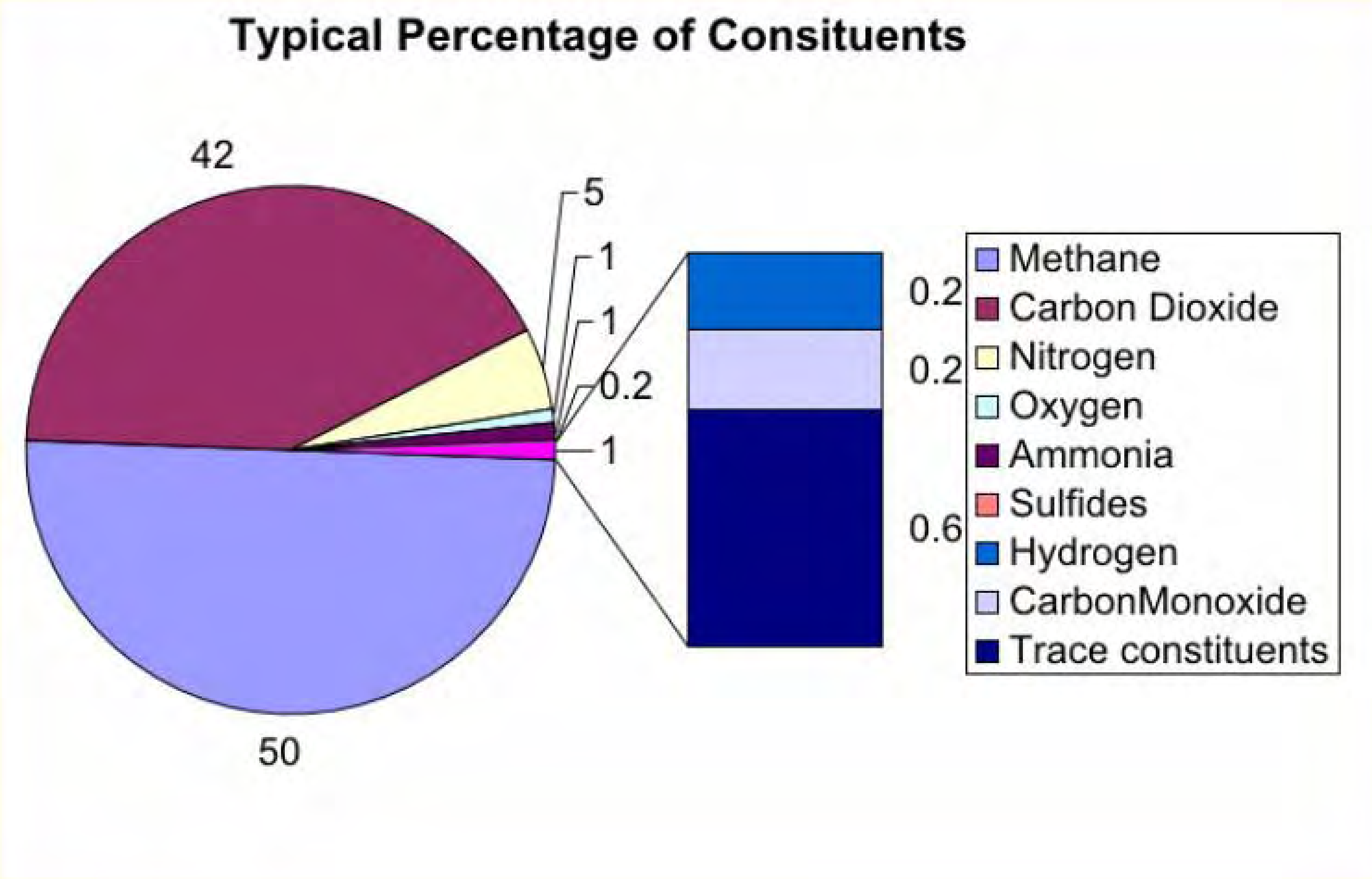
Micropores

SE Kansas CBM Production

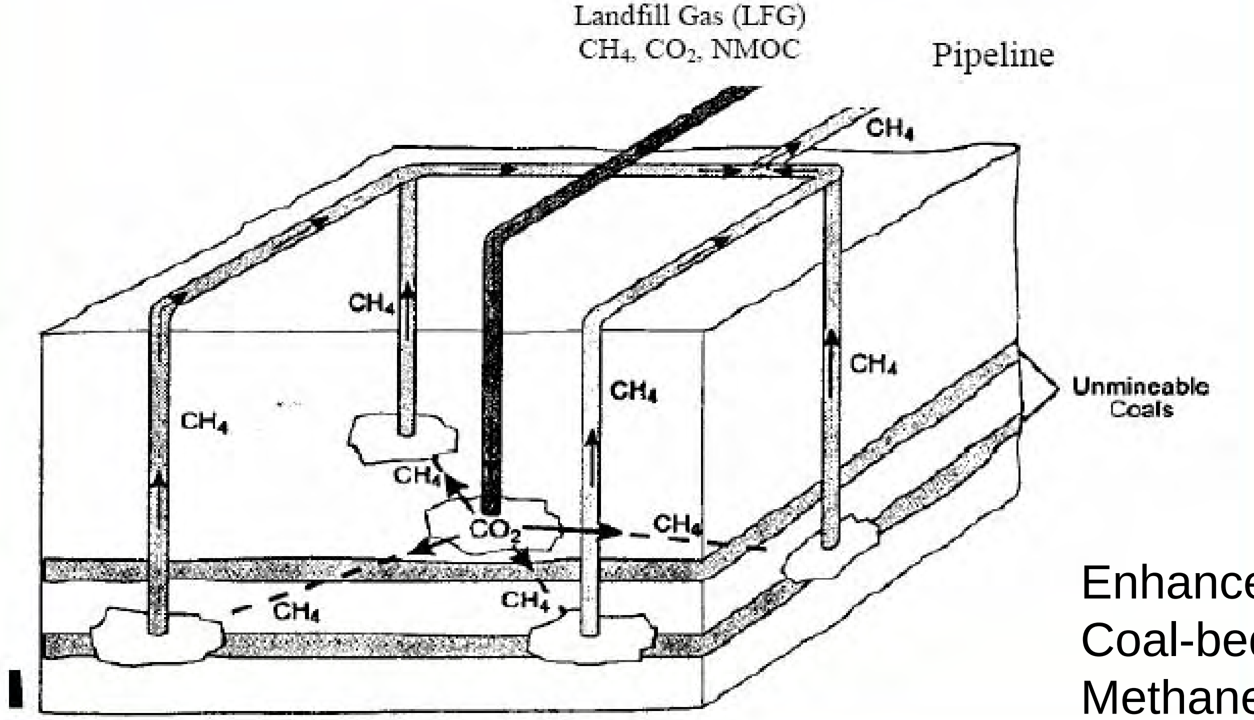


March 9, 2004

Landfill Gas

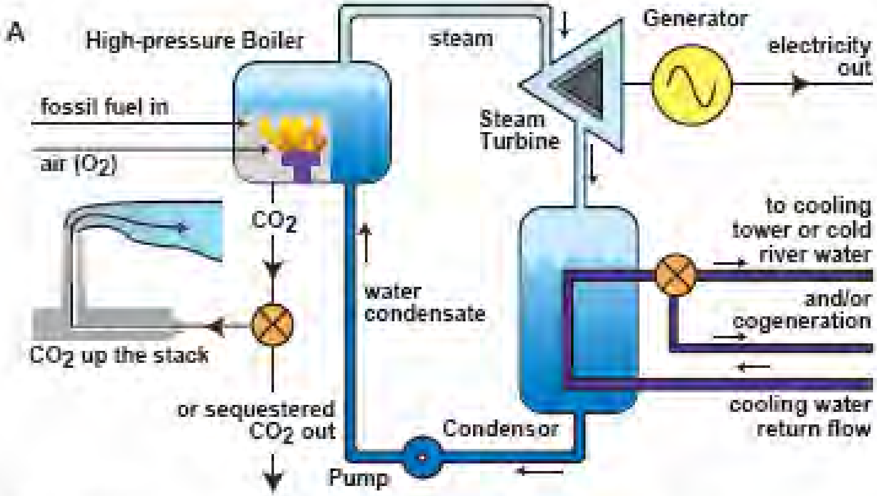


Landfill Gas



Enhance Coal-bed Methane Recovery

A



B

Fossil fuel	Energy content [TW-yr]	Carbon content [GTC]	(E_{fuel}/C) [TW-yr/GtC]	(E/C) [TW-yr/GtC]	Sequestration rate [GtC/yr]
Gas	1200	570	2.1	1.9 - 1.6	5 - 6
Oil	1200	750	1.6	1.4 - 1.2	7 - 8
Coal	4800	3690	1.3	1.2 - 1.0	9 - 10

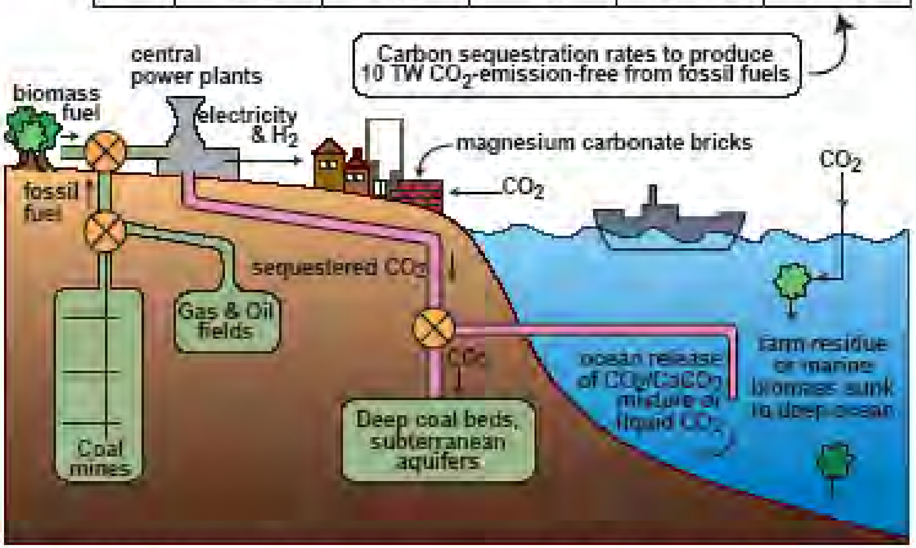


Fig. 1. (A) Fossil fuel electricity from steam turbine cycles. (B) Collecting CO_2 from central plants and air capture, followed by subterranean, ocean, and/or solid carbonate sequestration, could foster emission-free electricity and hydrogen production, but huge processing and sequestration rates are needed (5 to 10 GtC $year^{-1}$ to produce 10 TW emission-free assuming energy penalties of 10 to 25%).

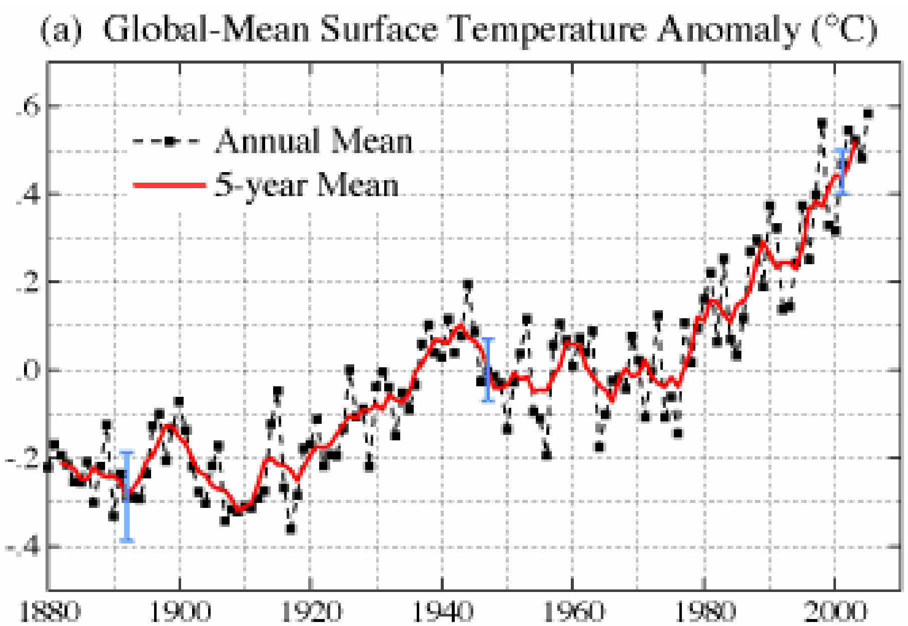
REVIEW: ENGINEERING

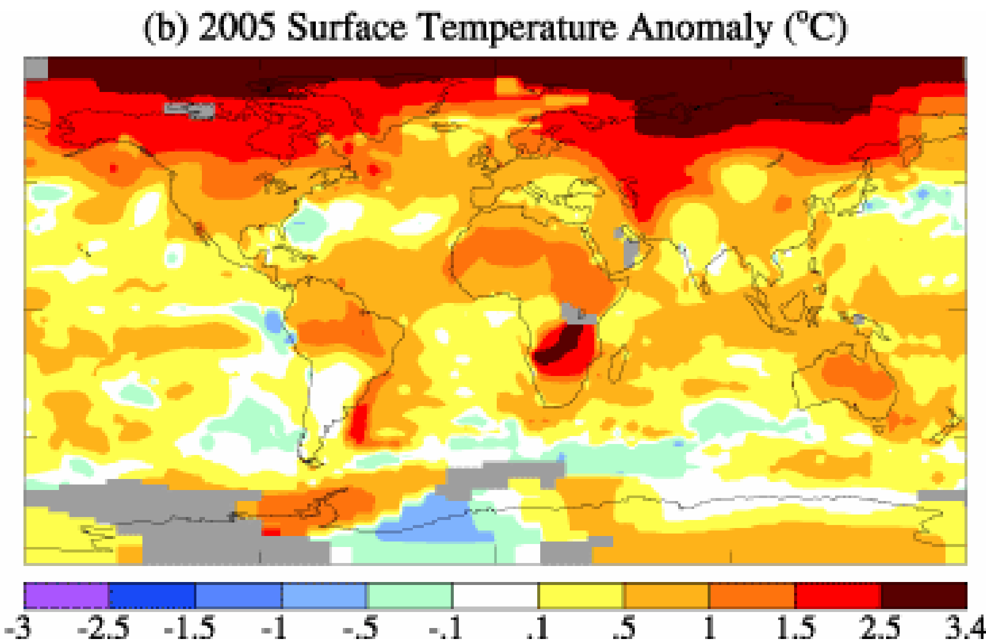
Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet

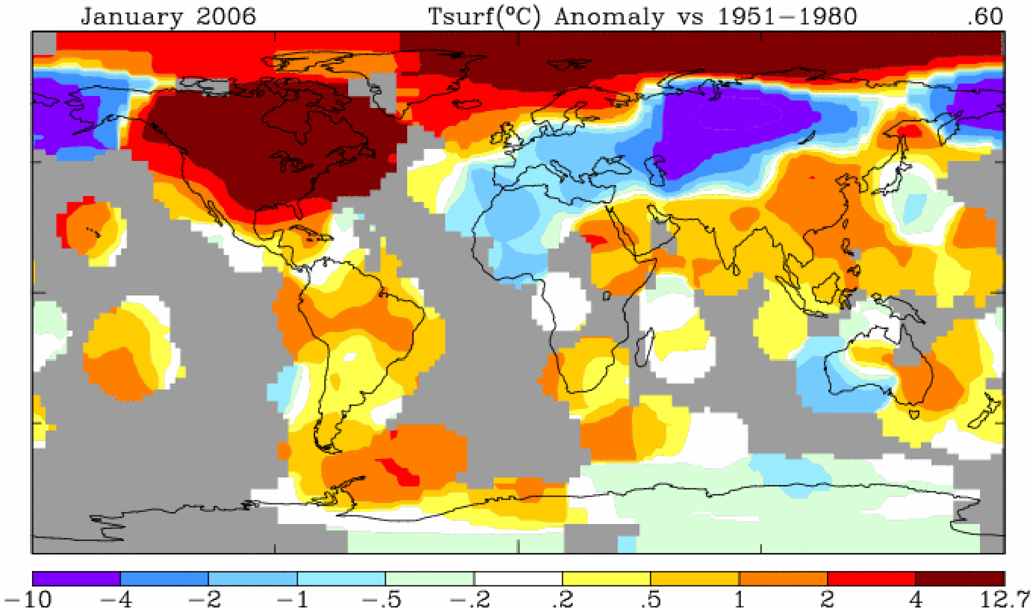
Martin I. Hoffert,[1*] Ken Caldeira,[3] Gregory Benford,[4] David R. Criswell,[5] Christopher Green,[6] Howard Herzog,[7] Atul K. Jain,[8] Haroon S. Kheshgi,[9] Klaus S. Lackner,[10] John S. Lewis,[12] H. Douglas Lightfoot,[13] Wallace Manheimer,[14] John C. Mankins,[15] Michael E. Mauel,[11] L. John Perkins,[3] Michael E. Schlesinger,[8] Tyler Volk,[2] Tom M. L. Wigley[16]

http://www.sciencemag.org/cgi/reprint/298/5595/981.pdf

Global Temperature Trends: 2005 Summation







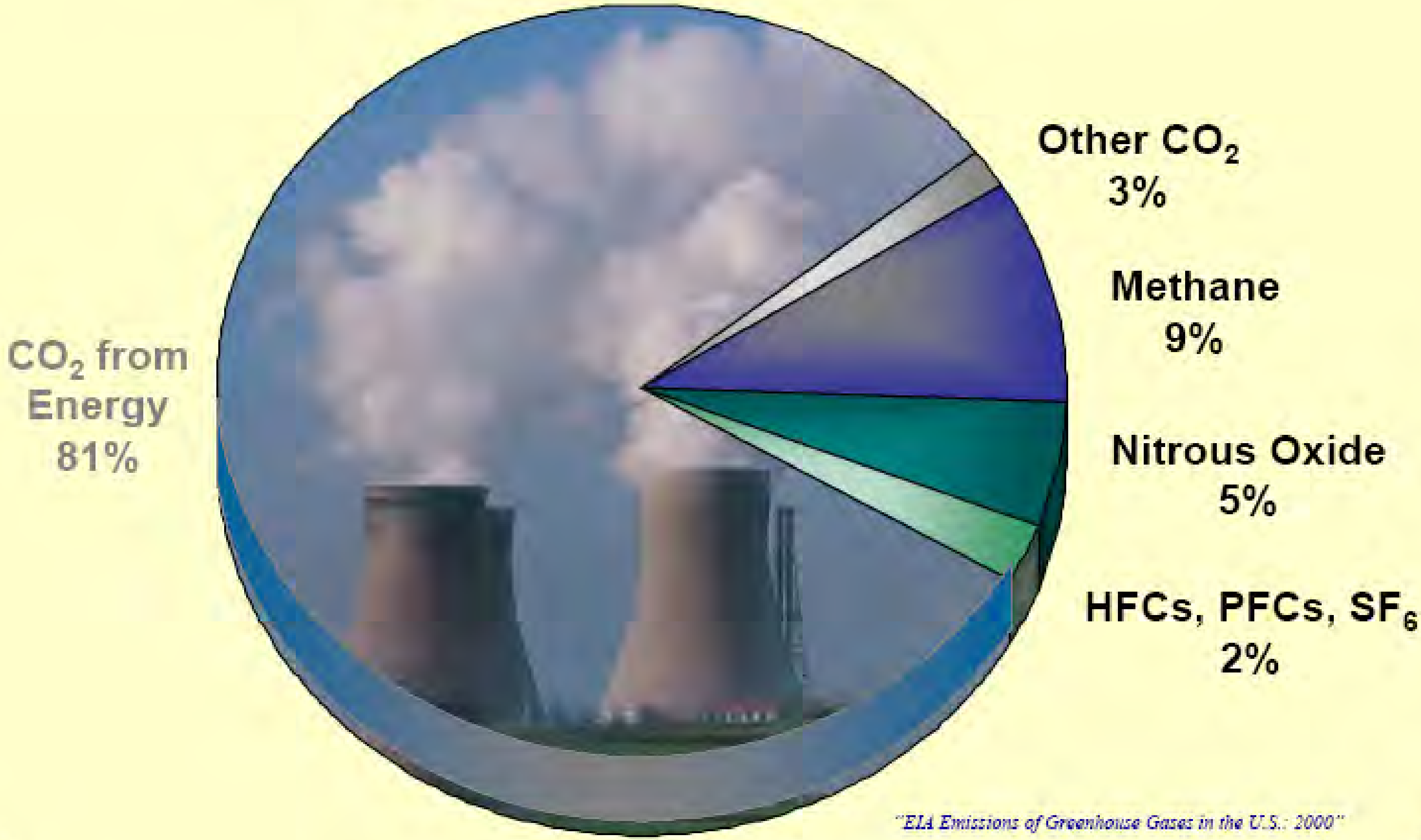
January 2006 was not warm everywhere in the northern hemisphere

http://data.giss.nasa.gov/gistemp/

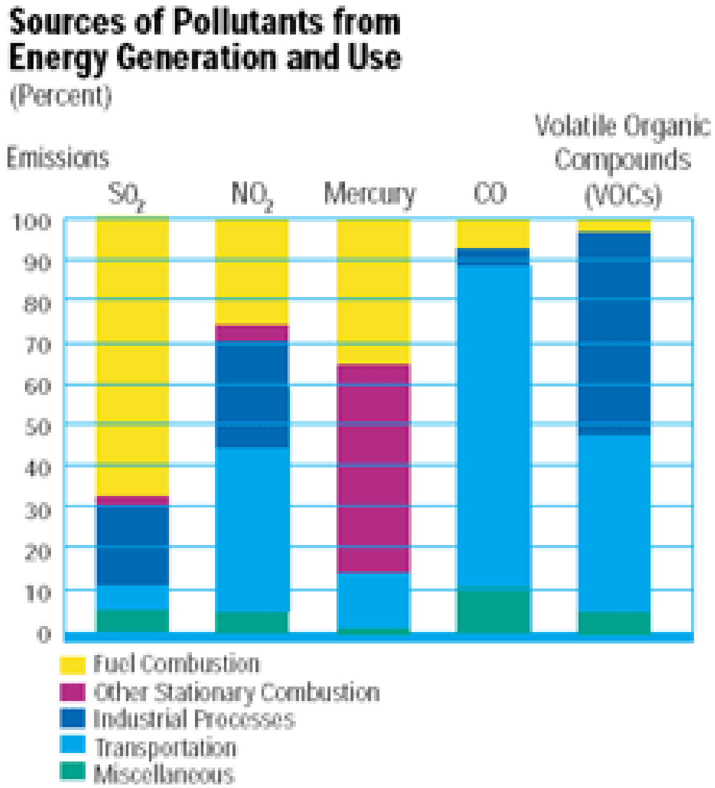
CO_2 & CH_4 Primary GHG Contributors

United States Greenhouse Gas Emissions

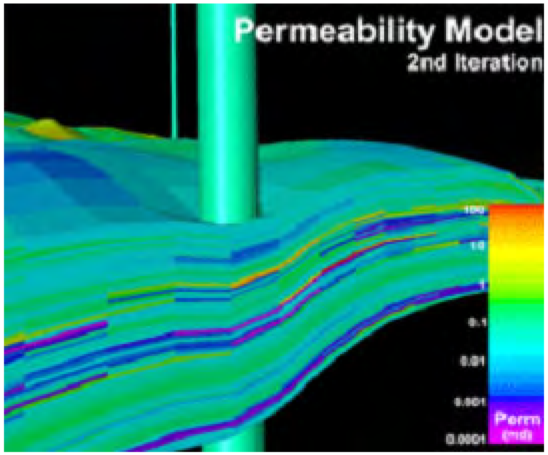
(Equivalent Global Warming Basis)

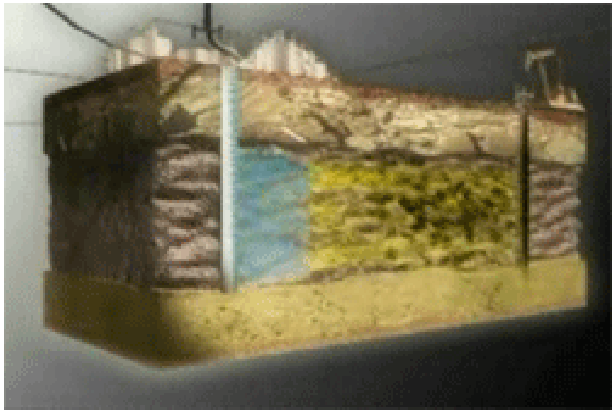


"EIA Emissions of Greenhouse Gases in the U.S.: 2000"

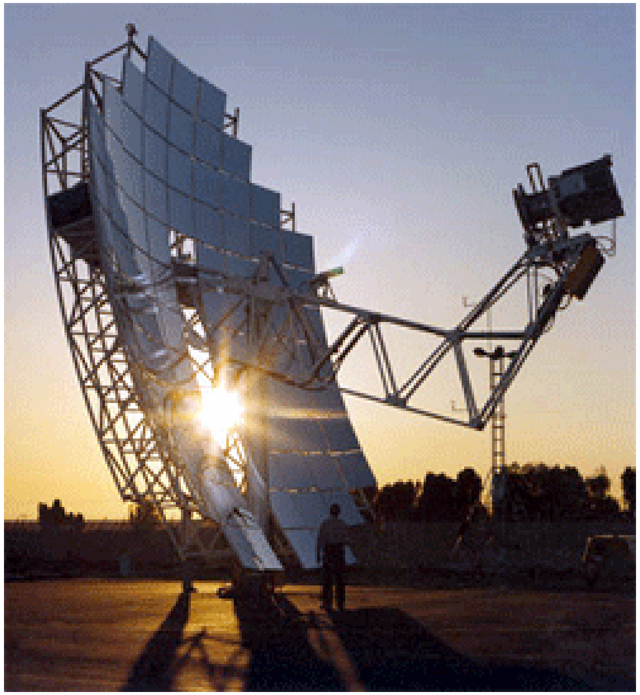


KU THE UNIVERSITY OF KANSAS

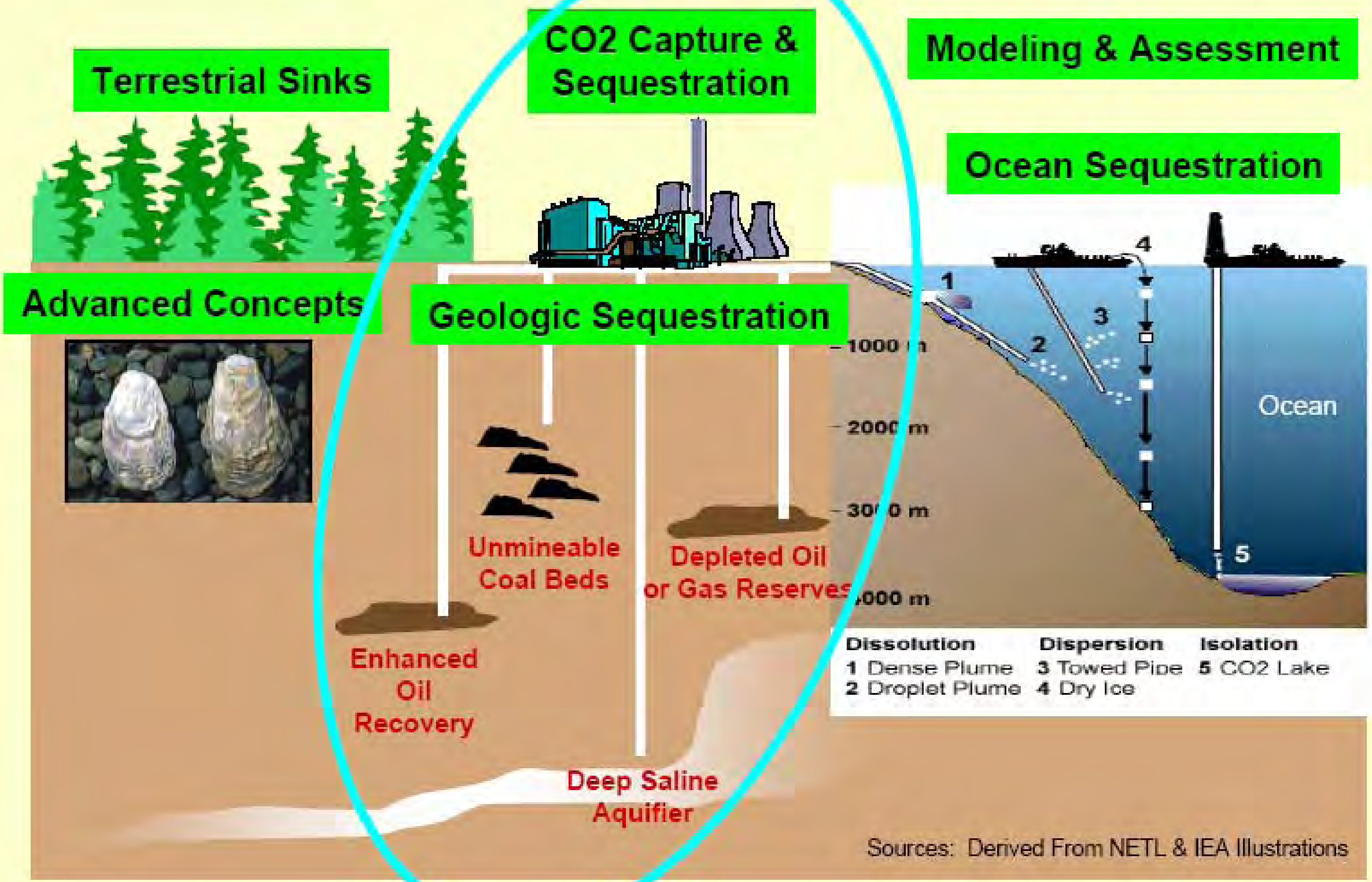




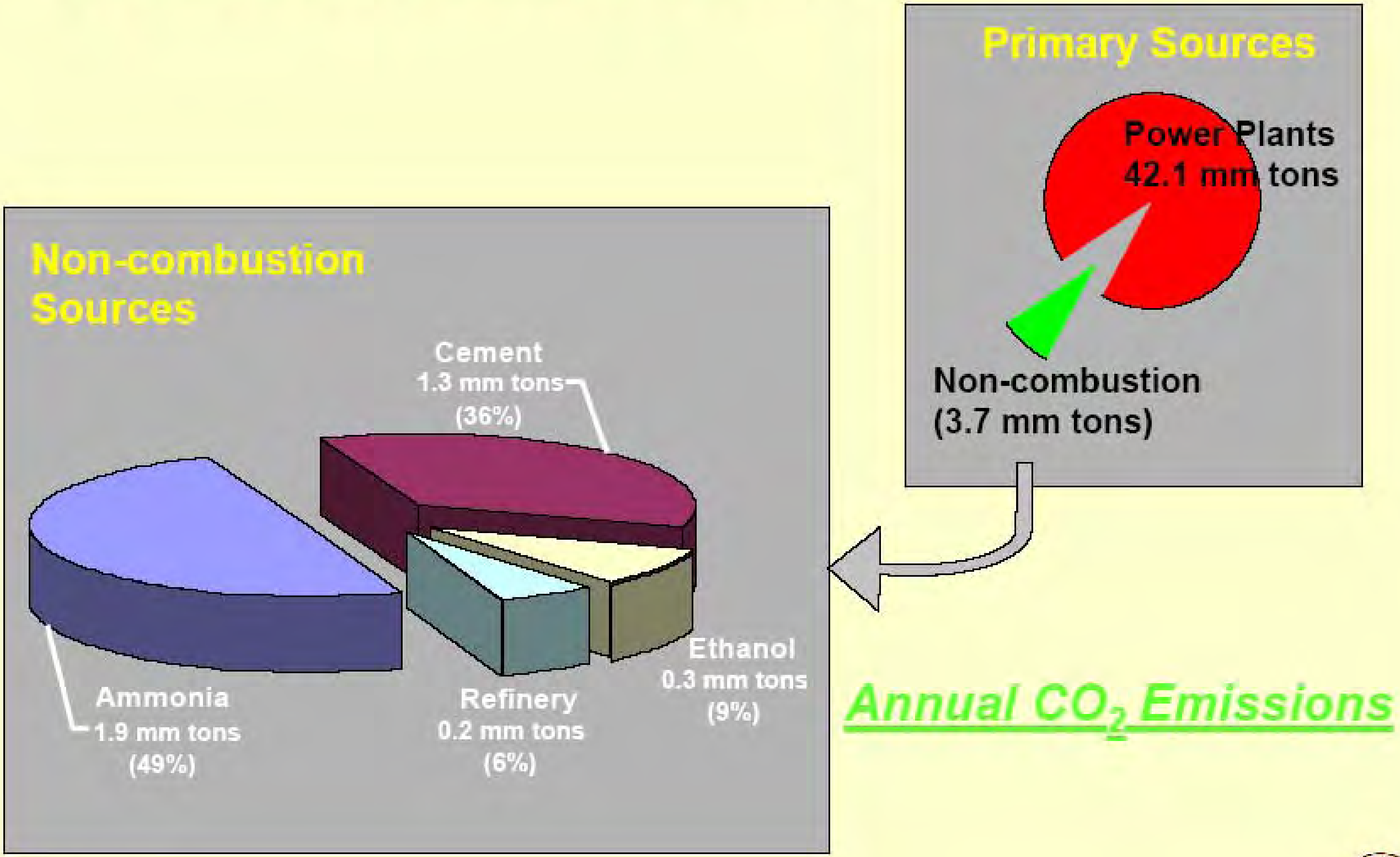
KANSAS · GEOLOGICAL SURVEY · UNIVERSITY OF KANSAS



CO_2 Sequestration Options



Kansas Sources for CO_2 Capture



ATMOSPHERIC SCIENCE

The Greenland Ice Sheet and Global Sea-Level Rise

Julian A. Dowdeswell

The flow of several large glaciers draining the Greenland Ice Sheet is accelerating. This change, combined with increased melting, suggests that existing estimates of future sea-level rise are too low.

The changing mass of the great ice sheets of Greenland and Antarctica represents the largest unknown in predictions of global sea-level rise over the coming decades. At 1.7 million km^2, up to 3 km thick, and a little smaller than Mexico, the Greenland Ice Sheet would raise global sea level by about 7 m if it melted completely. This could take from a millennium to a few thousand years (if melting were the only mechanism by which it lost mass) depending on the magnitude of future warming (*1*). Of more immediate concern are several sets of new observations, derived largely from remote-sensing satellites. As reported by Rignot and Kanagaratnam (*2*) on page 986 of this issue, the velocities of several large glaciers draining the ice sheet to the sea, already among the fastest-flowing on Earth, have recently doubled to reach over 12 km year^{-1}. In addition, the ice sheet has experienced a greater area of surface melting this year than at any time since systematic satellite monitoring began in 1979 (*3*). Both these changes increase mass loss from the ice sheet, with the implication that current estimates of global sea-level rise over the next century, of about 0.5 ± 0.4 m (*4*), may be underestimated.

The Greenland Ice Sheet gains mass through snowfall and loses it by surface melting and runoff to the sea, together with the production of icebergs and melting at the base of its floating ice tongues. The difference between these gains and losses is the mass balance; a negative balance contributes to global sea-level rise and vice versa. About half of the discharge from the ice sheet is through 12 fast-flowing outlet glaciers, most no more than 10 to 20 km across at their seaward margin, and each fed from a large interior basin of about 50,000 to 100,000 km^2. As a result, the mass balance of the ice sheet depends quite sensitively on the behavior of these outlet glaciers.

Two changes to these glaciers have been observed recently. First, the floating tongues or ice shelves of several outlet glaciers, each several hundred meters thick and extending up to tens of kilometers beyond the grounded glaciers, have broken up in the past few years (*5*). Second, measurements of ice velocity made with satellite radar interferometric methods have demonstrated that flow rates of these glaciers have approximately doubled over the past 5 years or so (*2*, *5*). The effect has been to discharge more

The author is at the Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER, UK. E-mail: jd16@cam.ac.uk

Published by AAAS

<u>Hybrids</u>: now; on the horizon -- plug-in *when batteries evolve*
<u>Fuel-Cells</u>: probably commercial in 2015 to 2020
<u>Electric</u>: Lithium-ion batteries and beyond
will make electric cars practical
<u>Clean diesel</u>: now, but not readily available
low sulfur/particulates
<u>Flex-fuel</u>: E85/85% ethanol -- now.

Ethanol

- E85 (85% ethanol) gasoline replacement
  - Fewer total toxics
  - Reduced ozone-forming volatile organics (15%)
  - Reduced carbon monoxide (40%)
  - Reduced nitrogen oxide (10%)
  - Reduced sulfate (80%)
  - Lower reactivity of hydrocarbon emissions
  - Higher ethanol and acetaldehyde emissions

Fermenting plant sugars from anything containing sugar, starch, or cellulose
More than 90% of ethanol comes from corn
FFV's – flexible fuel vehicles

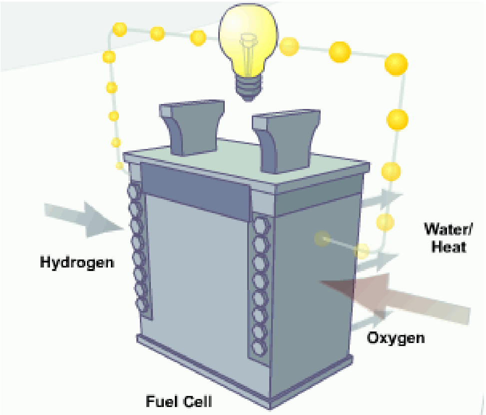
Fischer-Tropsch Liquids

- Convert coal, natural gas, and low-value refinery products to high-value, clean-burning fuel (*syngas*).
- Colorless, odorless, low toxicity.
- Interchangeable with conventional diesel fuel or blended with diesel at any ratio
- NO2 reduction, low particulates, reduced hydrocarbon and CO emissions
- 10% more cost than diesel
- Low availability

Liquified Natural Gas

- Almost 100% methane
- Half particulates of diesel
- Reduced CO, N2, and volatile HC
- Drastic reductions in toxic and carcinogenic pollutants
- Only fleet vehicle outdoors
- Expensive to equip vehicle

Fuel Cells



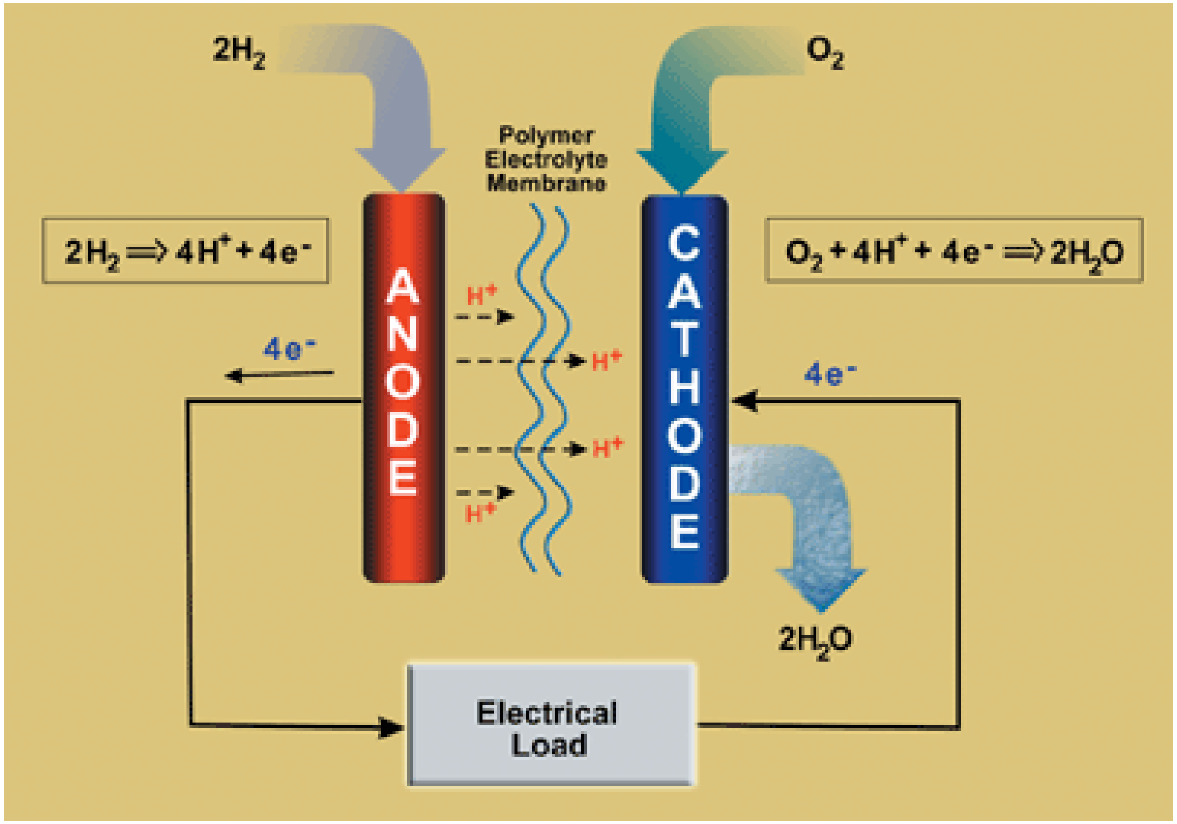
"With a new national commitment, our scientists and engineers will overcome obstacles to taking these cars from laboratory to showroom, so that the first car driven by a child born today could be powered by hydrogen, and pollution-free."

2003 State of the Union Address

Fuel Cells

In the near term, pilot hydrogen fueling facilities are being developed that are based on liquid hydrogen, natural gas (steam methane reforming), and electricity (electrolysis). As an alternative, some manufacturers are considering using fuel reformers to allow fuel cell vehicles to use conventional fuels or chemical hydrogen storage.

Fuel Cells



Fuel cells operating on pure hydrogen achieve <u>zero emissions</u>. Fuel cells can achieve 40 to 70 percent efficiency, which is substantially greater than the 30 percent efficiency of the most efficient internal combustion engines.

All fuel cells contain two electrodes - one positively and one negatively charged - with a substance that conducts electricity (electrolyte) sandwiched between them.

http://www.epa.gov/fuelcell/basicinfo.htm

Fuel Cell Types

Proton Exchange Membrane (PEM -- sometimes also called "polymer electrolyte membrane") - Considered the leading fuel cell type for passenger car application; operates at relatively low temperatures and has a high power density.

Phosphoric Acid - The most commercially developed fuel cell; generates electricity at more than 40 percent efficiency.

Molten Carbonate - Promises high fuel-to-electricity efficiencies and the ability to utilize coal-based fuels.

Solid Oxide - Can reach 60 percent power-generating efficiencies and be employed for large, high powered applications such as industrial generating stations.

Alkaline - Used extensively by the space program; can achieve 70 percent power-generating efficiencies, but is considered too costly for transportation applications.

Direct Methanol - Expected efficiencies of 40 percent with low operating temperatures; able to use hydrogen from methanol without a reformer. (A reformer is a device that produces hydrogen from another fuel like natural gas, methanol, or gasoline for use in a fuel cell.)

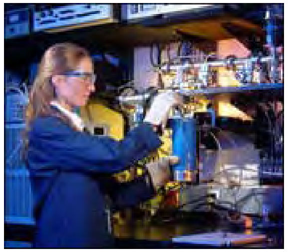
Regenerative - Currently being researched by NASA; closed loop form of power generation that uses solar energy to separate water into hydrogen and oxygen.

Fuel Cell Research

Deadline Extended for Hydrogen Production Cost Request
January 26, 2006
Through a *Federal Register* Notice (PDF 93 KB) released January 12, 2006, the Department of Energy (DOE) requested information to support an independent progress assessment by the DOE Hydrogen Program in meeting research and development cost goals for hydrogen production using distributed natural gas reforming technology. Download Adobe Reader.

To be economically competitive with the present fossil fuel economy, the cost of fuel cells must be lowered by a factor of ten or more and the cost of producing hydrogen must be lowered by a factor of four. In addition, the performance and reliability of hydrogen and fuel cell technologies must be improved dramatically.

http://www.hydrogen.energy.gov/research.html (Feb. 2006)



Fuel Cell Research

Roadmap on Manufacturing R&D
DOE maps the path to a hydrogen-powered future in its *Roadmap on Manufacturing R&D for the Hydrogen Economy* (PDF 2.04 MB). Download Adobe Reader.

Released in January 2006, the draft *Roadmap* is designed to guide research and development in hydrogen manufacturing processes. It's open for public comment for 45 days.
Based on the results of the Manufacturing R&D for the Hydrogen Economy Workshop in July 2005, the 80-page document consolidates recommendations from hydrogen power experts in the Federal government, universities, national laboratories, and industry.

Led by DOE, the workshop was supported by the National Institute of Standards and Technology and coordinated with the Manufacturing R&D Interagency Working Group of the National Science and Technology Council.

Fuel Cell Research

Fuel Cell Research and Development
This solicitation closes April 5, 2006. More information and application instructions for industry, academia, and other interested parties are available via funding opportunity number DE-PS36-06GO96017 on DOE's E-Center. Information for national laboratories is available via funding opportunity number DE-PS36-06GO96018.
Codes & Standards for the Hydrogen Economy
High Temperature, Low Relative Humidity Polymer-Type Membranes
High Temperature Solid Oxide Technologies Research

http://www.hydrogen.energy.gov/financial_opportunities.html

Japanese Putting All Their Energy Into Saving Fuel
By Anthony Faiola
Washington Post Foreign Service
Thursday, February 16, 2006; A01

Electric Vehicles

EV Battery Types

- **Lead-Acid**— Provides a low-cost, low-range (less than 100 miles) option with a 3-year life cycle.
- **Nickel-Metal Hydride** — Offers a greater driving range and life cycle, but is currently more expensive than lead-acid batteries.
- **Nickel-Cadmium** — Offers a range of 100 miles, a long life, and faster recharges than lead-acid batteries, but is more expensive and has lower peak power and recharging efficiency.
- **Lithium-Ion** — Offers the potential for a long driving range and life cycle, but is currently very costly.
- **Zinc-Air** — Currently under development. Provides superior performance compared to current battery technology.
- **Flywheels** — Currently under development. Could be capable of storing a larger amount of energy in smaller, lighter weight systems than chemical batteries.

Wind Power

Wind and Prairie Initiative

In January 2005, Governor Sebelius publicly outlined her policies and initiatives regarding the debate over wind-energy development and preservation of the Tallgrass Prairie in the Flint Hills region. The KEC's Wind and Prairie Task Force (WPTF) had submitted its report and recommendations to the Governor in June 2004. Governor Sebelius subsequently discussed the WPTF report with various stakeholders throughout the second half of 2004. She turned to the KEC to take the lead in implementing some components of the policy (see Appendix 7).

The Governor's vision for wind energy in Kansas included:

- Endorsing the KEC recommendations for wind energy. The Governor introduced her own legislation for a \$.005 per kWh transparent, tradable state Production Tax Credit. The bill would have limited new incentives for wind-energy projects to areas outside the Heart of the Flint Hills.
- Calling for 1,000 MW of installed electric generation (equal to about 10% of current capacity), to be voluntarily produced from renewable resources in 10 years.
- Requesting the KEC to evaluate the impact of having State and Regent's facilities use 2.5–5% of electricity on average statewide from renewables; asking KCC to consider full range of benefits on utilities' use of renewable energy (see p. 25).
- Requesting the KEC to analyze utility programs to allow consumers to voluntarily purchase "green" power and how to support utilities to offer it (see p. 22).

KEC Kansas Energy Council

http://www.kansasenergy.org/KEC/reports/KEC_EnergyReport2006.pdf

Wind Energy Siting Handbook:

Guideline Options

for

Kansas Cities and Counties

KANSAS ENERGY COUNCIL

April, 2005

Special Report 2005-1

http://www.kansasenergy.org/KEC/documents/wind_siting_handbook.pdf

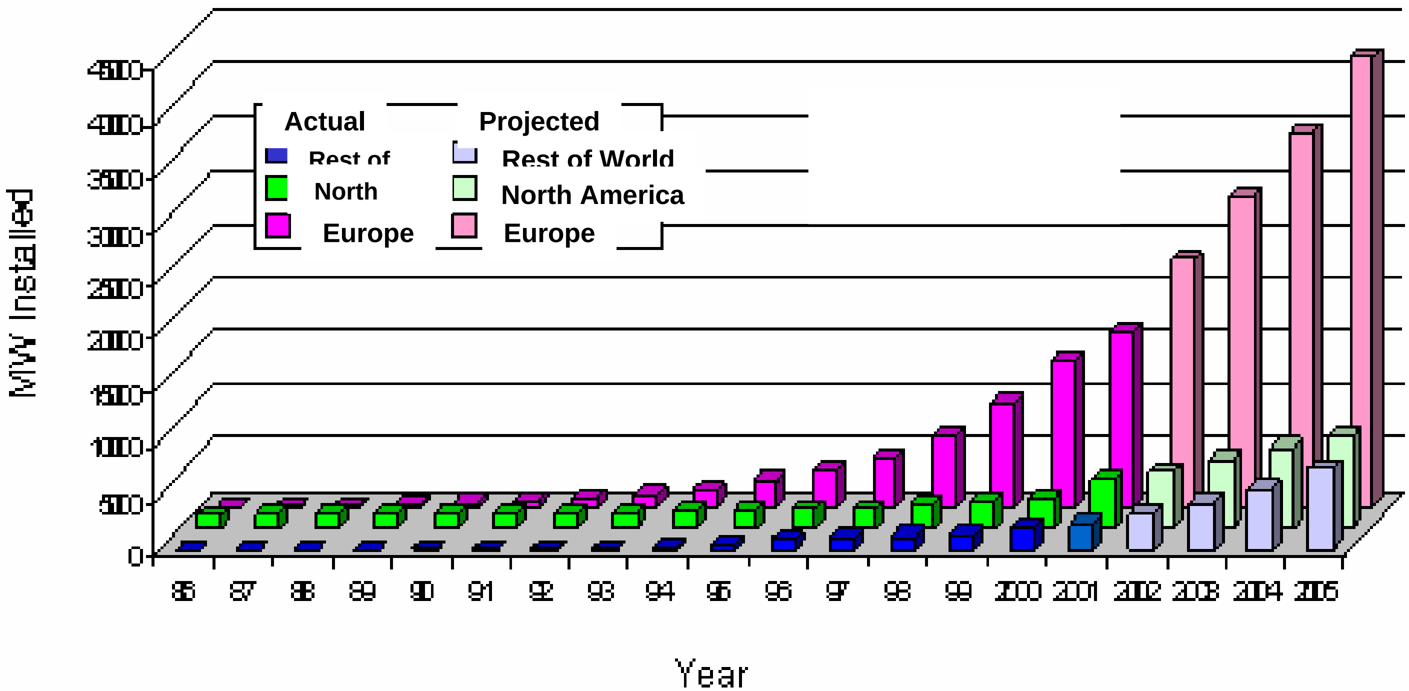
Table 1—Overview of Midwestern and Great Plains utility green pricing programs, 2005

Program Name	Utility	State	Renewable Energy Technology	Cost (¢/kWh)	Customer	Number of Subscribers
OG&E Wind Power	Oklahoma Gas & Elect.	OK	Wind	~0.74[21]		10,000
Windsource	Xcel Energy	CO	Wind	1.00[22]	All	
Windsource	Xcel Energy	MN	Wind	2.00	All	11,000
Renewable Advantage	MidAmerican Energy	IA	Wind	na.	All	3,200
Wind Power Program	Fort Collins Utility	CO	Wind	1.00		1,200
Second Nature	Alliant Energy	IA/MN/WI	Wind	2.00	Residential	11,544
PECO wind	Exelon	PA	Wind	2.54	Consumer	
Wind Power	Madison Gas & Elect.	WI	Wind	3.33	Res./Biz.	
GreenChoice	Austin Energy	TX	Wind/ Landfill gas	0.504		

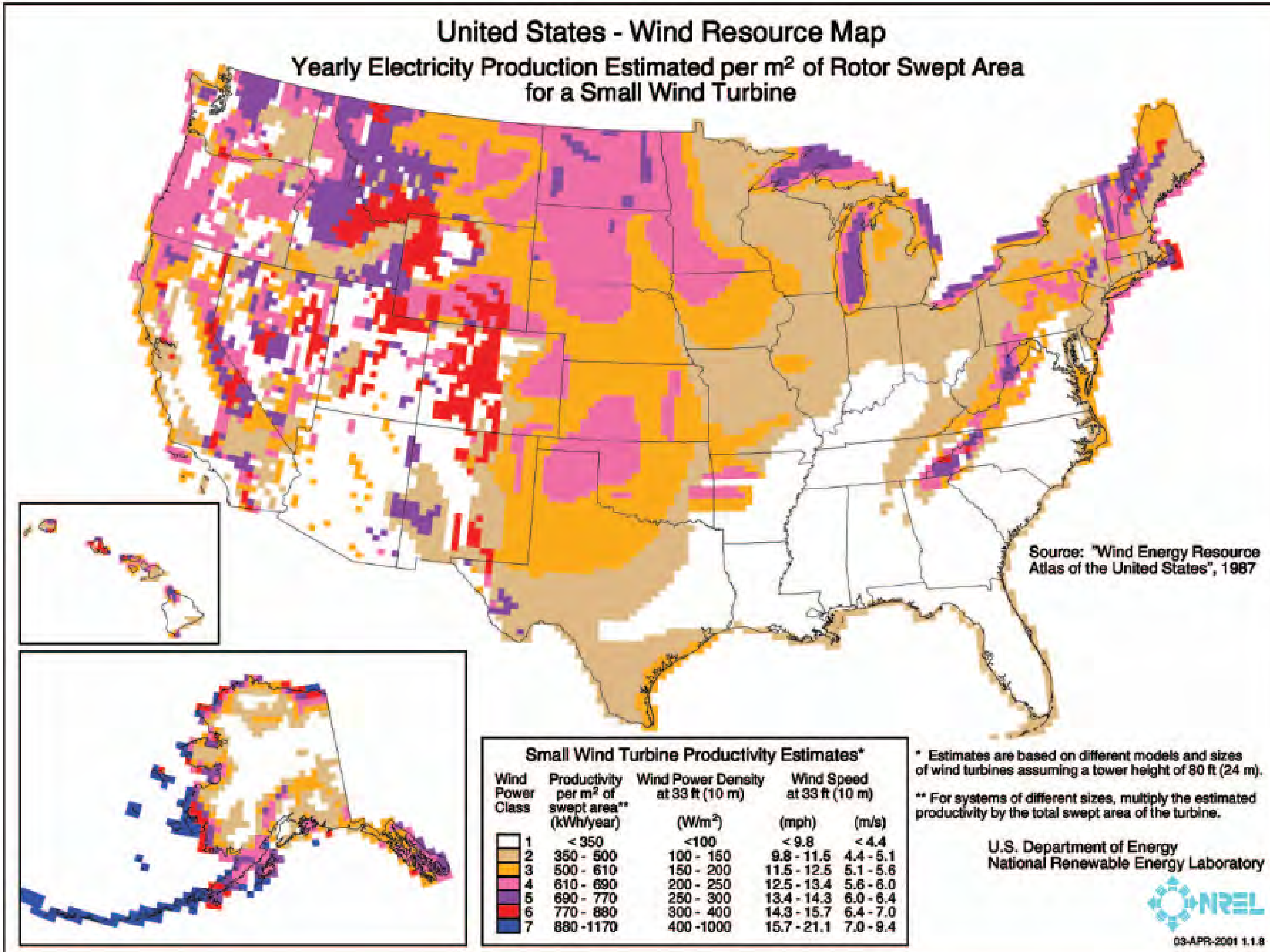
Kansas Energy Council

http://www.kansasenergy.org/KEC/reports/KEC_EnergyReport2006.pdf

Growth of Wind Energy Capacity Worldwide

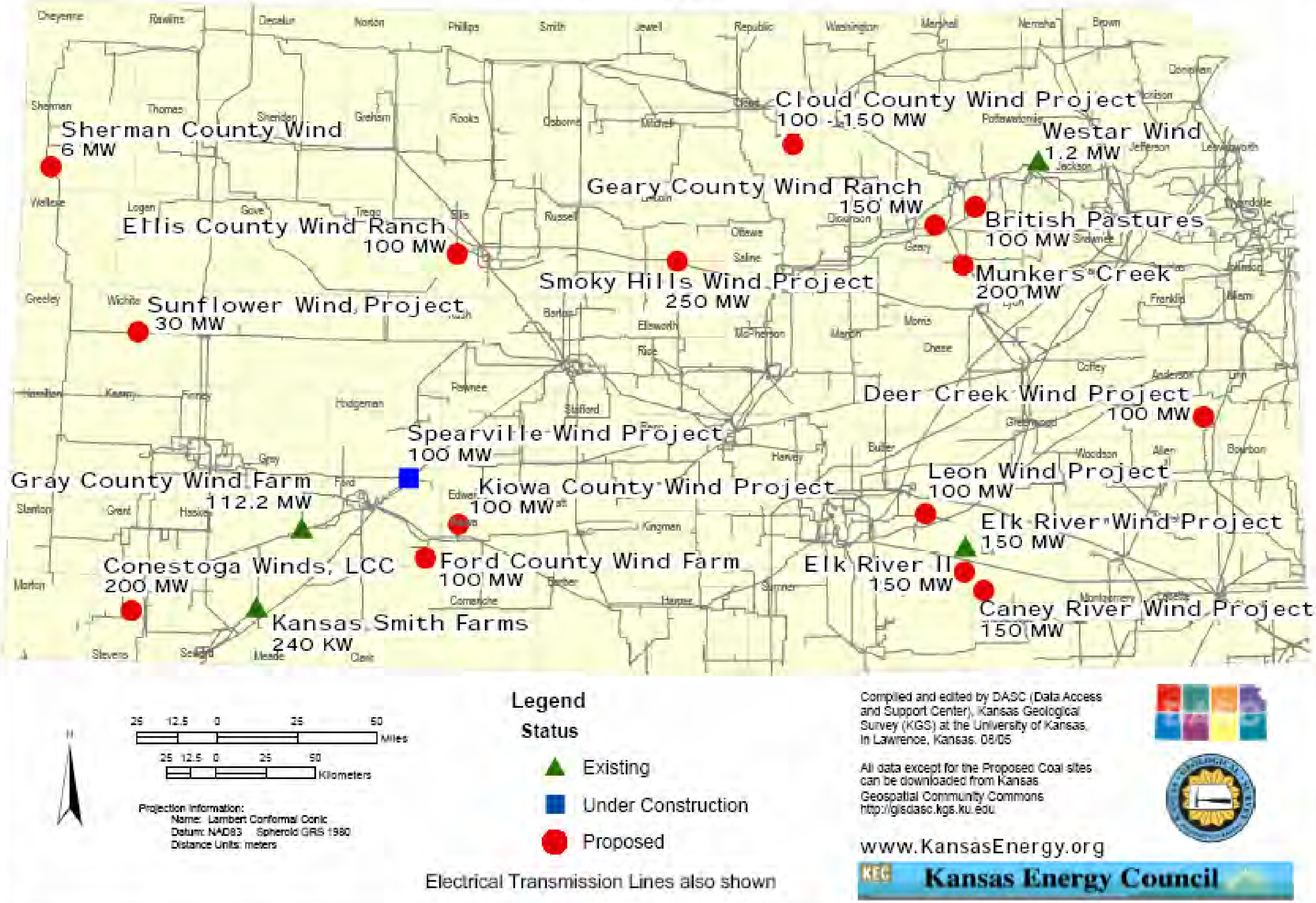


Sources: IEA Wind Energy Annual Report 2002
BTM Consult Aps, March 2001
Windpower Monthly, January 2002


United States - Wind Resource Map
Yearly Electricity Production Estimated per m² of Rotor Swept Area for a Small Wind Turbine
Source: "Wind Energy Resource Atlas of the United States", 1987
Small Wind Turbine Productivity Estimates*
Wind Power Class
Productivity per m² of swept area** (kWh/year)
Wind Power Density at 33 ft (10 m) (W/m²)
Wind Speed at 33 ft (10 m) (mph) (m/s)
1 < 350 <100 < 9.8 < 4.4
2 350 - 500 100 - 150 9.8 - 11.5 4.4 - 5.1
3 500 - 610 150 - 200 11.5 - 12.5 5.1 - 5.6
4 610 - 690 200 - 250 12.5 - 13.4 5.6 - 6.0
5 690 - 770 250 - 300 13.4 - 14.3 6.0 - 6.4
6 770 - 880 300 - 400 14.3 - 15.7 6.4 - 7.0
7 880 -1170 400 -1000 15.7 - 21.1 7.0 - 9.4
* Estimates are based on different models and sizes of wind turbines assuming a tower height of 80 ft (24 m).
** For systems of different sizes, multiply the estimated productivity by the total swept area of the turbine.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
03-APR-2001 1.1.8

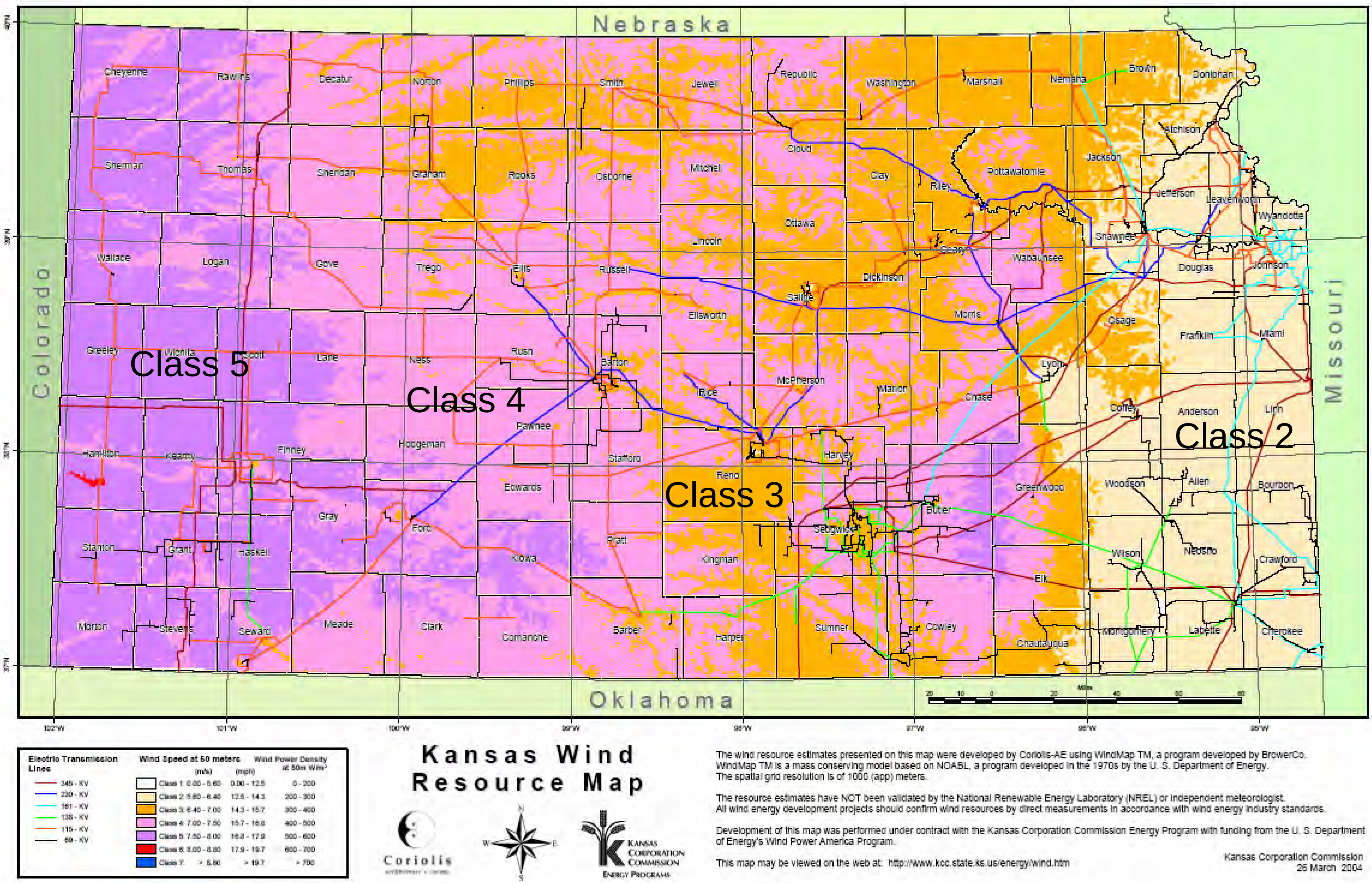
PROPOSED and EXISTING WIND PROJECTS in KANSAS

January 2006



http://www.kansasenergy.org/KEC/WindProjects.pdf

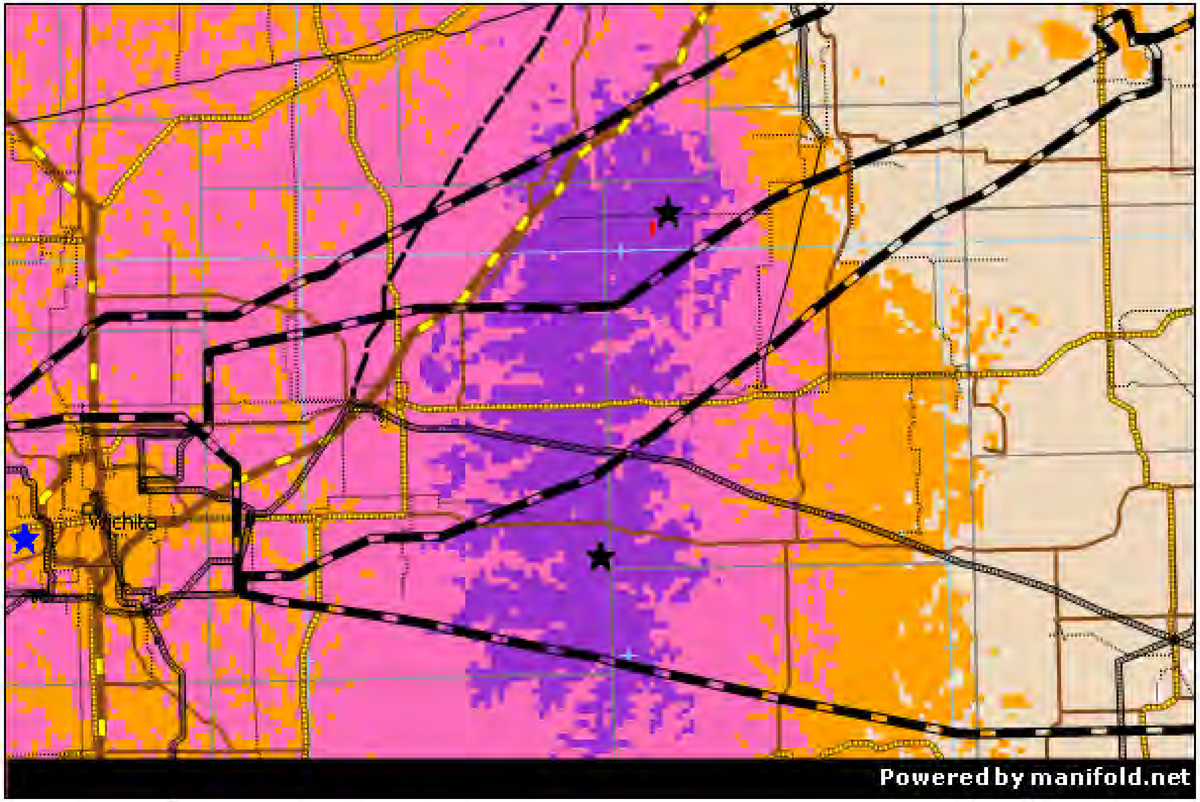
Class 5 wind power ~ less expensive that gas-fired electrical generation
Class 4 wind power ~ less expensive than new coal-fired electrical generation



http://www.coriolis-ae.com/kswindmap/default.asp

Kansas Wind Resource Map

Estimated average yearly wind speeds at 50 meters in meters/second



Center | 96°32'06"W:37°48'49"N | 1:1000000

Power classes in the legend are based on the average speed and a Weibull k value of 2.0, but not all locations will have the same power class for a given wind speed.

The wind resource estimates presented on this map were developed by Coriolis-AE using WindMap™, a program developed by BrowerCo. WindMap™ is a mass conserving model based on NOABL, a program developed in the 1970s by the U. S. Department of Energy. The spatial grid resolution is of 900 (app) meters at the statewide level, and 300 (app) meters at a lower scale.

Layers

Legend

Kansas Cities
KS Cities >25k Pop.

Kansas Highways
State Route
US Route
Interstate Route

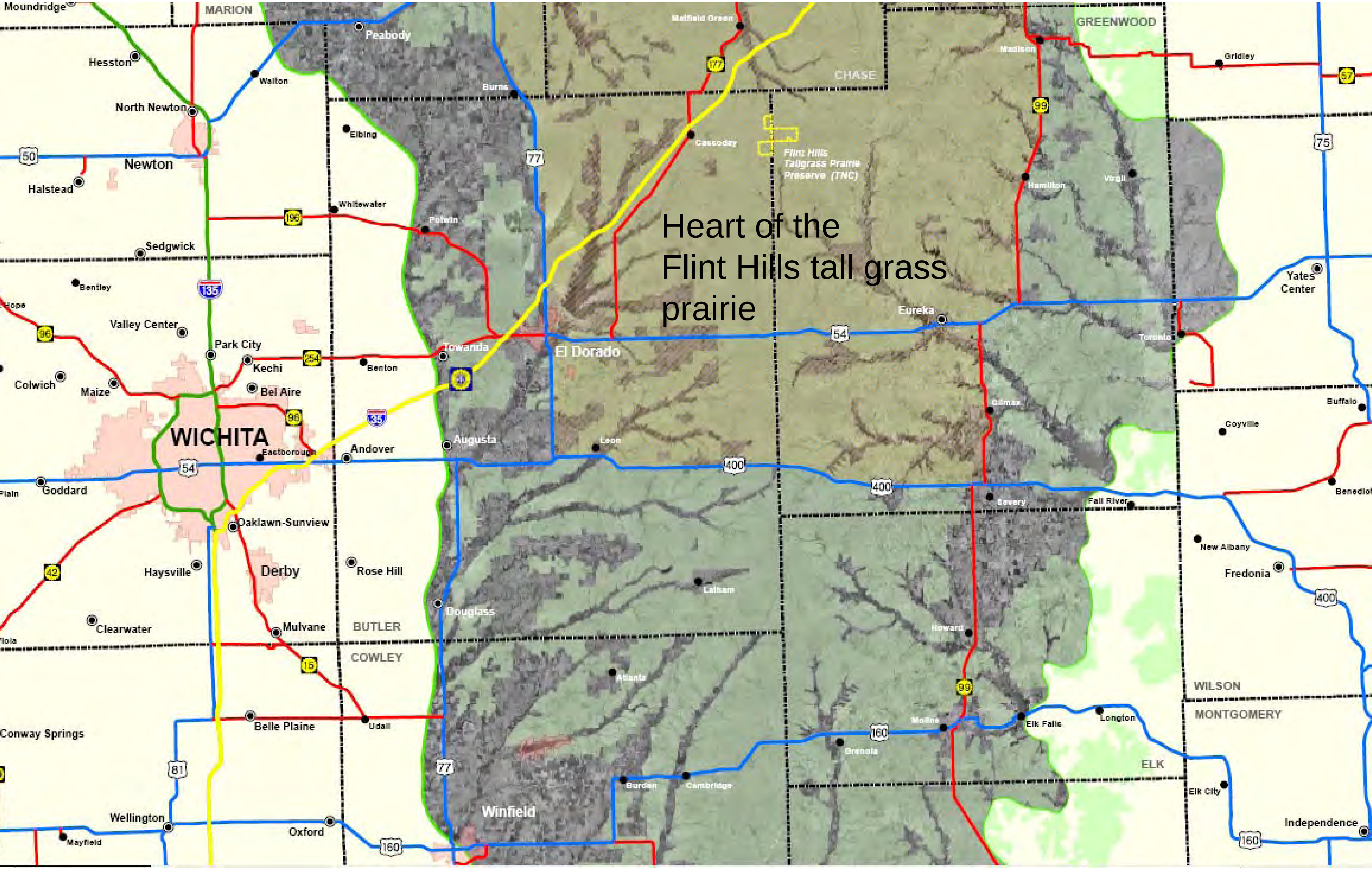
Meteorological Site
NWS primary
NWS secondary
UWIG

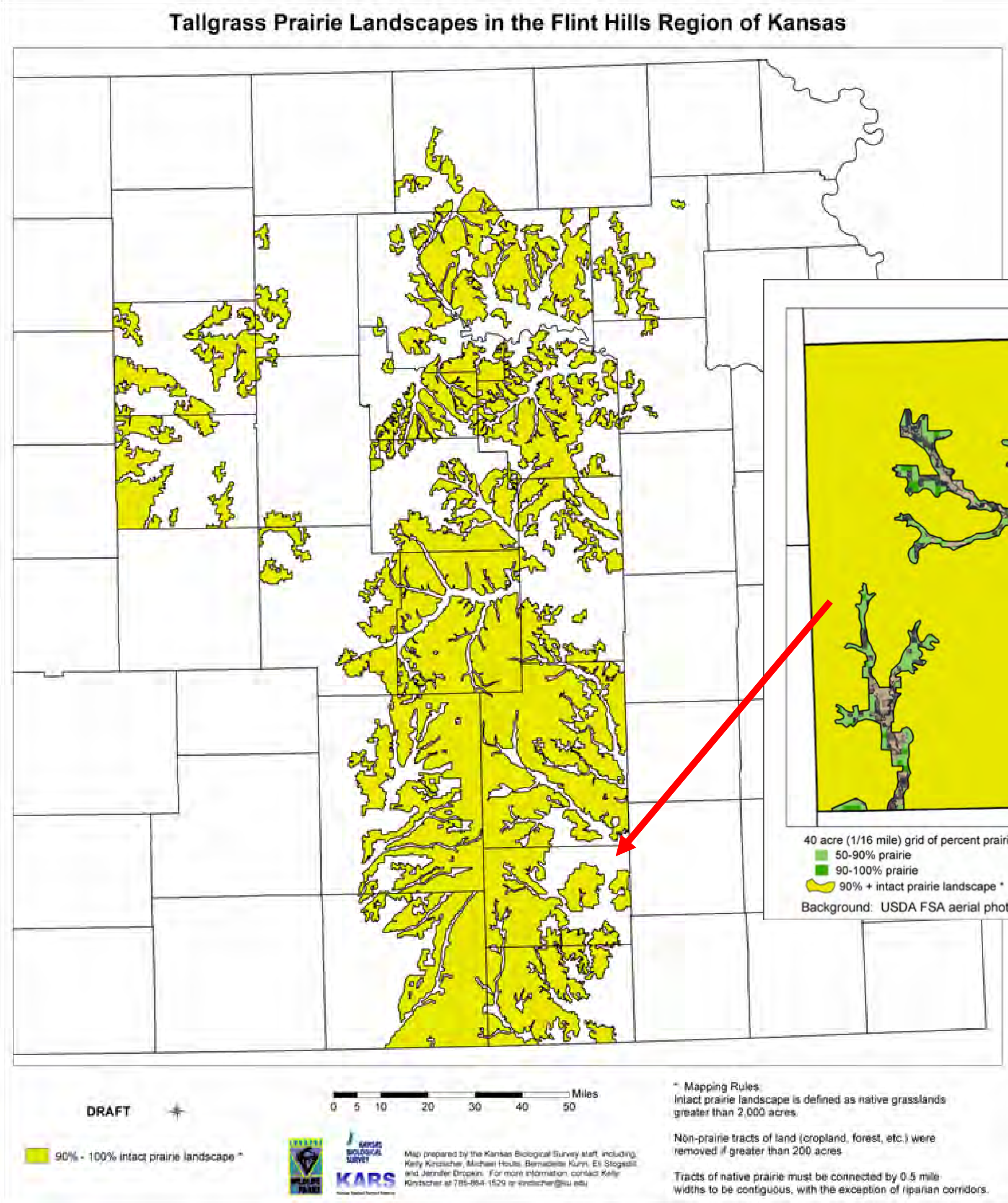
Electric Transmission Lines
Voltage in KW
34.50
69.00
115.00
138.00
161.00
230.00
345.00

Wind speed at 50M (m/s)
Class 1: 0.00 - 5.60
Class 2: 5.60 - 6.40
Class 3: 6.40 - 7.00
Class 4: 7.00 - 7.50
Class 5: 7.50 - 8.00
Class 6: 8.00 - 8.80
Class 7: > 8.80

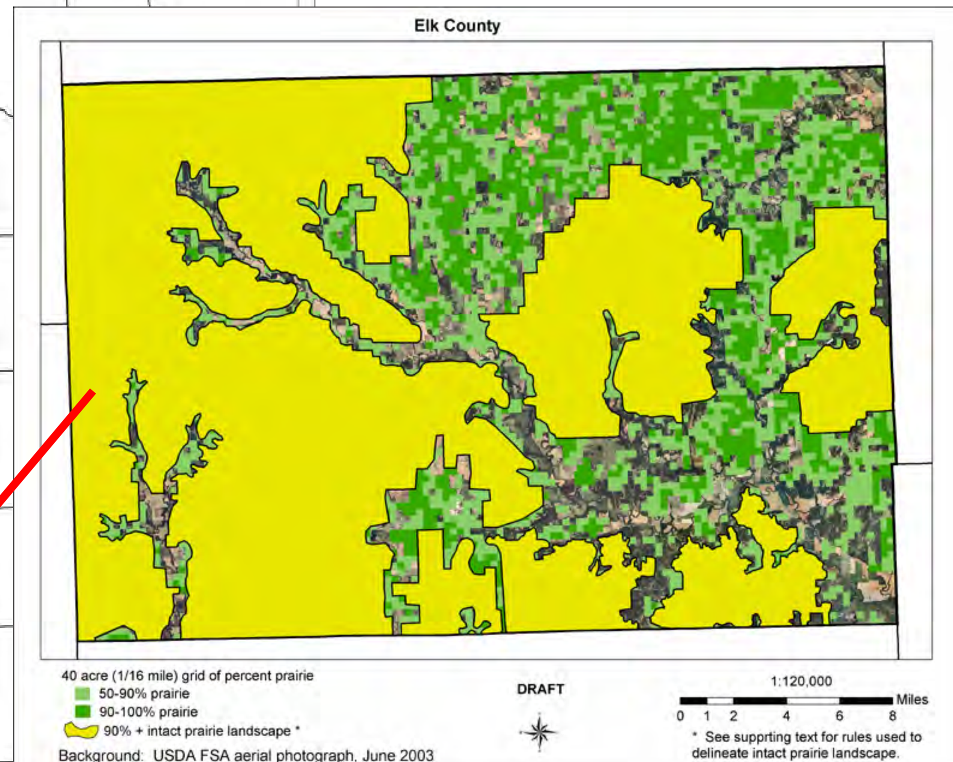
Views
Bear Creek Ridge
Gun Barrel Hill
Southern Flint Hills
Statewide

Choices to be made about land use for alternative energy



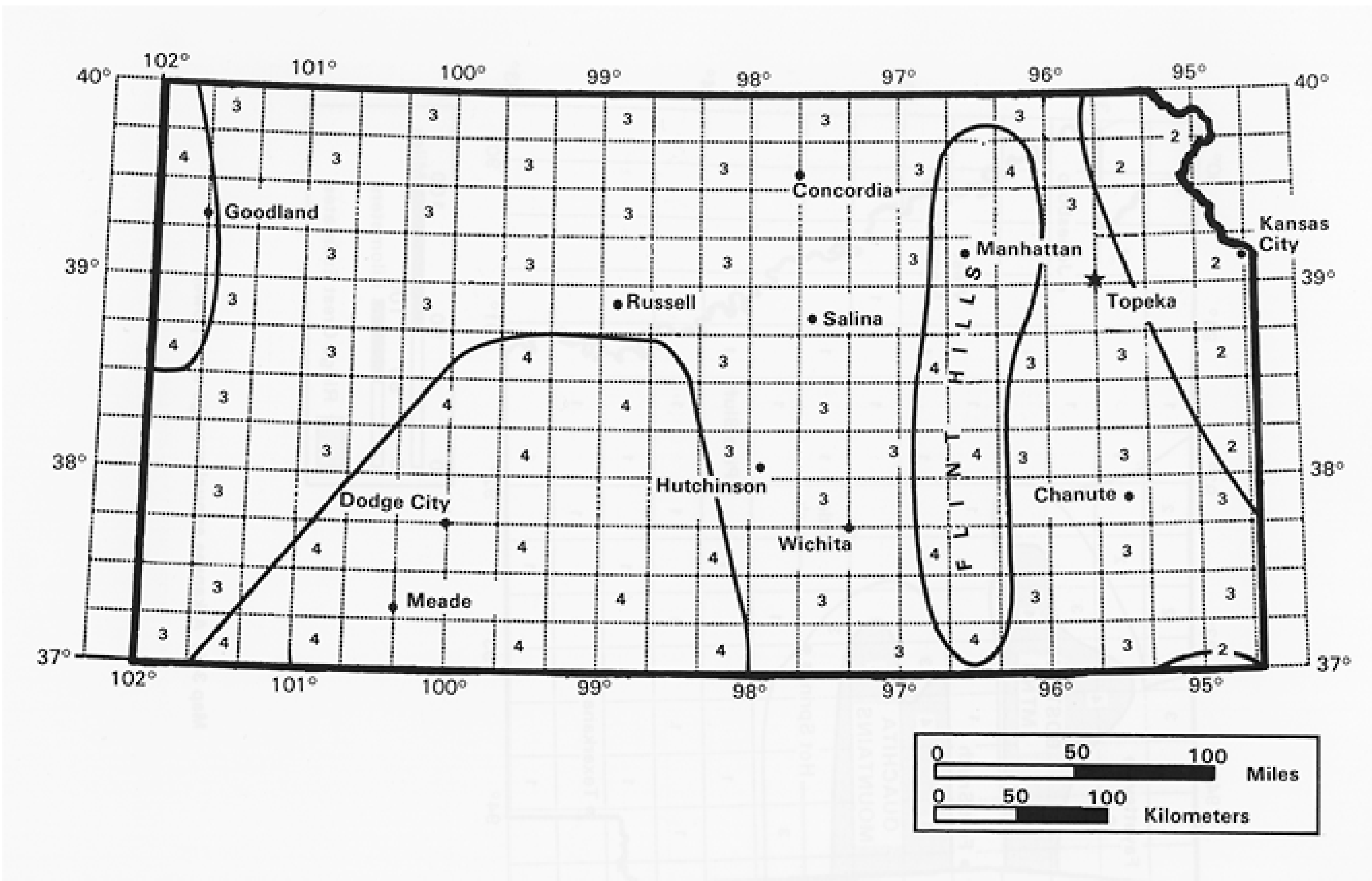


Elk County, Kansas



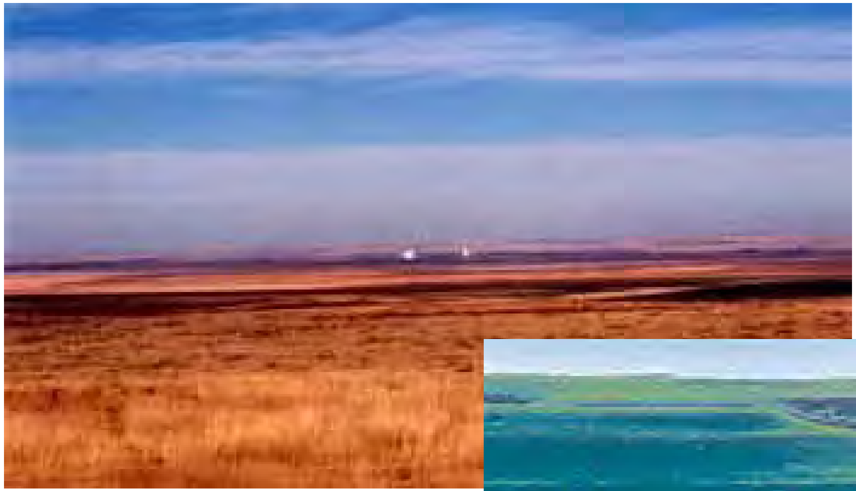
http://www.kansasenergy.org/KEC/FHmaps/FHPrairie_small.pdf

1990's map from Pacific Northwest Lab. report for NREL

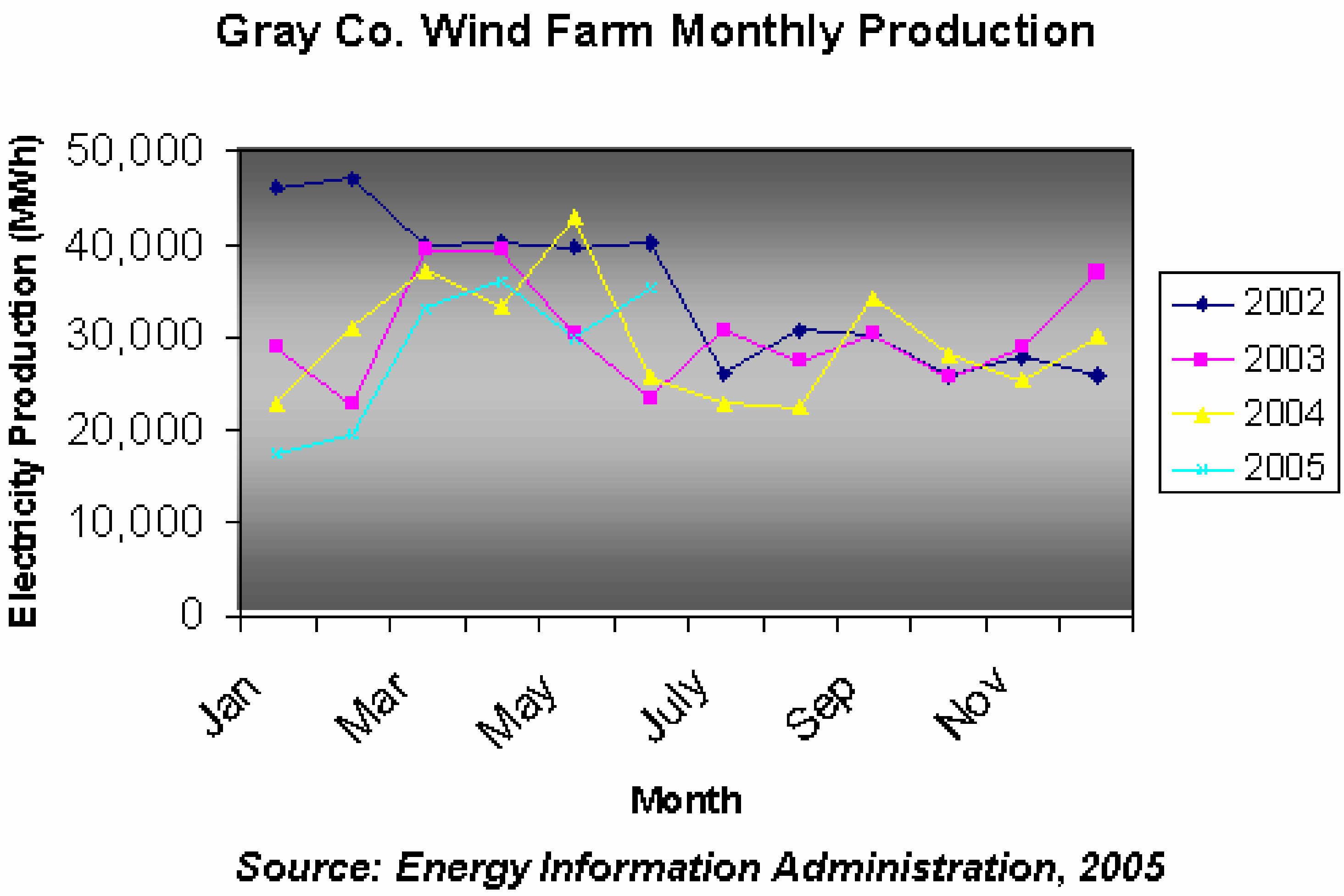


http://www.kansasenergy.org/wind_resources.htm

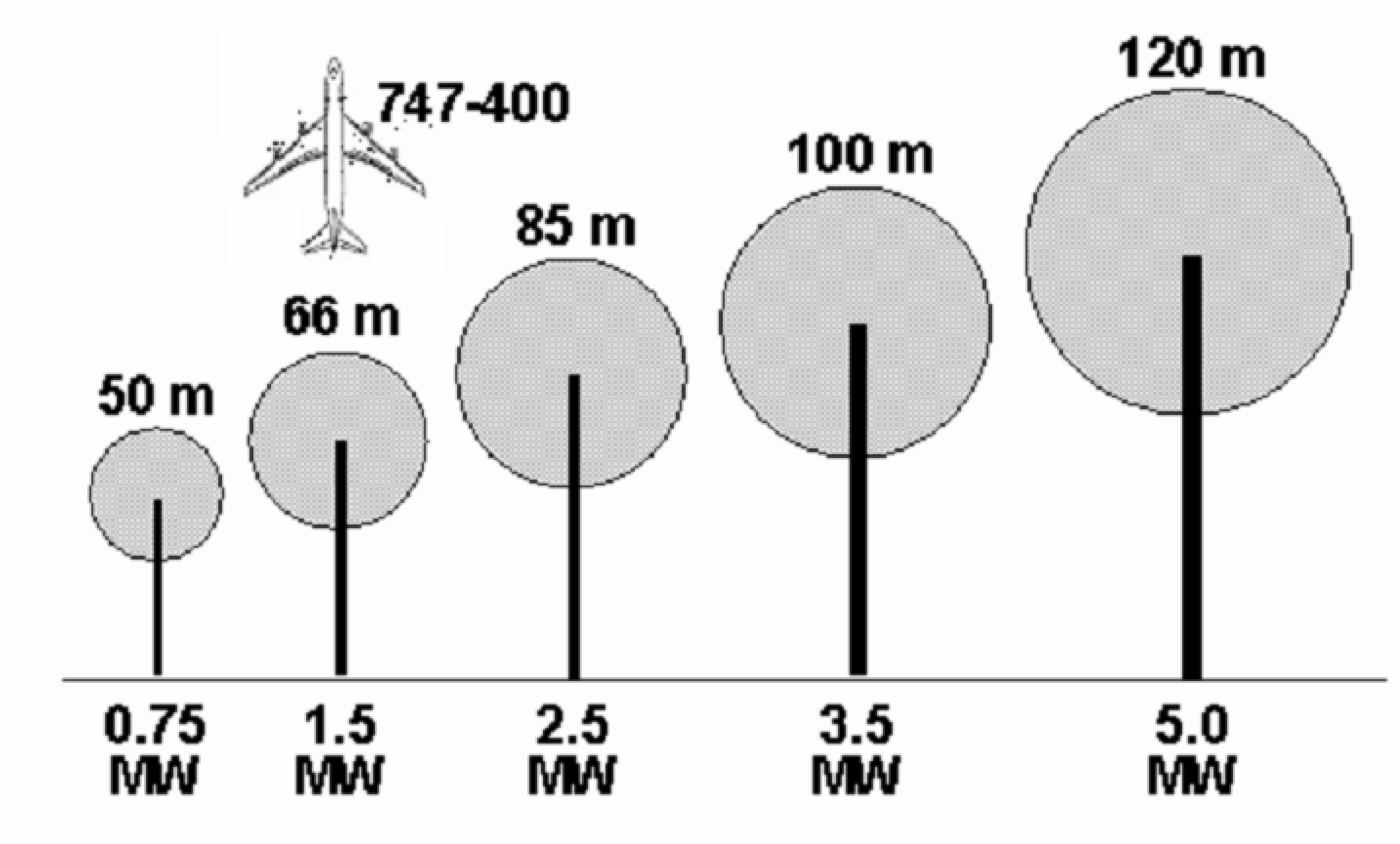
Wind energy information resources abound

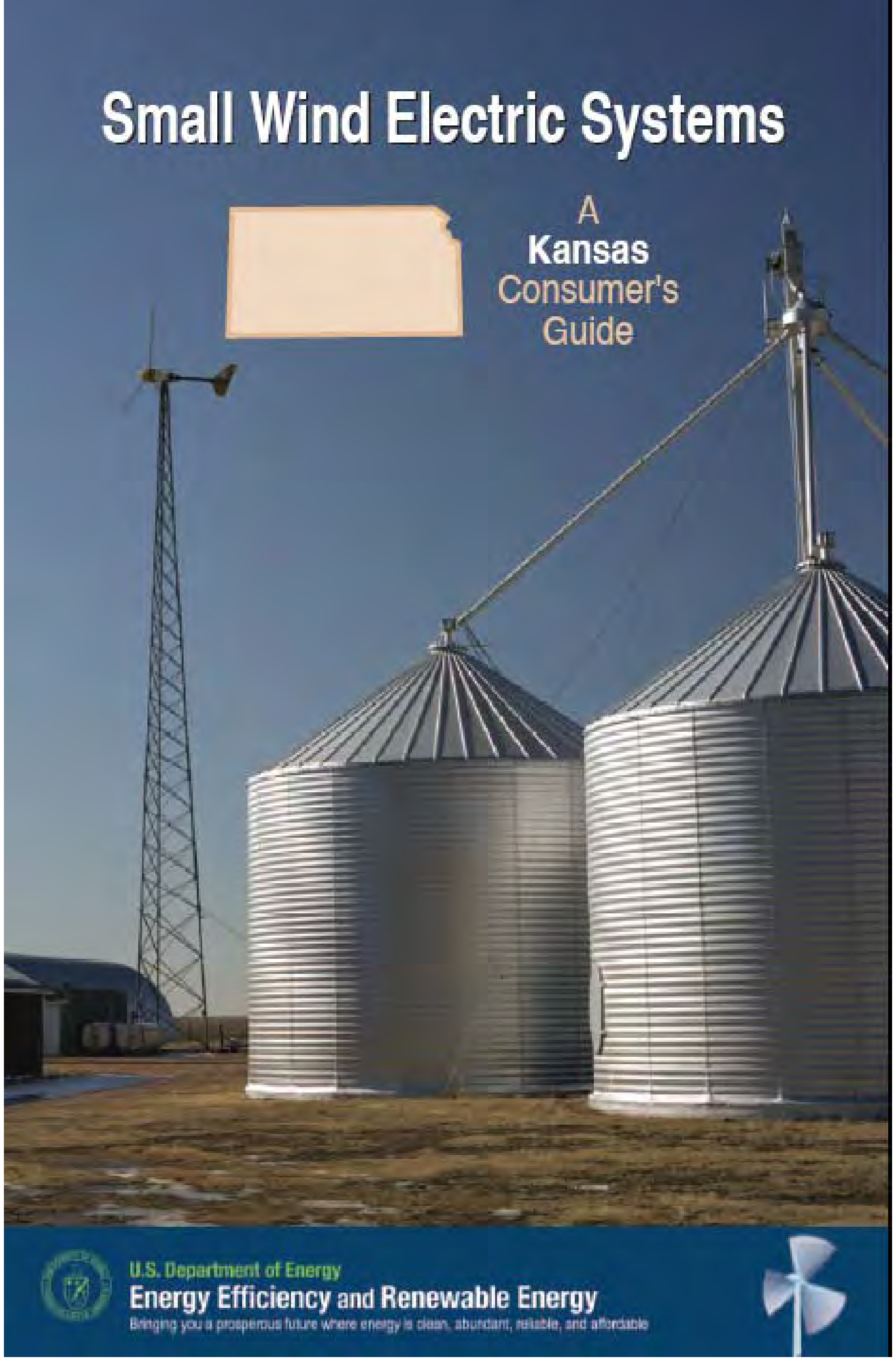


Kansas presently ranks third in the United States in total wind energy potential behind North Dakota and Texas. In fact, the top three states have enough wind energy potential to supply the total electrical needs of all lower 48 states.


Gray Co. Wind Farm Monthly Production
Electricity Production (MWh)
50,000
40,000
30,000
20,000
10,000
0
Jan
Mar
May
July
Sep
Nov
Month
2002
2003
2004
2005
Source: Energy Information Administration, 2005

Wind Turbine Rotor Diameter and Rated Capacity



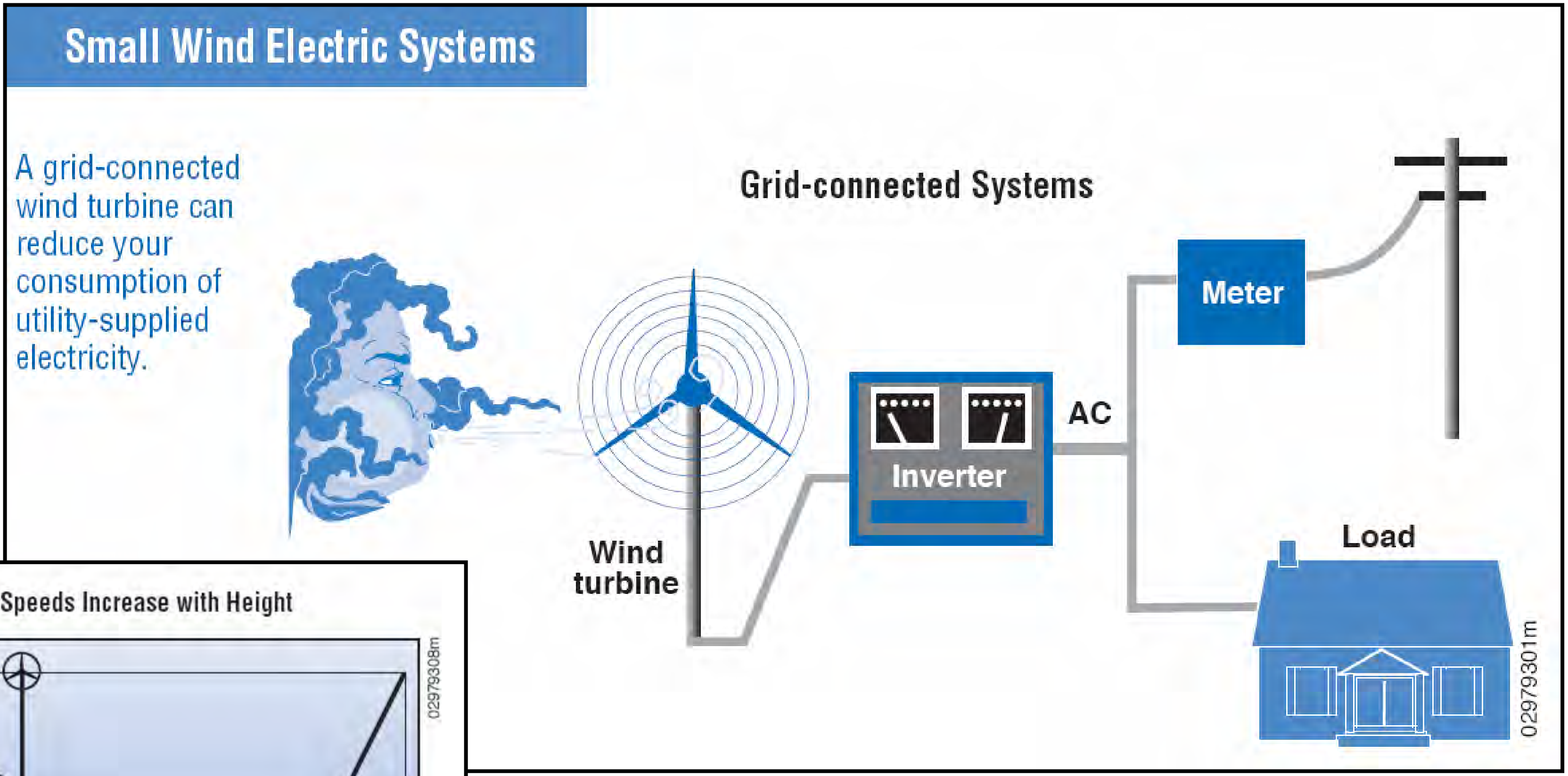


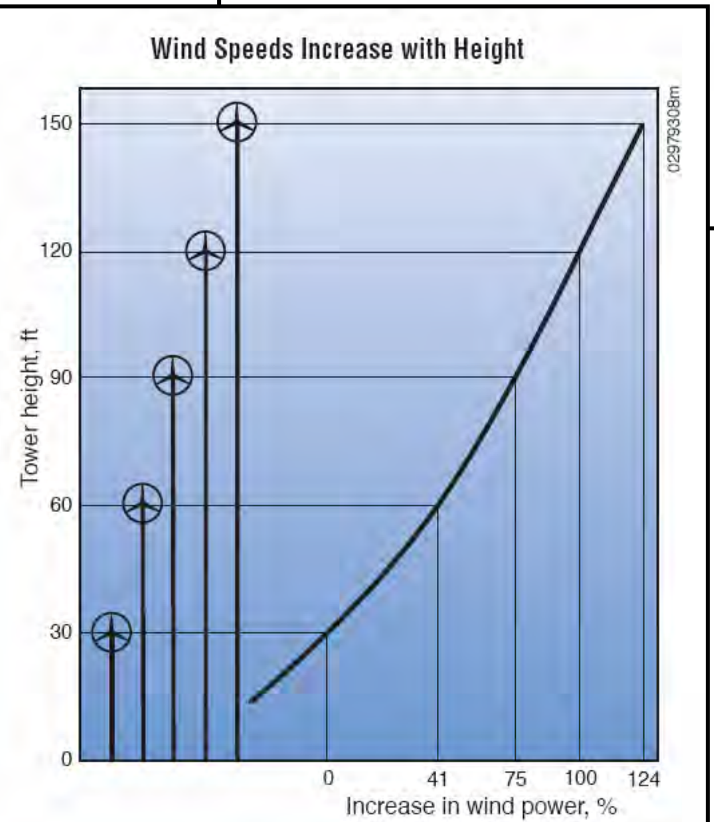
What Do Wind Systems Cost?

A small turbine can cost anywhere from $3,000 to $35,000 installed, depending on size, application, and service agreements with the manufacturer. (The American Wind Energy Association [AWEA] says a typical home wind system costs approximately $32,000 (10 kW); a comparable photovoltaic [PV] solar system would cost over $80,000.)

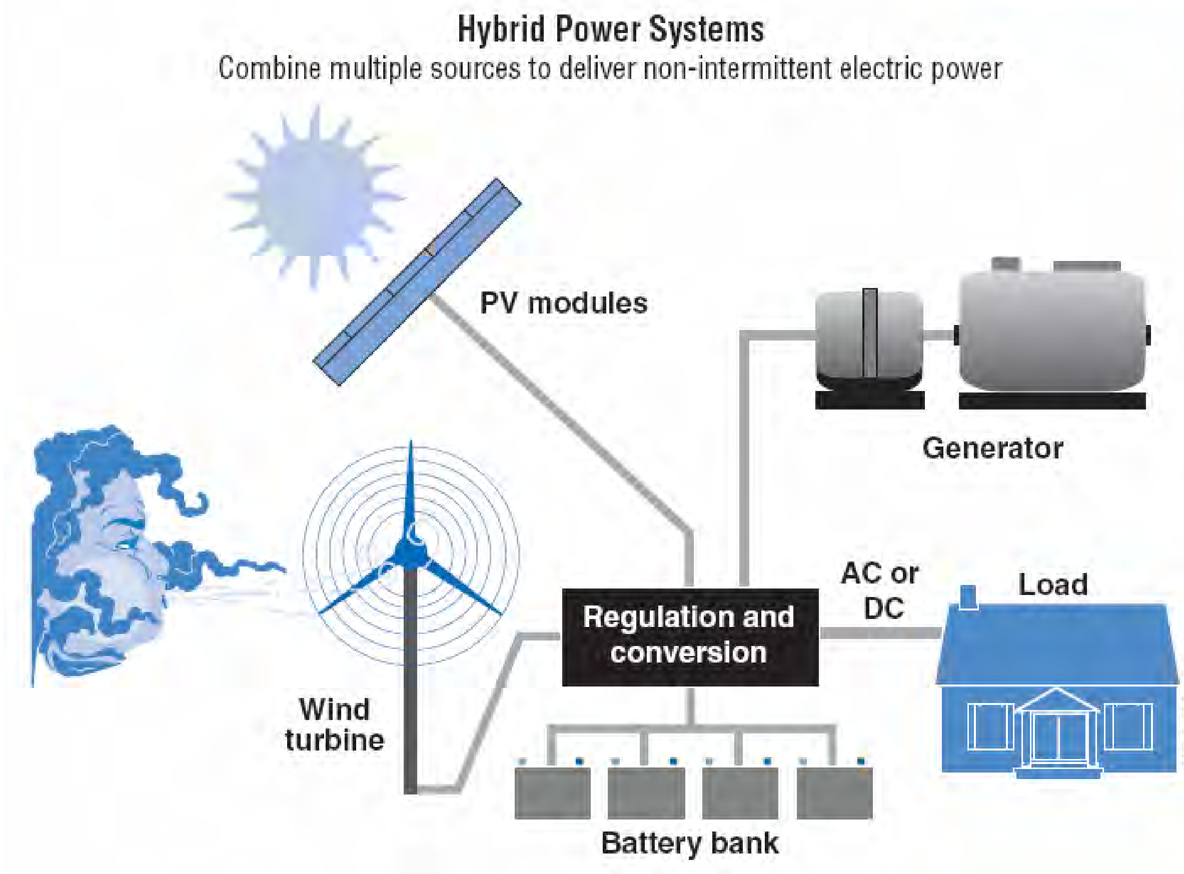
A general rule of thumb for estimating the cost of a residential turbine is $1,000 to $3,000 per kilowatt. Wind energy becomes more cost effective as the size of the turbine's rotor increases. Although small turbines cost less in initial outlay, they are

http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/small_wind/small_wind_ks.pdf





http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/small_wind/small_wind_ks.pdf



A hybrid system

Grid-connected systems can be practical if the following conditions exist:

- You live in an area with average annual wind speed of at least 10 mph (4.5 m/s).
- Utility-supplied electricity is expensive in your area (about 10 to 15 cents per kilowatt-hour).
- The utility's requirements for connecting your system to its grid are not prohibitively expensive.
- There are good incentives for the sale of excess electricity or for the purchase of wind turbines.

Federal regulations (specifically, the Public Utility Regulatory Policies Act of 1978, or PURPA) require utilities to connect with and purchase power from small wind energy systems.

http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/small_wind/small_wind_ks.pdf

http://www.sciencemag.org/cgi/reprint/309/5734/548.pdf
Science v. 309, 22 July 2005, p. 548-549.

Fields of gold. Solar power is the most promising renewable energy source.

- Humans now consume 13 terawatts (TW) of power
- 85% from fossil fuels
- By 2050, human may consume 30 TW
- 10 TW of energy ~ 10,000 nuclear plants (Japan, Europe, China, Russia, South Korea and U.S. building experimental fusion reactor in France)
- Wind at all windy locations ~ 72 TW (Stanford research with 80 meter towers using global wind potential)
- Peak oil production ~ now reached
- Natural gas supply ~ 200 years
- Coal supply ~ 2000 years

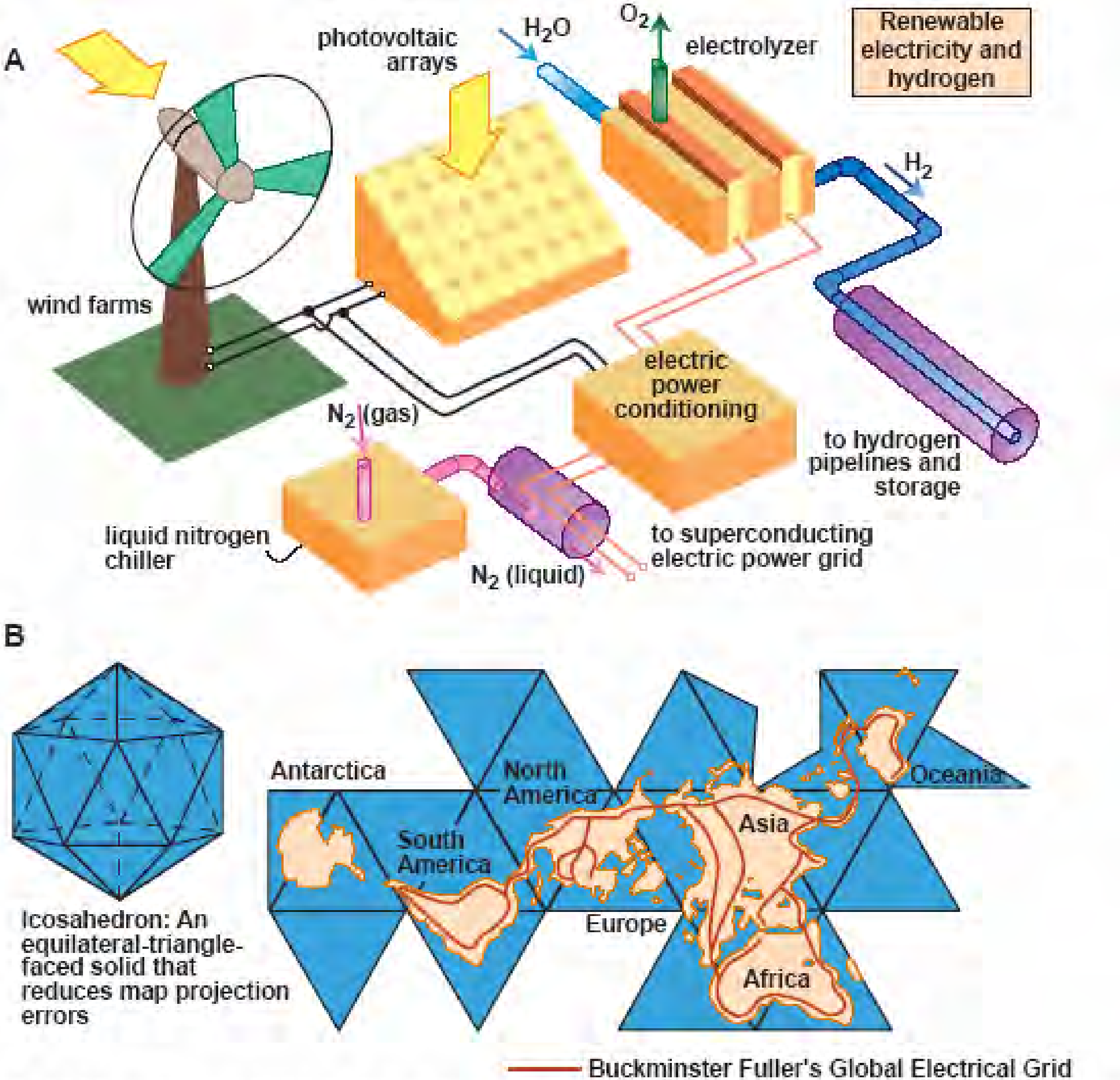
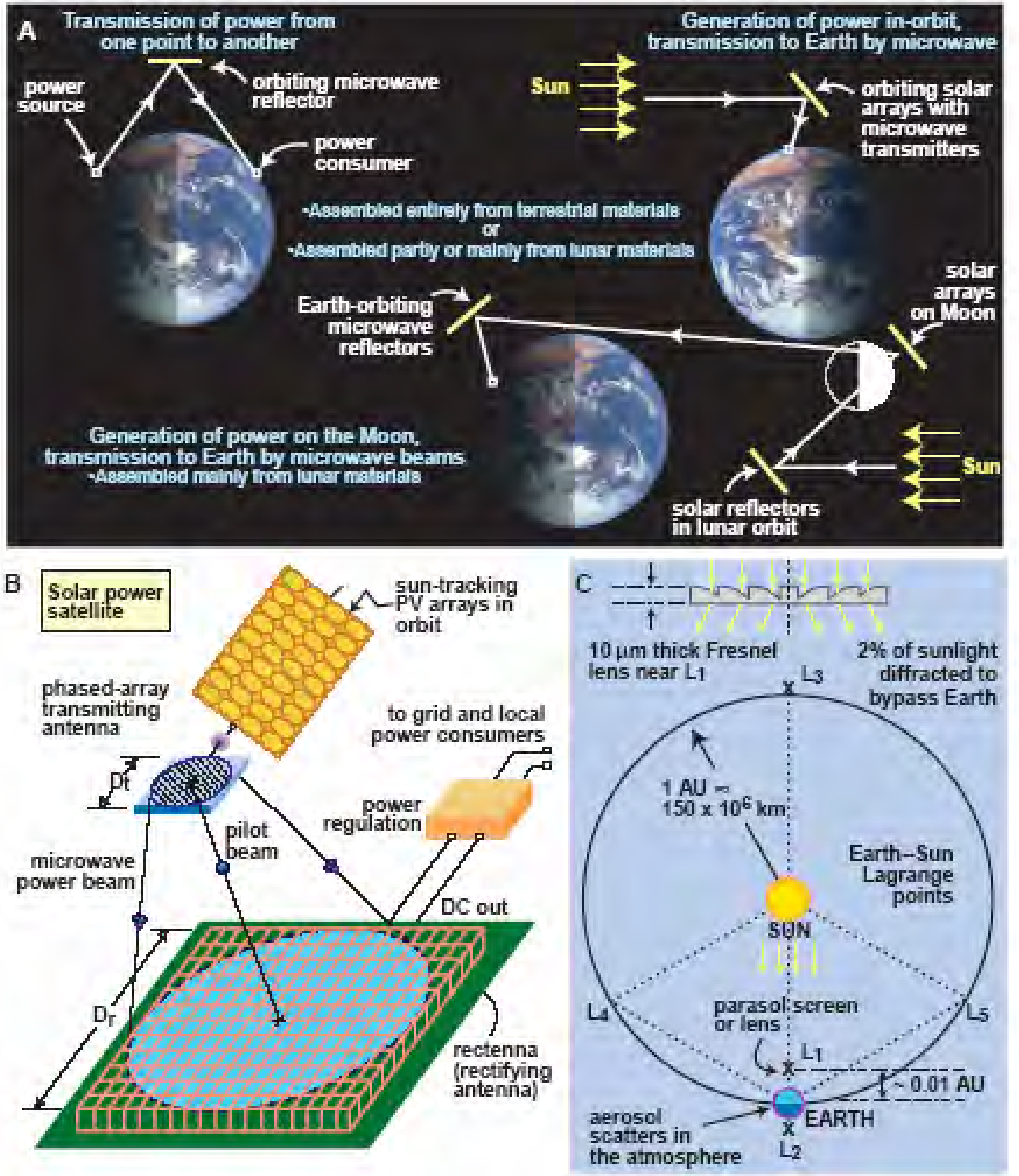


Fig. 2. (**A**) Mass-produced widely distributed PV arrays and wind turbines making electrolytic H_2 or electricity may eventually generate 10 to 30 TW emission-free. (**B**) The global grid proposed by R. Buckminster Fuller with modern computerized load management and high-temperature superconducting (HTS) cables could transmit electricity from day to night locations and foster low-loss distribution from remote, episodic, or dangerous power sources. (The resistivity of HTS wires vanishes below the 77 K boiling point of nitrogen available from air.)

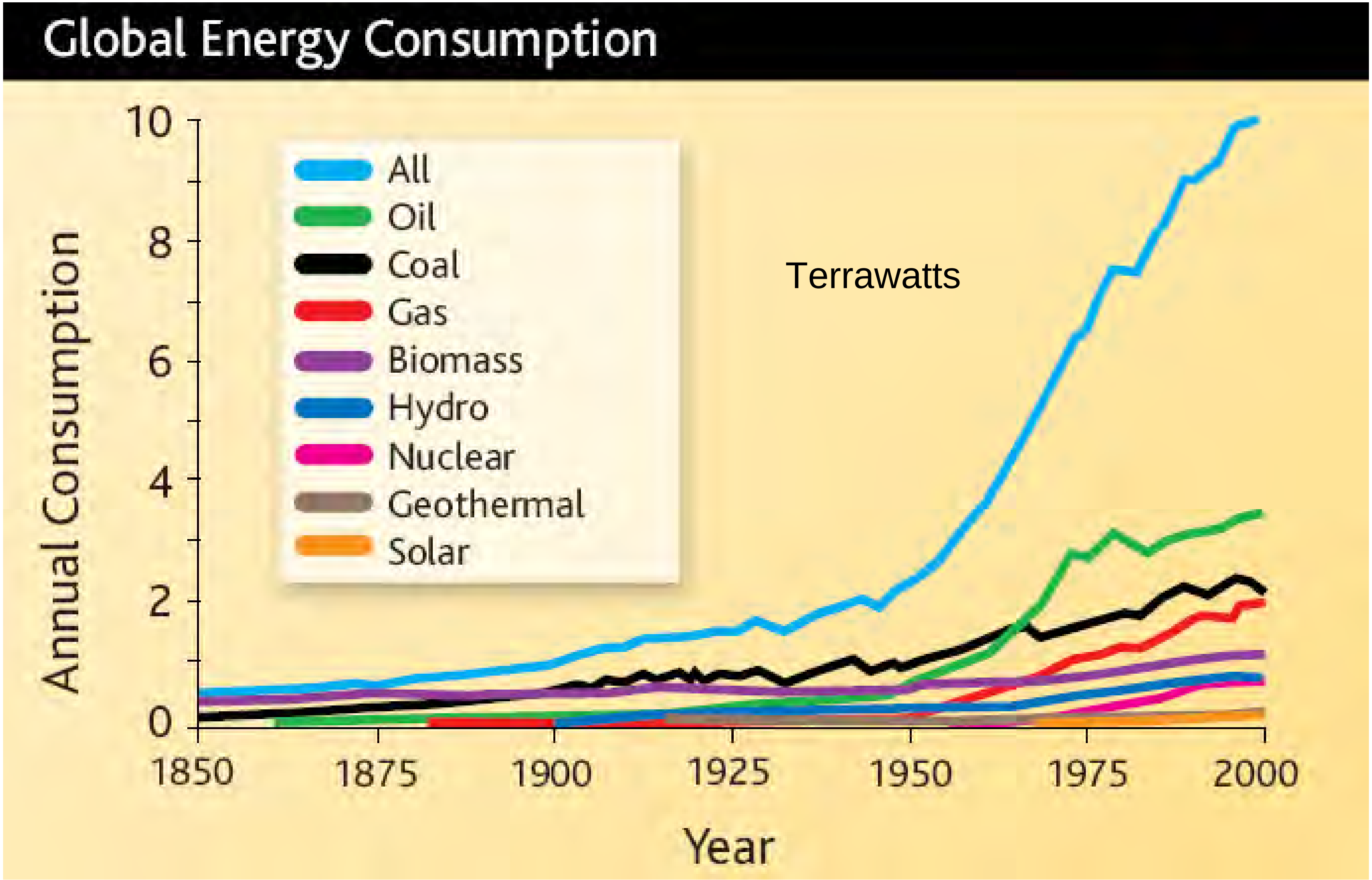
Mass Produced Widely-Distributed PV Arrays and Wind Turbines Making H2 or Electricity

http://www.sciencemag.org/cgi/reprint/298/5595/981.pdf

Capturing Solar Power in Space



http://www.sciencemag.org/cgi/reprint/298/5595/981.pdf



http://www.sciencemag.org/cgi/reprint/309/5734/548.pdf

Science v. 309, 22 July 2005, p. 548-549.

Future for Solar depends on price and mass production

Solar: photovoltaic panels: currently produce 3 gigawatts of electricity, 40% growth, $7.5 billion industry

20 TW from solar use 0.16% of land surface

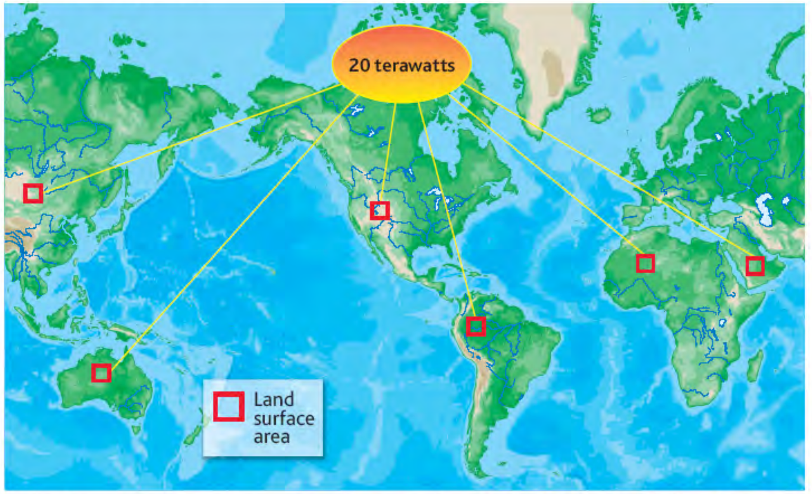
Solar panels on every one of 70 homes in U.S. = 0.25 TW (only 1/10 of electricity consumed in U.S.)

Solar Farms and massive storage systems or production facilities for derived energy fules such as generation of hydrogen fuel from water.

Cost is biggest hurdle. Solar energy needs to be 50x less expensive than current. Research needed to develop *basic enabling breakthrough technologies*.

- **Nanotechnology**: more efficient, cheaper solar cells
- **Plastic cells**: cheap polymers
- **Solar concentrators** to focus light, strip hydrogen gas from fossil fuels and sequester CO2, split water to hydrogen

NEWS FOCUS



Global need. This map shows the amount of land needed to generate 20 TW with 10% efficient solar cells.

Cost to generate electricity:

- Solar: $0.25 to $0.50 per kwh
- Wind: $0.05 to $0.07/kwh
- Natural gas: $0.025 to $0.05/kwh
- Coal: $0.01 to $0.04/kwh

Sun: 57,000 TW every moment (on hour basis, more energy than humans use in year)

http://www.sciencemag.org/cgi/reprint/309/5734/548.pdf

Science v. 309, 22 July 2005, p. 548-549.

Department of Energy Requests $23.6 Billion for FY 2007

Increased Funding to Advance National Security, Reduce Dependence on Oil, and Boost Economic Competitiveness

Advanced Energy Initiative

The Advanced Energy Initiative aims to reduce America's dependence on imported energy sources. The FY 2007 DOE budget requests **$2.1 billion** to meet these goals, an increase of $381 million over FY 2006. Funding will help develop clean, affordable sources of energy that will help reduce the use of fossil fuels and lead to changes in the way we power our homes, businesses and cars.

The FY 2007 budget request emphasizes investment in alternative fuel technologies. Numerous DOE offices will benefit from the Advanced Energy Initiative. The Office of Science (**$539 million**) budget incorporates funding for nuclear fusion, including the ITER project, an experimental reactor that puts the U.S. on the pathway to furthering the potential of nuclear fusion as source of environmentally safe energy; solar, biomass and hydrogen research programs.

The Office of Energy Efficiency and Renewable Energy (**$771 million**) budget includes considerable funding increases for hydrogen technology, fuel cell technology, vehicle technology, biomass, solar, and wind research programs. The Office of Fossil Energy (**$444 million**) supports the Coal Research Initiative and other power generation/stationary fuel cell research programs. The Office of Nuclear Energy, Science and Technology (**$392 million**) includes $250 million for the Global Nuclear Energy Partnership (GNEP); and also supports Generation IV, Nuclear Power 2010, and the Nuclear Hydrogen Initiative.

Office of Energy Efficiency and Renewable Energy ($1.2 billion)

Office of Energy Efficiency and Renewable Energy budget requests $1.2 billion, $2.6 million (0.2%) more than the FY 2006 appropriations. Much of this funding is an integral part of the Advanced Energy Initiative and expands key programs that focus on developing new energy choices, including:

- Hydrogen Fuel Technology ($114 million);
- Fuel Cell Technology ($82 million);
- Biomass ($150 million), including research into cellulosic ethanol, made from switch grass, wood chips and stalks;
- Solar America Initiative ($148 million);
- Vehicle technology ($166 million);
- Wind projects ($44 million).

Definitions of terms used in this brochure

BTU British Thermal Unit—A common method of indicating the amount of heat energy removed by an air conditioner.

CF Cubic feet.

kWh KiloWatt hour—A unit of electrical energy equivalent to using one kiloWatt of electricity for one hour. A kilo Watt is a unit of power equal to 1000 Watts.

W Watt—A measurement of power and the rate of energy expended. One horsepower equals about 746 Watts.

Want to know how much electricity a specific appliance uses?

Use this formula:

Appliance wattage* x avg hours used per month ÷ 1000 = monthly kWh

*wattage can be found on most appliances

Printed using soy-based inks on paper that contains 100% recycled post-consumer waste and is 100% process chlorine-free.

Efficiency Vermont
your resource for energy saving

Toll-free 1-888-921-5990
255 South Champlain St. • Suite 7 • Burlington, VT 05401-4894
www.efficiencyvermont.com

ECS1a-1005

Your Guide to Electrical Use in Your Home

Efficiency Vermont
your resource for energy savings

…cutting-edge communication and information technology to give customers real-time information about energy use. In advanced phases they could be used to remotely control air-conditioning settings or activate "smart" appliances.

http://www.efficiencyvermont.org/Docs/Appliance%20Uasage%20Broc05.pdf

ELECTRICAL USAGE CHART

for a typical four-person household

★ = ENERGY STAR *availability*

	MONTHLY AVERAGE			ANNUAL AVERAGE	
APPLIANCE	HOURS IN USE	kWh USED	MONTHS USED	ANNUAL kWh	ANNUAL COST
Air Conditioner–central	125	375	3	1125	$146
Air Conditioner 8,000 BTU–room/window ★	100	90	3	270	$ 35
Air Purifier	730	37	6	219	$ 28
Aquarium with heater, light, filter	360	34	12	410	$ 53
Clothes Dryer–electric (6 loads per week at 45 minutes)	20	75	12	900	$117
Clothes Dryer–gas (6 loads per week at 45 minutes)[1]	23	9	12	110	$ 14
Clothes Washer (7 loads per week)[2] ★	30	9	12	108	$ 14
Coffeemaker (1.5 pots per day)	30	5	12	54	$ 7
Computer with monitor ★	60	8	12	90	$ 12
Dehumidifier (moderately damp basement) ★	250	200	6	1200	$156
Dishwasher–air dry (4 loads per week) ★	16	8	12	96	$ 12
Dishwasher–heat dry (4 loads per week) ★	16	13	12	154	$ 20
Electric Blanket (queen size)	240	8	6	50	$ 7
Fan–box or floor stand	71	11	3	32	$ 4
Fan–ceiling (without lights) ★	150	12	6	72	$ 9
Freezer Chest, 18 CF, manual defrost, 20 years old	730	75	12	897	$117
Freezer Chest, 18 CF, manual defrost, 10 years old	730	51	12	610	$ 79
Freezer Chest, 17 CF, manual defrost, new ★	730	36	12	426	$ 55
Freezer Upright, 17 CF, auto defrost, 20 years old	730	112	12	1342	$174
Freezer Upright, 17 CF, auto defrost, 10 years old	730	90	12	1082	$141
Freezer Upright, 17 CF, auto defrost, new ★	730	57	12	685	$ 89
Freezer Upright, 17 CF, manual defrost, 20 years old	730	76	12	917	$119
Freezer Upright, 17 CF, manual defrost, 10 years old	730	51	12	608	$ 79
Freezer Upright, 17 CF, manual defrost, new ★	730	40	12	479	$ 62
Furnace Fan	178	152	6	914	$119
Hair Dryer (10 minutes per day)	5	6	12	75	$ 10
Heat Tape–30' (thermostatically controlled)	365	77	6	460	$ 60
Heater–electric baseboard: 10'	240	300	5	3000	$390
Heater–engine block	180	135	4	540	$ 70
Heater–portable (1500 watt, 8 hours per day)	240	360	6	2160	$281
Heating System–hot water circulator (3 zones)	178	48	6	288	$ 37
Hot Tub–indoor	70	196	12	2350	$306

	MONTHLY AVERAGE			ANNUAL AVERAGE	
APPLIANCE	HOURS IN USE	kWh USED	MONTHS USED	ANNUAL kWh	ANNUAL COST
Hot Tub–outdoor	128	298	12	3577	$465
Humidifier	230	29	6	173	$ 22
Lighting–compact fluorescent bulb (100W equivalent) ★	100	3	12	32	$ 4
Lighting–fluorescent light (two 40W tubes and ballast) ★	100	9	12	106	$ 14
Lighting–incandescent (100W bulb) ★	100	10	12	120	$ 16
Lighting–outdoor flood, compact fluorescent ★	90	2	12	29	$ 4
Lighting–outdoor flood, incandescent ★	90	11	12	130	$ 17
Microwave Oven (15 minutes per day) ★	8	11	12	137	$ 18
Oven (2 hours per week)	8	21	12	255	$ 33
Oxygen Concentrator	240	96	12	1152	$150
Radio/Tape Player	153	2	12	18	$ 2
Range–large cooking surface unit	8	19	12	230	$ 30
Range–small cooking surface unit	8	10	12	125	$ 16
Refrigerator–18 CF, 20 years old	730	98	12	1181	$154
Refrigerator–18 CF, 10 years old	730	70	12	845	$110
Refrigerator–18 CF, new ★	730	41	12	486	$ 63
Refrigerator–22 CF, side-by-side, 20 years old	730	135	12	1619	$210
Refrigerator–22 CF, side-by-side, 10 years old	730	96	12	1146	$149
Refrigerator–22 CF, side-by-side, new ★	730	56	12	675	$ 88
Satellite/Cable Receiver Box ★	730	18	12	219	$ 28
Stereo	90	5	12	54	$ 7
Swimming Pool Filter Pump	365	274	4	1095	$142
Television–15" to 27" standard ★	150	18	12	216	$ 28
Television–27" LCD flat screen ★	150	18	12	216	$ 28
Television–42" Plasma ★	150	49	12	588	$ 76
Toaster Oven (5 minutes per day)	3	4	12	43	$ 6
Water Heater–50 gallon tank	83	386	12	4626	$601
Waterbed Heater (queen size)	256	96	12	1152	$150
Well Pump	17	12	12	140	$ 18

[1] *Cost does not include gas use.*

[2] *Cost does not include hot water.*

High Energy Use Appliances—operating costs annually of $100 or more—are listed in green.

Average usage data compiled by Efficiency Vermont.

What this chart can show you

With this chart, you'll be able to see how quickly your energy bill can add up when you use appliances and lighting not manufactured with energy efficiency in mind. For example, take a look at lighting. If you have ten lamps in your house, each with a 100W incandescent bulb, you can expect to pay about $160 to light your home each year. Energy-efficient bulbs will keep those lamps lit for around $47. Plus, they last six to eight times longer.

About this chart

This chart is a guide and individual household costs may vary.

- The appliances listed are all electric appliances.
- *Hours in Use* is based on a typical four-person household. Your hours may vary; adjust accordingly.
- *Annual kWh* may vary considerably depending upon model, age, and use.
- *Annual Cost* is based upon the statewide average of 13 cents per kiloWatt hour (kWh).

To estimate the Annual Cost of operating an appliance: Multiply the *Annual kWh* by your utility's kWh rate or by the statewide average of .13; for example:

Annual Cost for a Television–15"-27"

216	x	.13	=	$28
Annual kWh		*kWh rate statewide average*		ANNUAL COST

http://www.efficiencyvermont.org/Docs/Appliance%20Uasage%20Broc05.pdf

Nuclear Energy

U.S. Nuclear Regulatory Commission

Home | Who We Are | What We Do | Nuclear Reactors | Nuclear Materials | Radioactive Waste | Facility Info Finder | Public Involvement | Electronic Reading Room

Power Reactor Status Report for February 16, 2006

UNEVALUATED INFORMATION PROVIDED BY THE FACILITY

Region 4

TOP

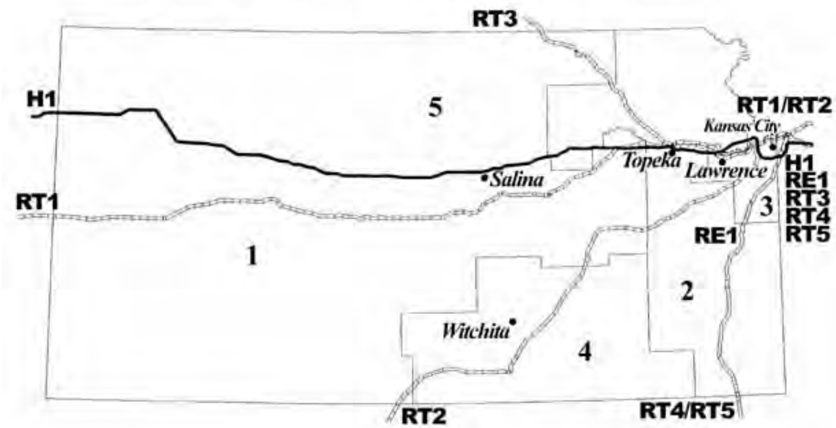
Unit	Power
Arkansas Nuclear 1	100
Arkansas Nuclear 2	100
Callaway	100
Columbia Generating Station	60
Comanche Peak 1	100
Comanche Peak 2	100
Cooper	100
Diablo Canyon 1	100
Diablo Canyon 2	100
Fort Calhoun	100
Grand Gulf 1	100
Palo Verde 1	25
Palo Verde 2	100
Palo Verde 3	100
River Bend 1	0
San Onofre 2	0
San Onofre 3	100
South Texas 1	100
South Texas 2	100
Waterford 3	100
Wolf Creek 1	100

Notes:

- Reactor status data collected between 4 a.m. and 8 a.m. each day.
- All times are based on eastern time.

http://www.nrc.gov/reading-rm/doc-collections/event-status/reactor-status/2006/20060216ps.html#r2

TRANSPORTATION OF NUCLEAR WASTE IN KANSAS

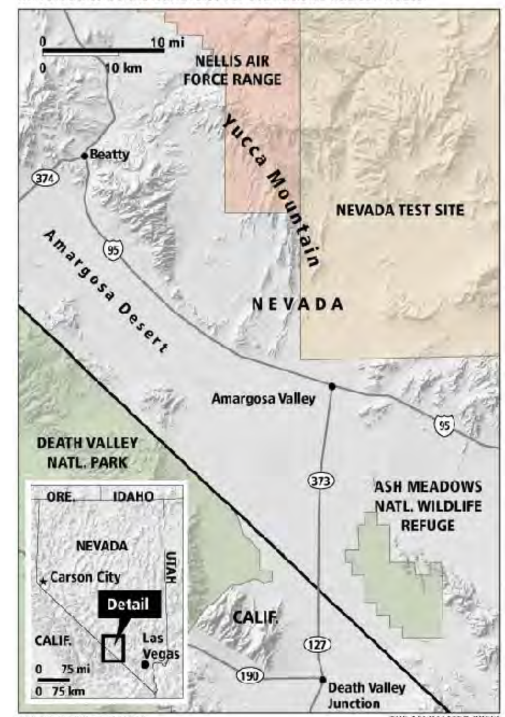


http://www.mindfully.org/Nucs/Maps/ks.htm

Number of nuclear units: **1**
Wolf Creek, Burlington, Kan.
Nuclear energy supplies **20.4 percent** of the electricity generated in Kansas.

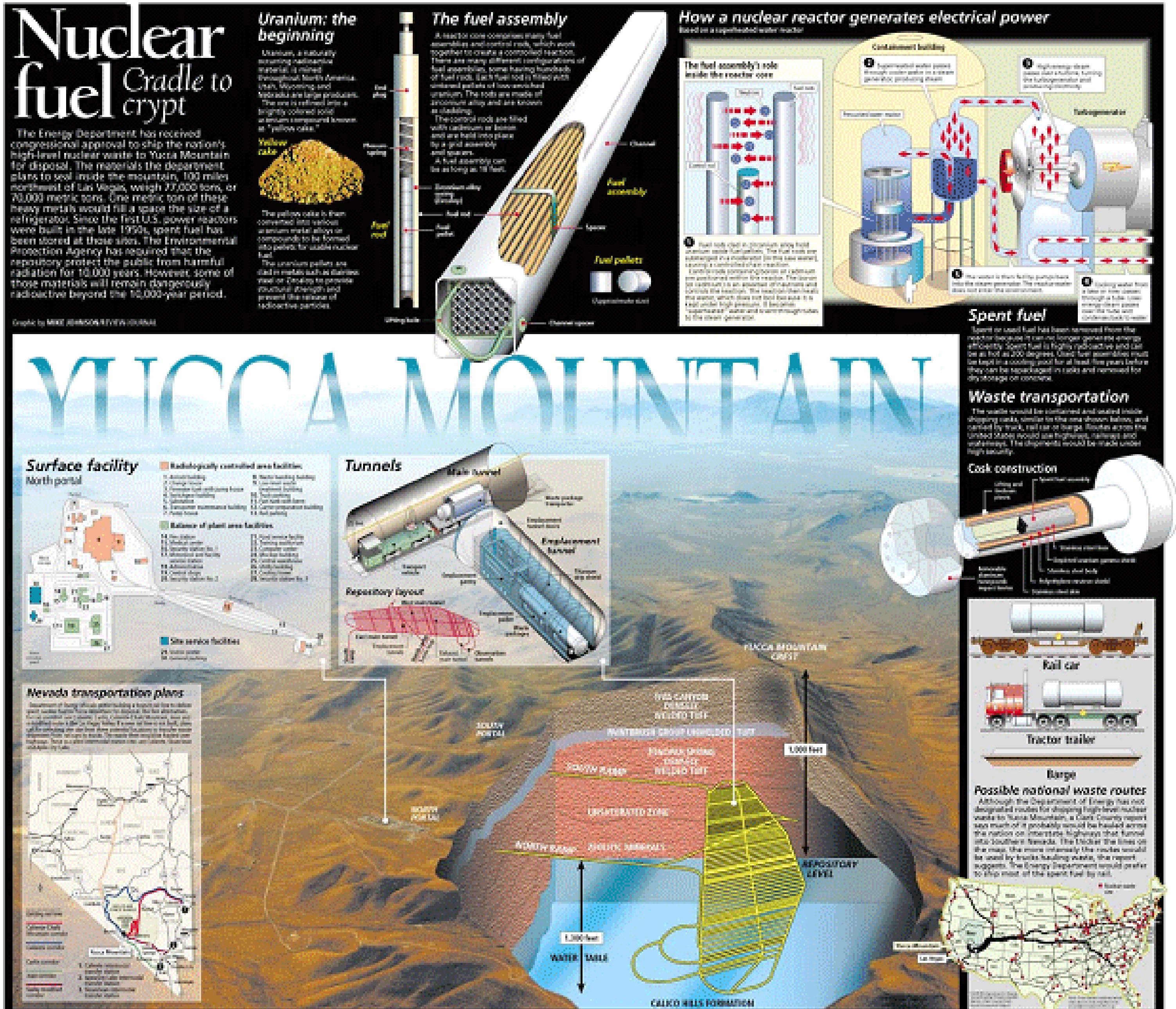
Nuclear dump

On Thursday, the energy secretary formally selected Yucca Mountain in Nevada to be the burial site for the nation's nuclear waste.

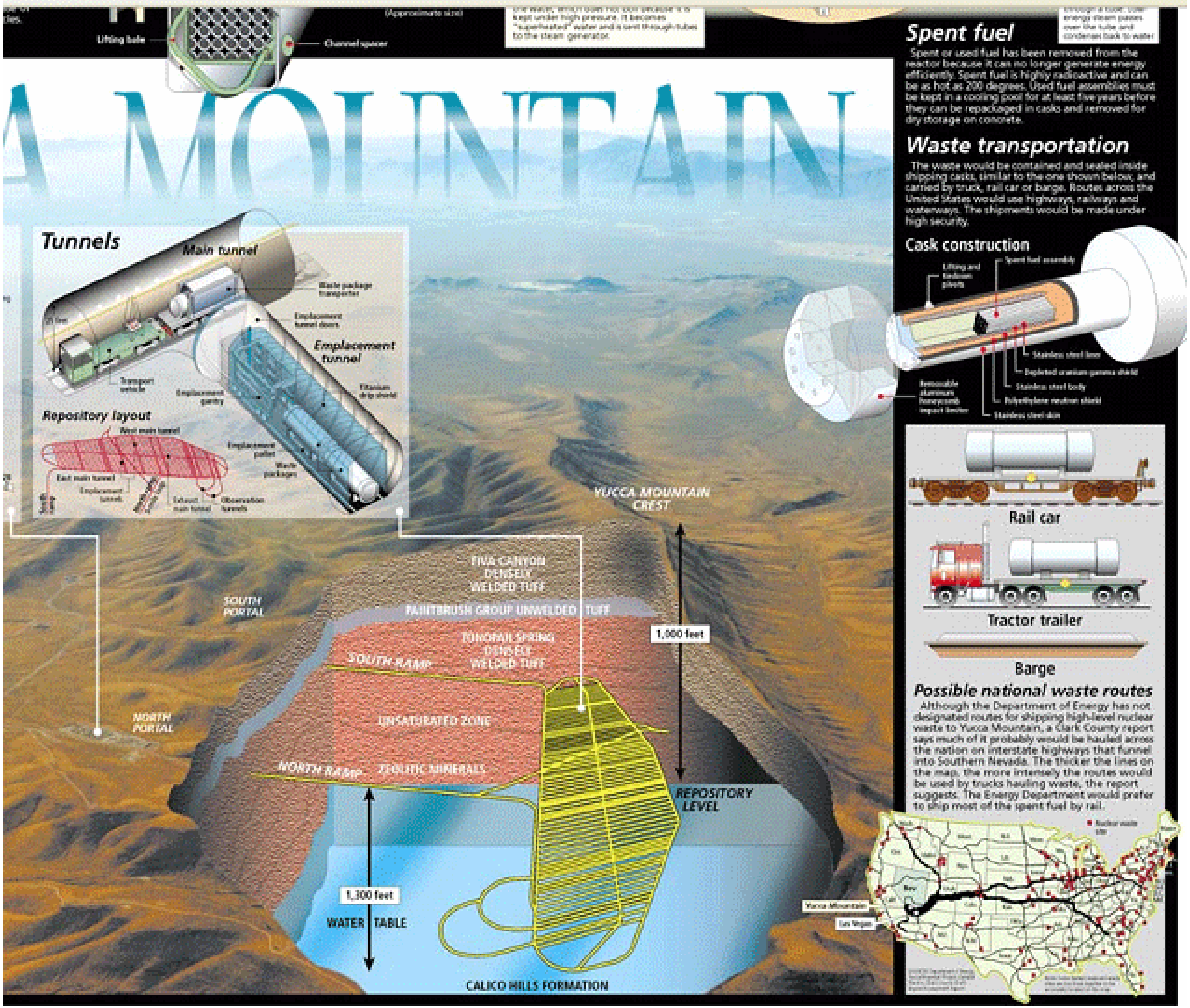


SOURCES: ESRI; GCT; USGS
THE ASSOCIATED PRESS

http://www.reviewjournal.com/news/yuccamtn/yuccamap.jpg



http://www.reviewjournal.com/lvrj_home/2002/Jul-10-Wed-2002/photos/waste.jpg



http://www.reviewjournal.com/lvrj_home/2002/Jul-10-Wed-2002/photos/waste.jpg

Environmental Aspects of Nuclear Power in Kansas

(+)

During 2000, Kansas' nuclear power plants avoided approximately 49,000 tons of sulfur dioxide emissions, 20,000 tons of nitrogen oxide emissions, and 2.09 million metric tons of carbon emissions.

(-)

Since 1985, consumers of electricity from Wolf Creek have committed **$176 million** into the federal Nuclear Waste Fund to finance nuclear waste management. Used fuel at Wolf Creek is being temporarily stored in water-filled vaults.

http://www.nei.org/documents/maps/statebystate/kansas.html

Conclusions

- Energy Research in Kansas & KU is addressing alternative energy options
- Energy use and fuel sources being evaluated with high prices
- Policy changes being developed at state and national levels to support alternative forms of energy
- Changing views on fossil energy dependence based on higher prices, unstable political situations in areas of current supply, and climate change, remaining resources
- Are high oil and gas prices good? – provide incentives to develop alternative energy
- Biomass, ethanol, biodiesel, synfuels, land fill gas, carbon sequestration are viable options in Kansas today
- Fuels Cells are wave of future in transportation and residential energy
- Electric Vehicles are hintered by energy storage
- Wind Power is economic
- Nuclear is viable option under right conditions for transportation and storage of waste. Fusion power is on the horizon.