Energy, Renewable Energy & Wind Energy

Issues for Kansas

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Presentation Outline

- United States and World Energy Outlook
- Renewable Energy Background
- Kansas' Place with Energy/Renewables
- Wind Energy Basics
- Wind Energy Economics
- Issues/Factors Affecting Wind Energy
- Next Steps

Energy Policy - Kansas

Major Objective

Improve total system efficiency with respect to all energy resources

- Improved end-use efficiency benefits
  - Resource Allocation (fossil fuels and renewables)
  - Environment (air emissions, water quality, sustainability)
  - Economics
  - Energy-profit Ratio (EPR)

Community/State Dialogue "What's in Your Energy Policy?"

- Kansas – The Net Energy Importer

"Kansas continued to import a record amount of its energy in 2003. This trend, which began in 1997, has seen energy consumption rates outpace energy production, requiring significant amounts of money to bring in energy resources from out of state." (Kansas Energy Plan – 2004, page 5)

- What are implications for our economy (local & state)?
  - Kansas simply can not produce itself out of this with conventional resources
  - Will we still have to continue to export $$$ or can we change this?
  - Will we be held to price volatilities?
- What are the environmental implications?
  - Sustainability (economic, environmental, energetic, etc.)?
- Other considerations?

Community/State Dialogue "What's in Your Energy Policy?"

- Kansas - The Sustainable State
  - New energy/power (in many forms) from energy-efficiency and in-state renewables
  - What are implications for our economy?
    - Lower, higher, or levelized prices over time?
    - Price volatility aspects with current sources would to some extent be removed
    - Begin to control our own destiny
  - What are implications for our environment?

Energy Issues – Quick Overview

- World energy consumption expected to increase **58%** by 2025
- United States consumption expected to increase **40%** by 2025
- Petroleum forecast to remain as the primary source of energy to 2025 and will increase in developing countries significantly
- There are “X” conventional energy sources that are decreasing to be applied to “Y” population; therefore the need to develop and implement new sources
- What will be the effect on Kansas? Pro-active or reactive?

Reference: World Oil Outlook

Current State of Affairs - Economically

The Way We Live Now

By Jeremy Siegel

Our trade deficit, which reached a near-record $41 billion in September and a record $12.7 billion with China, has aroused the anxieties of many Americans. Politicians are bemoaning the loss of jobs to China, India and other developing countries, and Warren Buffett has characterized America as "Squanderville," a country with an insatiable appetite for imports, paid for by piling up IOUs abroad.

But look at the big picture. The trade deficit is a consequence of larger demographic and economic forces at work in the world. The rapid aging of the developed countries combined with the striking economic growth in China and India are the major cause of these trade flows. Europe and Japan will eventually run trade deficits, too, and the result will not be as dire as many think.

The most critical problem facing the U.S.—and all developed countries—is the aging of the population, which impacts not only our trade balance but also the viability of Social Security and Medicare. Aging will also influence the value of all our assets, including stocks, bonds and real estate. A self-sufficient economy needs enough workers to produce goods that will be consumed not only by the workers and their families, but also by all the elderly. Historically this has never been a problem, since the young have always greatly outnumbered the old. But the demographic picture is now different. In 1950 there were seven workers per retiree in the U.S., a number now down to five. Starting in 2010, when baby boomers begin to retire, this ratio will plummet. By 2030, it will fall below three.

It was once necessary to build factories in the U.S. and bring workers here to produce output. Now factories can be built anywhere and products shipped world-wide. As a result of the communications revolution, service industries such as consulting, research and customer service can operate as efficiently abroad as from the U.S. These are major developments. Productivity cannot be increased fast enough in the U.S. to solve the population problem. But productivity can be increased at a rapid rate in China, India and the rest of the developing world.

We are fortunate that this is so, and that the age profile of these developing countries is very young, in contrast to the developed world. The years when boomers will be in retirement coincide with a sharp increase in the number of productive workers aged 30-50 in the developing world. In the next decades these countries will enjoy a consumption boom and a healthy trade surplus. And with the dollars they receive from selling us goods, they will be buying not only our government bonds, but corporate bonds and stocks and even real estate. These trade deficits will involve huge transfers of capital from the U.S. But the dollar need not fall in response to this shift in capital ownership. Given the age profiles of these countries, such transfers are inevitable. The old have always transferred wealth to the young. In the future the young will be from developing countries, buying our capital with dollars they receive from selling us goods.

Currently, the West and Japan have less than 15% of the world's population, yet produce more than half of the world's GDP. This imbalance will not persist. At the rate that China is growing, its economy will exceed the U.S. in 10-15 years and the combined economic output of China, India and the rest of the developing world will be three to four times the size of that produced in the West and Japan by the middle of this century. Yet these developments are not something to fear. We must look to China and other countries as *opportunities*, not as threats. Huge markets await those willing to tackle them. The demands from developing nations for infrastructure, health care, education, and managerial and technical expertise will be enormous.

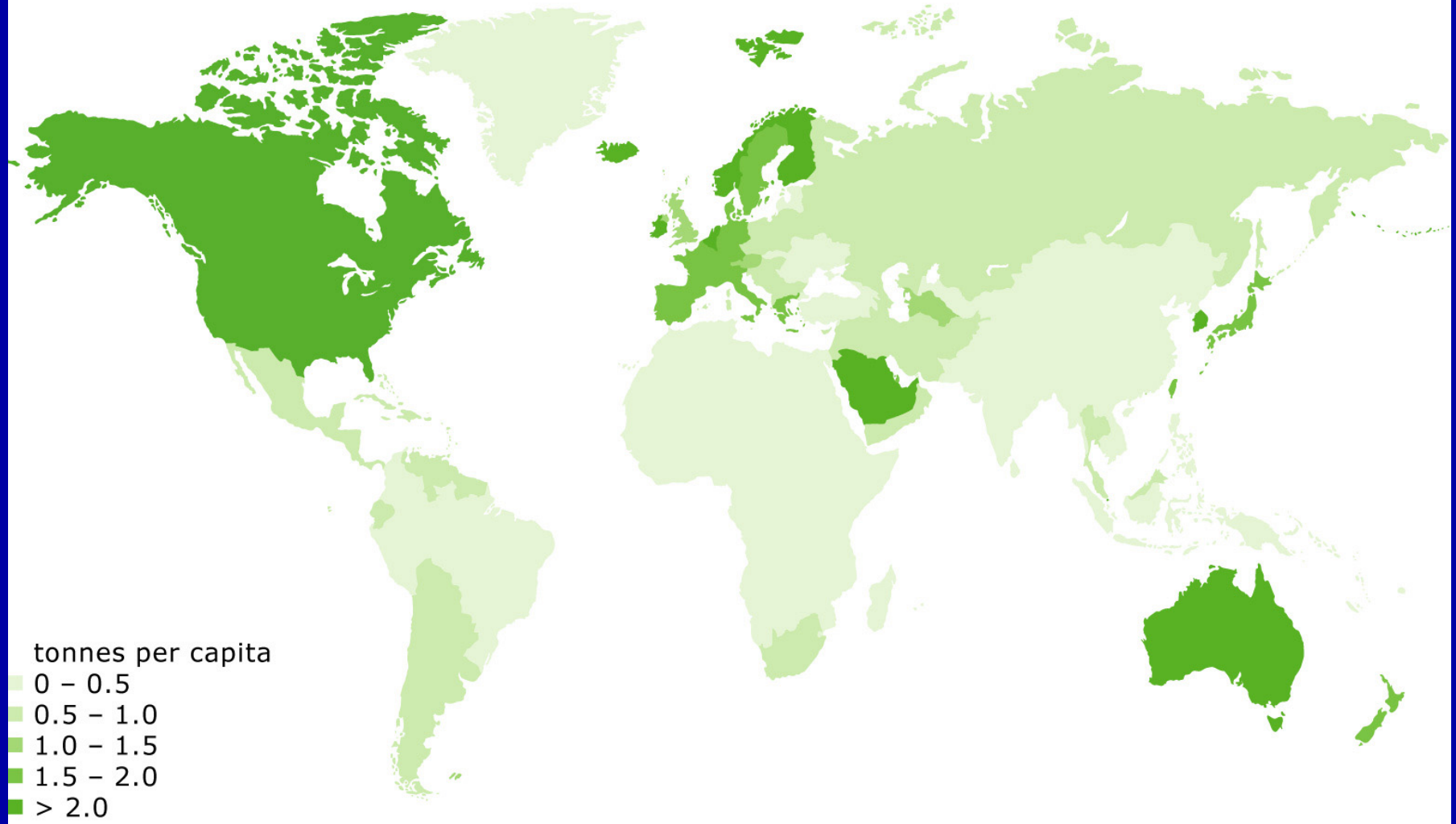
Now is not the time to look inward. Growth in the world economy is not just good for other countries; it is also vital to us. The age profile of the world's population will necessarily entail a trade deficit for aging nations. If we descend to protectionism and fragment the world economy, it is our own future that will be most at risk.

Mr. Siegel is a professor of finance at Wharton.

WSJ 1/26/04

map of oil consumption per capita

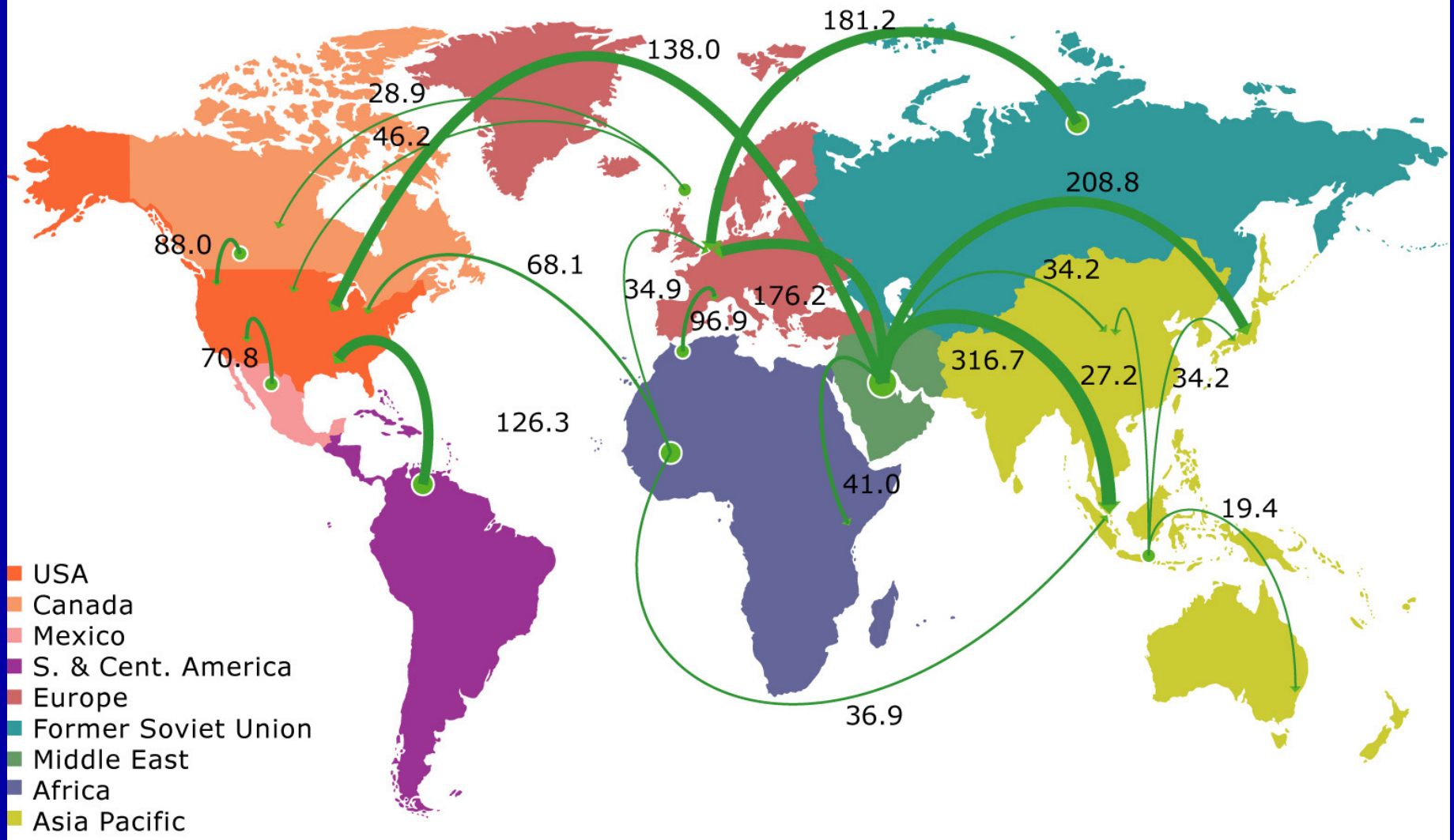
Tonnes



bp statistical review of world energy 2002

map of major oil trade movements

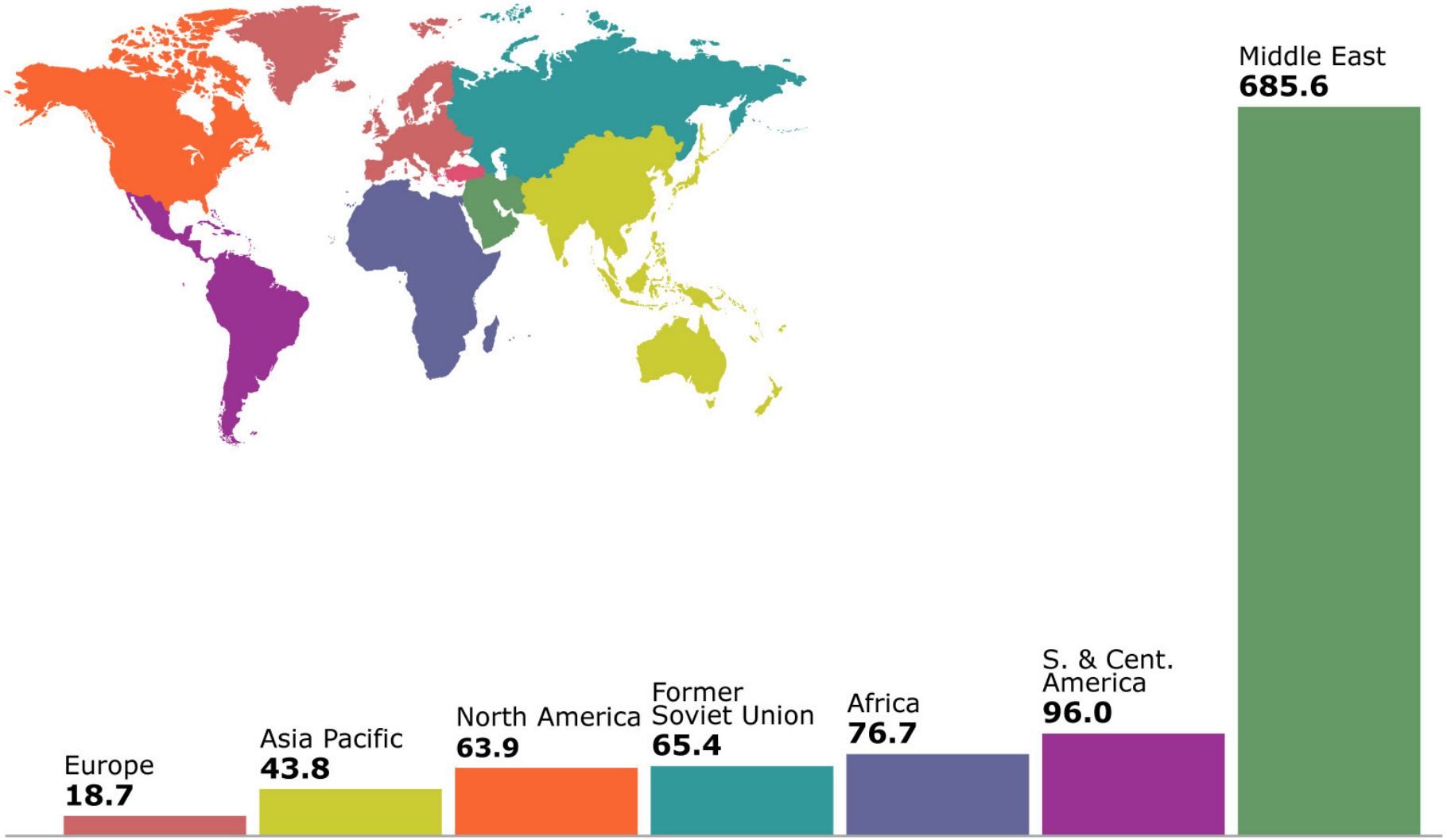
Trade flows worldwide (million tonnes)



bp statistical review of world energy 2002

map of proved oil reserves at end 2001

Thousand million barrels



Current State of Affairs - Energy

Oil

Shell shock

The Economist 1/17/04

A dramatic cut in Shell's reserves has the oil world buzzing

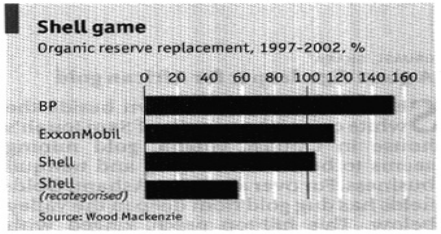
HOW on earth can an oil company lose a fifth of its reserves overnight? And not any old oil company, but that very model of a modern oil major, Royal Dutch/Shell, which has long boasted of the excellence of its management.

On January 9th, Shell said that it was downgrading nearly four billion barrels of oil and gas—a whopping fifth of its total reserves—from "proven" reserves to "probable" or other, even less-certain, categories. As proven reserves are one of the main metrics used by analysts to value oil firms, investors were not pleased. Shares in the world's third-biggest oil firm promptly fell by 7%, amid fears of worse to come.

In some respects, Shell's shock news is not as bad as it seems. The firm has not actually lost any oil. Michael Lynch of Strategic Energy & Economic Research, an industry consultancy, explains that, under the oil industry's murky accounting practices, "shifting a project from proven to probable is like moving it out of a cash account to accounts receivable. It is still an asset, but not as valuable because of the lower certainty." Shell still expects to bring most of the reclassified oil and gas to market eventually. It stresses that there has been no restatement of financial results, like at Enron or WorldCom—though it is surely undeniable that the firm has restated data of great importance to investors.

Still, this fiasco could yet lead to big changes, both at Shell and in the industry as a whole. The firm's boss, Sir Philip Watts, was never a favourite of investors, but now he faces intense pressure to go. He has long been seen as aloof and uncommunicative—an impression he reinforced this week by going to ground and leaving other executives to manage the bad news.

Now investors are questioning his competence. The revised figures suggest that, on Sir Philip's watch, Shell has performed far worse than previously thought on several important measures. Wood Mackenzie, a consultancy, calculates that in 1997-2002, the firm's rate of replacement of reserves—which are inevitably depleted as firms pump hydrocarbons out of the ground—was not 105% as previously thought, but an abysmal 57%, significantly below that of both BP and Exxon Mobil (see chart). Recalculated, Shell's "finding and development" costs in that period jump from an already relatively high $4.27 per barrel to $7.90 per barrel.



There is no evidence of criminal wrongdoing. And there is no precise legal standard or industry agreement on how to classify reserves. Under guidelines on what firms can call "proven reserves" issued by America's Securities and Exchange Commission (SEC), managerial discretion is allowed and reclassifications tolerated. Indeed, revisions—both up and down—are fairly common. What is uncommon is the breathtaking size of this reduction in reserves, the largest ever.

As has been widely noted, Sir Philip was previously in charge of Shell's exploration and production. That means that he knew, or should have known, how accurately the firm was booking new oil and gas discoveries. All eyes will be on him at Shell's fourth-quarter results presentation, due on February 5th—if he is there.

Shell's error may prompt an industry- ▸▸

Renewable Energy Resources

Common Criticisms & Misconceptions of Renewable Energy

- "They are too diffuse"
  - That can be a good thing
- "They can never meet a significant portion of our energy needs"
  - Depends on their end-use
- "They cost too much"
  - Consider all costs and especially life-cycle costing
- "It takes more energy to make renewable energy hardware than it ever produces"
  - Not true and renewables provide a sustainable EPR
- "We have lots of fossil fuel"
  - We do, but will we be able to get to it and do we really want to use it

Reasons for Renewable Resources

Biomass, Wind, Solar

- 3 “E’s”
  - energy →
    - sustainable energy-profit ratio (EPR)
    - domestic supply versus imports (control of our own destiny)
  - environmental →
    - at worst, a “closed-carbon” cycle; at best, no carbon emissions
    - no sulfur dioxide emissions
    - no heavy metals
  - economic →
    - petroleum trade imbalance currently ~$90 billion per year; projected to $206 billion in 2025 ($2001)
    - lost “opportunity cost” with trade imbalance means loss of capital in US → loss of investment in renewable energy → loss of jobs → loss of sustainable energy future

Energy Balance of Wind Energy

- Throughout its 20-year lifetime, the average turbine produces 80 times more energy than the amount used to build, maintain, operate, dismantle and scrap it (EPR = 80+).

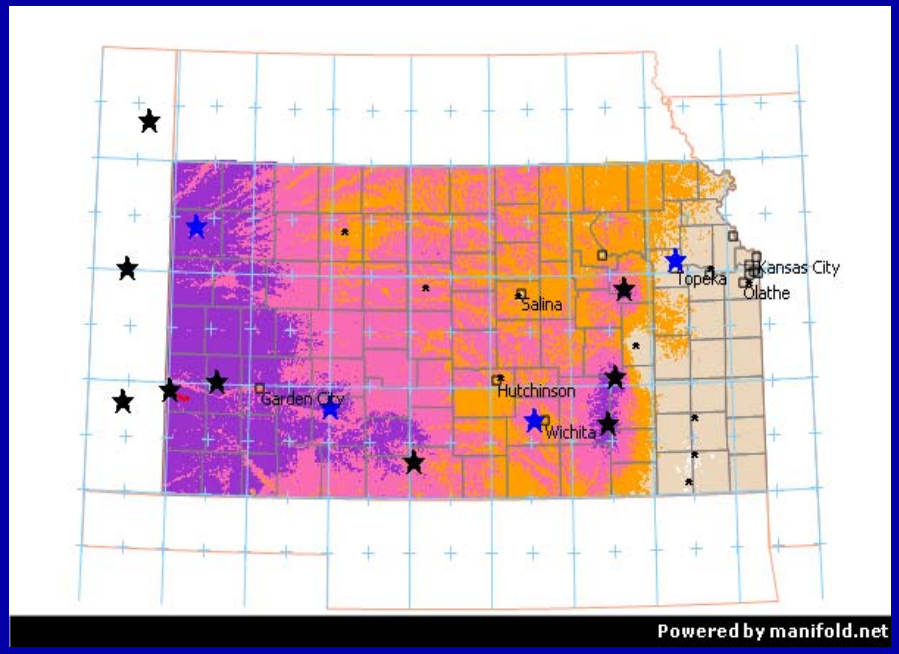
- In general, it takes only 2 to 3 months for a wind turbine to recover all the energy required to build and operate it.

- EPR of switchgrass for CHP = 7-10
- EPR of grain-based ethanol = 1.34

Wind Energy

Kansas Wind Energy Potential

- Kansas's wind energy resources are significant
- Kansas is commonly associated with being the 1st to 3rd "windiest" state in the US
- The state has been severely underdeveloped (for a variety of reasons)
- Difference between what "blows", what can be economically developed, and end-use of wind
  - This is extremely critical to the "success" of wind energy projects



Wind Power Isn't Perfect

- Wind Power output varies over time
- Wind Power is location-dependent
- Wind Power is transmission-dependent for tie-in to the grid
- Wind Power has environmental impacts (pro / con)
- Wind Power can only meet part of the electrical load

Wind Energy Basics

Physical & Engineering Aspects

Wind Power Equation

P = ½ * air density * Area Swept by Rotor * Wind Speed^3

$$P = \frac{1}{2} * \rho * A * V^3$$

1) Power in the wind is correlated 1:1 with area and is extremely sensitive to wind speed (the cubic amplifies the power significantly)

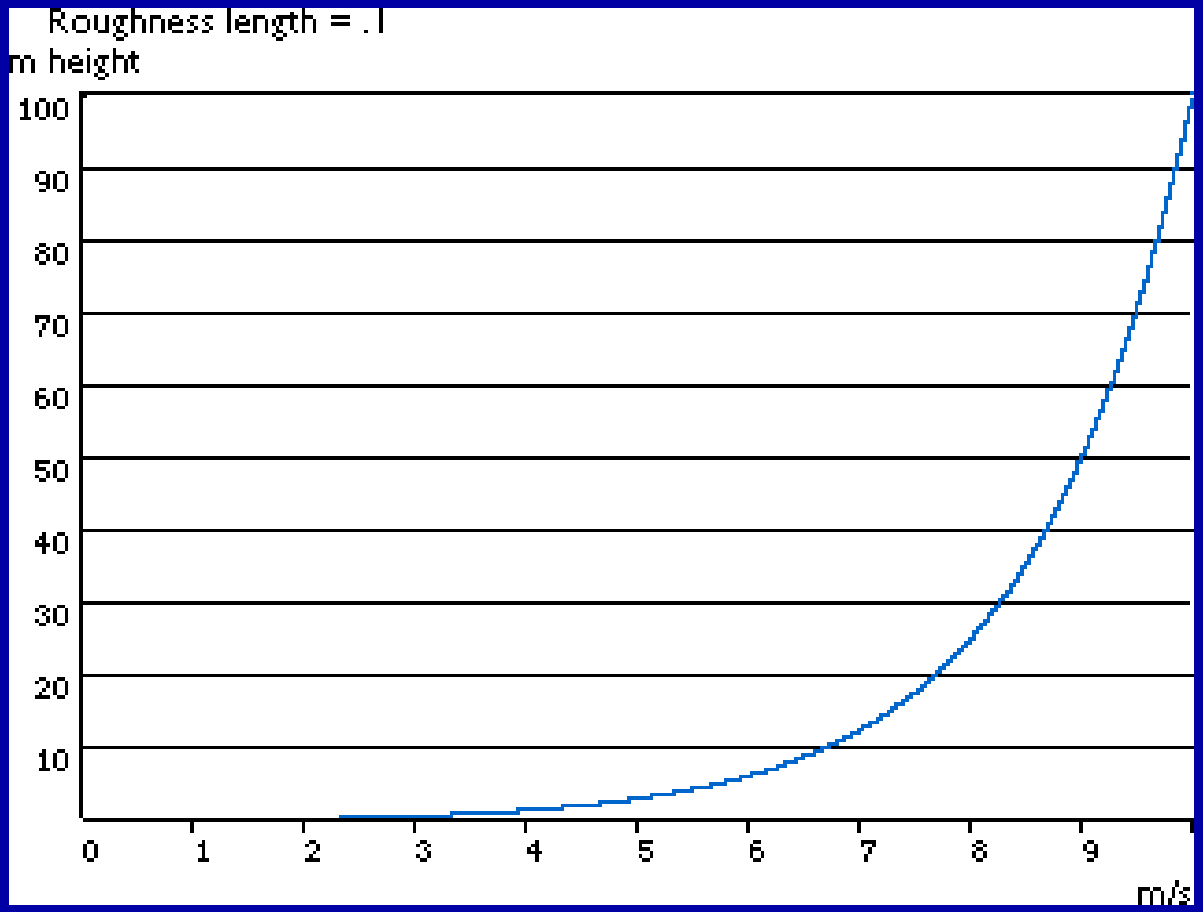
2) If the wind speed is twice as high, it contains $2^3 = 2 \times 2 \times 2 = 8$ times as much energy

3) A site with 16 mph average wind speed will generate nearly 50% more electricity and be more cost effective than one with 14 mph average wind speed (16*16*16) / (14*14*14) = 1.4927

4) Therefore, it "pay$" to hunt for good wind sites with better wind speeds

Power in the Wind

Velocity is Related to Height Above the Ground



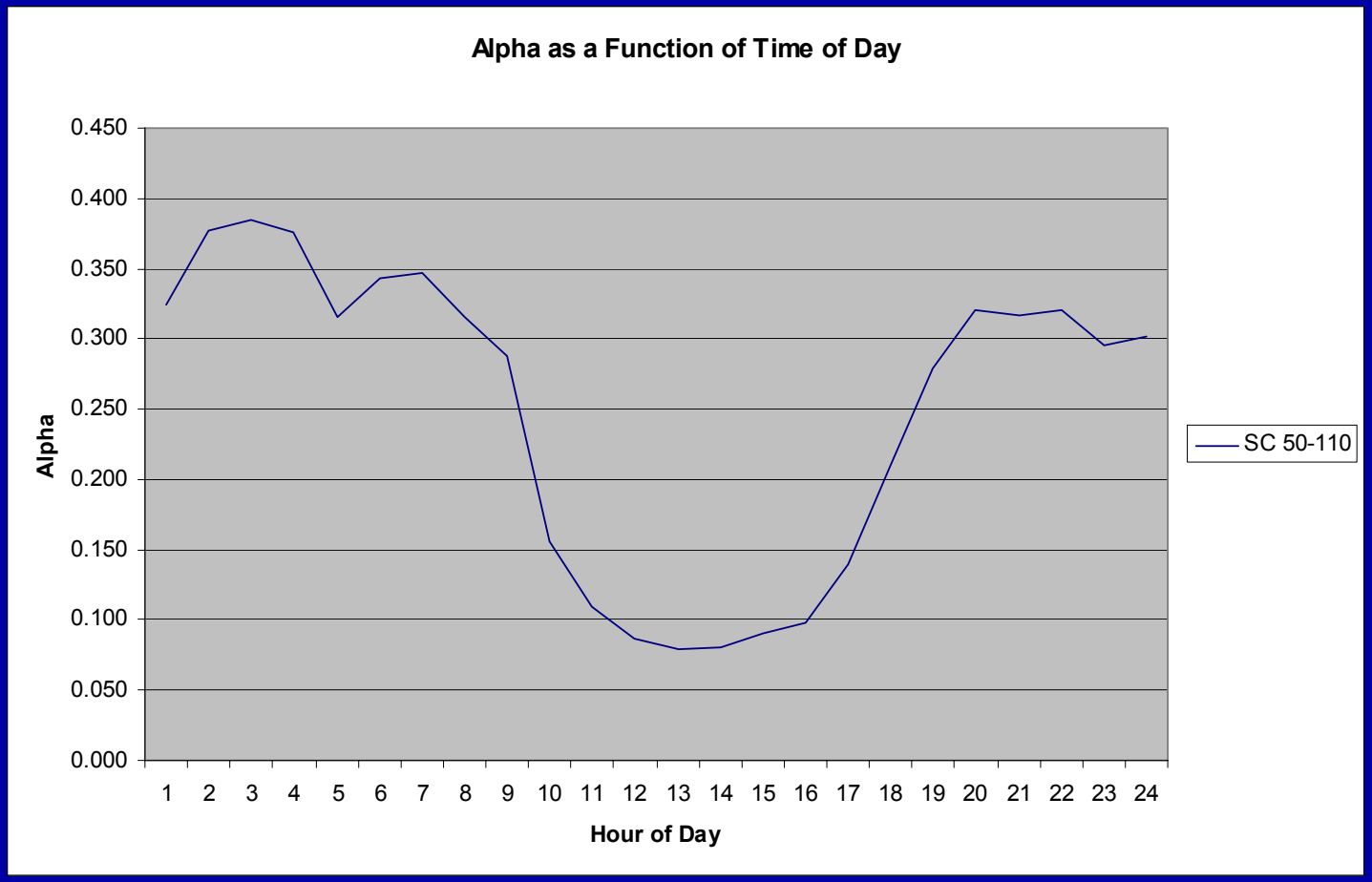
Alpha (α) Coefficient

- α is function of the wind velocity and its height above the ground

$$\alpha = \frac{\log (V_{H2} / V_{H1})}{\log (H2/H1)}$$

- α is an indicator of the "goodness" of a particular site; the greater the α, the better the site in terms of wind resources, economics, environmental benefit, etc.
- α can, and does, vary annually, monthly, and daily
- α, in general, is 0.143 (1/7 power law) (general United States average)
- α in the Flint Hills is generally greater than 0.143 (0.16 to 0.24)

Alpha Variation with Time



Variability: Quantifying Wind Power Performance

- 99% Availability
- >90% Operating Time*
- 30 – 40% Capacity Factor

* Lake Benton, Minnesota Analysis of Windfarm Operation

Physical & Operating Characteristics of Different Wind Turbines

	0.66 MW Vestas	1.5 MW GE	1.8 MW Vestas	2.5 MW GE	3.0 MW Vestas
Hub Height (m)	55	80-85	67-70	80	80-90
Rotor Diameter (m)	47	70.5	80	88	90
Swept Area by Rotor (m^2)	1,735	3,904	5,027	6,082	6,362
Cut-in Speed (m/s)	4	3	4	3	4
Cut-out Speed (m/s)	15	12	16	12	15
Rated Speed (m/s)	25	25	25	25	25

Wind Energy Economics

Wind Insures Against Fuel Price Risk

- Platts "conservatively estimates that generating electricity from renewable sources can ultimately save consumers more than $5/MWh (1/2¢ per kW-h) by eliminating fuel price risk"*

*4/8/03 announcement re "Power Price Stability: What's it Worth?"

- Value of domestic fuel source (wind) would have a direct benefit on the Kansas/community

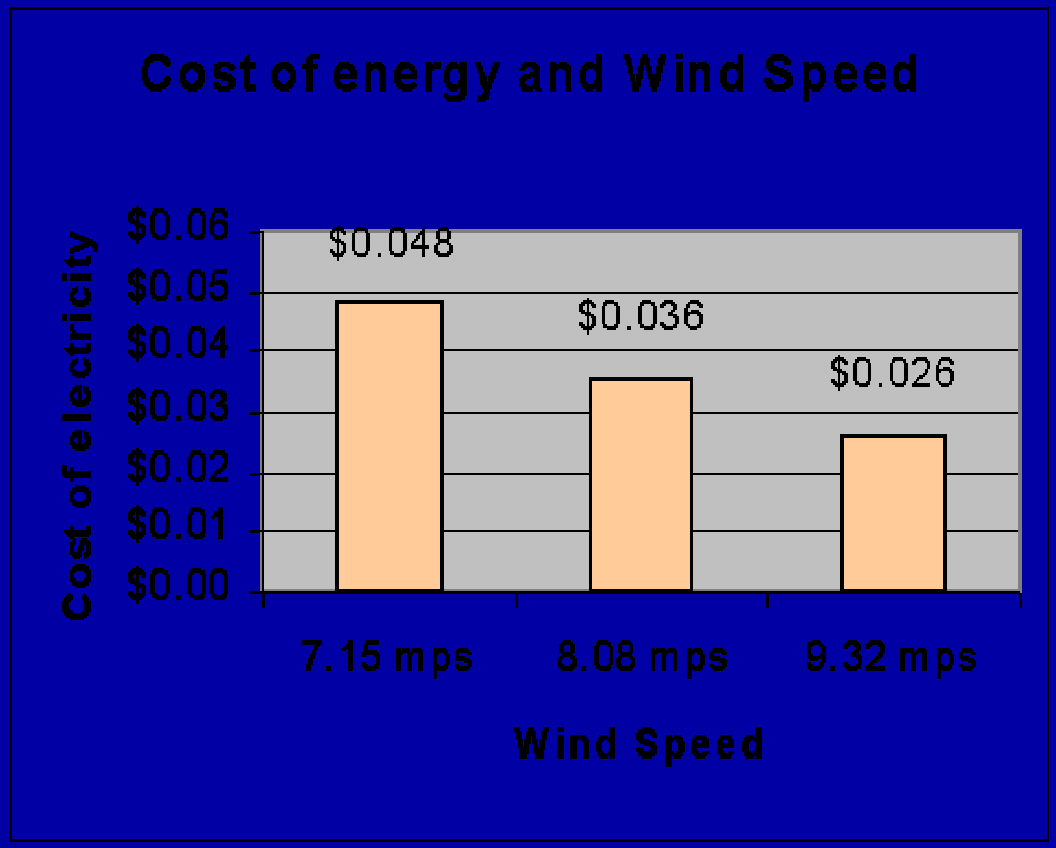
- Wind energy "Fuel" is inflation-proof; therefore impervious to fuel price hikes

Comparative Cost of Wind Energy

- Cost of wind energy is strongly affected by average wind speed and size of wind farm

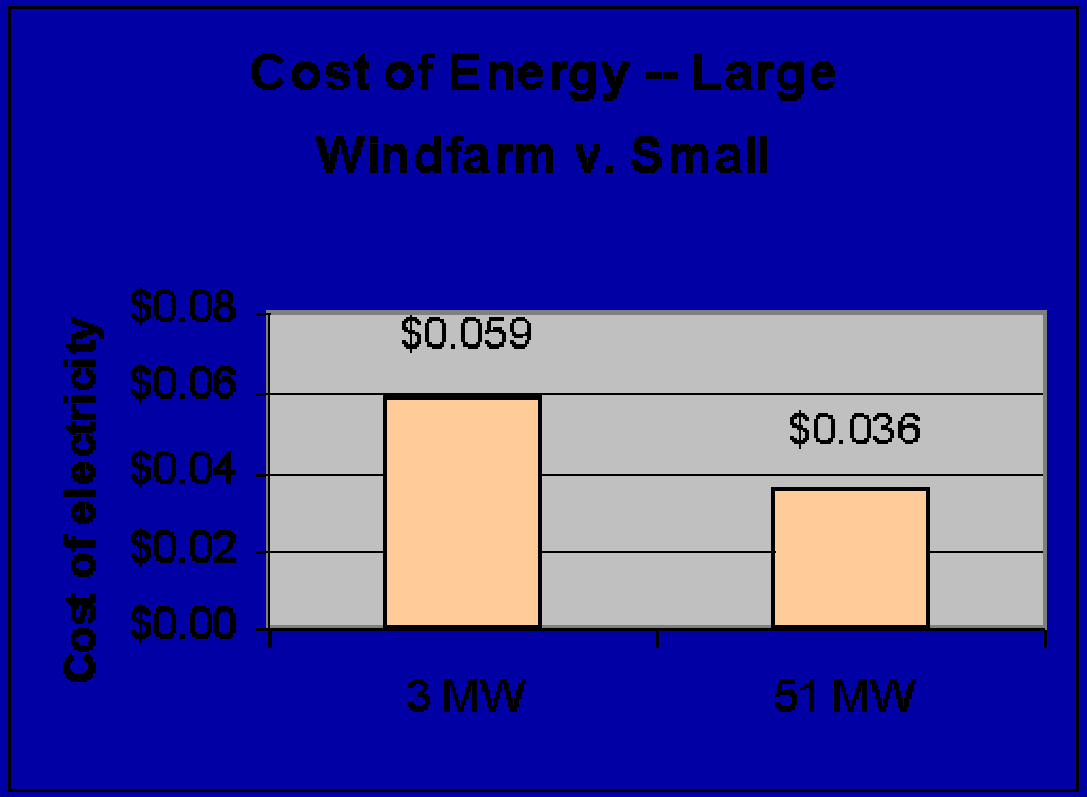
- The taller the turbine tower and the larger the area swept by the blades, the more powerful and productive (cost-effective) the turbine

Wind Power Costs
Wind Speed



Assuming the same size project (total MW installed), the better the wind resource, the lower the cost; capture more energy for the same capital/ installed/ maintenance cost

Wind Power Costs
Project Size

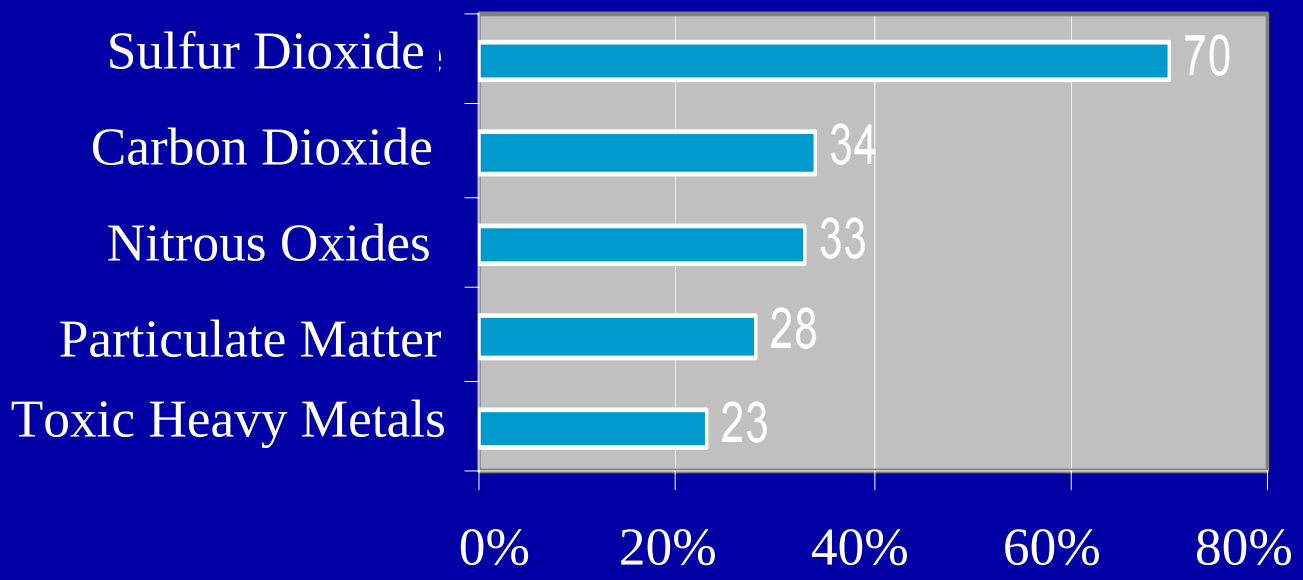


Assuming the same wind speed, a larger wind farm is more economical; economy-of-scale associated with wind farm installation

Environmental and Other Factors Associated With Energy Sources

Benefits of Wind Power Environmental

Electric Utilities are a Primary Source of Our Nation's Air Pollutants, including:



Source: Northwest Foundation, 12/97

Siting Issues

- Turbine reliability
- Aesthetics
- Noise
- Bird collisions
- Shadow flicker
- Ice
- Safety
- Property values

Aesthetics

- Modern turbines use tubular towers
- Turbines at many sites must be separated in all directions to avoid turbulence
- Larger size = wider spacing
- Modern turbines rotate about once every 4 seconds

Siting of Wind Turbines

- Energy content of wind varies with the cube of the wind speed. (Twice as much wind yields eight times as much energy.)

- Roughness of the terrain affects local wind speed. Very rough terrain may create turbulence which may decrease energy production and increase wear and tear on turbines.

Land Use & Wind Energy

- In a typical wind park, turbines and access roads occupy less than 1% of the area. The remaining 99% of the land can be used for farming or grazing, as usual.

Noise & Wind Energy

- Wind farm at 750-1000 feet is no noisier than a kitchen refrigerator or a moderately quiet room.

- Background noise generally masks any turbine noise completely, especially at wind speeds of 8+ meters/second.

- Comparison of noise levels:
  - Rural night-time background 20-40 dB (A)
  - Wind farm at 1100 feet 35-45 dB (A)
  - Truck at 30 mph at 350 feet 65 dB (A)

Birds & Wind Energy

- Danish Ministry of Environment shows that power lines are a much greater danger to birds than wind turbines.
- Radar studies show that birds tend to change their flight route 100-200 meters before the turbine and pass above it at a safe distance.
- In Denmark there are several examples of falcons nesting in cages mounted on wind turbine towers.
- Minnesota: four year intensive post-installation field study with the conclusion that there was *no significant impact*
- Altamont (CA) <u>appears</u> to be an anomaly

It's about Trade-offs/Choices – What's Important to Kansans?

- Decrease of end-use efficiency (33% versus 60% with CHP) with co-firing and possible increased costs for energy with switchgrass **versus** societal benefit of improved and sustainable water quality and decreased greenhouse gas emissions

- Increased cost of energy with wind, fuel cells and the H_2 economy **versus** improved electricity reliability, improved air quality, and decreased greenhouse gas emissions

- Implement an RPS that may (or may not) have greater near-term energy prices **versus** gaining "sustainable prosperity" in the long-term for all Kansans

- Wind energy development and production in the Flint Hills resulting in improved air quality, improved environment, and economic benefit **versus** disturbance of one of Kansas's most scenic (if not the most scenic) areas (ditto for Cape Cod !!!)

Next Steps

1) Develop a Kansas Renewable Resources Action Plan (KRRAP) that encompasses economic, energetic, and environmental considerations for all of Kansas

2) Undertake a preliminary renewables-based hydrogen initiative that focuses on utilizing the state's vast renewable resource base