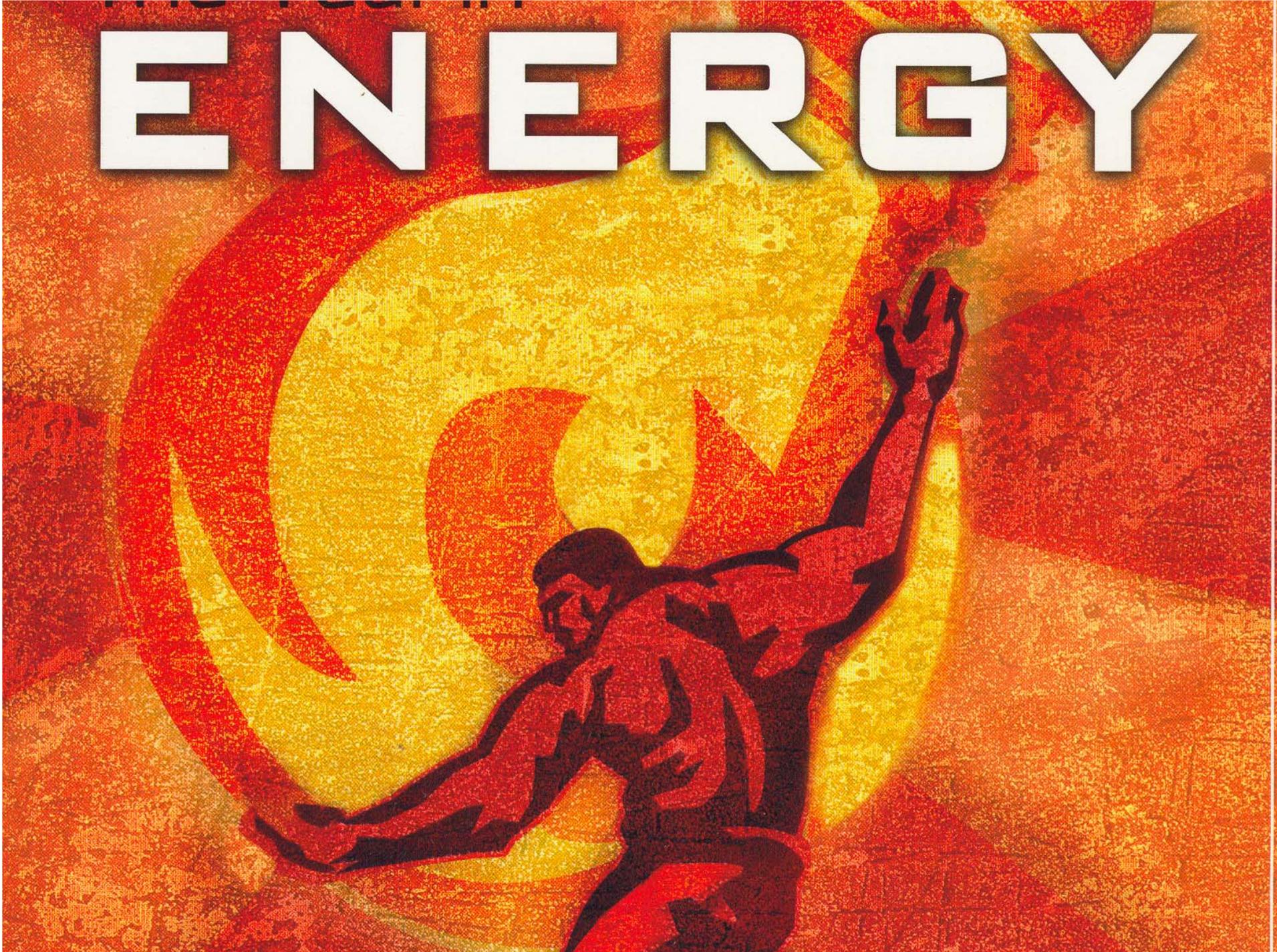


# ENERGY

















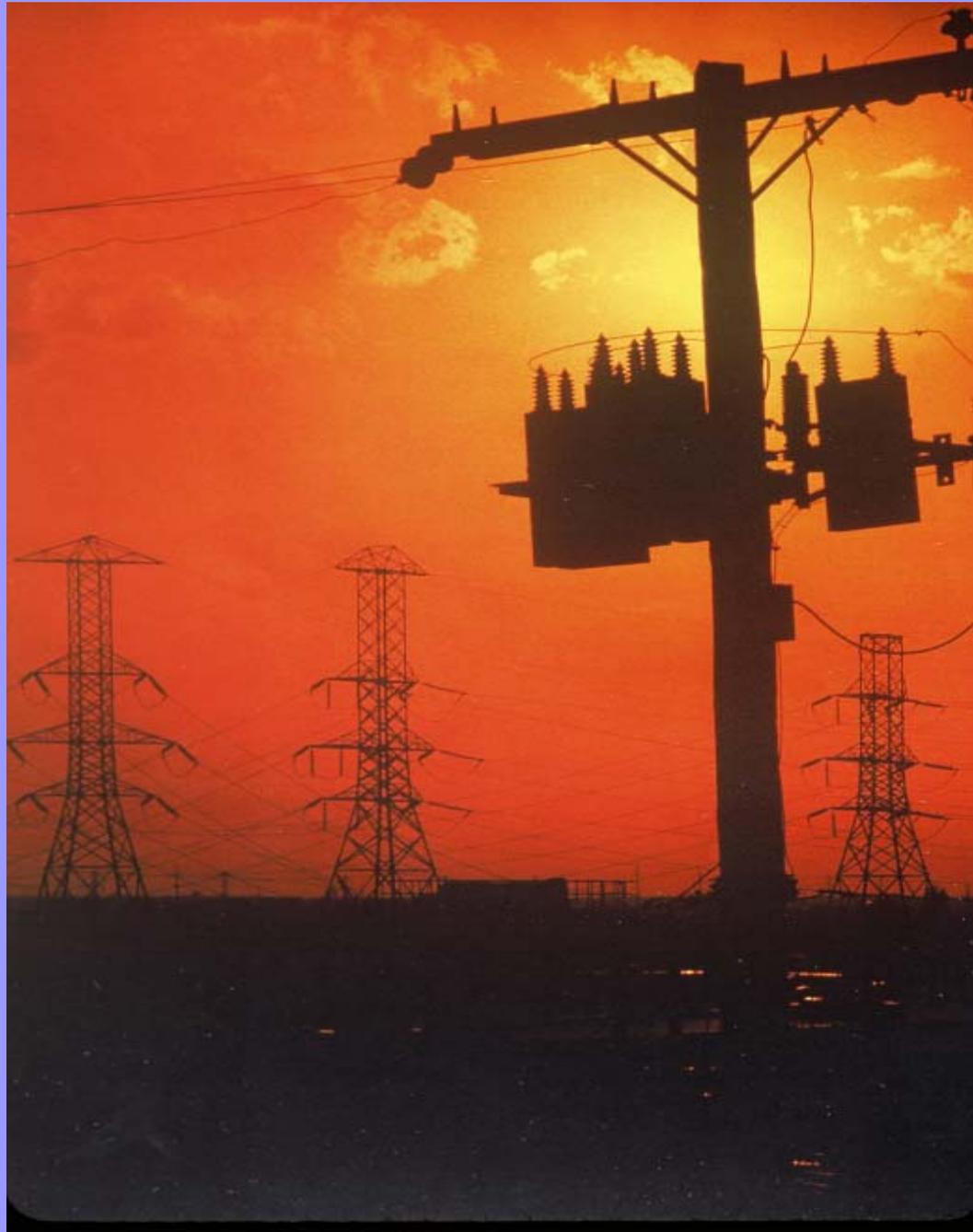


Matthew Simmons: Energy is the Earth's  
Most Precious Resource

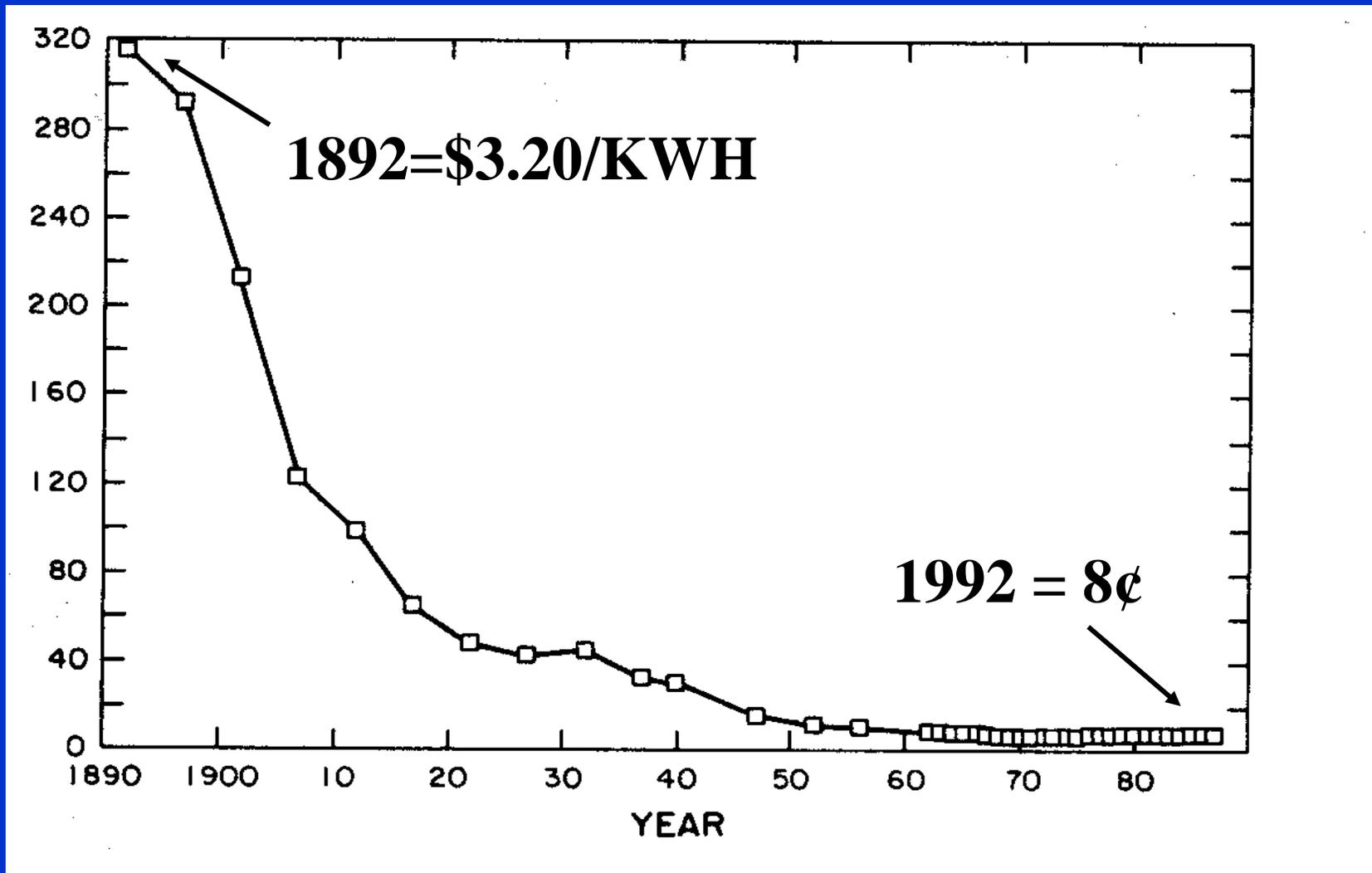
Modern energy was the greatest 20<sup>th</sup>  
century innovation. Electricity, Internal  
Combustion Engine

Technology, telecommunications,  
advanced agriculture, medical science...  
without primary energy, none would  
happen...

Energy invented prosperity



# AN AMAZING CENTURY

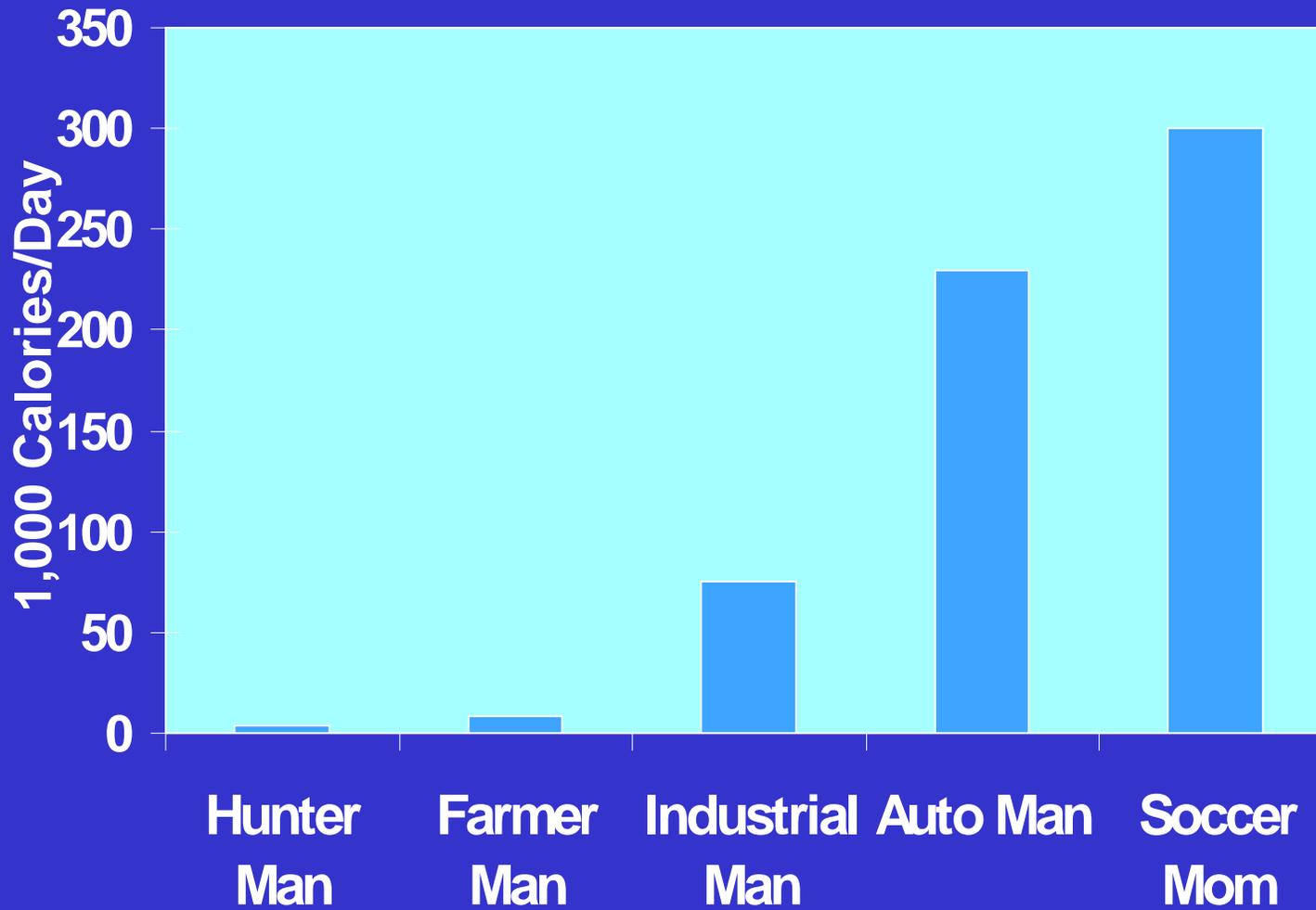




“Lance has a top end of about 600 watts. He can produce 1200 watts for a very short time, less than 20 seconds.

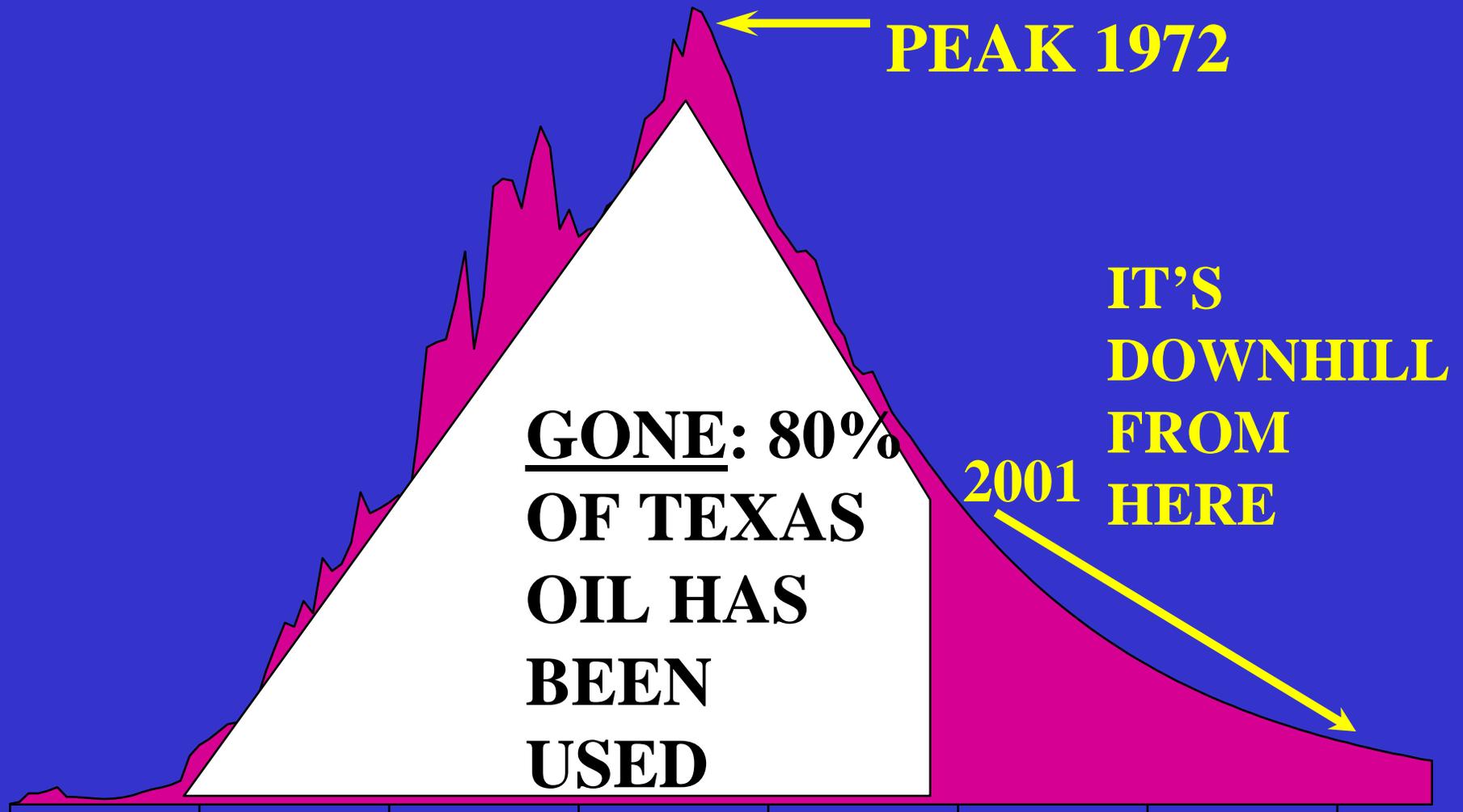
He can maintain 500 watts for 30 minutes going uphill. No one else in the world can do that consistently.”

# EVOLUTION OF HUMAN ENERGY USE





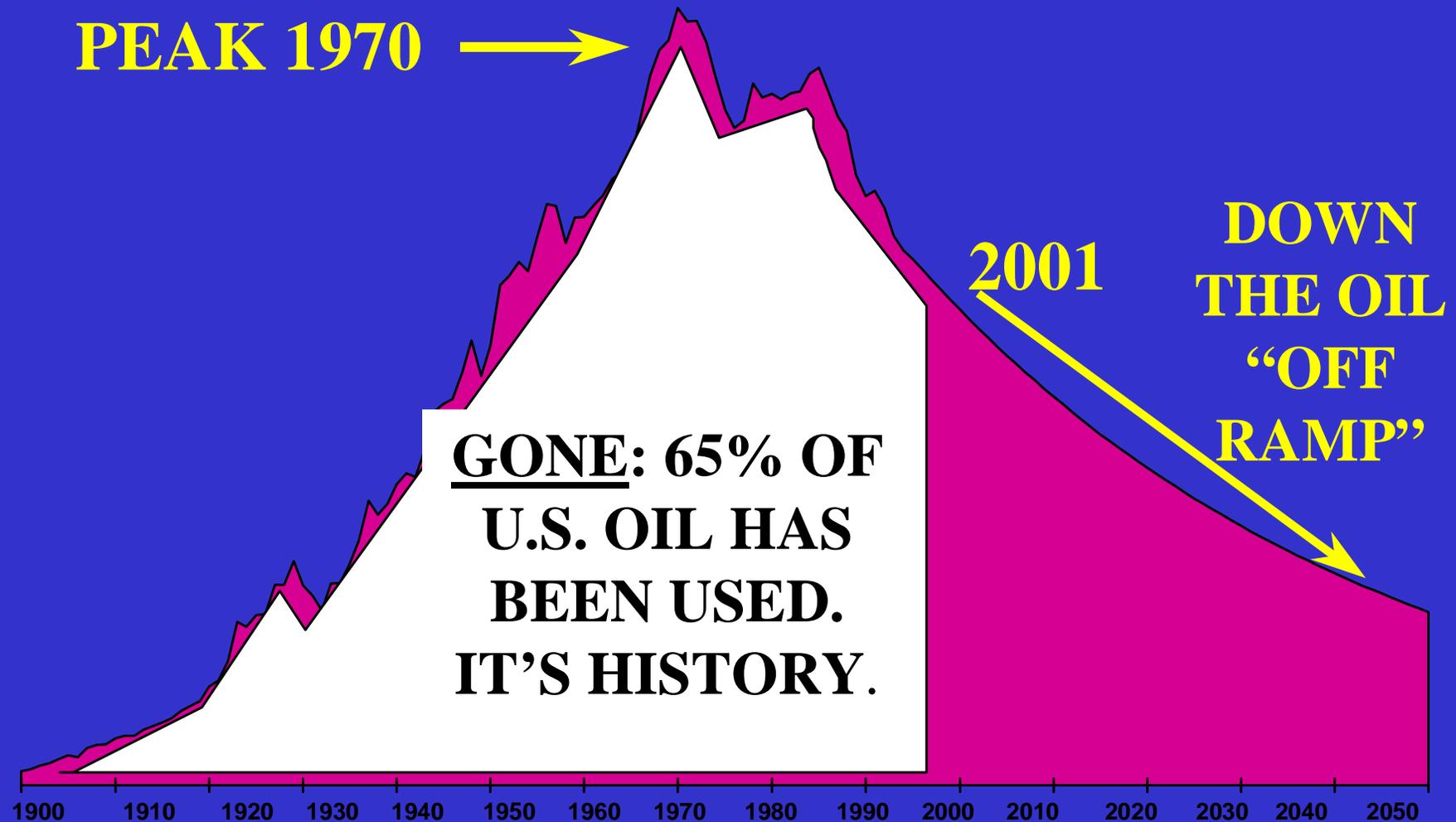
# TEXAS OIL PRODUCTION 1900-2050





# U.S. OIL PRODUCTION 1900 TO 2050

PEAK 1970 →



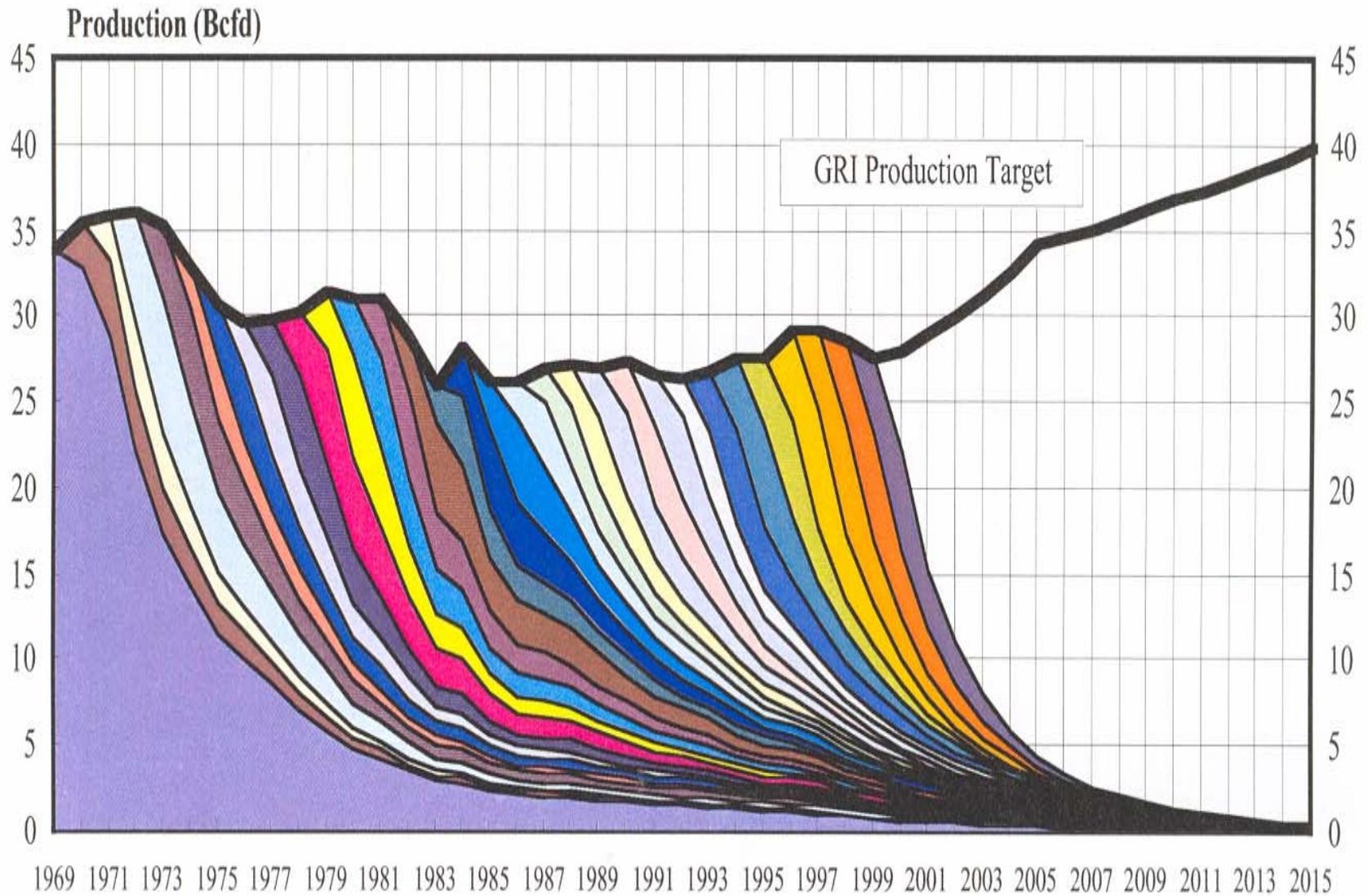








# FORECAST FOR GULF COAST





## **Methane Madness**

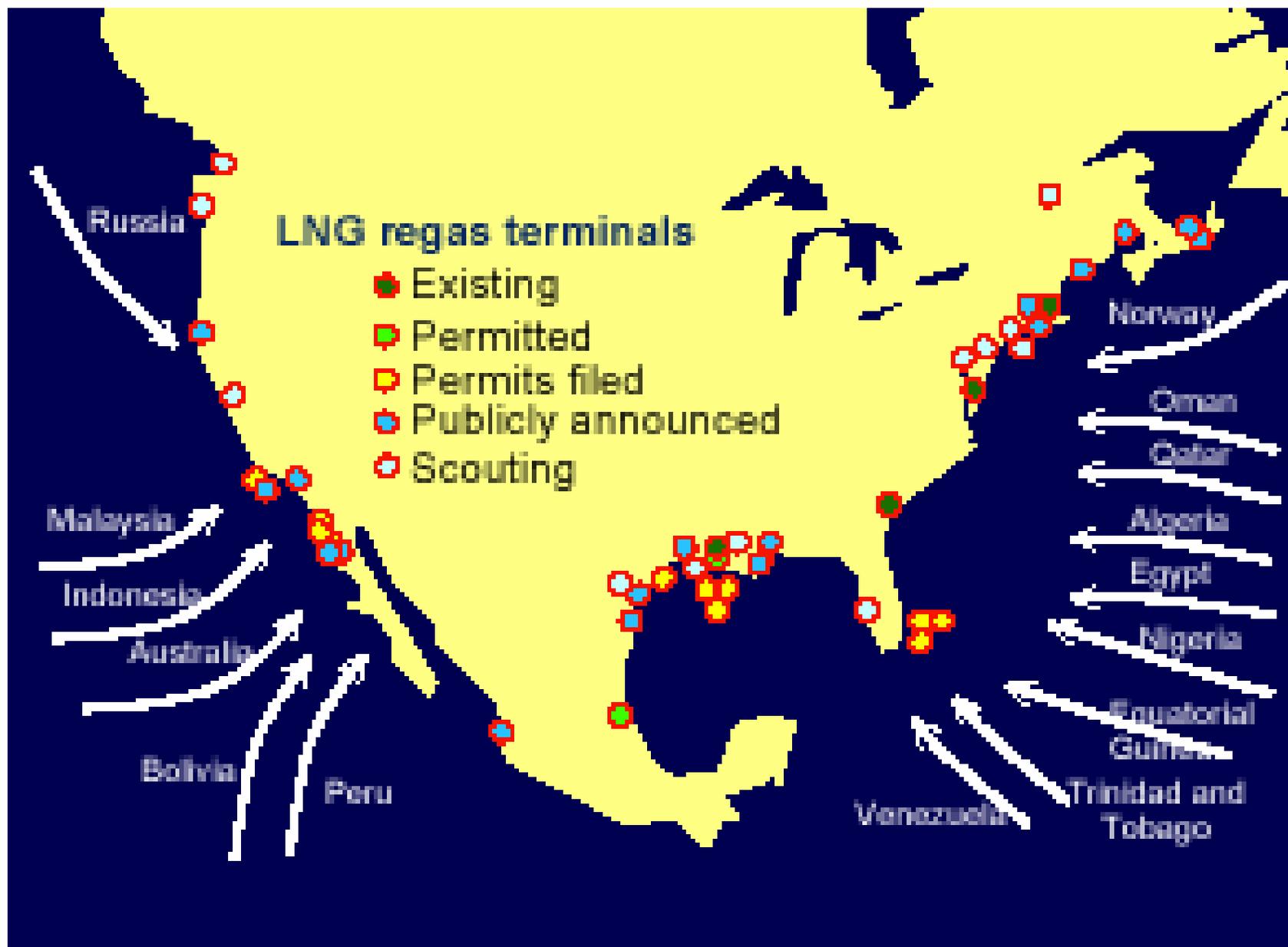
**“In 1997, 600 rigs kept production flat.**

**In 2001, 1000 rigs were needed to keep production steady.**

**In 2002, production fell 3%.**

**US producers will find it very difficult to reverse these trends.”**

**Raymond James**

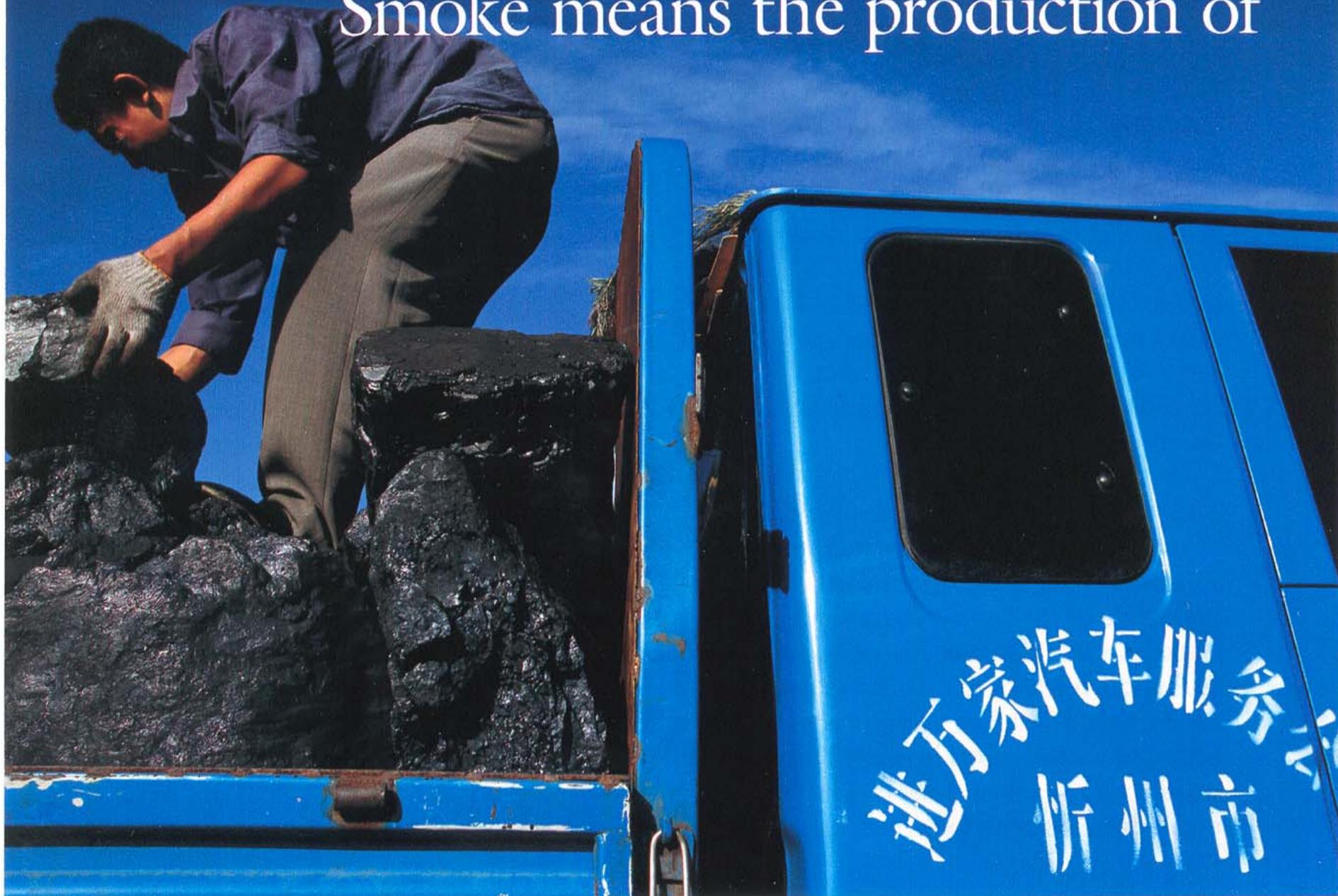


*Figure 5: Growth in North American LNG regas projects*

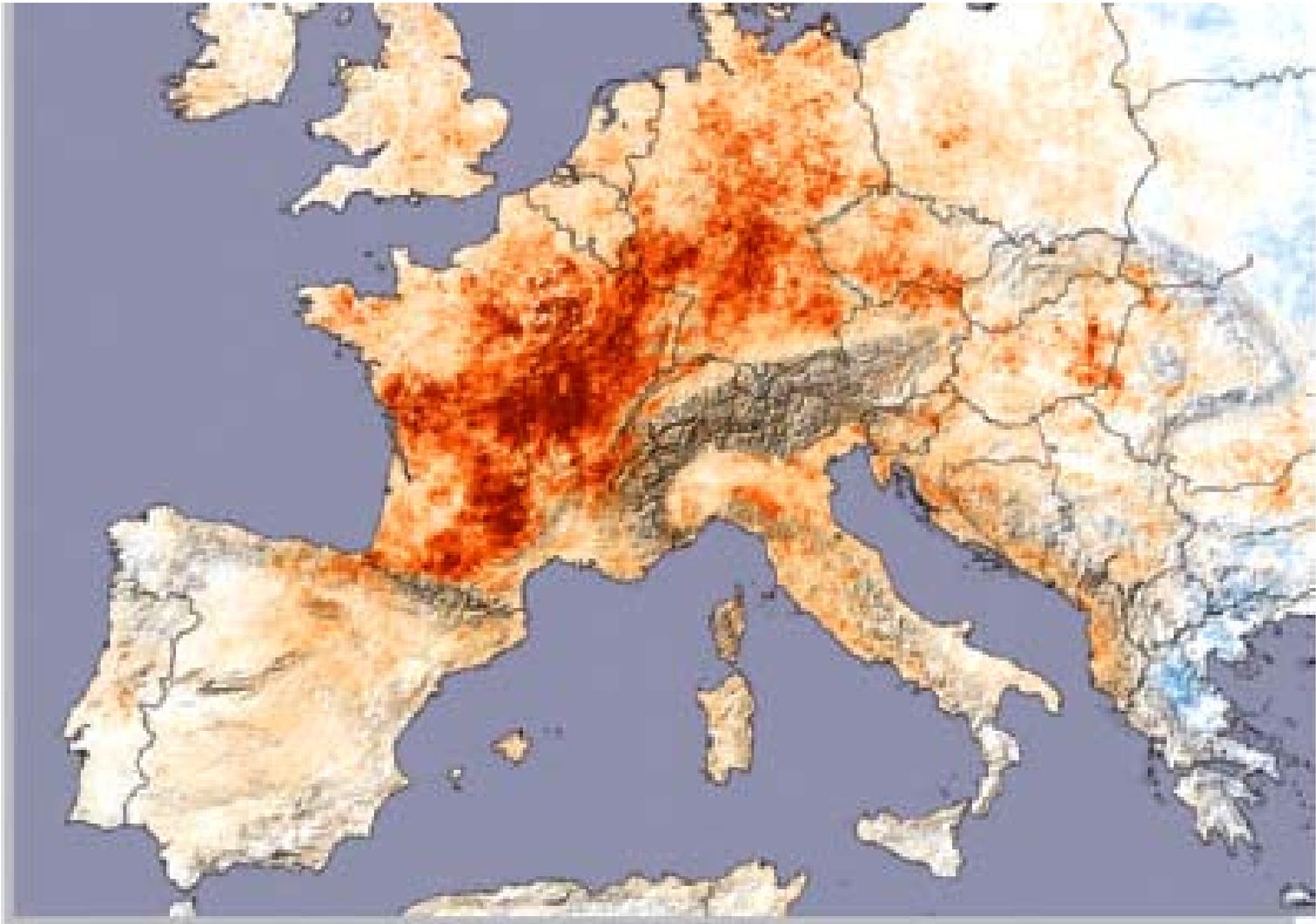


Source: BG

Smoke means the production of







Land surface temperature difference (K)



# EPRI: THE CLIMATE CHALLENGE

Fossil Fuels are the basis of prosperity. Burning these fuels produces carbon dioxide, a greenhouse gas. Some of the carbon produced today will still be in the atmosphere a century from now

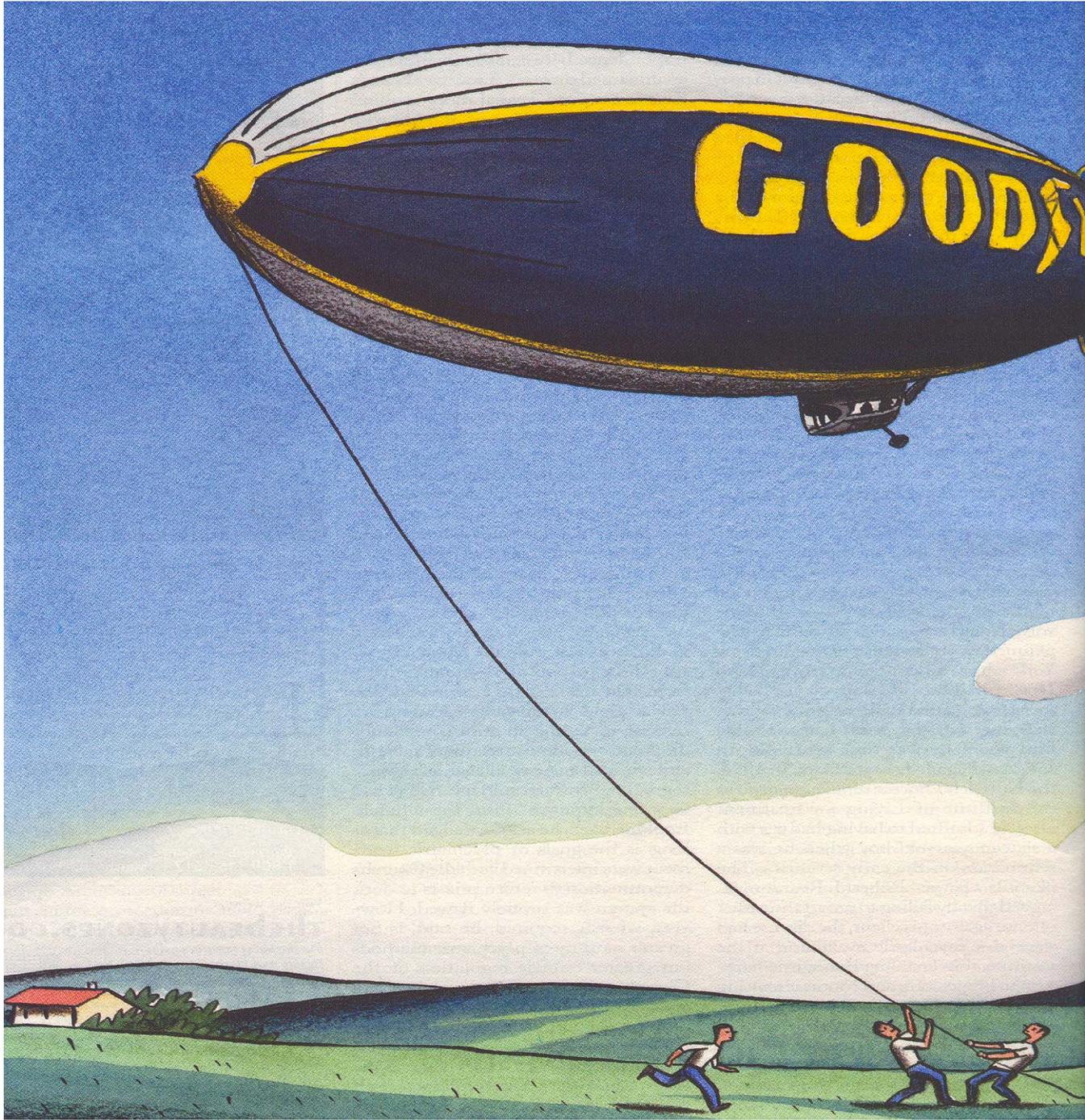
To stabilize atmospheric concentrations of CO<sub>2</sub>, emissions must fall during a century when they would otherwise likely double or triple...

Solution: Energy efficiency & new lower-emitting technologies, “Electrify the world”



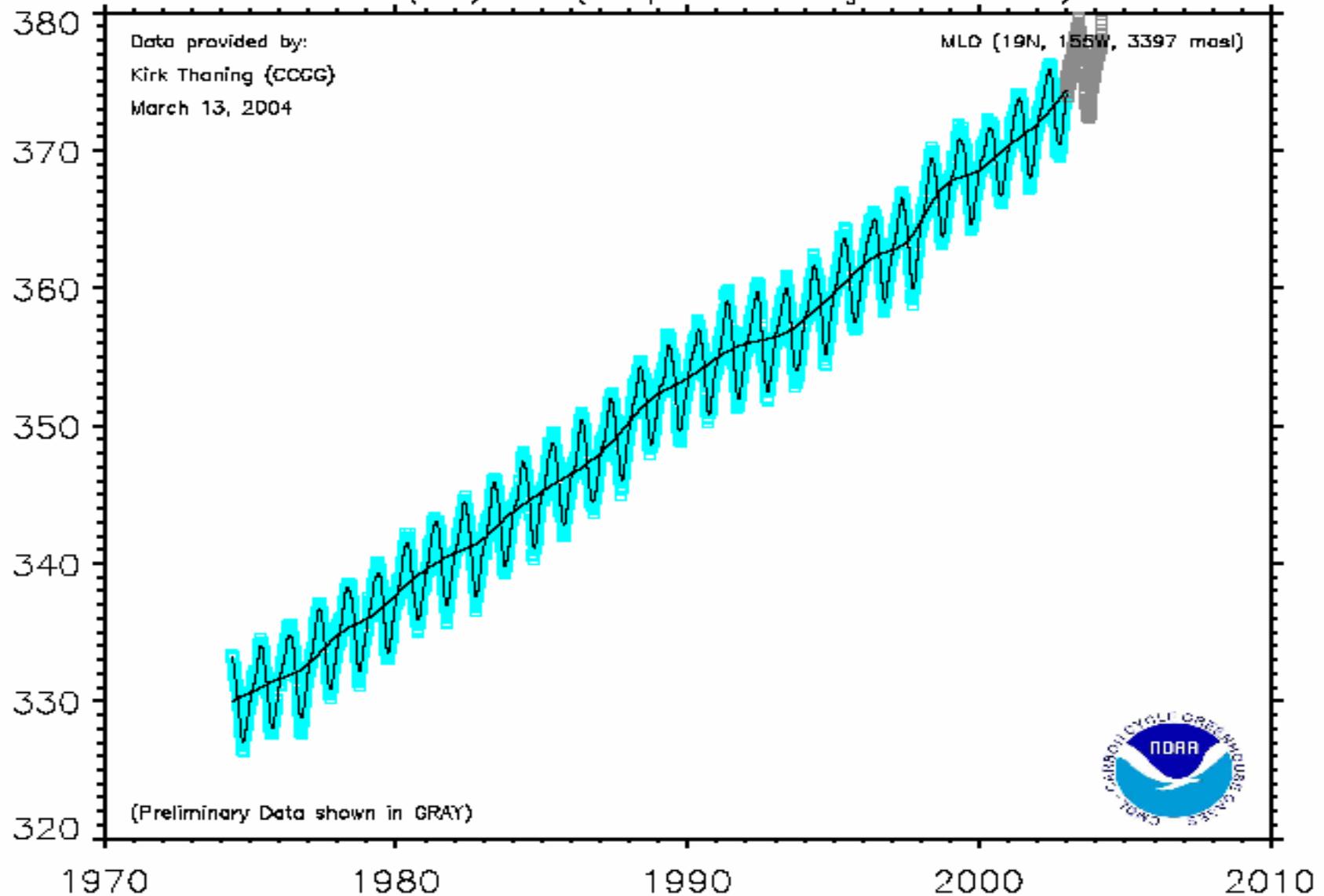
Each year humans dump 30 billion tons of carbon dioxide into the atmosphere...



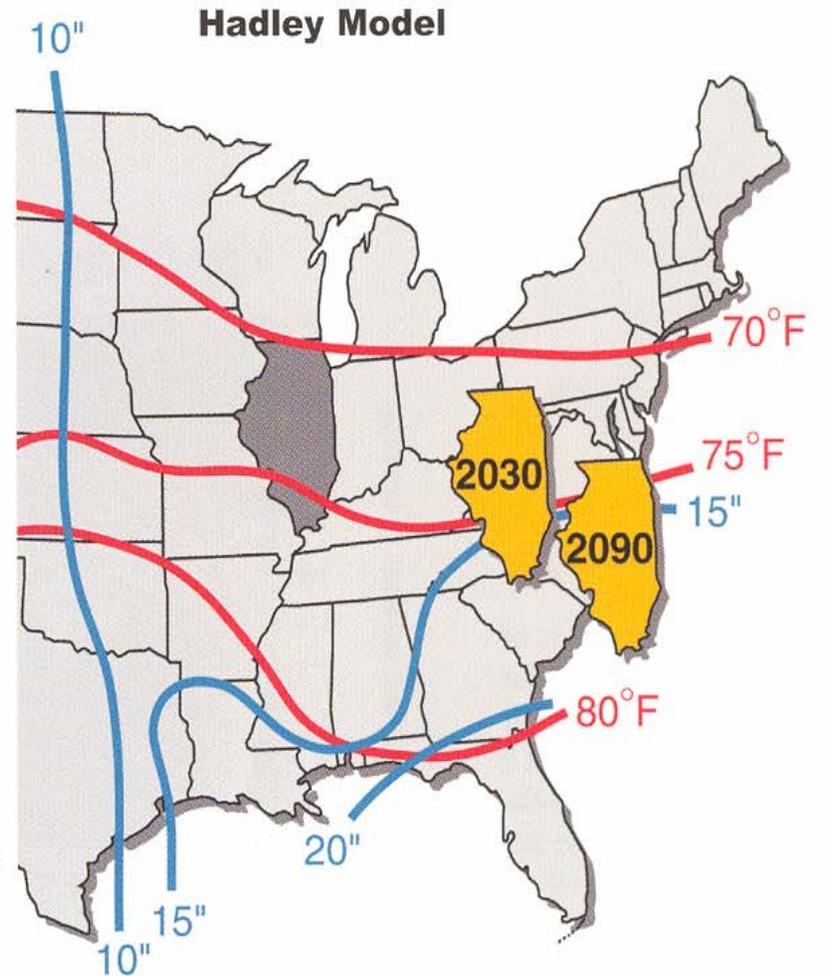
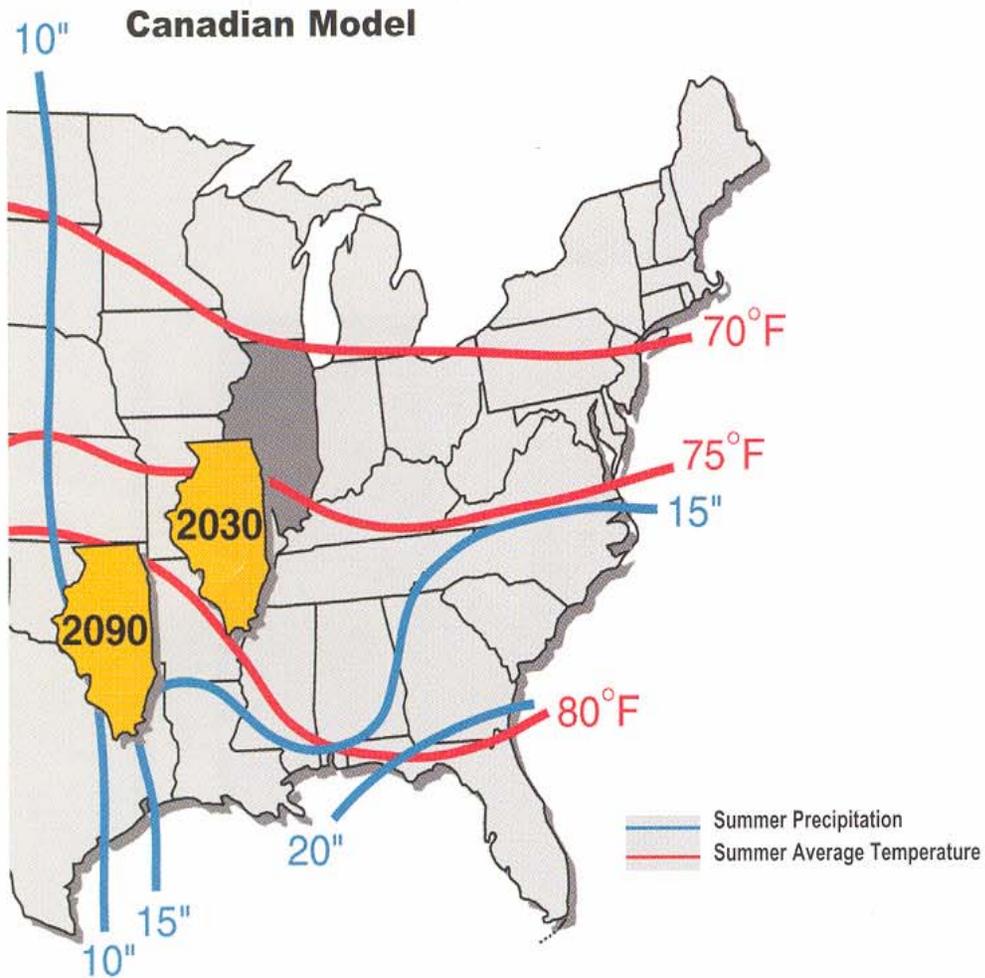


# Mauna Loa, Hawaii, United States

In Situ (Obs) Data (Sample Intake Height: 3397 masl)



**“We are not in Kansas anymore...”**



Glenwood Springs

# Post Independent

[www.postindependent.com](http://www.postindependent.com)

## Cutting carbon part of equation for Holy Cross

Customers want  
utility to be green

BY JEREMY HEIMAN

*Special to the Post Independent*

Holy Cross Energy isn't a green giant among electric utilities, but the company is expanding its efforts to be green.

The local energy co-op is

"Our customers believe using fossil fuels causes global warming."

Bob Gardner  
Holy Cross Energy

coal and natural gas for electric power produces carbon



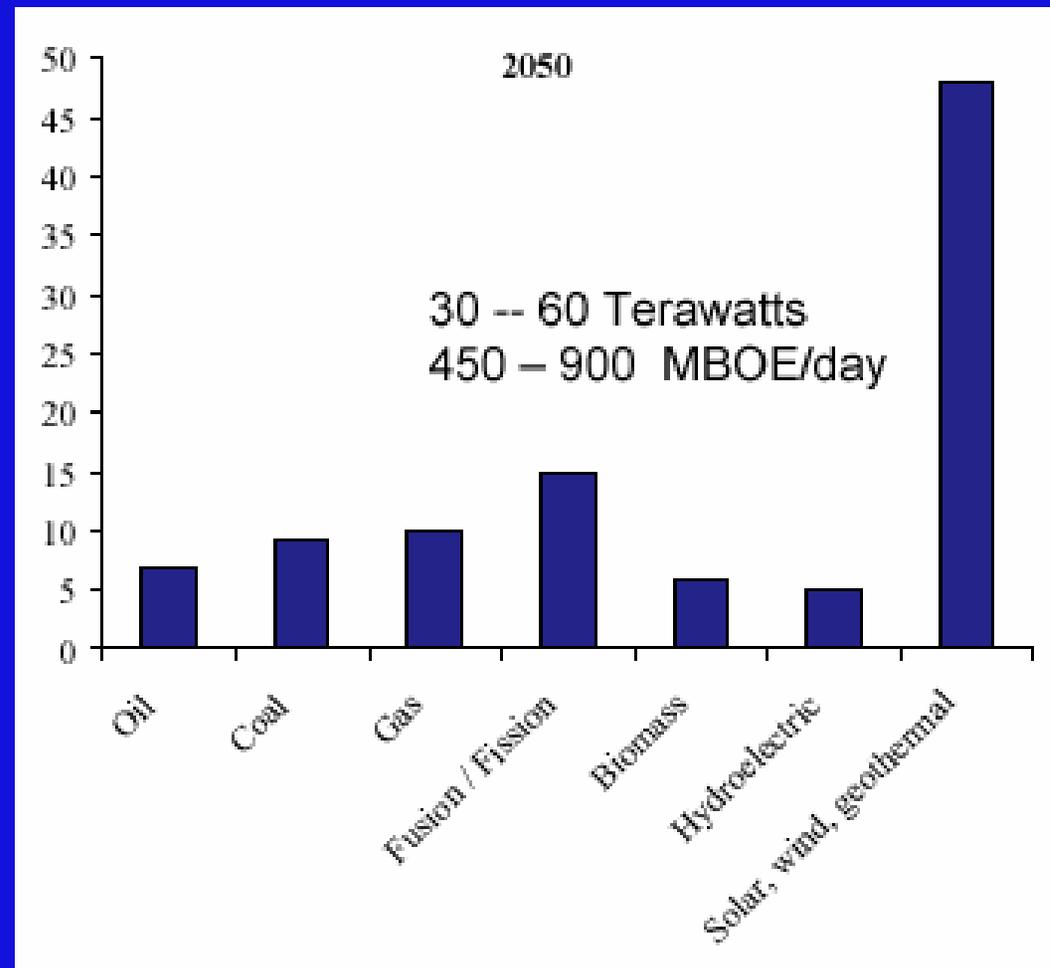
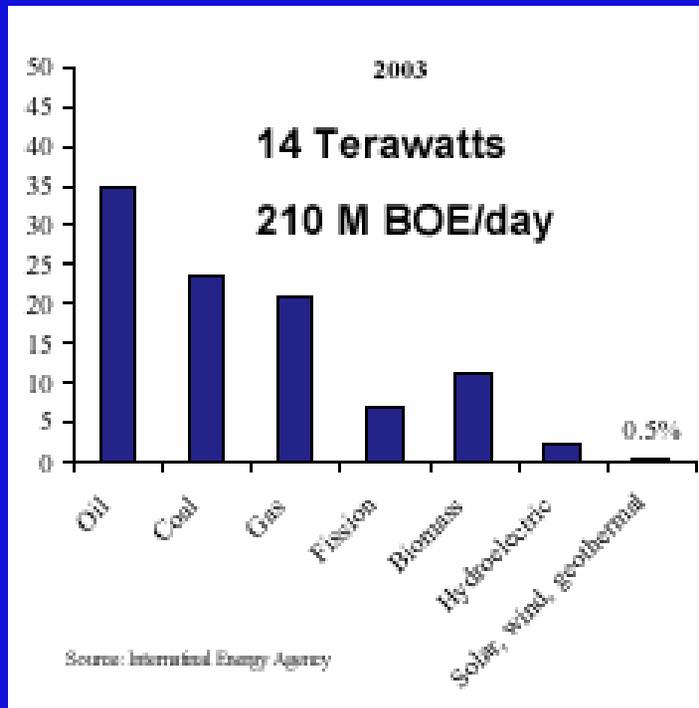
# Humanity's Top Ten Problems for next 50 years

1. ENERGY
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION



2003	6.3	Billion People
2050	9-10	Billion People

# The ENERGY REVOLUTION (The Terawatt Challenge)



The Basis of Prosperity

20<sup>st</sup> Century = OIL

21<sup>st</sup> Century = ??

# 14 Enabling Nanotech Revolutions

1. Photovoltaics -- a revolution to drop cost by 10 to 100 fold.
2. H<sub>2</sub> storage -- a revolution in light weight materials for pressure tanks, and/or a new light weight, easily reversible hydrogen chemisorption system
3. Fuel cells -- a revolution to drop the cost by nearly 10 to 100 fold
4. Batteries and supercapacitors -- revolution to improve by 10-100x for automotive and distributed generation applications.
5. Photocatalytic reduction of CO<sub>2</sub> to produce a liquid fuel such as methanol.
6. Direct photoconversion of light + water to produce H<sub>2</sub>
7. Super-strong, light weight materials to drop cost to LEO, GEO, and later the moon by > 100 x, to enable huge but low cost light harvesting structures in space; and to improve efficiency of cars, planes, etc.
8. Nanoelectronics to revolutionize computers, sensors and devices.

## **Brainstorming the Future**

- Think of South Dakota as the center of an “energy island” with a 500 mile radius**
- Encompassing Minneapolis, Chicago, Kansas City, Denver, Cheyenne, Powder River Basin**
- Then challenge yourself to run this “island” for 50, 100, 200 years, forever...**

# Possible Energy Goals

- **Affordable, efficient, reliable, clean energy system**
- **New Transportation Fuel**
- **Low Carbon Electricity**
- **Heating Fuel**
- **Fertilizer**

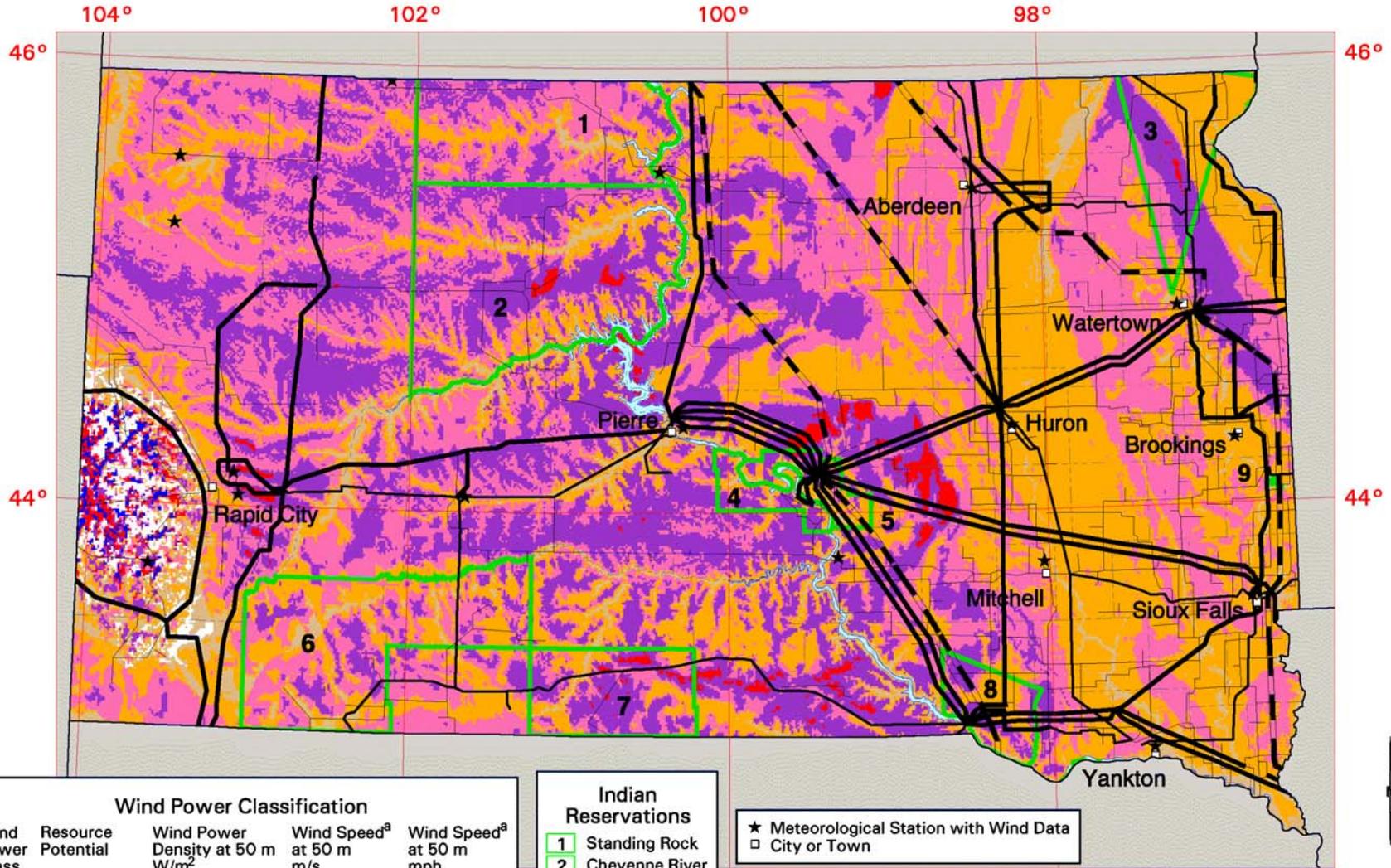
# INTRIGUING QUESTION #1

Could You Run  
South Dakota on  
Energy Crops?

Ethanol, biodiesel,  
wind power...



# South Dakota - Wind Resource Map



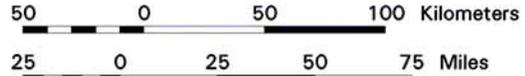
Wind Power Classification				
Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m <sup>2</sup>	Wind Speed <sup>a</sup> at 50 m m/s	Wind Speed <sup>a</sup> at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

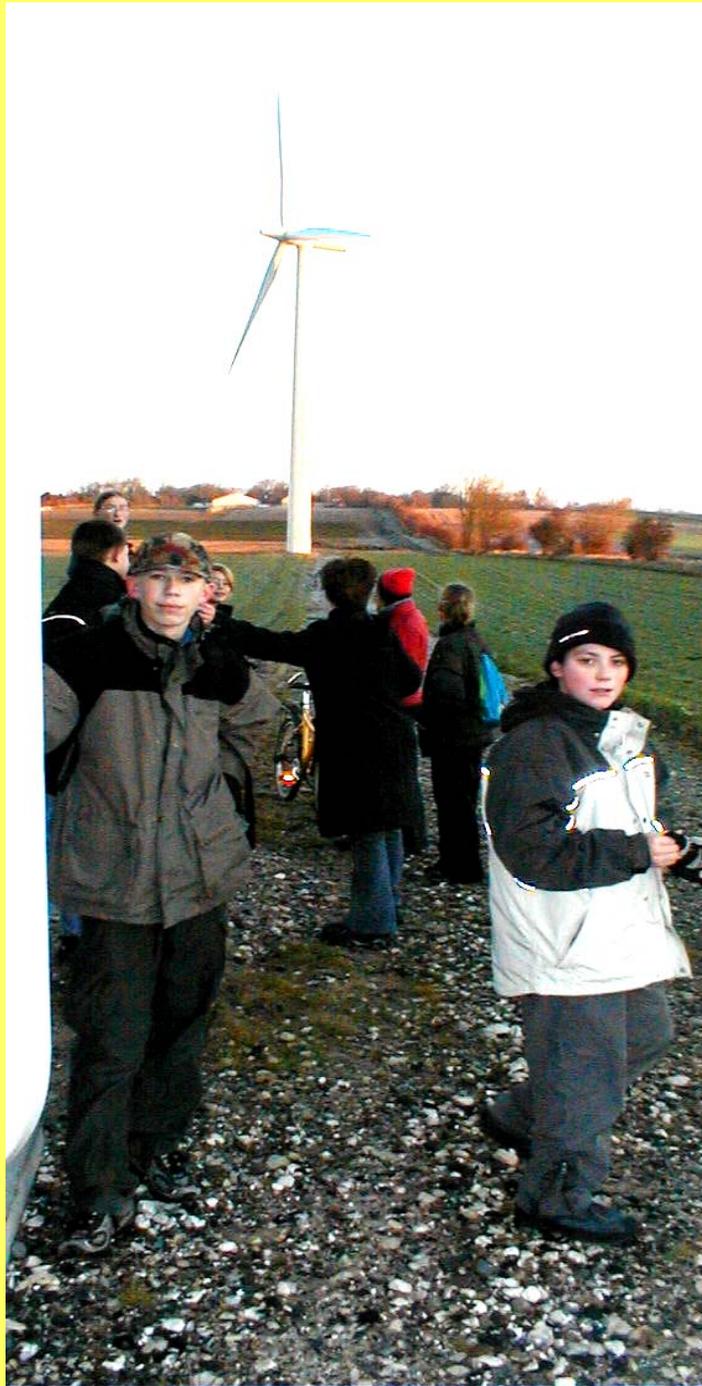
<sup>a</sup> Wind speeds are based on a Weibull k value of 2.0

Indian Reservations	
1	Standing Rock
2	Cheyenne River
3	Lake Traverse
4	Lower Brule
5	Crow Creek
6	Pine Ridge
7	Rosebud
8	Yankton
9	Flandreau

★ Meteorological Station with Wind Data  
 □ City or Town

Transmission Line Voltage	
	69 Kilovolts
	115 Kilovolts
	230 Kilovolts
	345 Kilovolts





## Danish Renewable Energy Island...

Selected in nation wide  
contest...

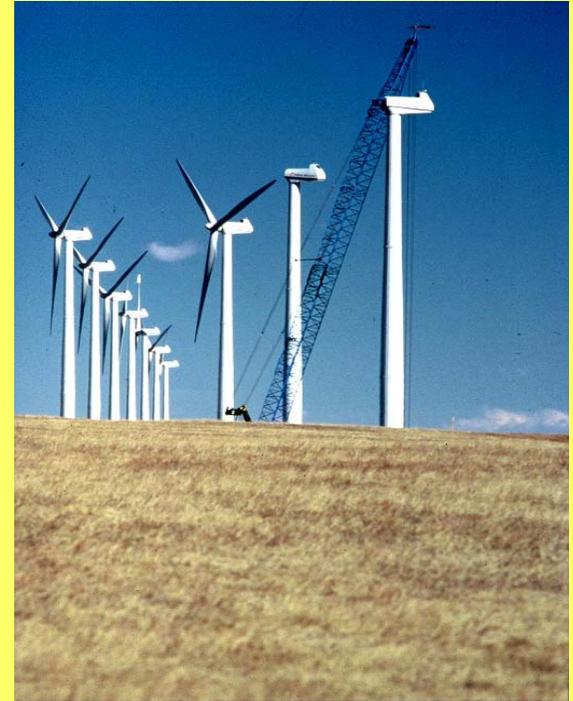
Denmark: 18%  
electricity from wind...

5% own shares of utility  
scale wind turbines..

## INTRIGUING QUESTION 2

Could South Dakota be a test case for

- Carbon capture at coal plants,
- Compressed air storage to firm wind,
- Carbon sequestration in agricultural soils?



# INTRIGUING QUESTION 3

Could Wind and Wind-  
Generated Hydrogen

Someday Be South  
Dakota's Largest Export

Worth \$1 Billion/year?



*Carpe Ventem?*

[www.aspencore.org](http://www.aspencore.org)



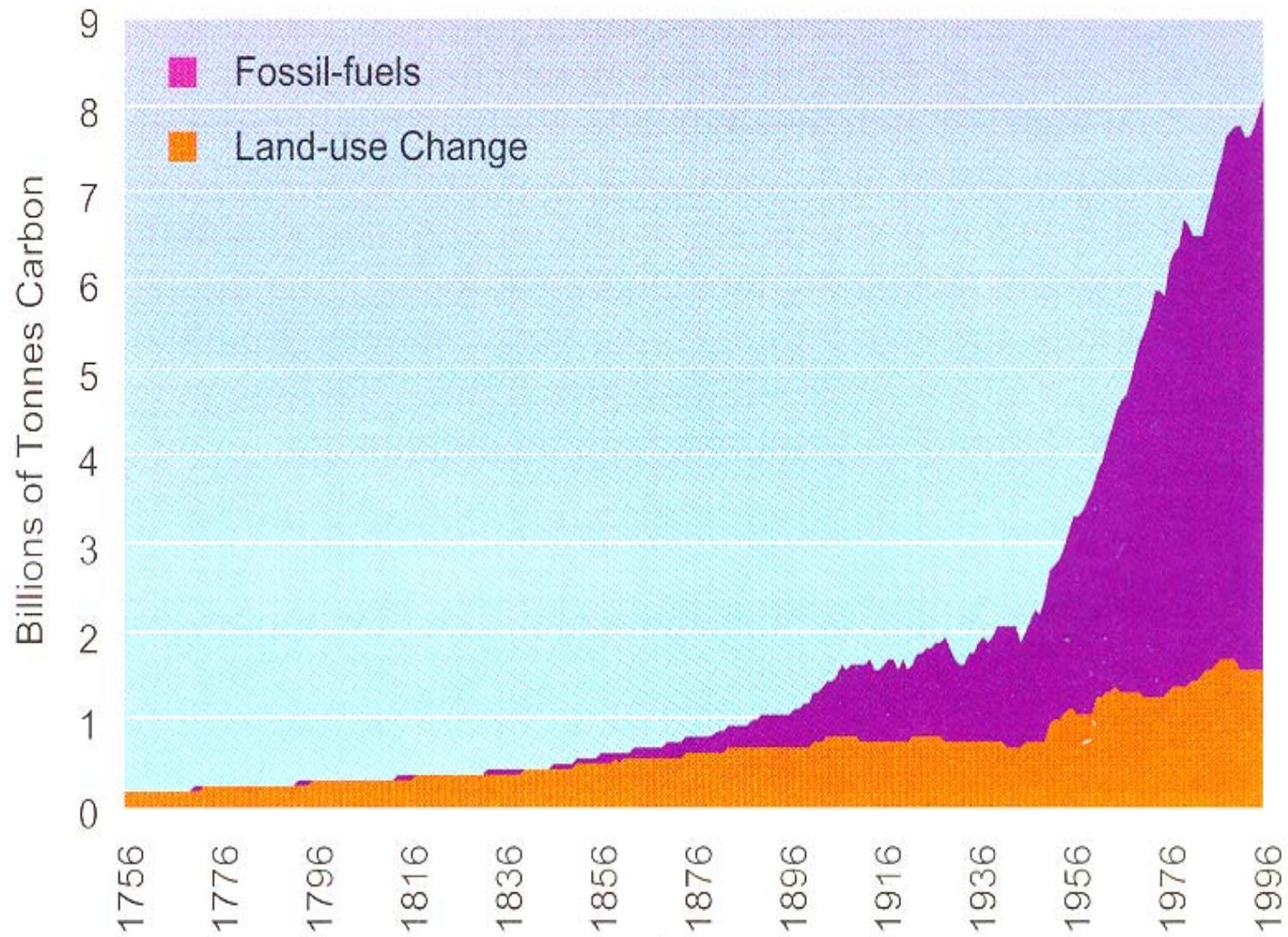


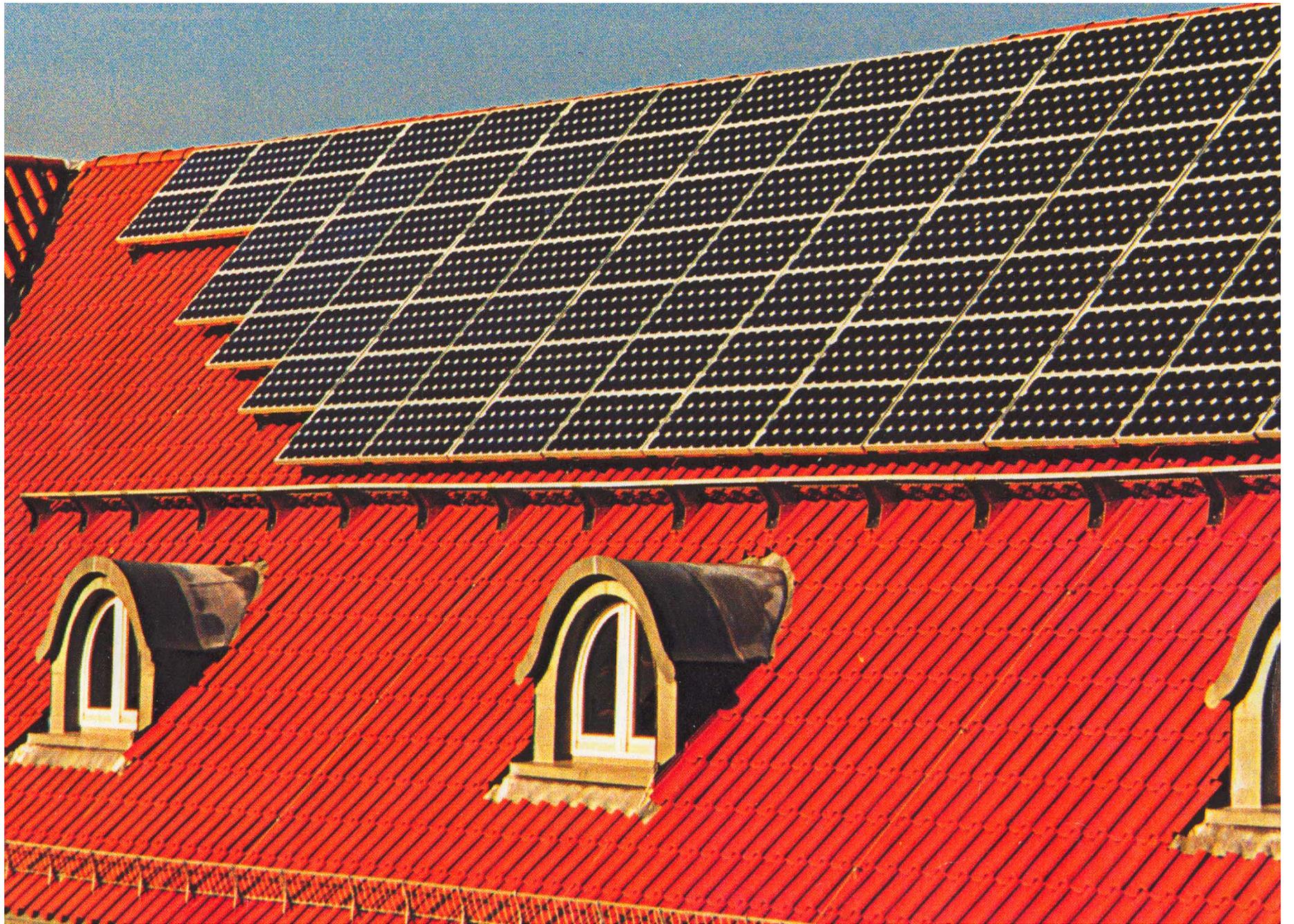


**Community Office for Resource Efficiency**

[www.aspencore.org](http://www.aspencore.org)

# Global Carbon Emissions



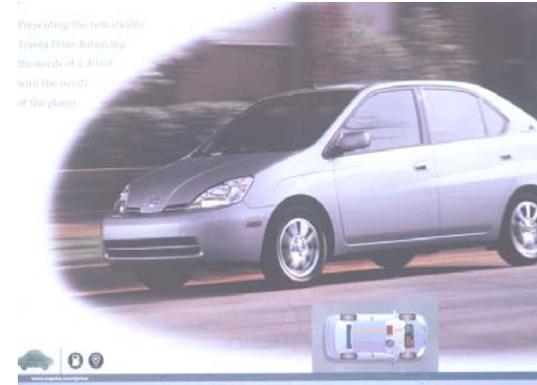


ntry.





# OPTIONS FOR CUTTING 10,000 POUNDS...



- Hybrid Electric Vehicle \$300/Month
- New House \$1500/Month
- Carbon-free Electricity \$5-15/Month