Lecture 4: Monday, February 4, 2008

HW#1 is due in class next Wednesday, February 6.
We will have a Q&A session today.
Reminders: handwrite (neatly) or use Word.
OK to discuss and check answers with friends, but write it up yourself, and show all work!

The class web site
http://www.physics.rutgers.edu/~karin/140
includes required reading (articles and weblinks) and useful course information (including the homeworks)

Special permission?
Email Ms. Julia Sotory jsotory@physics.rutgers.edu

Problem 1 (4 points)

The gas tank in your car holds 13.2 gallons of gas. Show your work!

(a) If you get 30 miles per gallon, how far can you go on one tank of gas?

(b) If you were to improve your gas mileage by 10%, how far could you go?

Improve gas mileage by 10% means get 10% more miles per gallon

Problem 2 (8 points)

Your house has an oil-fired heating system. Show your work!

(a) If you burn 5 gallons of heating oil per day in January, how much CO2 do you emit that month? Use 26 lbs of CO2 emitted per gallon of heating oil. How much carbon do you emit that month? Use 7.1 lbs of carbon emitted per gallon of heating oil. *(this is 2 questions)*

(b) If there were a carbon tax of $60 per ton of CO2 , how much would the tax add to the price of a gallon of heating oil? (remember a ton is 2000 lbs)

(c) How much would the tax in (b) add to your heating oil bill for January?

(d) Search on the Internet for a recent news report (2007 or 2008) that gives the amount of a carbon tax proposed or imposed by some national, regional or local government. How much is the tax per ton of CO2 or, if given that way, per ton of carbon (attach a printout of the page and be careful--a tax per ton of carbon just counts the weight of the carbon atoms--see part (a)). How much would the tax you found add to the price of a gallon of heating oil?
(this is 2 questions)

What's the difference between
a carbon tax per ton of CO_2 and
a carbon tax per ton of carbon?

The atomic mass number of C is 12
The atomic mass of O is 16
So one ton of CO_2 contains 0.27 tons of carbon (12/44)

If you emit 1 ton of CO_2 and the carbon tax is \$10 per ton of CO_2, what is the tax you pay?

If you emit 1 ton of CO_2 and the carbon tax is \$10 per ton of carbon, what is the tax you pay?

Problem 3 (8 points) Show your work!

(a) If you use heating oil as fuel at $3.80 per gallon, how much do you pay for 1 Btu?

(b) How many Btus does it take to bring 25 gallons of water from room temperature (72 F) to boiling point (212 F)? (1 gallon of water weighs 8.34 lbs.)

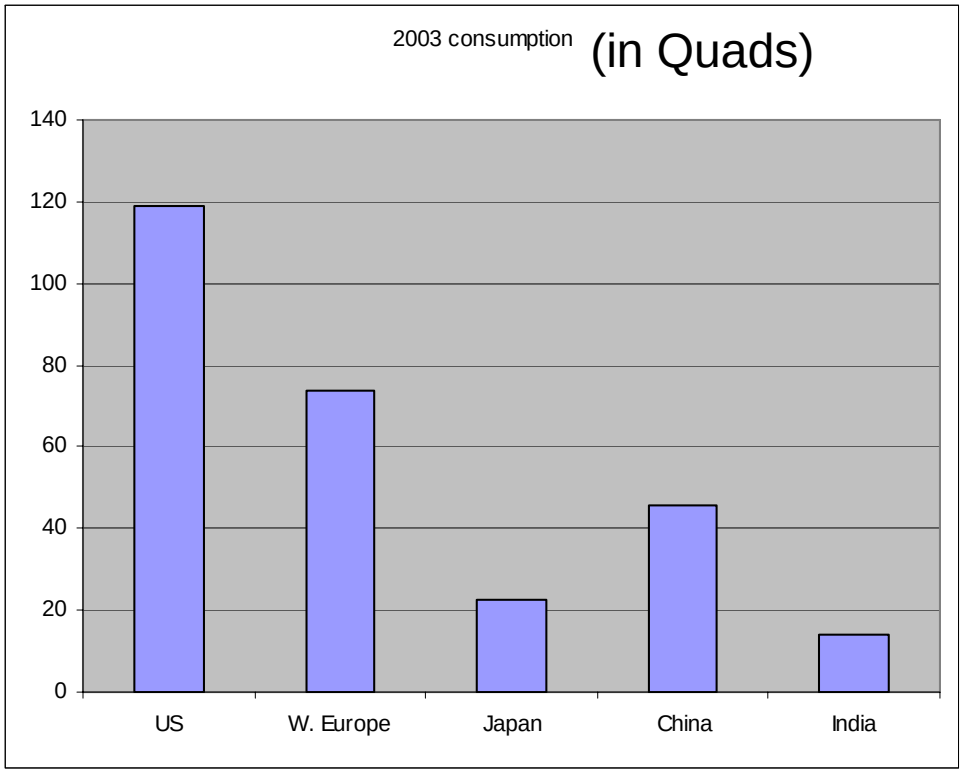
(c) If you use heating oil as the fuel, how much does it cost?

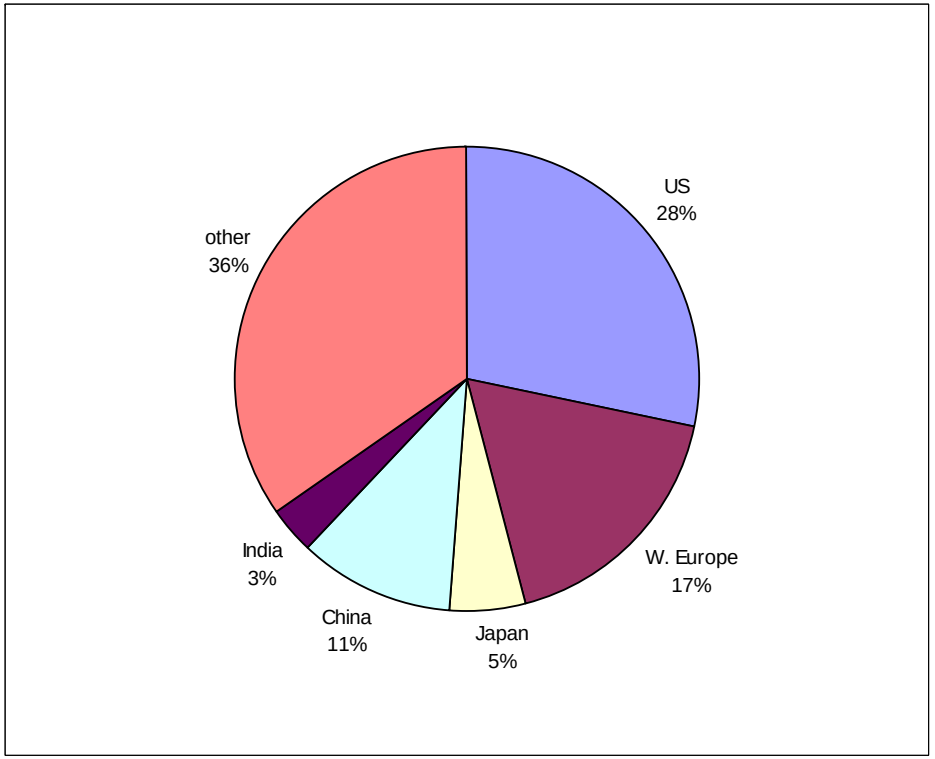
(d) If instead you use natural gas as the fuel at $13.50 per thousand cubic feet, how much does it cost to heat the water in (b)? Which is cheaper?

Energy content of various fuels

1 barrel (42 gallons) of crude oil = 5,800,000 Btu
1 gallon of gasoline = 124,000 Btu
1 gallon of heating oil = 139,000 Btu
1 gallon of diesel fuel = 139,000 Btu
1 barrel of residual fuel oil = 6,287,000 Btu
1 cubic foot of natural gas = 1,026 Btu

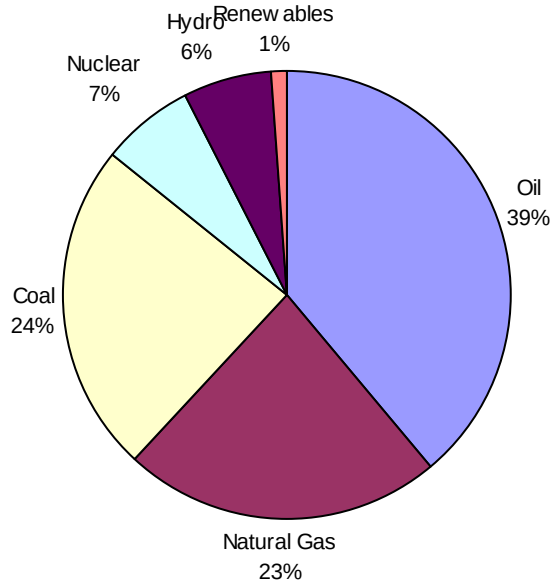
2003


2003 consumption (in Quads)
140
120
100
80
60
40
20
0
US
W. Europe
Japan
China
India

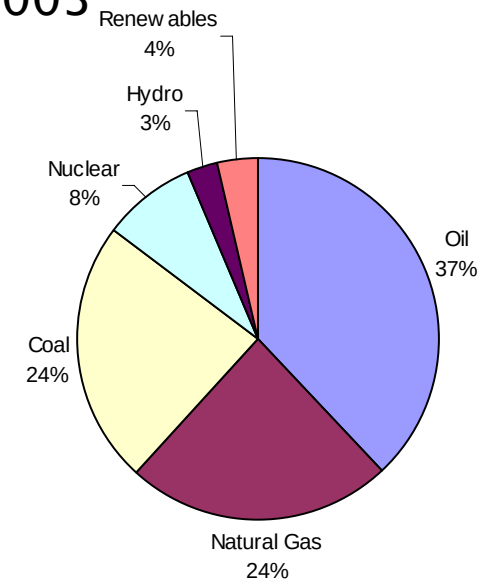

US
28%
W. Europe
17%
Japan
5%
China
11%
India
3%
other
36%

Energy consumption by source

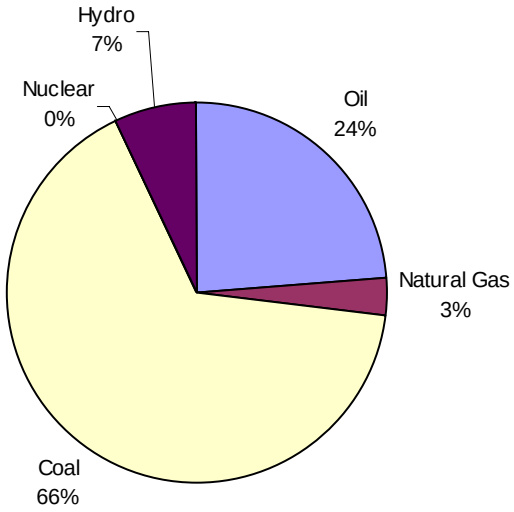
World 2003

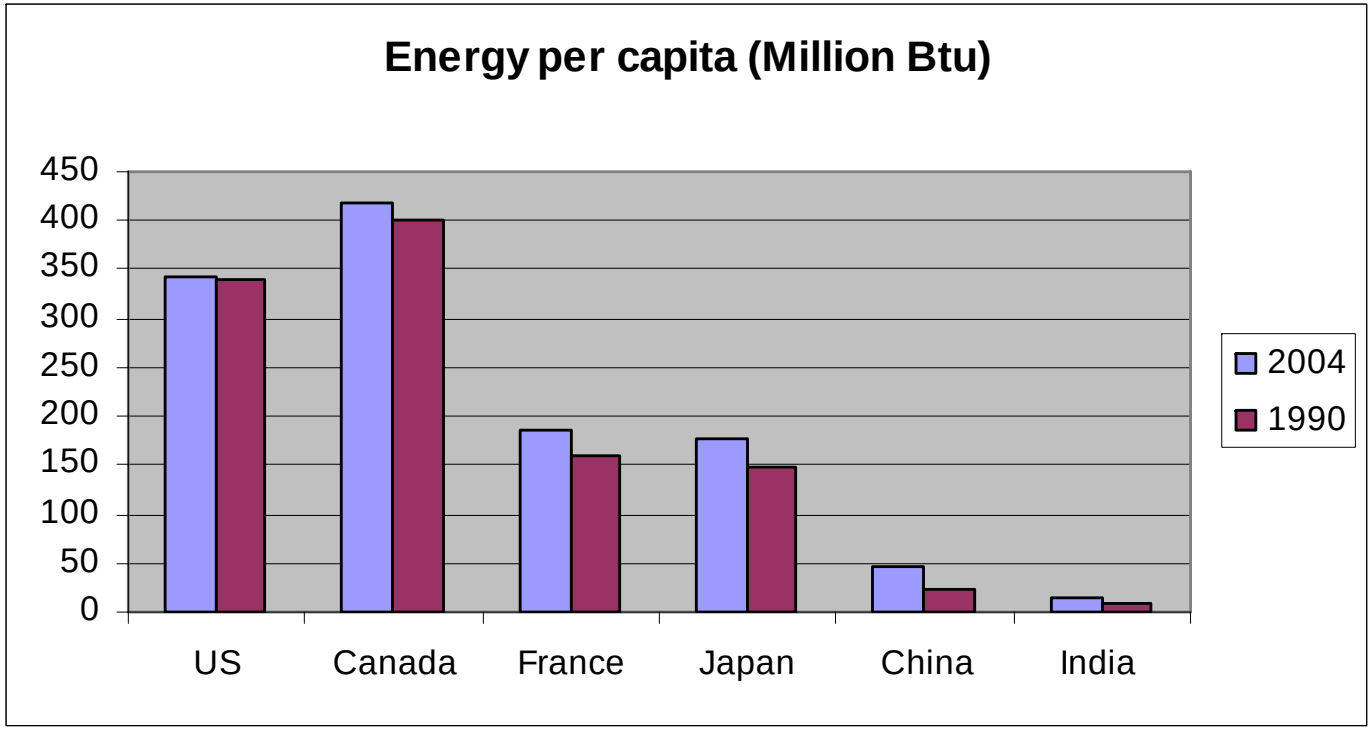


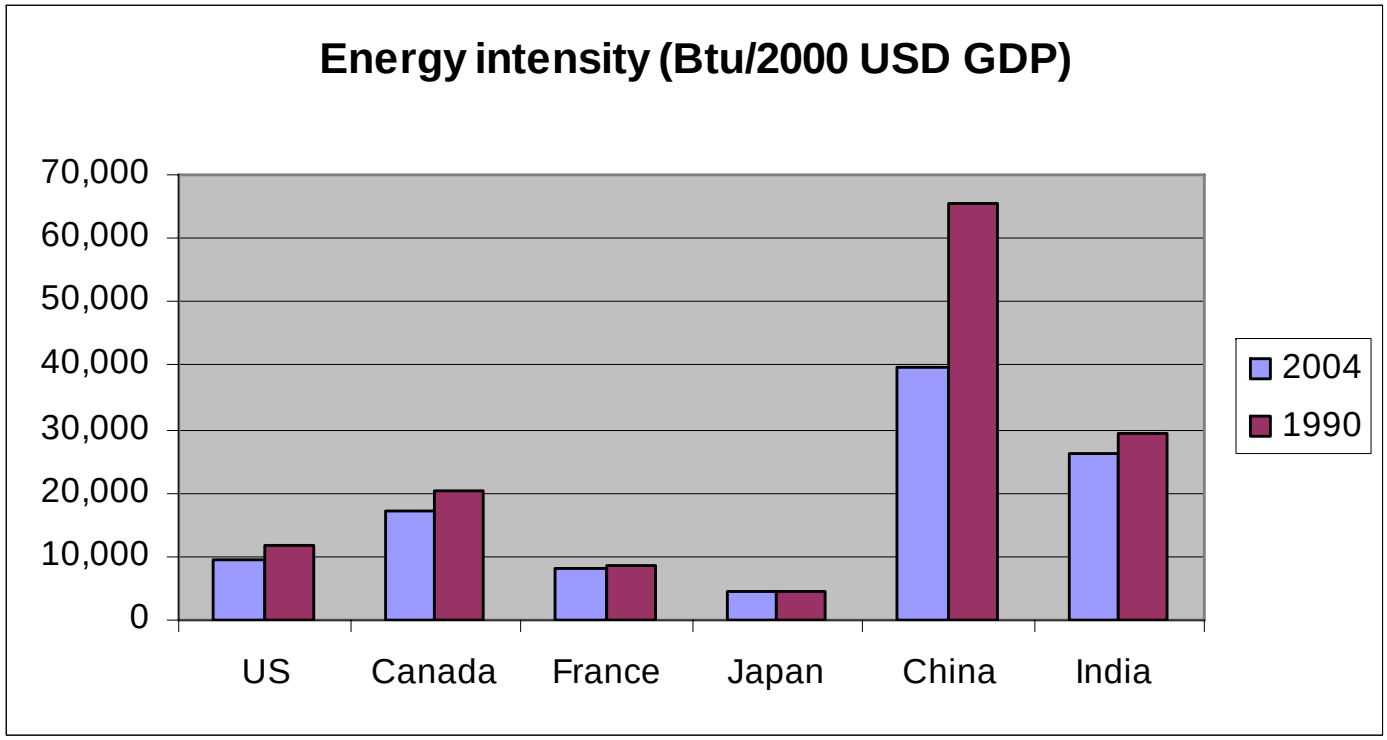
US 2003



China 2002




Energy per capita (Million Btu)
450
400
350
300
250
200
150
100
50
0
US
Canada
France
Japan
China
India
2004
1990


Energy intensity (Btu/2000 USD GDP)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
US
Canada
France
Japan
China
India
2004
1990

PSE&G Gas

Usage	Meter **2829183**
Actual reading Jan 17	935
Actual reading Dec 15	912
Difference	23
Conversion to CCF	x 1.0120
CCF total	23.276
Conversion to therms	x 1.03500
Total therms	24.091

Charges		Rate - RSG
Delivery		
Service charge		$5.79
Distribution charge	24.091 therms @ $0.2519613	6.07
Total Delivery		**$11.86**
Supply*		
BGSS Commodity	24.091 therms @ $0.79822340	19.23
Total Supply		**$19.23**
Total gas charges		**$31.09**

PSE&G Electric

Usage	Meter **126628218**
Actual reading Jan 17	26155
Actual reading Dec 15	25647
Total kWh	508

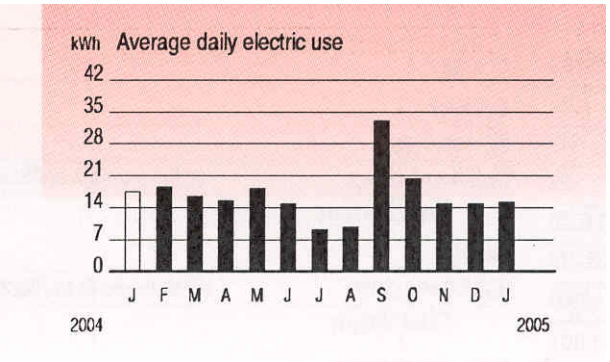
Charges		Rate - RS
Delivery		
Service charge		$2.41
Distribution charges		
kWh charges	508 kWh @ $0.053818898	27.34
Sub-Total Delivery		**$29.75**
Supply*		
BGS Energy		
Charges	508 kWh @ $0.054842520	27.86
Sub-Total Supply		**$27.86**
Total electric charges		**$57.61**

Date Delivered 08:09 1/17/05
Gallons Delivered 180.4
Driver No 429 Truck No 1129

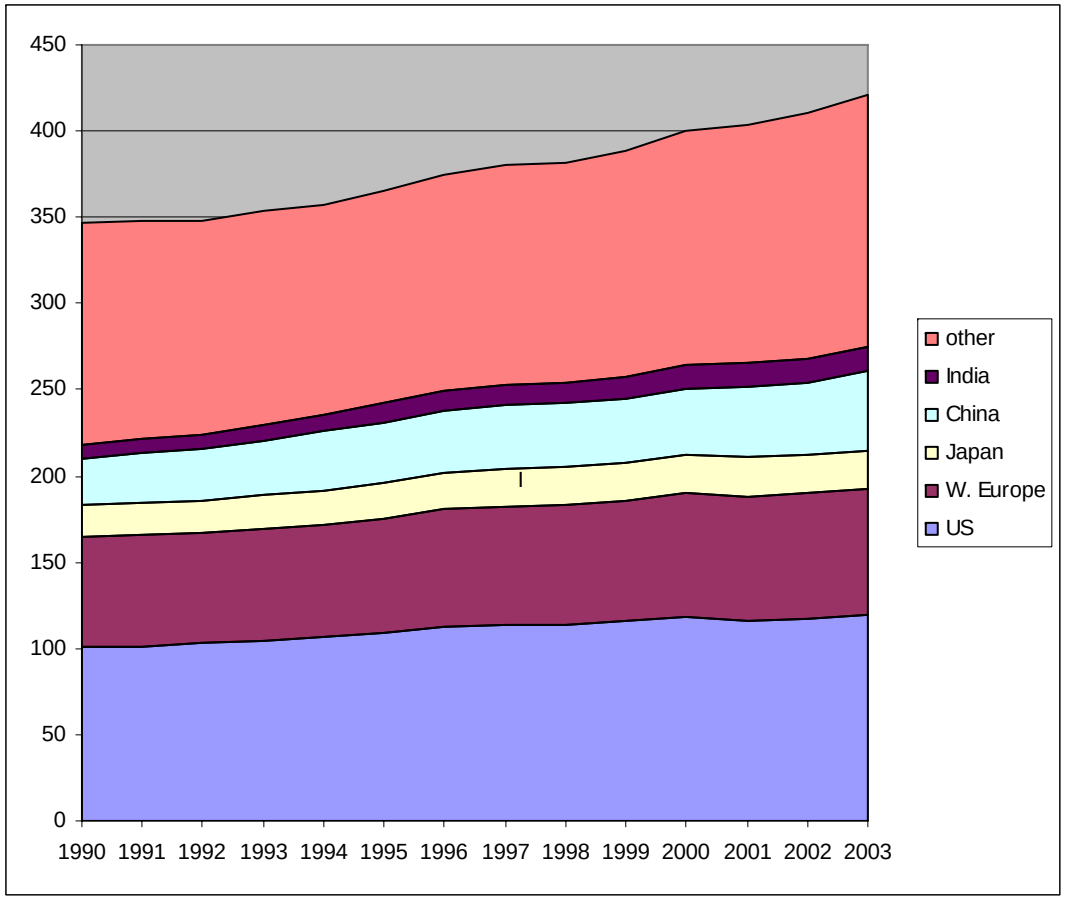
DESCRIPTION OF CHARGE	AMOUNT
#2 HEATING OIL	351.60
<180.4 Gallons @ $1.949>	
TOTAL # THIS DELIVERY	$351.60

SALESMAN: _____

ITEM	QTY	PRICE	AMOUNT
UNLEAD	8.428 gal	1.839	15.50
		TAX	0.00
		TOTAL $	15.50



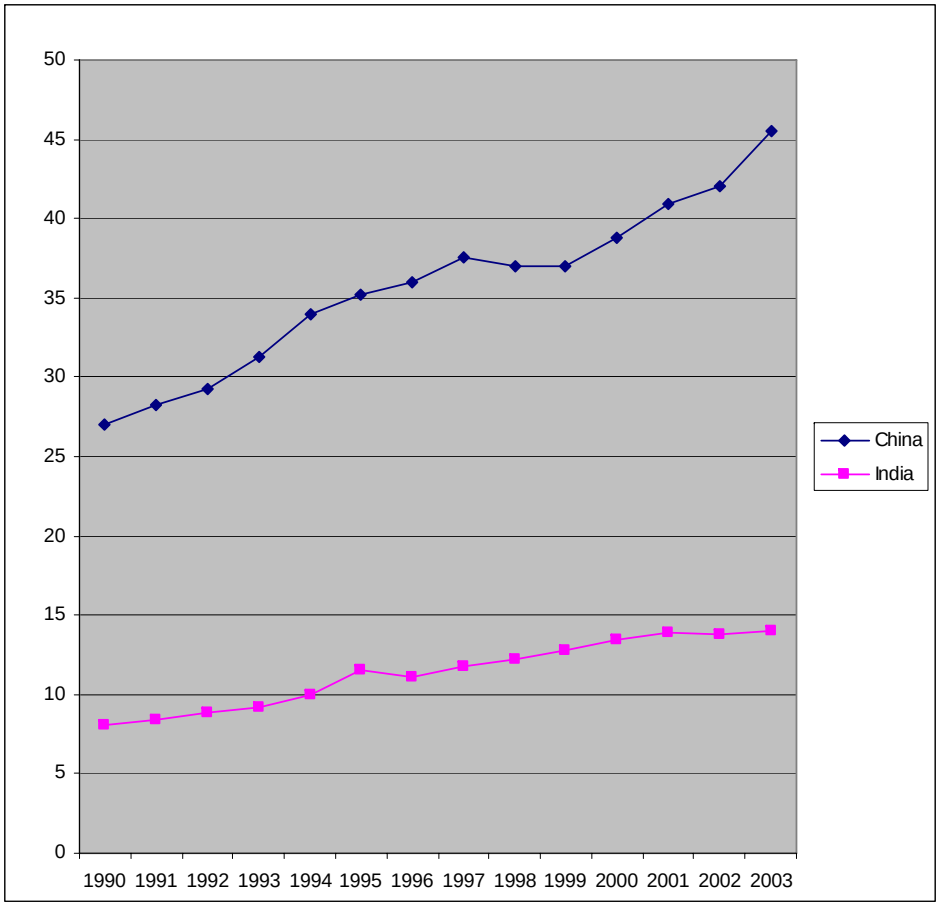
Energy consumption information: International



Annual energy consumption, in quads

(a quad is 1 quadrillion Btu, that is, 1 with 15 zeros (10^{15})

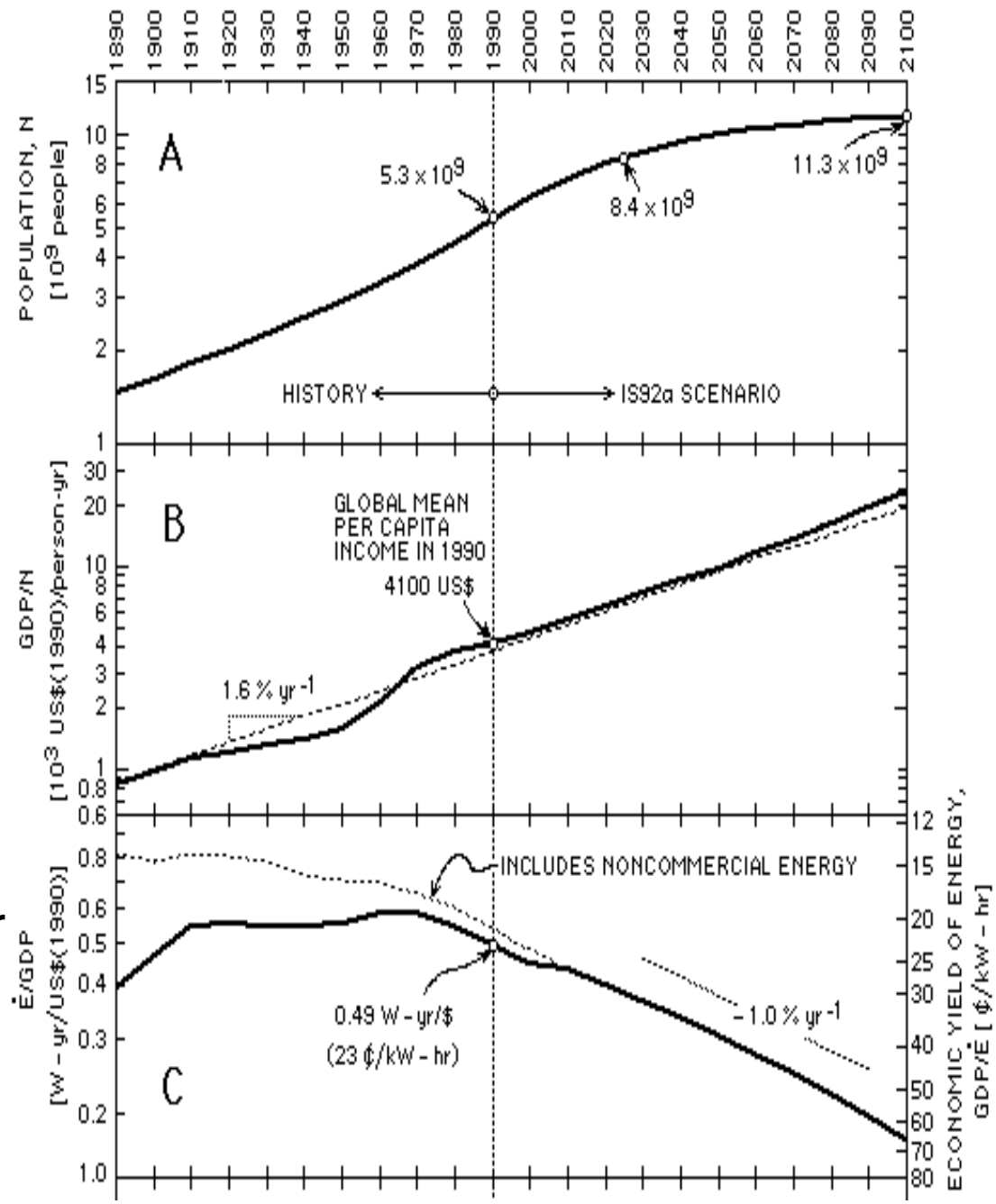
Growth of energy consumption in China and India 1990-2003



Population Growth to
10 - 11 Billion
People in 2050

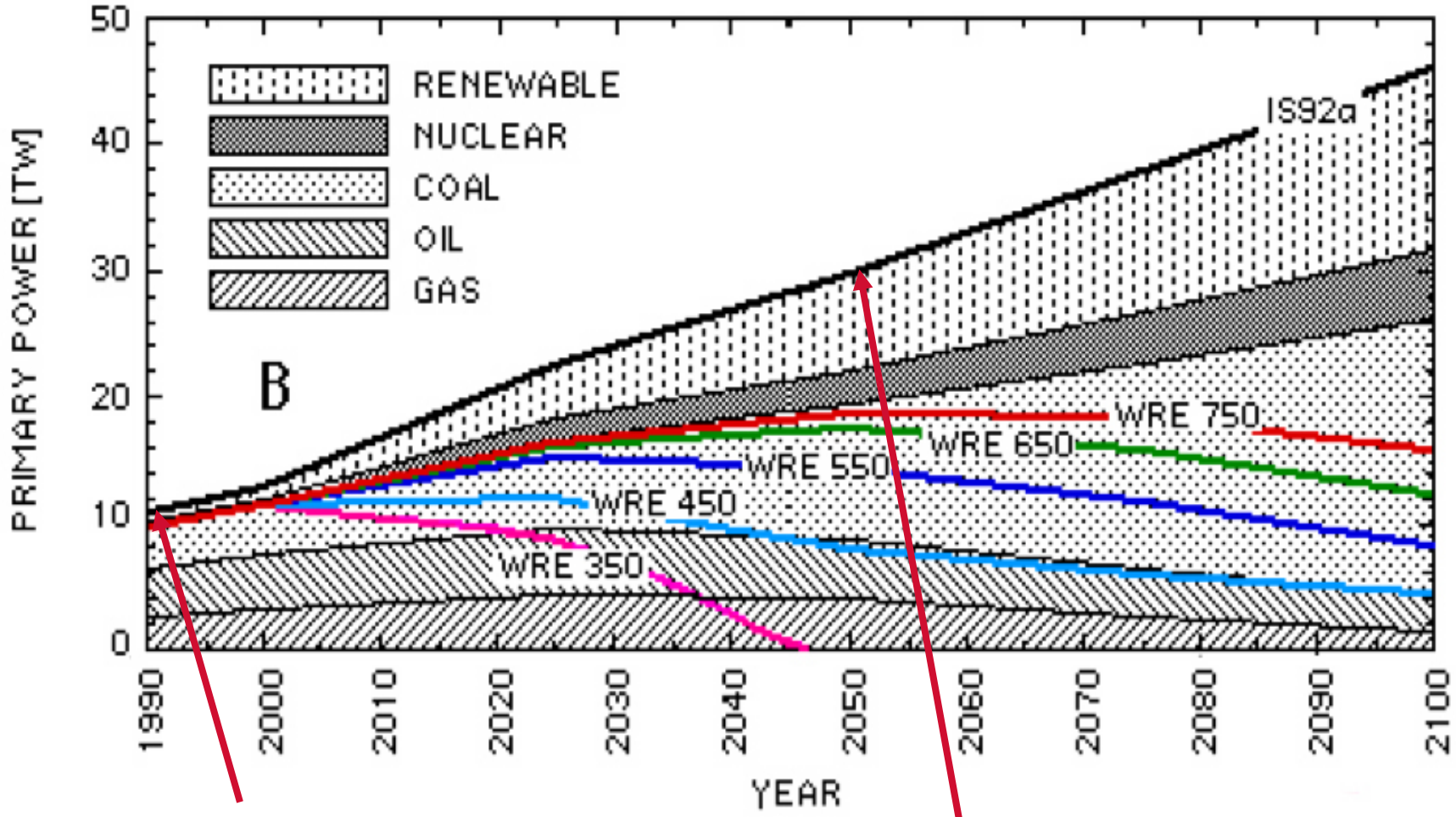
Per Capita GDP Growth
at 1.6% yr^{-1}

Energy consumption per
Unit of GDP declines
at 1.0% yr^{-1}



Nathan Lewis, Stanford

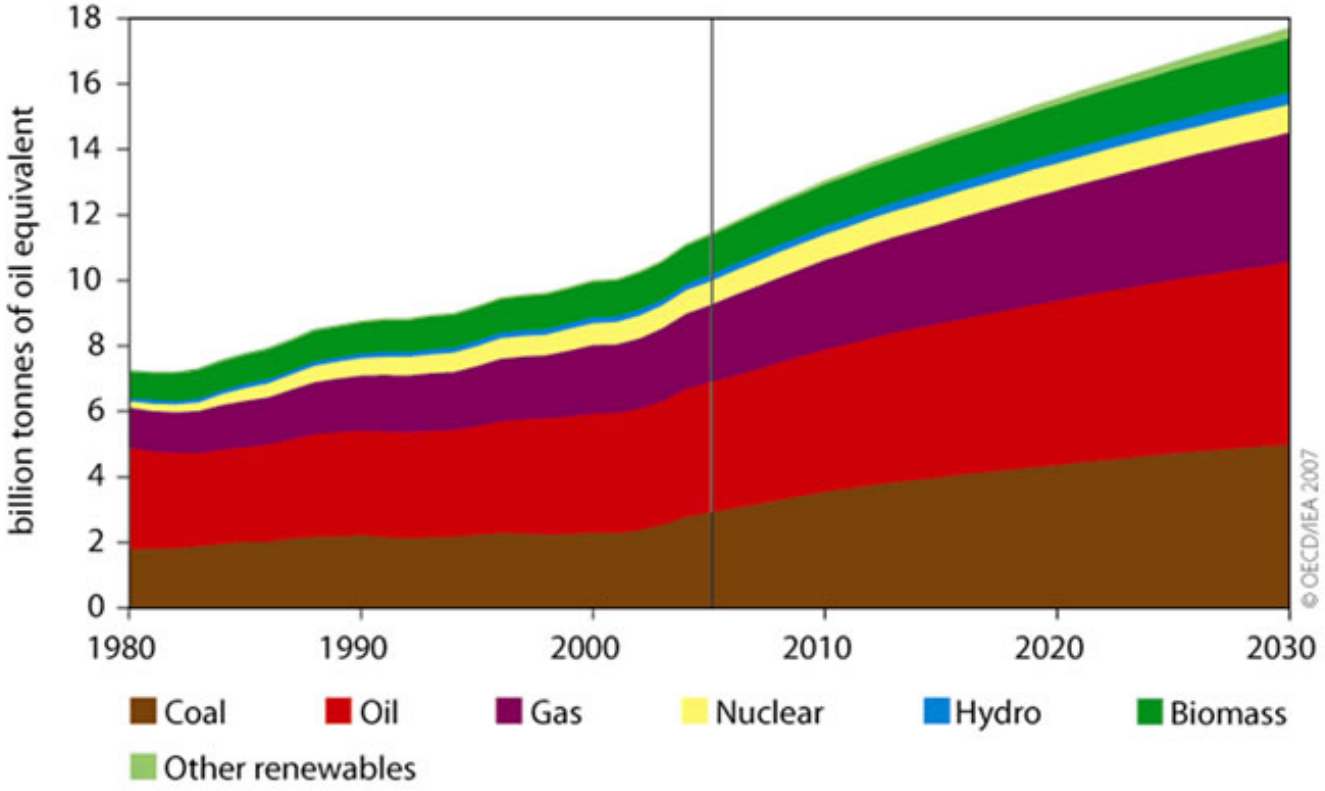
Total Primary Power vs Year



1990: 12 TW 2050: 28 TW

Nathan Lewis, Stanford

World Primary Energy Demand in the Reference Scenario



Units of energy

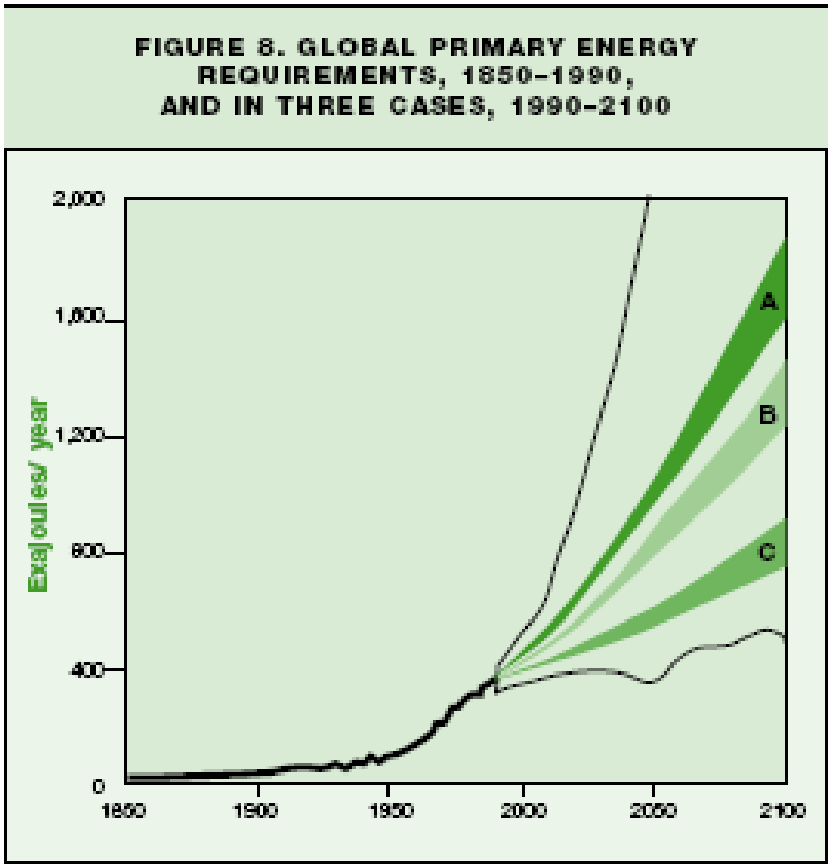
1 Btu = 1055 J = 252 cal
Ton of oil equivalent (toe) = 40 million Btu = 42 GJ

1 food Calorie = 1000 cal
1 Btu = 252 cal
1 kWh = 3413 Btu

Units of power = energy/time

1 W = 1 J/s = 3.41 Btu/h
1 hp = 746 W

"It is very difficult to make an accurate prediction, especially about the future"
Attributed to Danish physicist Niels Bohr, quoting Danish cartoonist Storm P.



The figure also shows the wide range of future energy requirements for other scenarios in the literature. The vertical line that spans the scenario range in 1990 indicates the uncertainty across the literature of base-year energy requirements.

Source: Nakićenović, Grübler, and McDonald, 1998; Morris and Lee, 1998; Nakićenović, Victor, and Morris, 1998.

Projections, not predictions
Based on various scenarios

- the *Reference Scenario* shows the trends in surging energy consumption and CO2 emissions under existing government policies;

- the *Alternative Policy Scenario* shows how policies driven by concerns for energy security, energy efficiency and the environment, under discussion but not yet adopted, could curb growth in energy demand;

- the *High Growth Scenario* analyses what would happen to energy use if current high levels of economic growth in China and India persist through the projection period.

From World Energy Outlook 2007, to be discussed more in a few minutes

WEEK IN REVIEW DESK

The World; China's Economic Engine Needs Power (Lots of It)

By JIM YARDLEY (NYT) 1023 words
Published: March 14, 2004

Correction Appended

BEIJING - FOR all the hoopla about China's booming economy, its manufacturing muscle and its potential to become a great power, the world's most populous country is struggling to keep the lights on. And the sporadic blackouts that plagued much of China last year are raising complicated questions for the Communist Party and for the rest of the world:

How and where will China get the energy it needs to maintain its economic growth? And how much will the environment suffer for it?

"It's one of the hottest issues facing the international energy industry," said Scott Roberts, chief representative in the Beijing office of Cambridge Energy Research Associates, a consulting firm based in Massachusetts. "The growth has been explosive, and I think it has caught many people in China and elsewhere off guard."

China's emergence has already roiled commodities markets, as the country has become a voracious consumer of energy and raw materials. Last year, its oil imports rose by nearly a third. It also built so many new cars, factories, airports and high-rises that it passed the United States to become the world's biggest steel importer, according to the Iron and Steel Statistics Bureau, a British-based information clearinghouse for the steel industry. Last year, China accounted for almost a third of the world's consumption of finished steel.

Electricity consumption jumped by 15 percent. Domestic coal production rose by 100 million tons -- and still there were shortages.

Yet China's appetite today is modest compared with what is estimated for the future; the country's energy needs are expected to more than double by 2020. This prospect has the Communist Party reportedly rolling out plans for at least 100 new power plants, including nuclear, hydropower and coal-fired ones. It has also raised concerns that efforts to improve China's polluted environment will be muted by the demand for power.

China is trying just about every possible avenue to satisfy its power demands, and none offers a completely risk-free or "clean" solution. Plans call for at least 20 nuclear plants to be built by 2020. Hydropower projects, regarded by many Chinese officials as a clean power source, are threatening to disrupt the ecological balance on many important rivers that flow out of the high Tibetan plateau.

China's primary energy source, and its dirtiest, is coal, which accounts for almost 70 percent of the power supply. Coal is a primary source of greenhouse gases, and experts predict that by 2020 China could pass the United States to become the world's biggest source of carbon dioxide. That this is happening is perhaps not surprising, because America is an economic, if not political, model for China.

"The fundamental problem is that China is following the path of the United States, and probably the world cannot afford a second United States," said Zhang Jianyu, program manager for the Beijing office of Environmental Defense, an American-based advocacy group.

In an address earlier this month before the annual meeting of the National People's Congress, Prime Minister Wen Jiabao captured the competing pressures of the economy when he cited environmental protection and called for building a "conservation-minded society." Yet he also exhorted the country to develop more energy sources.

"We must speed up the development of large coal mines, important power generating facilities and power grids, the exploration and exploitation of petroleum and other important resources," he said.

Michelle Billig, a former energy attaché in the United States Embassy in Beijing, said China's leaders are improving energy efficiency and becoming more environmentally friendly. She noted that China is completing the creation of fuel-efficiency standards that are better than those in the United States. The government is also experimenting with buses and taxis that run on natural gas and expanding its use of "clean" coal technology.

"In some ways, they are addressing these issues a lot more seriously than we are in the United States," said Ms. Billig, now an international affairs fellow with the Council on Foreign Relations.

But experts agree that such efforts, as yet, are making only a tiny difference and that too often environmental restraints are brushed aside to meet the demand for power. Mr. Zhang said China's environmental degradation is already being measured in economic losses. He said state officials estimate that acid rain causes about $13 billion, while air pollution reduces the annual gross domestic product by about 3 percent.

China is also often inefficient in its energy use. Mr. Roberts, the Cambridge Energy consultant, said that the worst Chinese industries waste 70 percent more energy than their counterparts in the United States. He also noted that China's electricity consumption grew by 15 percent last year and 10.4 percent in 2002 -- a spike in demand he said was equal to total power consumption in Brazil.

"They are adding a middle-sized country every two years in terms of energy consumption," he said.

This helps explain why energy security is an increasingly important issue for Chinese leaders, particularly regarding oil. China began importing oil in the early 1990's, partly because its own supplies were leveling out, but also because of rising demand. Now the American invasion of Iraq has shown Chinese leaders, dependent on Middle East oil, how vulnerable they could become.

A December 2003 analysis of China's energy situation by Deutsche Bank noted that in response to the Iraq war, China has begun building a group of storage facilities to create a strategic oil reserve. The report also noted that the country is aggressively pursuing oil deals around the world, from neighboring Kazakhstan and Russia to other oil fields in South America and even Canada. Earlier this year, President Hu Jintao made visits to African countries with significant oil fields.

For now, power officials are warning citizens that another spate of blackouts is likely. Last year, nearly two-thirds of the provinces and autonomous regions experienced varying degrees of blackouts. This year, officials say, could be as bad, or maybe worse.

The New York Times
nytimes.com

November 7, 2006

China to Pass U.S. in 2009 In Emissions

By KEITH BRADSHER; JAD MOUAWAD CONTRIBUTED REPORTING FROM NEW YORK.

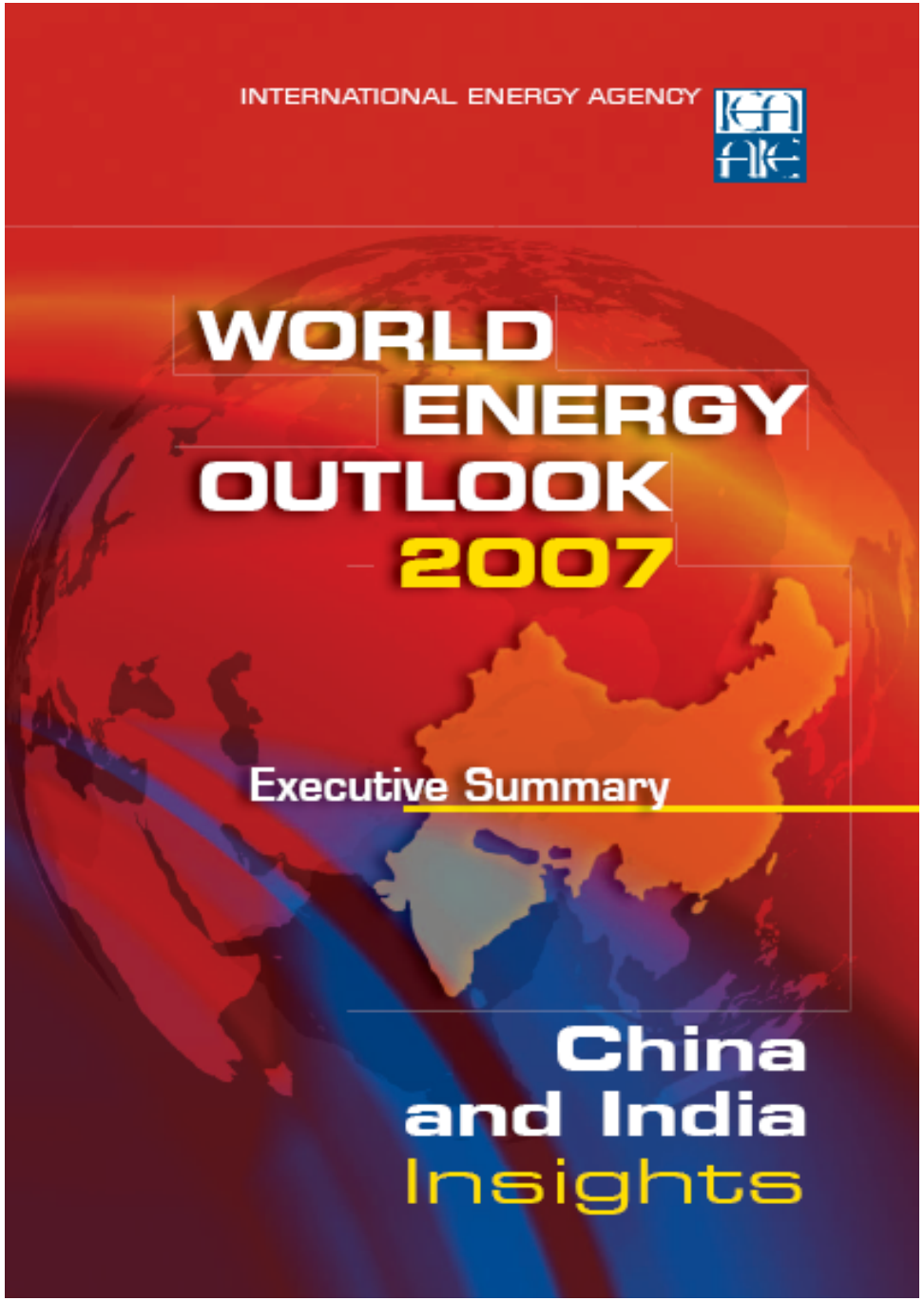
China will surpass the United States in 2009, nearly a decade ahead of previous predictions, as the biggest emitter of the main gas linked to global warming, the International Energy Agency has concluded in a report to be released Tuesday.

If nothing is done, global energy demand is projected to grow 53 percent by 2030, the energy agency said. Oil consumption is seen jumping to 116 million barrels a day, compared with 85 million barrels now, mostly because of increased oil consumption in developing countries.

Demand for coal, mostly for power generation, will rise 59 percent. As a result, energy-related carbon dioxide emissions will increase 55 percent, to 44.1 billion tons in 2030.

Worldwide coal consumption has risen as much in the last three years as it had in the previous 23 years, Mr. Birol said. China accounts for 90 percent of the increase, the result of steeply rising demand for electricity that is mostly generated by coal-fired power plants.

India is responsible for about 8 percent of the increase in coal use, and the United States for most of the rest, Mr. Birol said. The agency's forecast of China's carbon dioxide emissions also reflects a revised prediction that China's economy will grow 5.5 percent a year over the next quarter-century, slightly higher than previously expected, which will result in higher energy use.


INTERNATIONAL ENERGY AGENCY
WORLD ENERGY OUTLOOK 2007
Executive Summary
China and India Insights

The volume is divided into the following parts:

Part I: Energy and major global issues

Chapter 1 introduces the economic aspects of energy and considers the relationship between energy and economic growth, the investment requirements needed to ensure sufficient and affordable energy for the future, and various aspects of energy pricing.

Chapter 2 addresses key social issues that affect and are affected by the way energy is produced and used, including poverty, women, urbanization and population. It stresses the critical challenge of finding ways to meet the needs of nearly one-third of the world's people whose choices in life are limited by inadequate access to energy services. The possibilities for the developing regions to take a development path that reduce harmful emissions are also discussed.

Chapter 3 considers the effects and limitations of current energy systems and trends, in terms of the environment. The consequences of various energy technologies, from indoor air pollution from household cooking stoves to urban air pollution and acidification, to chemical changes in the global atmosphere will be analysed in this context.

Chapter 4, on security issues, discusses how energy supply and demand affect issues of national, regional and global security.

Part II: The resources of energy and technology options

Chapter 5 reviews the potential of known energy fossil fuel and renewable resources to meet the world's projected demand for energy well into the next century.

Chapter 6 looks at the potential for energy end-use efficiency to offset demand by applying known technologies to provide people with more energy services from the same quantity of energy resources.

Chapter 7 discusses the potential role renewable energy resources and technologies including biofuels, hydropower, wind and solar energy can play in meeting local and global demand.

Chapter 8 considers advanced energy technologies that may be able to improve the safety and environmental soundness of nuclear power and fossil fuels.

Part III: Are sustainable futures possible?

Chapter 9 evaluates three energy scenarios, showing how different patterns of energy production and use, relate to the issues discussed in chapters 1-4. One "reference case" scenario is based on the extrapolation of current trends; the other two project more sustainable patterns of energy distribution and use.

Chapter 10 takes a closer look at the key role rural energy can play in improving the lives of people currently without access to modern energy services.

Part IV: Where do we go from here?

Chapter 11 examines how policies can impact patterns or energy production, distribution and use.

Chapter 12 looks at how the sustainable futures discussed in Part III may be realized. It analyses past successes and failures in the policy arena, as well as barriers to change.