

Comparative Energy Systems

Lecture 2

Satellite Observations of CO Concentrations: Can You Explain Their Locations?

Video links of CO concentrations in simulation are no longer available.

Gathered Wood is Important Historically & in Some Developing Nations Today

Pct. of Total Energy from "Primary Biomass": 2007	
Afghanistan	47.2
Bangladesh	42.0
Brasil	33.3
Cambodia	70.8
China	2.8
Ethiopia	92.5
Haiti	39.6
India	27.3
Kenya	19.5
Viet Nam	44.8
Source: United Nations	

This “Non-Commercial” energy is generally ignored

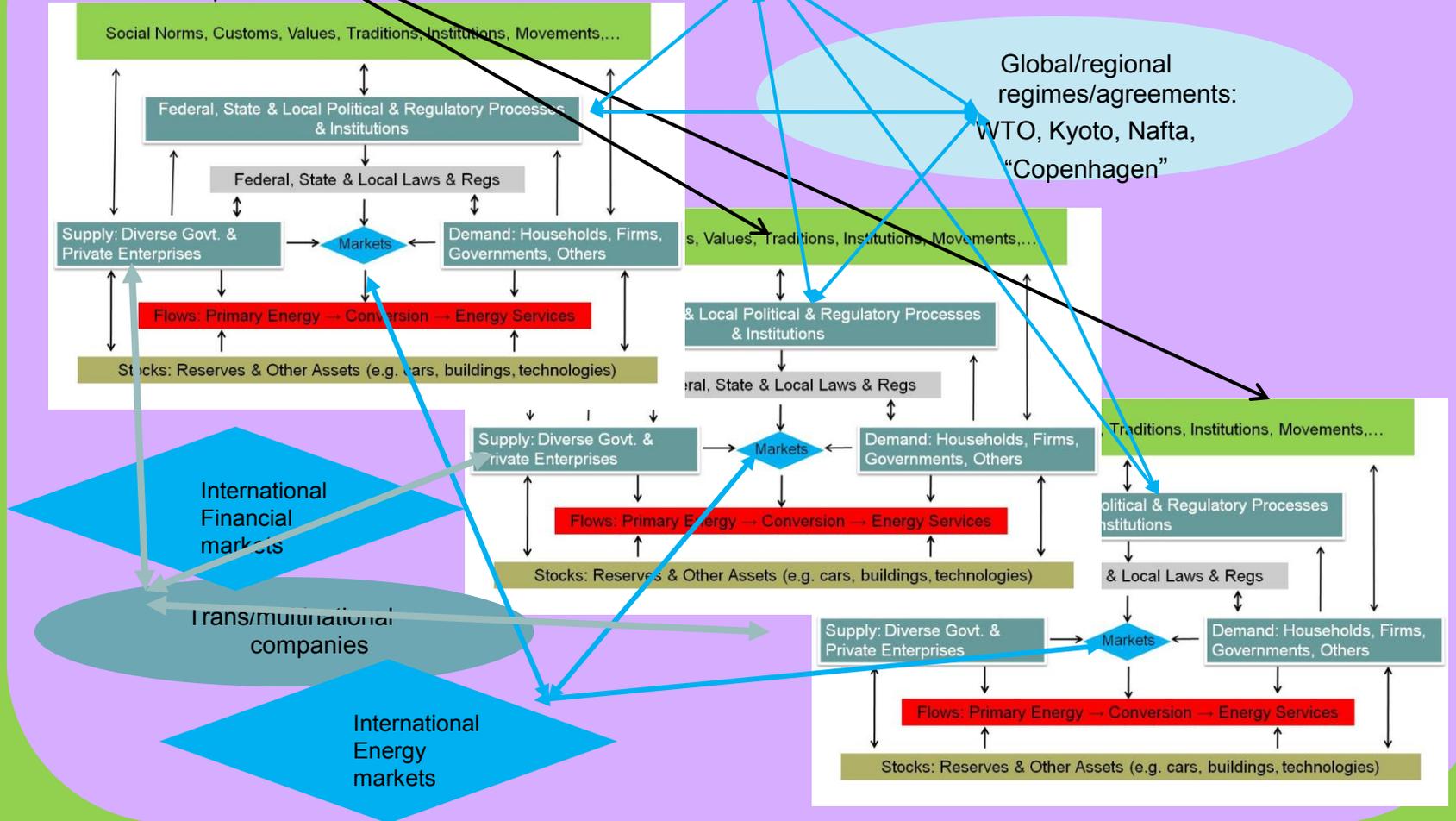
How Else Did Humans Acquire Energy Before Fossil Fuels?

- Mainly animals, wind, water
- Note that these resources, like wood, vary considerably from region to region – little wood in deserts
- Comparing pre-industrial energy systems at various times, big differences based on
 - available resources,
 - climate,
 - level of technology,
 - level of organization (rise/fall of empires), ...

The Global Energy System

Intercultural communication, emulation, rivalry
 International interdependence, rivalry, collaboration

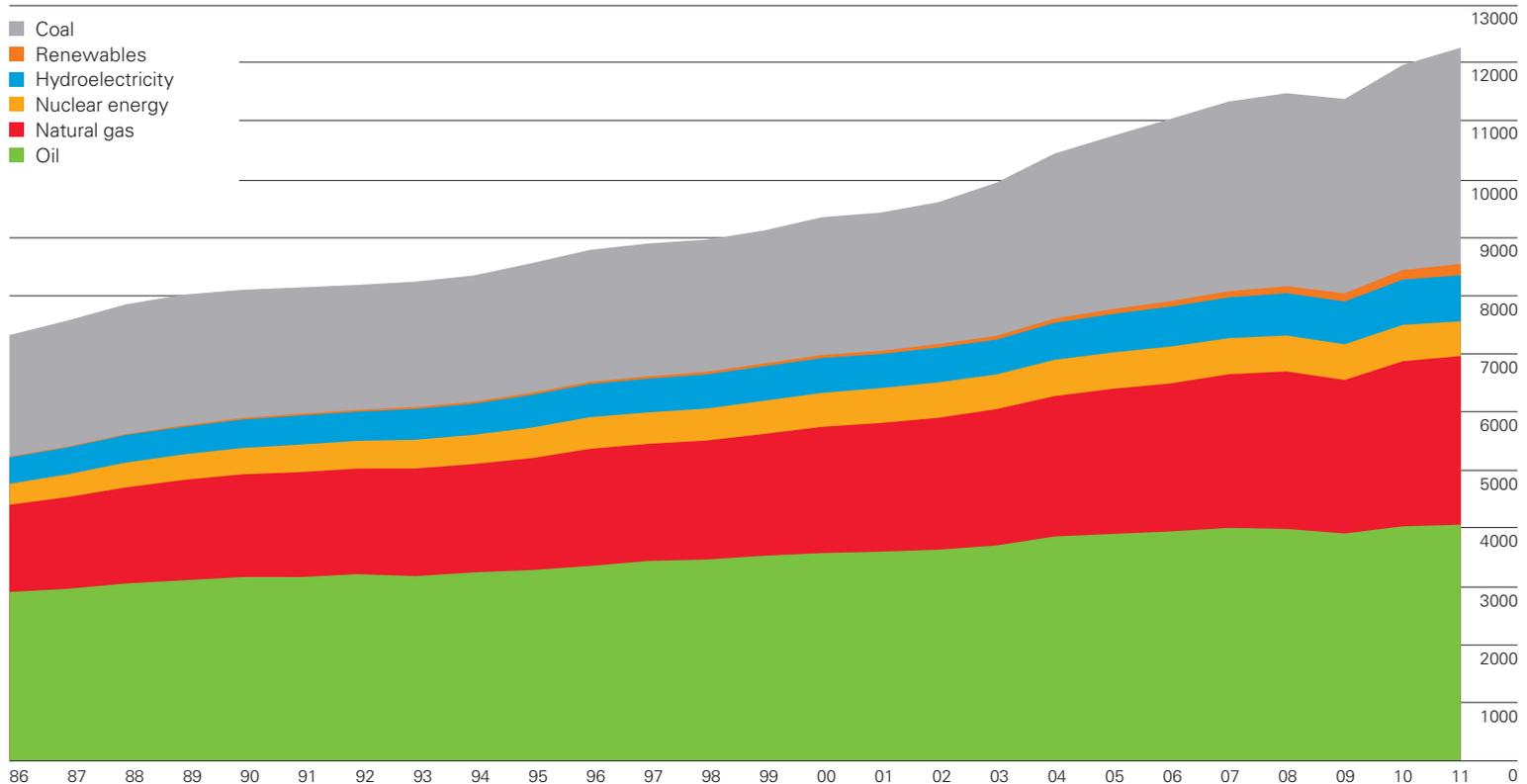
GHG



Global Primary (Commercial) Energy: Shares of Coal, Gas Are Rising

World consumption

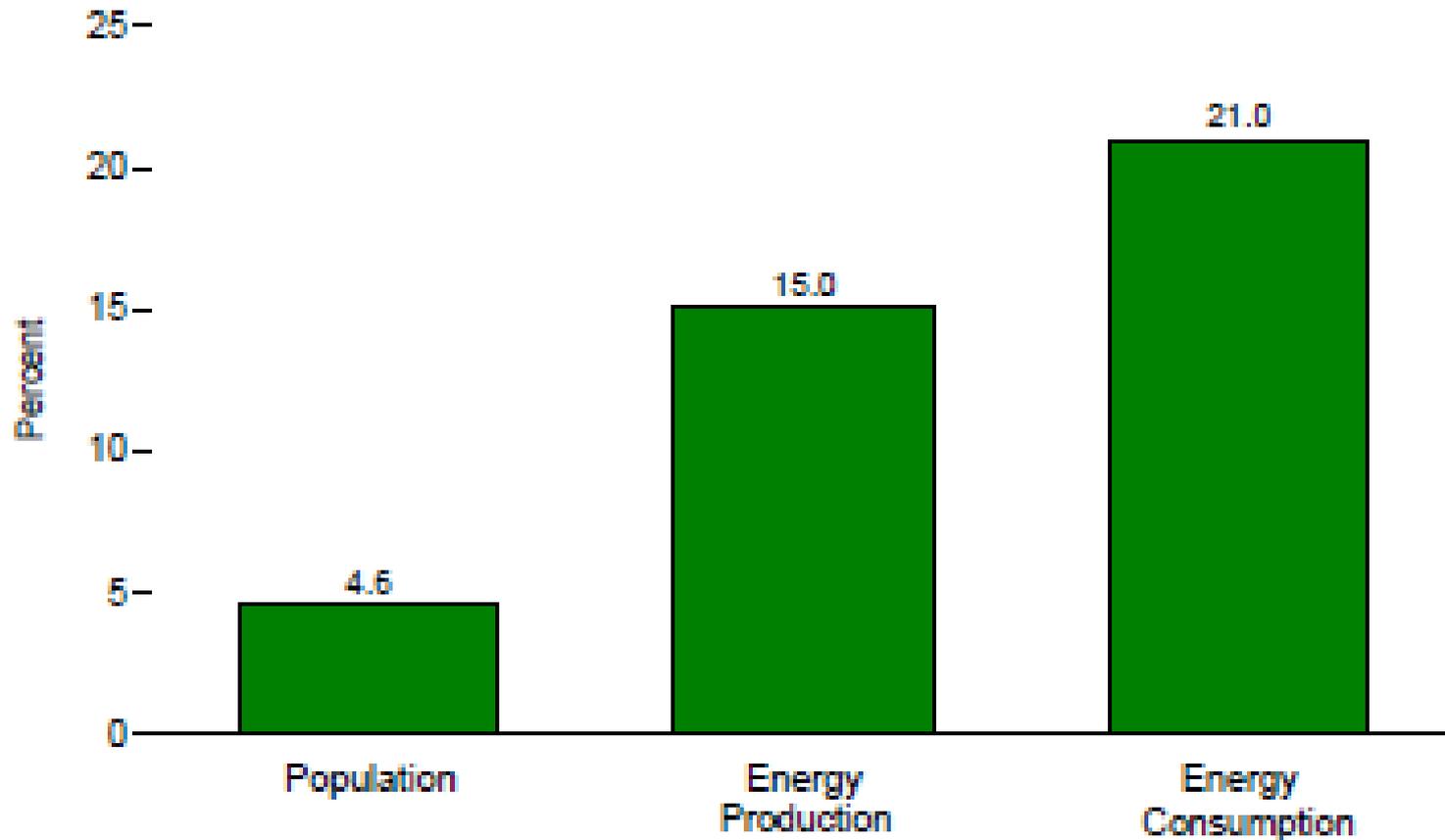
Million tonnes oil equivalent



World primary energy consumption grew by 2.5% in 2011, less than half the growth rate experienced in 2010 but close to the historical average. Growth decelerated for all regions and for all fuels. Oil remains the world's leading fuel, accounting for 33.1% of global energy consumption, but this figure is the lowest share on record. Coal's market share of 30.3% was the highest since 1969.

Courtesy of BP Statistical Review of World Energy 2012, BP p.l.c. Used with permission.

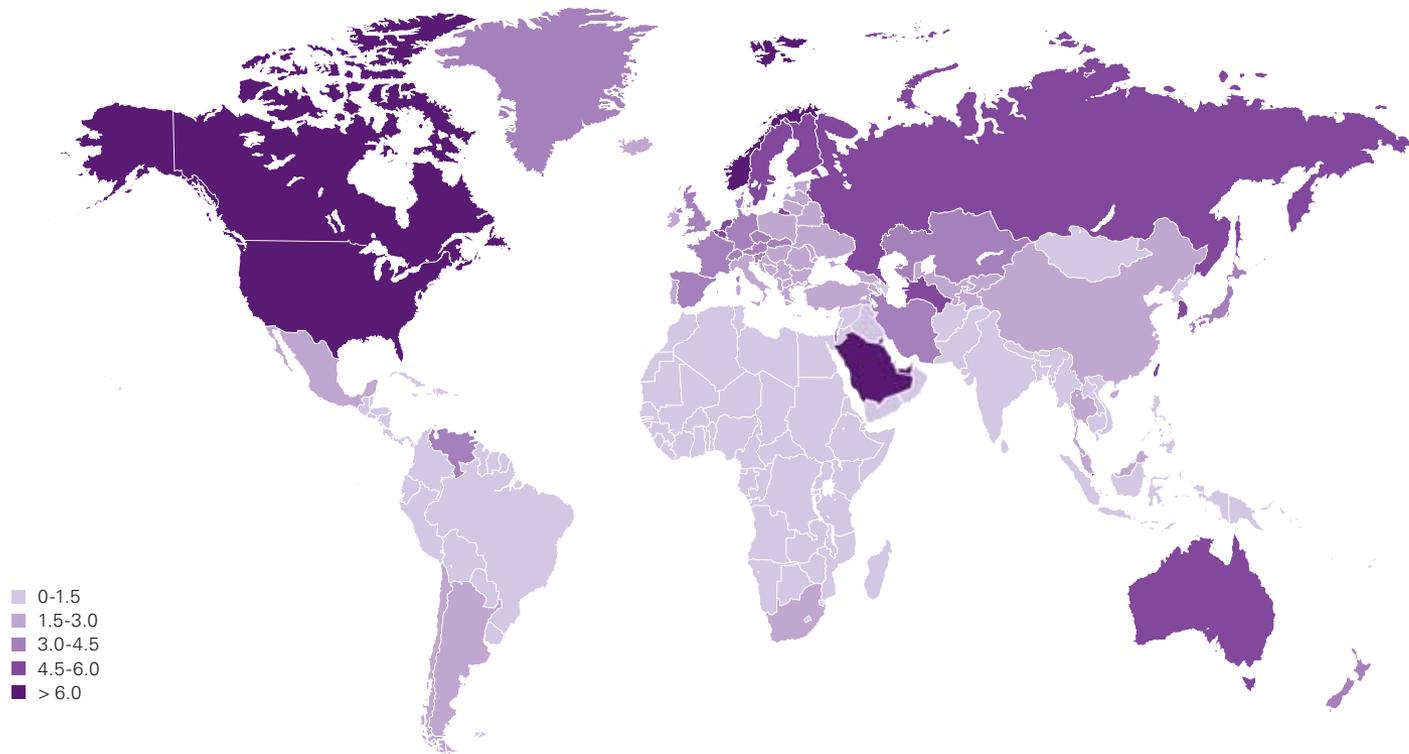
The U.S. Has Large Shares of World Energy Production & (Esp.) Consumption



Lots of Variation in Primary (Commercial) Energy per capita

Consumption per capita 2011

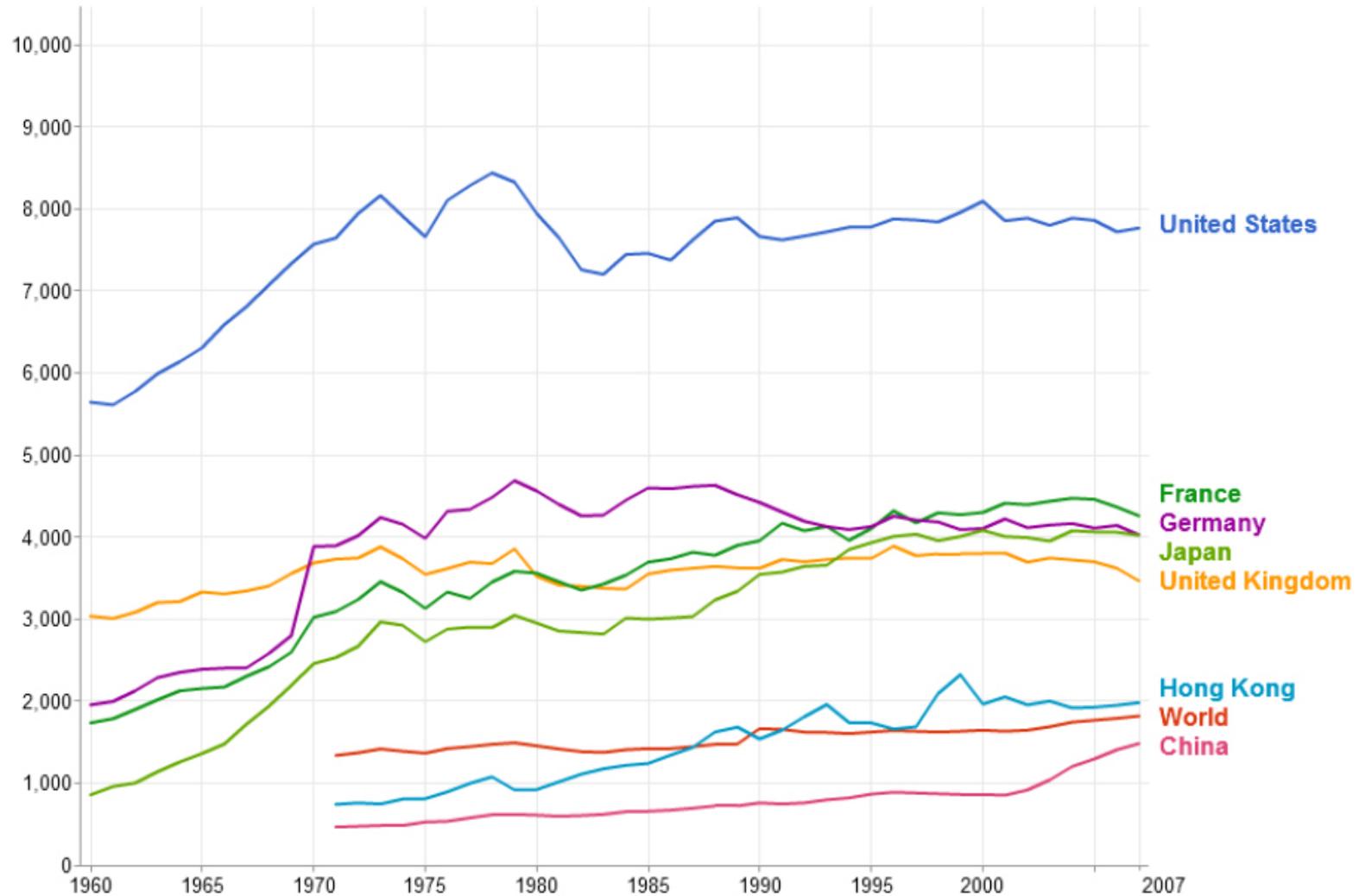
Tonnes oil equivalent



Courtesy of BP Statistical Review of World Energy 2012, BP p.l.c. Used with permission.

Energy use per capita per time

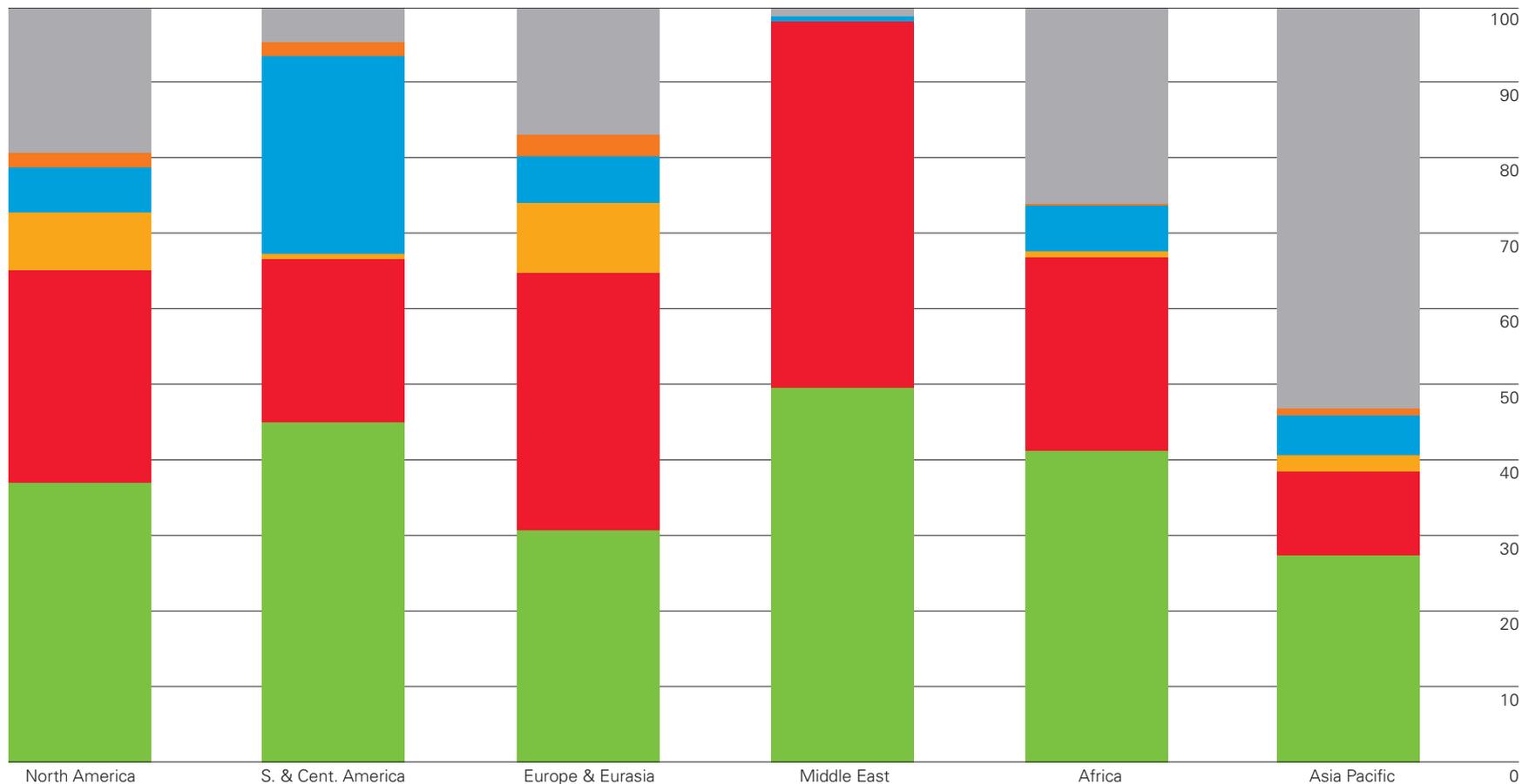
Primary energy use (before transformation to other end-use fuels) in kilograms of oil equivalent, per capita.



Data source: World Bank, World Development Indicators- Last updated May 7 2010

Regional consumption pattern 2011

Percentage



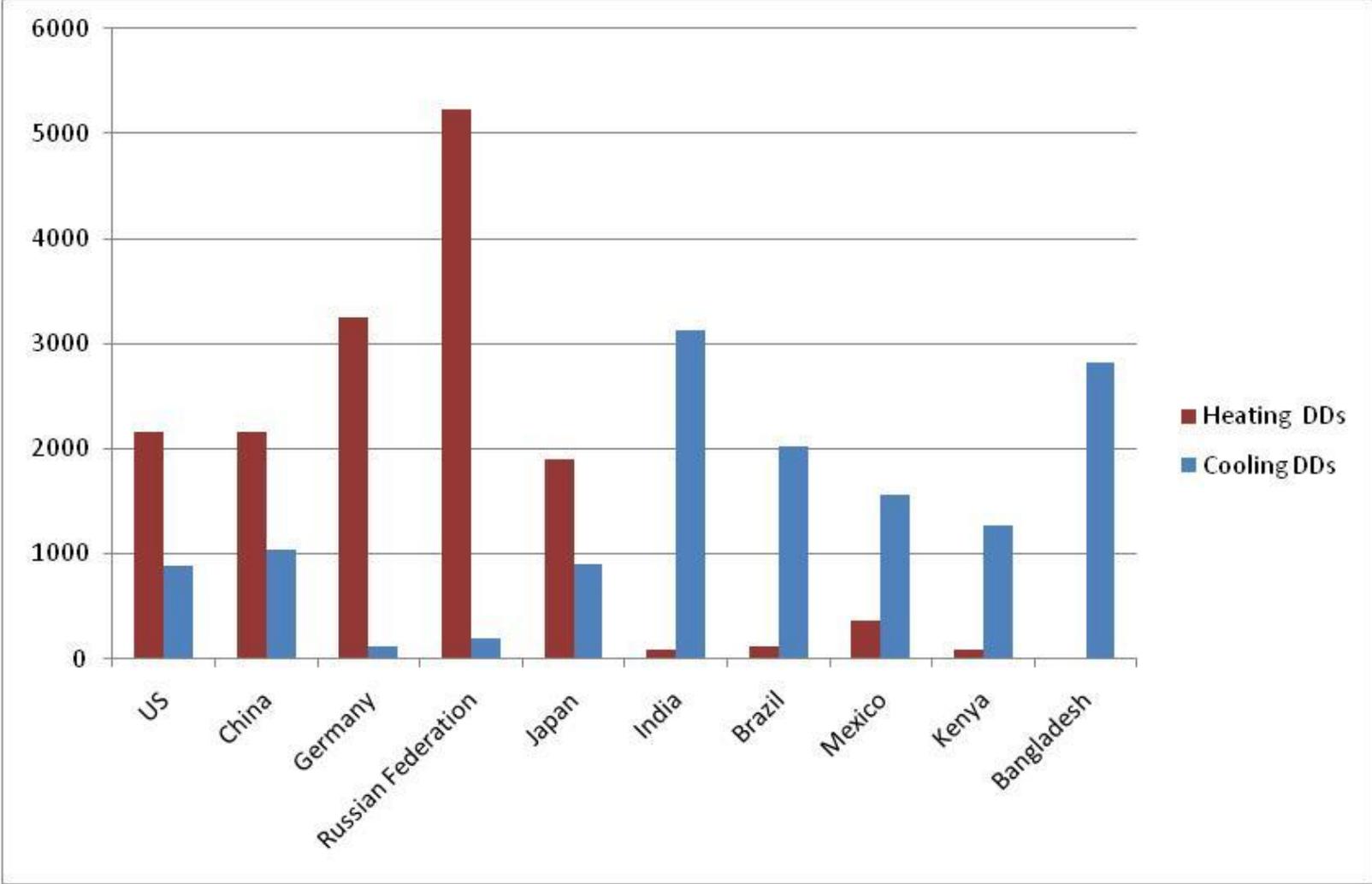
The Asia Pacific region is the world's largest energy consumer, accounting for 39.1% of global energy consumption and 68.6% of global coal consumption; the region also leads in oil consumption and hydroelectric generation. Europe & Eurasia is the leading region for consumption of natural gas, nuclear power, and renewables. Coal is the dominant fuel in the Asia Pacific region; natural gas is dominant in Europe & Eurasia, and oil is dominant in all other regions.

Courtesy of BP Statistical Review of World Energy 2012, BP p.l.c. Used with permission.

What Factors Determine Differences in National Energy Systems Today?

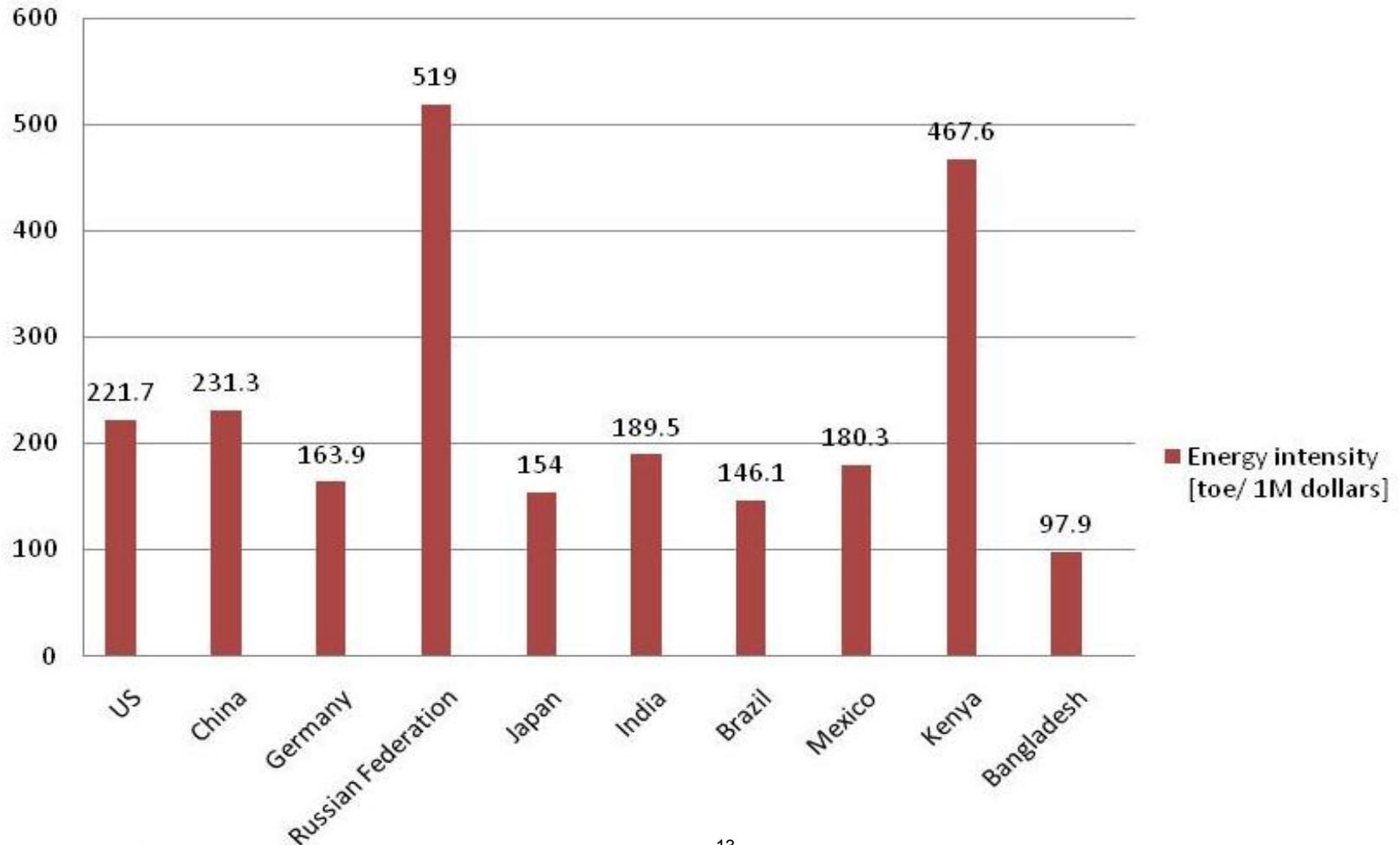
- Available resources
- Level of income/development
- Economic activity mix (e.g., manufacturing)
- Climate
- Government policies (e.g., subsidies)
- Culture, habits, etc...
- HISTORY (e.g., house sizes, city structures)
- ...?

Climate: Degree days

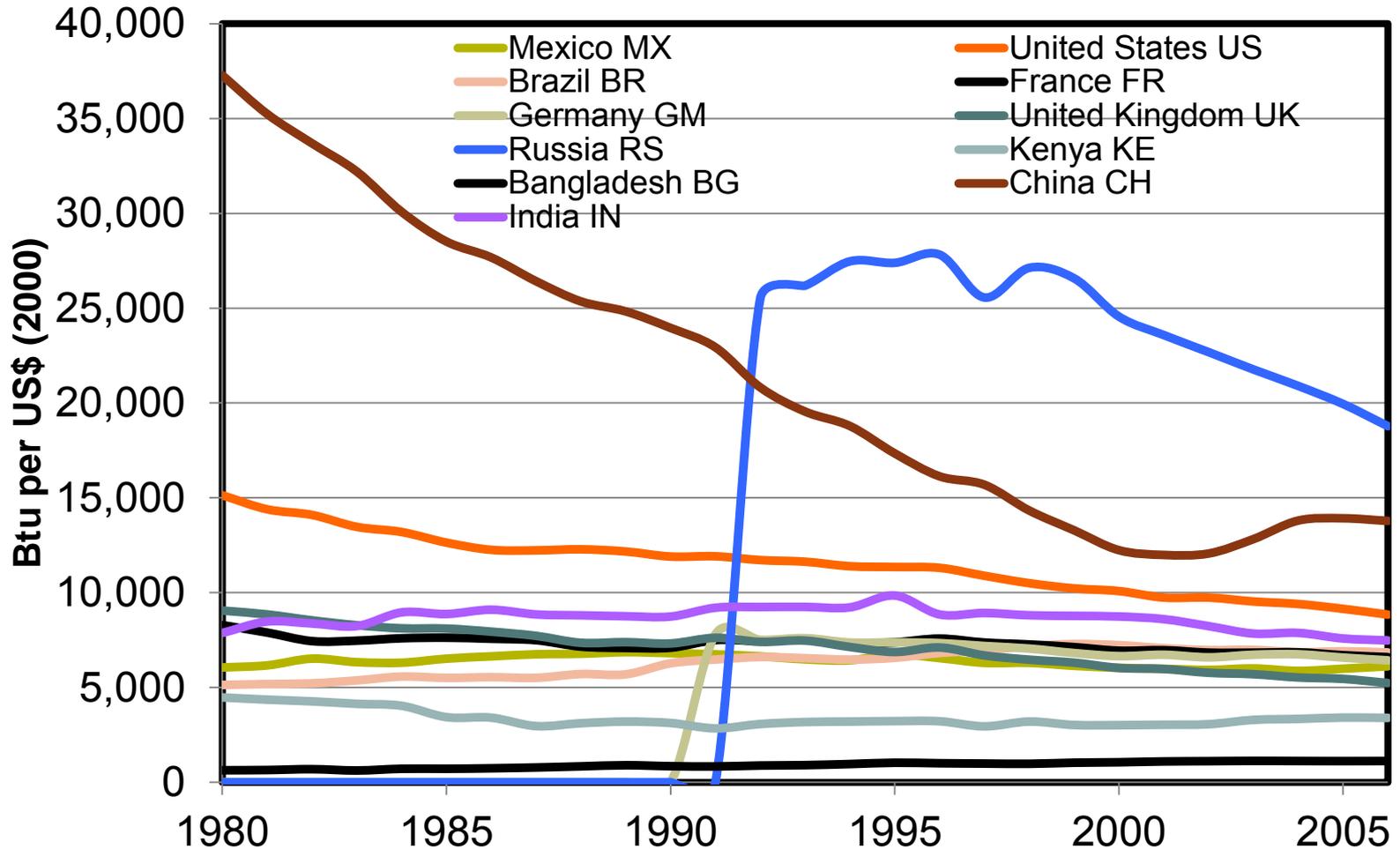


Energy intensity

Energy intensity
[toe/ 1M dollars] (2003)



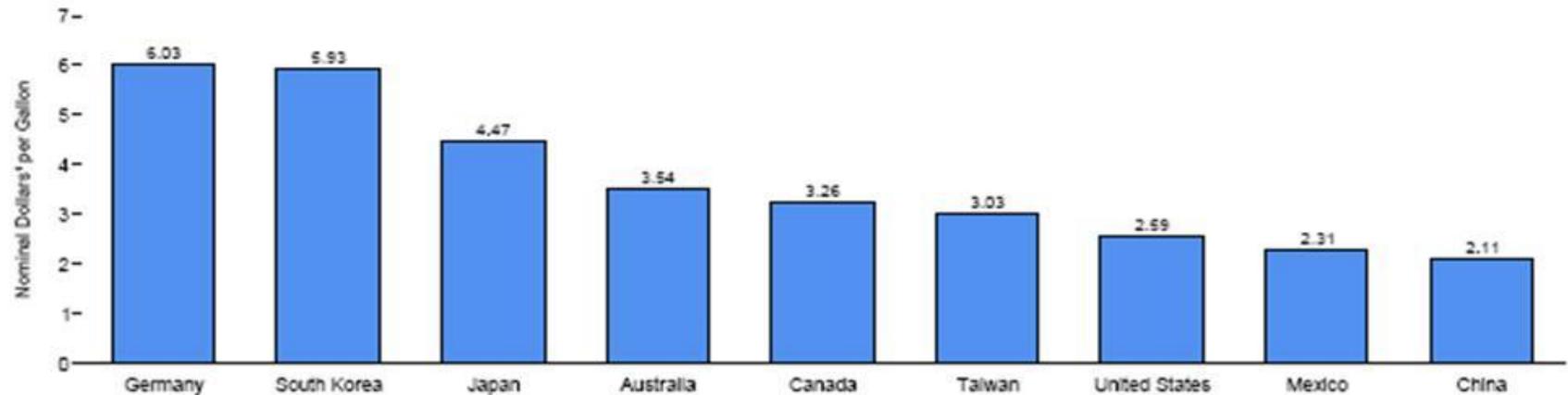
Energy/ GDP: A comparison



Gasoline Prices: Taxes & Subsidies

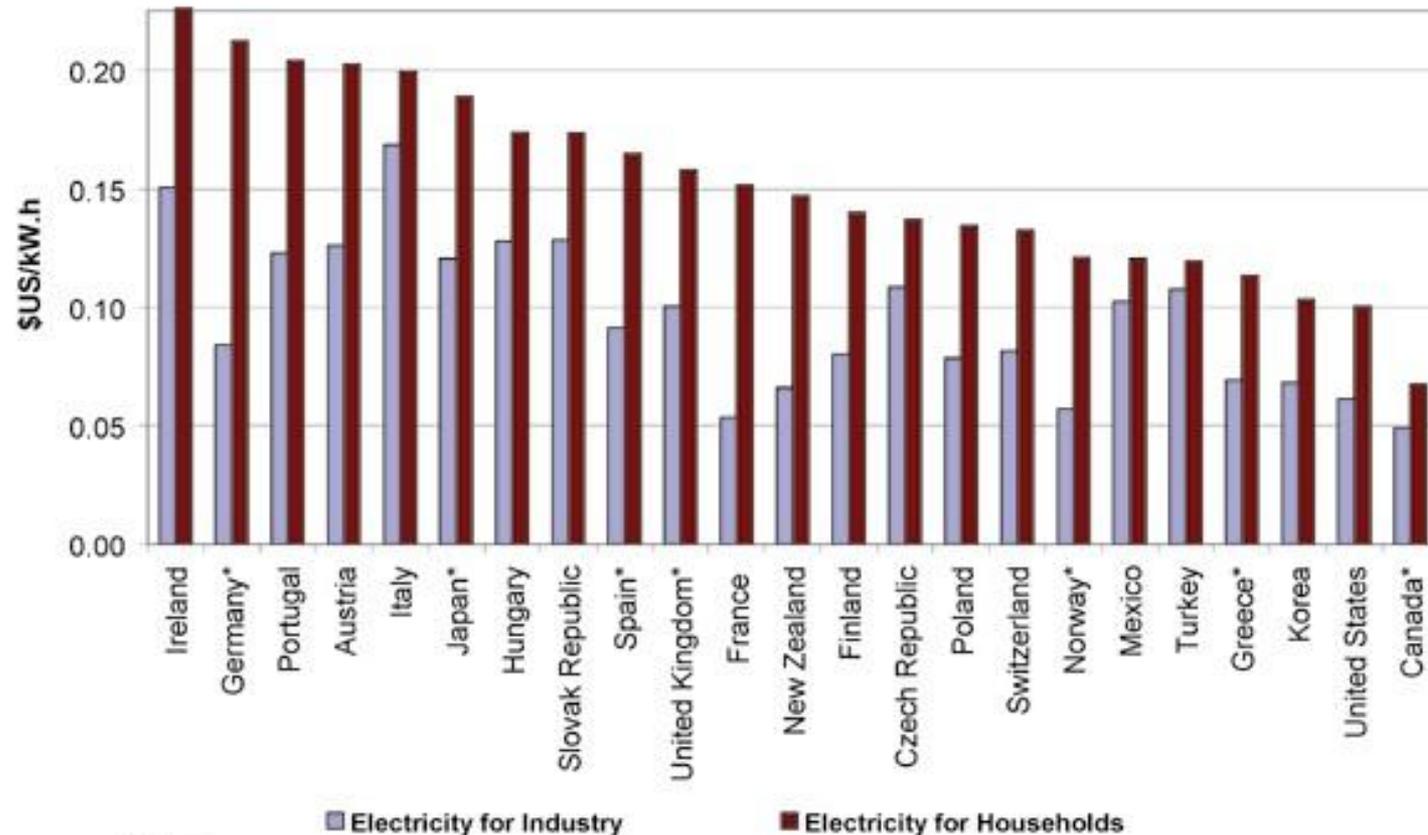
Figure 11.8 Retail Motor Gasoline Prices in Selected Countries, 2006

Regular Unleaded



Premium Unleaded²

Electricity Prices: Industry v. Households



Notes:

* Earliest available data

But where do prices come from?

- World prices for some inputs
- Local resources, costs
- Costs of capital, labor
- Efficiency/productivity
- Taxes/subsidies
- Environmental, other policies
- ...

Electricity consumption per capita

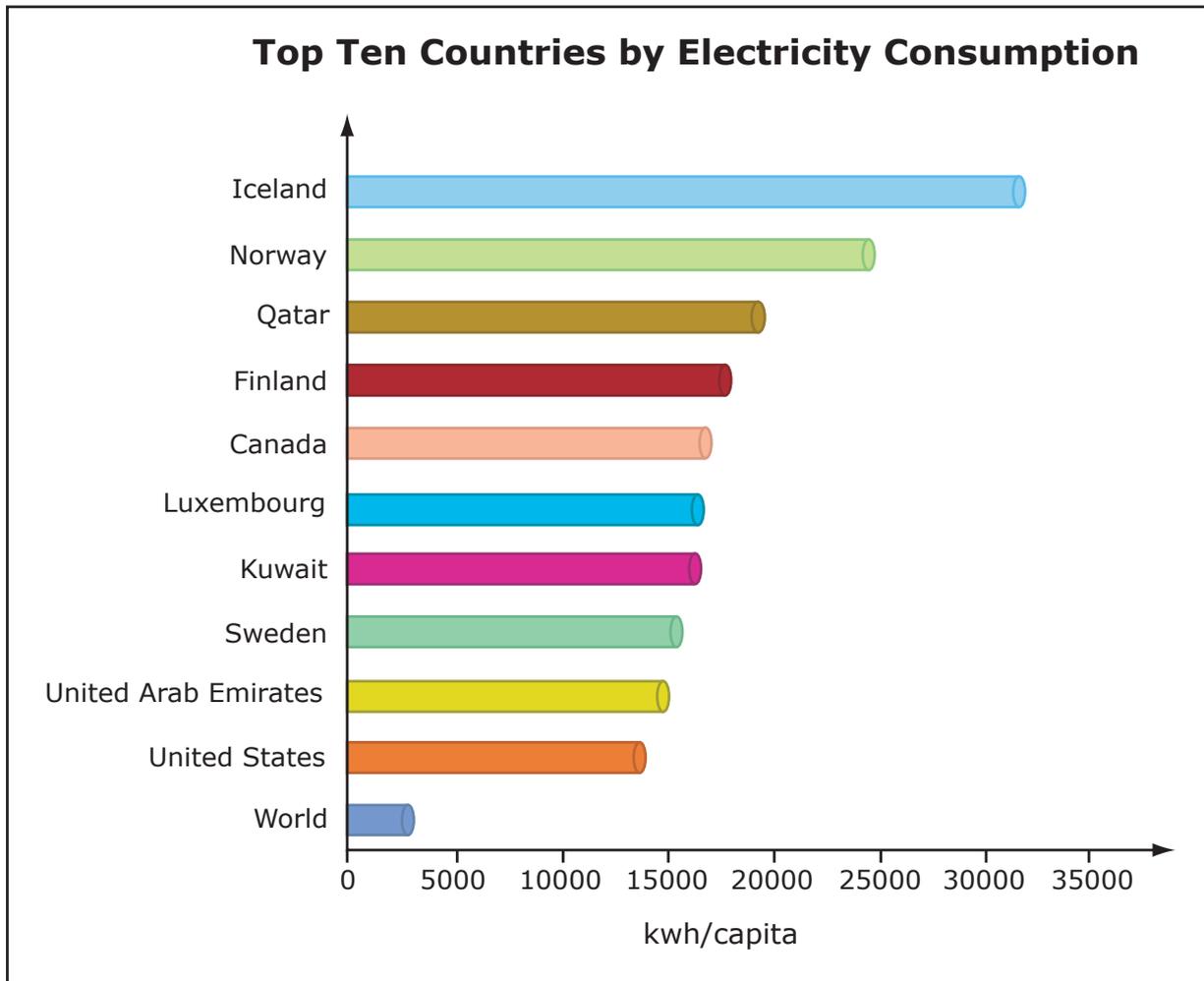


Image by MIT OpenCourseWare. Source: Infographic from "Ranking America."

Energy flow diagram for the United States in 2007 removed due to copyright restrictions.
Source: [LLNL-TR-473098: 2007 Estimated International Energy Flows](#).

Energy flow diagram for France in 2007 removed due to copyright restrictions.
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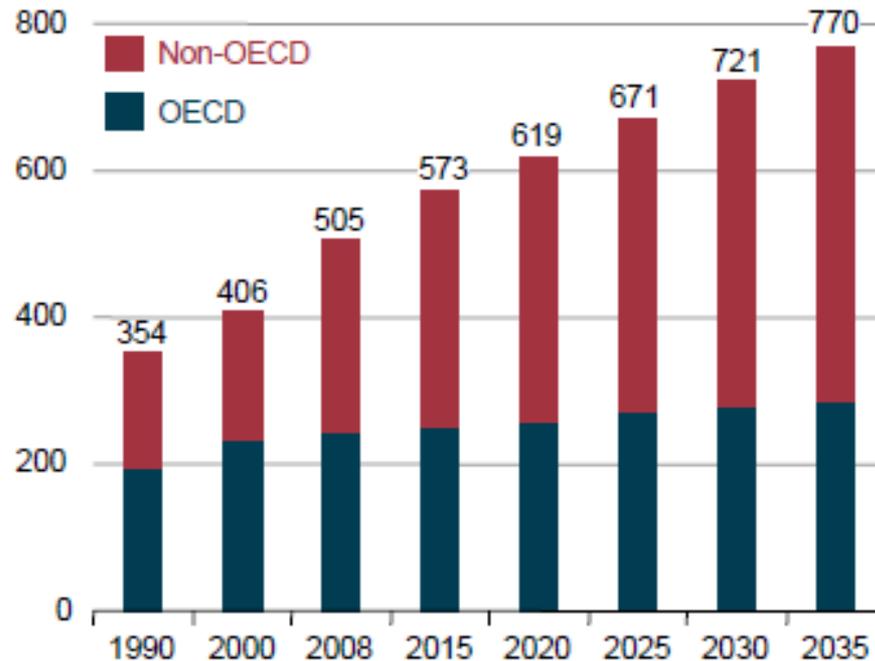
Energy flow diagram for Cambodia in 2007 removed due to copyright restrictions.
Source: [LLNL-TR-473098: 2007 Estimated International Energy Flows](#).

OECD Members: Generally Wealthy, 17.5% of 2009 World Population, 47.3% of 2009 World Energy Consumption

- » **Australia**
- » **Austria**
- » **Belgium**
- » **Canada**
- » **Chile**
- » **Czech Republic**
- » **Denmark**
- » **Estonia**
- » **Finland**
- » **France**
- » **Germany**
- » **Greece**
- » **Hungary**
- » **Iceland**
- » **Ireland**
- » **Israel**
- » **Italy**
- » **Japan**
- » **Korea**
- » **Luxembourg**
- » **Mexico**
- » **Netherlands**
- » **New Zealand**
- » **Norway**
- » **Poland**
- » **Portugal**
- » **Slovak Republic**
- » **Slovenia**
- » **Spain**
- » **Sweden**
- » **Switzerland**
- » **Turkey**
- » **United Kingdom**
- » **United States**

Growth Expected Mainly in Non-OECD

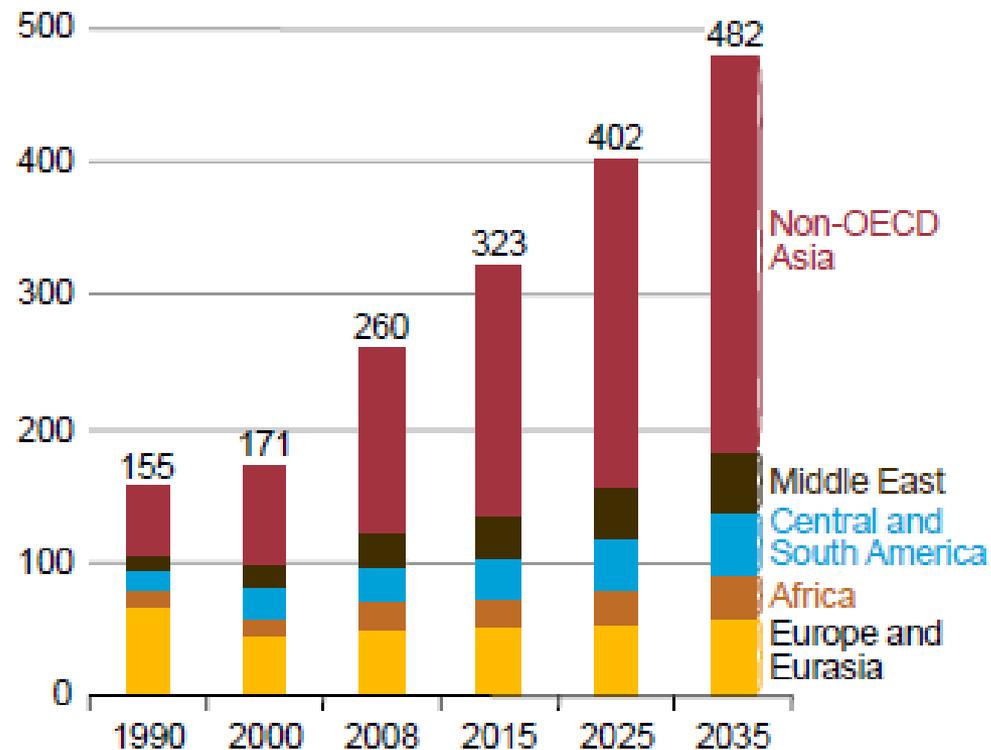
Figure 1. World energy consumption, 1990-2035
(quadrillion Btu)



In 2009, if world had **OECD (US)** actual energy/capita world energy would be **2.7 (4.3)** times actual – feasible?

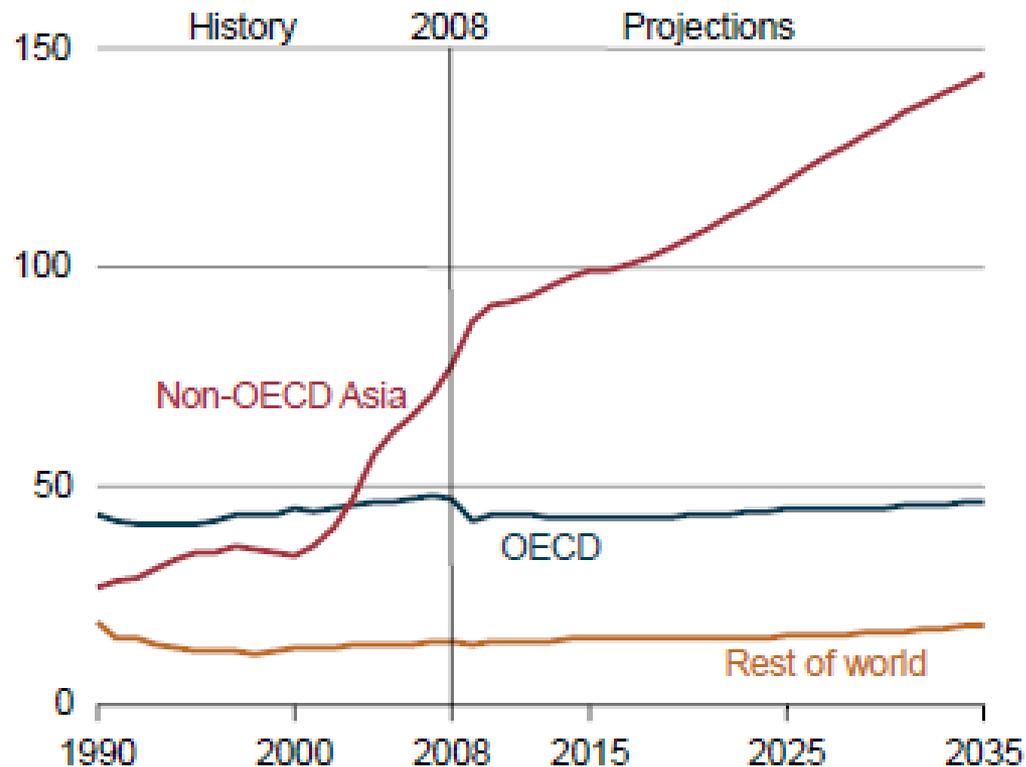
Non-OECD Growth Mainly in Asia: China + India

Figure 14. Non-OECD energy consumption, 1990-2035
(quadrillion Btu)



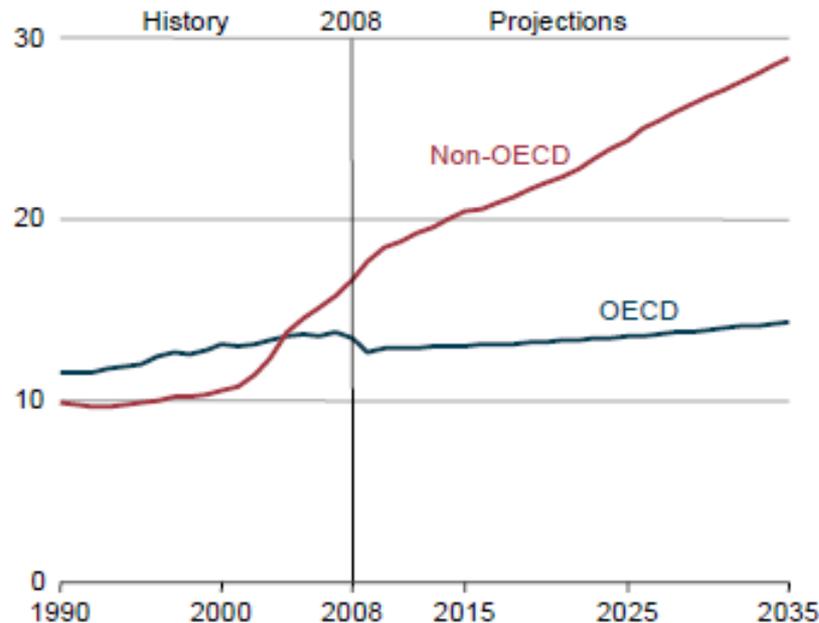
The Recent, Future(?) Growth in Coal Use: China and India

Figure 5. World coal consumption by region, 1990-2035 (quadrillion Btu)



Growth in CO₂ Emissions Projected to Come Mainly from non-OECD Nations

Figure 110. World energy-related carbon dioxide emissions, 1990-2035 (billion metric tons)

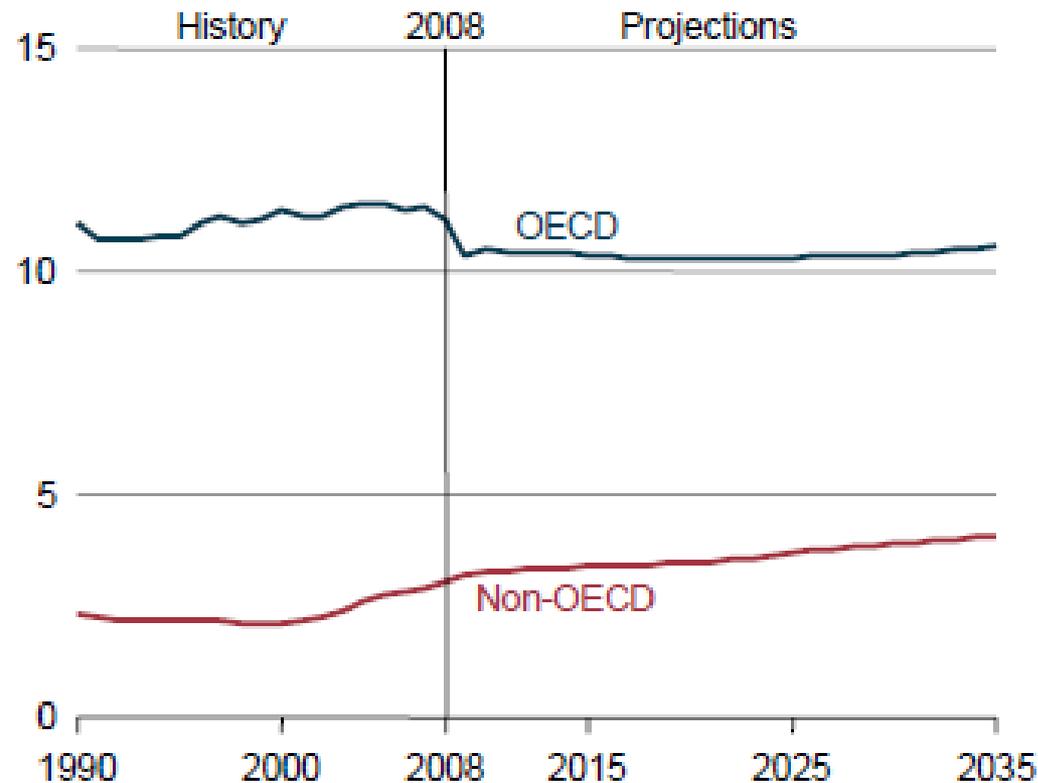


In 2008, **OECD** (**US**) accounted for **44.6%** (**19.3%**) of total, so

If world CO₂/capita were OECD (US) actual, world emissions would have been **2.5** (**4.3**) times actual – not good!

But Don't non-OECD Nations Deserve a Chance to Get Rich Like US??

Figure 11. World carbon dioxide emissions per capita, 1990-2035 (metric tons per person)



Some Final Thoughts

- National energy systems are incredibly diverse, with many drivers of diversity – not just resources
- Growth in energy use, CO₂ likely to come mainly from developing nations, esp. China
- If the world got rich using OECD/US models, huge increases in energy, CO₂ emissions
- Finding and moving to another growth path will be a great challenge by any standard

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15.031J / 14.43J / 21A.341J / 11.161J Energy Decisions, Markets, and Policies
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