World and U.S. Energy Use

T. A. Volk
SUNY-ESF, Syracuse, NY
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Primary energy world consumption

World primary energy consumption grew by 5.6% in 2010, the strongest growth since 1973. Growth was above average for oil, natural gas, coal, nuclear, hydroelectricity, as well as for renewables in power generation. Oil remains the dominant fuel (33.6% of the global total) but has lost share for 11 consecutive years. The share of coal in total energy consumption continues to rise, and the share of natural gas was the highest on record.

(BP Statistical Review 2011)
Energy Consumption by Country

United States: 80 Quadrillion Btu
China: 40 Quadrillion Btu
Russia: 20 Quadrillion Btu
India: 0 Quadrillion Btu
Japan: 0 Quadrillion Btu

Graph showing energy consumption by country from 1995 to 2008.
Projected Energy Consumption

Figure 13. Energy consumption in the United States, China, and India, 1990-2035 (quadrillion Btu)

(EIA 2011)
Sources of Energy by Region

Sub-Saharan Africa

- Combustible renewables and waste: 61.5%
- Coal: 20.9%
- Hydro: 13%
- Nuclear: 0.7%
- Geothermal, solar, etc.: 0.1%
- Gas: 2.5%
- Crude oil: 11.8%
- Petroleum products: 1.1%

OECD

- Combustible renewables and waste: 3.3%
- Coal: 20.8%
- Hydro: 2.0%
- Nuclear: 11.2%
- Gas: 21.3%
- Crude oil: 40.4%
- Petroleum products: 0.5%
- Geothermal, solar, etc.: 0.7%
Solid biomass consumption in 2003 in % of the total energy consumption

- 0 or not significant
- 2 to 10%
- 10 to 40%
- More than 40%
- No data

Source: World Resources Institute (WRI) searchable database.

Population relying on biomass for cooking and heating

Source: IEA 2002.
Primary energy consumption per capita

Consumption per capita 2010
Tonnes oil equivalent

(BP Statistical Review 2011)
FIGURE 3. RELATIONSHIP BETWEEN HDI AND PER CAPITA ENERGY USE, 1999/2000

The graph illustrates the relationship between Human Development Index (HDI) and per capita energy consumption (kgoe/capita) for various countries in 1999/2000. The x-axis represents per capita energy consumption, while the y-axis represents HDI. The scatter plot shows a general trend where countries with higher HDI values tend to have higher per capita energy consumption, though there is significant variation among countries.
World Energy Use Patterns

U.S. Share of World, 2007

- Population: 4.6%
- Energy Production: 15.0%
- Energy Consumption: 21.0%

Percent
History of U.S. Energy Use

Figure 5. Primary Energy Consumption by Source, 1775-2009

(EIA 2011)
Energy supply has changed on decadal scales

US energy supply since 1850

Source: EIA (Koonin 2011)
Sources of Renewable Energy

Renewable Energy as Share of Total Primary Energy Consumption, 2009

(EIA 2010)
Renewable Energy as Share of Total Primary Energy Consumption, 2009

- Nuclear Electric Power: 9%
- Natural Gas: 25%
- Petroleum: 37%
- Coal: 21%
- Renewable Energy: 8%

Renewable Energy Sources:
- Hydroelectric Power: 35%
- Wood: 24%
- Biofuels: 20%
- Wind: 9%
- Waste: 6%
- Solar/PV: 1%
- Geothermal: 5%
Estimated U.S. Energy Use in 2009: ~94.6 Quads

Source: LLNL 2010. Data is based on DOE/EIA-0364(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in Btu-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527
U.S. Energy Production and Consumption

(EIA 2011)
Production and Consumption

Figure 12. Production as Share of Consumption for Coal, Natural Gas, and Petroleum

(EIA 2011)
Past and future CO₂ atmospheric concentrations

Scenarios
- A1B
- A1T
- A1FI
- A2
- B1
- B2
- IBD20

Ice core data
Direct measurements
Projections

ppm

IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
World primary energy use and carbon dioxide emissions by region from 1971 to 1998

Primary energy

Carbon dioxide emissions

- Middle East
- Developing countries in Asia Pacific
- Latin America
- Economies in transition
- Africa
- Industrialized countries
Global distribution of large stationary sources of CO2

SRCCS Figure TS-2a
Impacts of Energy Use

- Monetized cost of externalities associated with current energy mix
- PM, SO₂ and NOₓ emission levels relative to ambient air
- Health effects associated with ‘hazardous pollutants’ including Hg and Pb excluded
- Ecosystem impacts, water pollution, national security effects not assessed
- Monetized based on willingness to pay to avoid impacts
- Over $120 billion/yr

(NAS 2009)
Impacts - Coal

- Aggregate damages associated with emissions of SO$_2$, NO$_x$, and PM from these coal-fired were approximately $62$ billion, or $156$ million on average per plant.
- Large differences among plants
- 50% of plants with the lowest damages produced 25% of the electricity but only 12% of the damages.
- 10% of plants with the highest damages produced 25% of the electricity and 43% of the damages.
- Cost is 3.2 cents per kWh
Impacts – Natural Gas

- Damages from natural gas is much lower than coal
- $740 million from 498 gas facilities
- Average annual damages per plant were $1.49 million,
  - lower damages per kWh
  - smaller plant sizes as well; net generation at the median coal plant was more than six times larger than that of the median gas facility
- **Average cost is 0.16 cents per kWh**

Distribution of aggregate damages among the 498 natural gas-fired power plants
Impacts - Transportation

• Light and heavy duty vehicles produced $56 billion in health and other non-climate-change damages
  – $36 billion from light-duty vehicles (1.2 to 1.7 cent per vehicle mile traveled (VMT))
  – $20 billion from heavy-duty vehicles. Across the range of

• Estimated damages ranged from 23 to 38 cents per gallon (with gasoline vehicles at 29 cents per gallon).
Where Are We Heading?
(Jacobson and Delucchi 2009)
Questions?