Energy Overview

Synthetic Biology
University of California Berkeley
February 22, 2006

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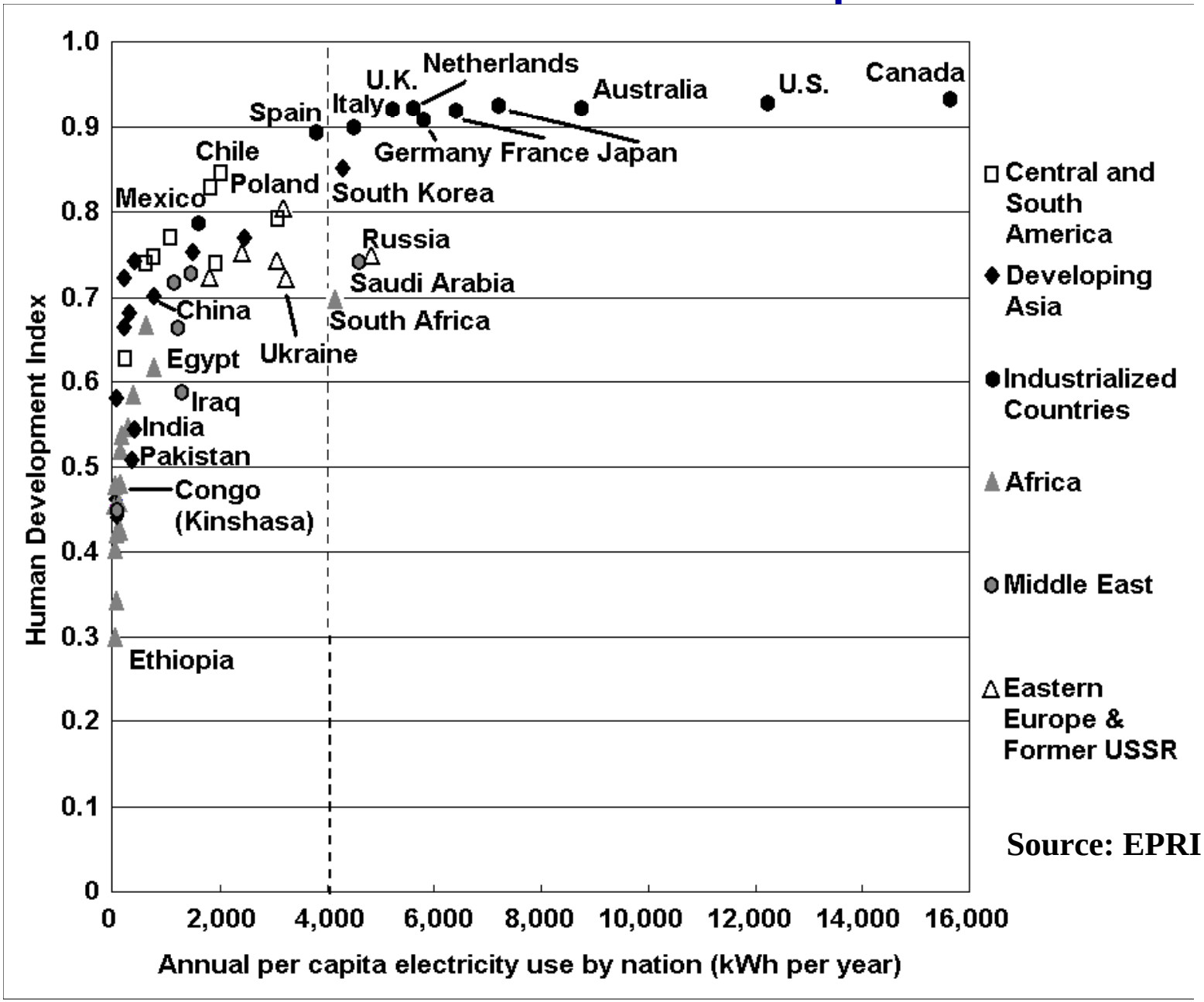
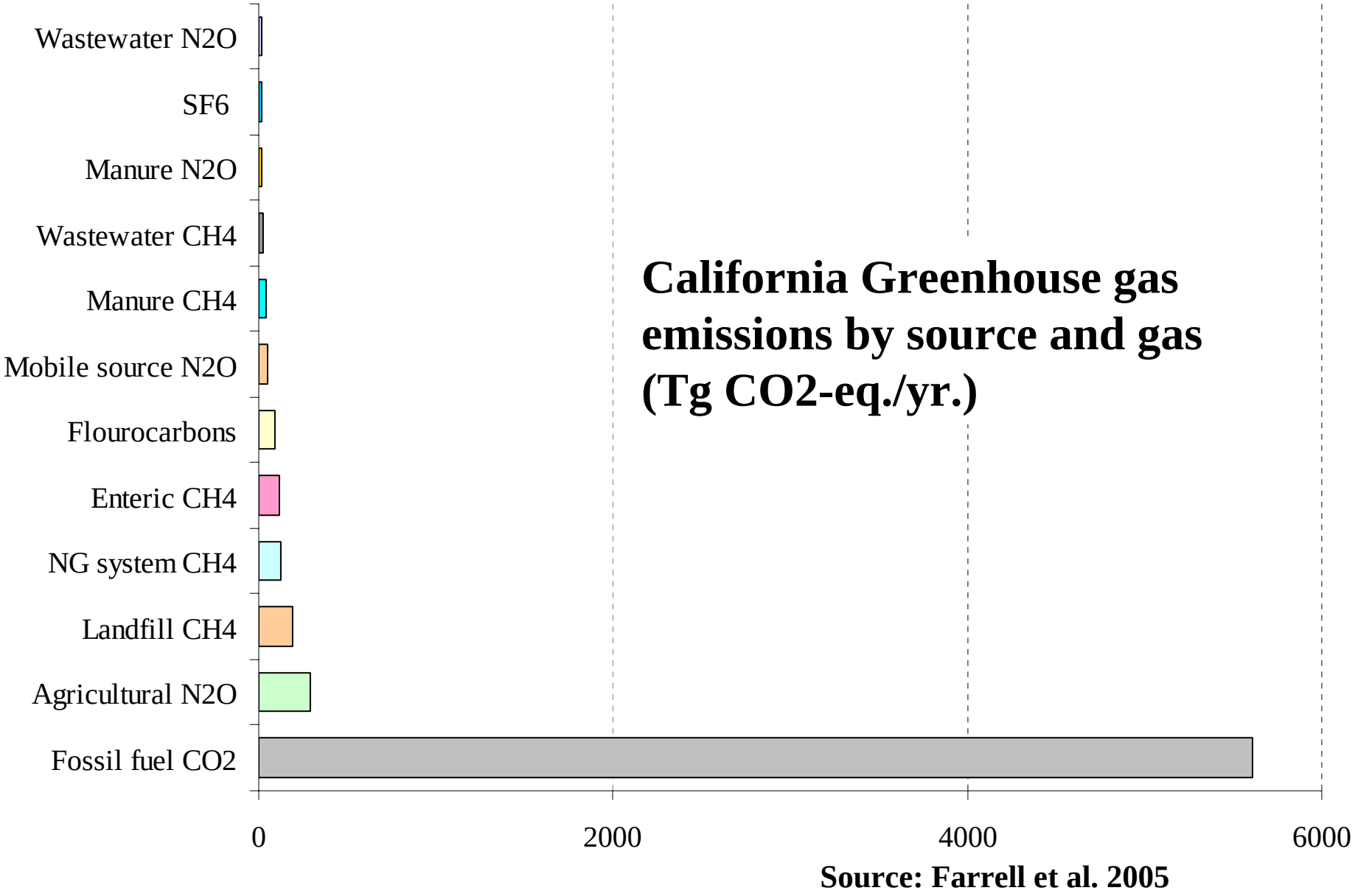
Electrification and Development



Source: EPRI

Climate Change



Source: Farrell et al. 2005

Interested in an interdisciplinary approach to sustainable development?

Minor in Energy and Resources

so you can explore issues like:

When will we run out of oil?

Why do so many people lack safe drinking water?

How will ecosystems respond to global warming?

***And,* what are the connections?**

For more information:

Prof. Richard Norgaard

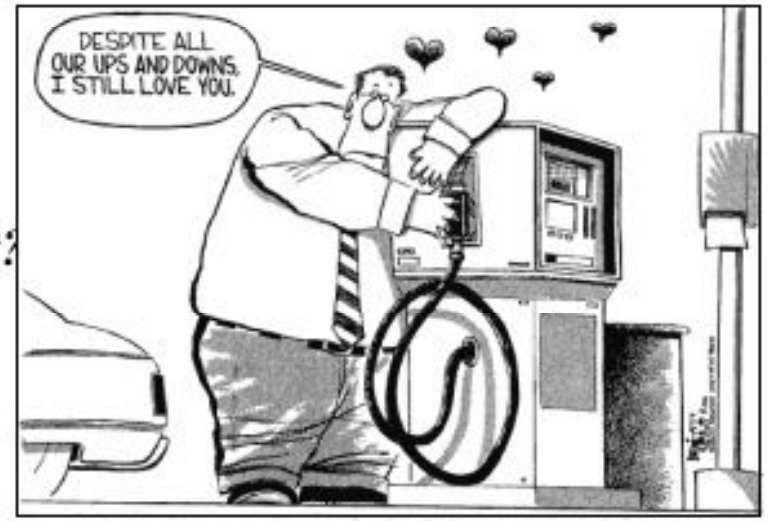
norgaard@berkeley.edu

Fall 2005:

ER100 - Energy & Society

Are you interested in questions like these…

- ***How did fossil-fuels help to define the 20th Century? What about the 21st?***
- ***What does energy use do to the environment?***
- ***What about renewable energy and conservation?***
- ***When will fuel cell cars be on the road?***



…then take ER100! You'll learn answers to these questions and more in this course about the technical *and* social aspects of our energy system.

Lectures: Tu & Th 2:00 - 3:30 PM in 180 Tan Hall

(+ 1 hour discussion per week & optional field trips)

Website: http://socrates.berkeley.edu/~kammen/er100

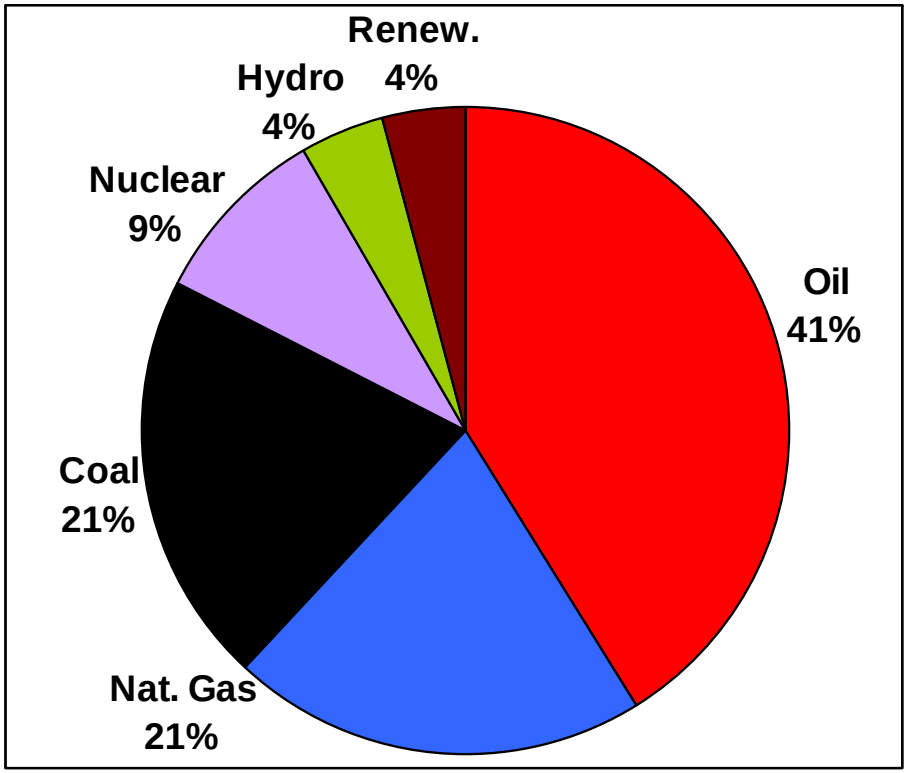
Professor Dan Kammen

Course control # 27403 (ERG)

No prerequisites

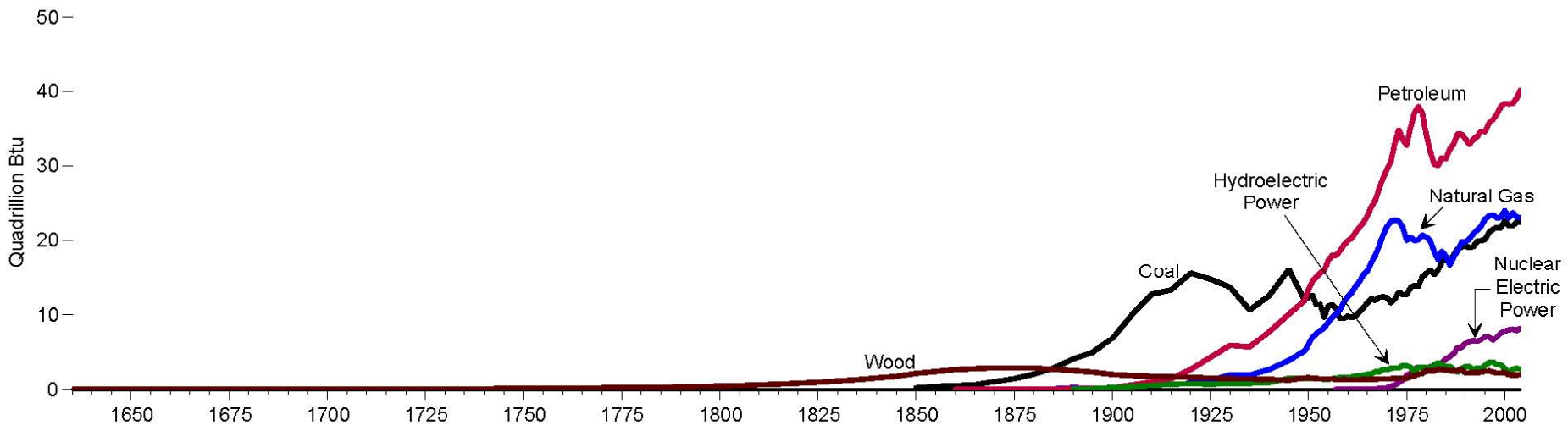
What kinds of energy do we Americans use?

Shares of U.S Primary Energy Sources



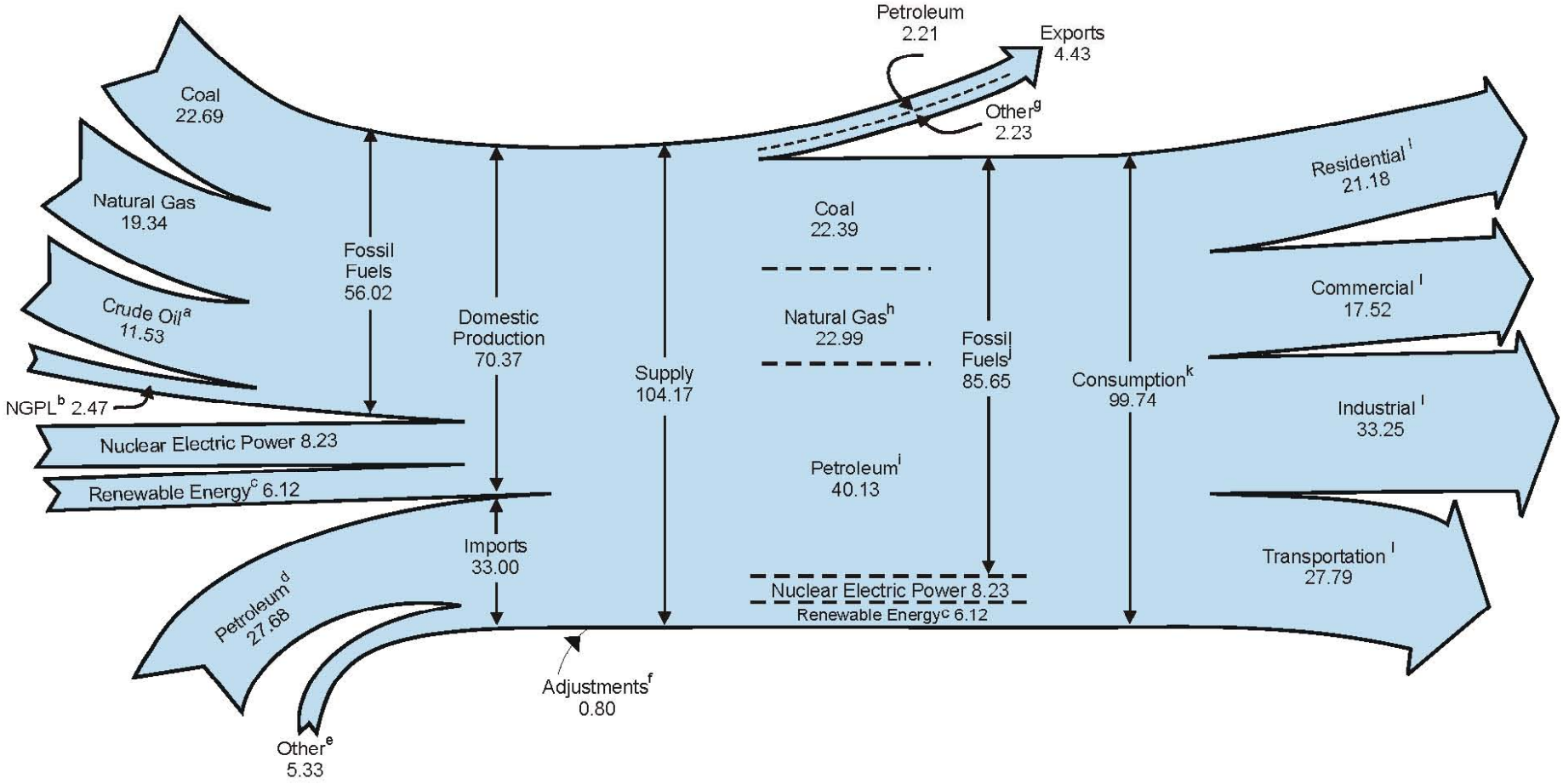
Source: U.S. Energy Information Administration
***Annual Energy Review* 2004**

Figure 5. Energy Consumption by Source, 1635-2004



How do we Americans use energy?

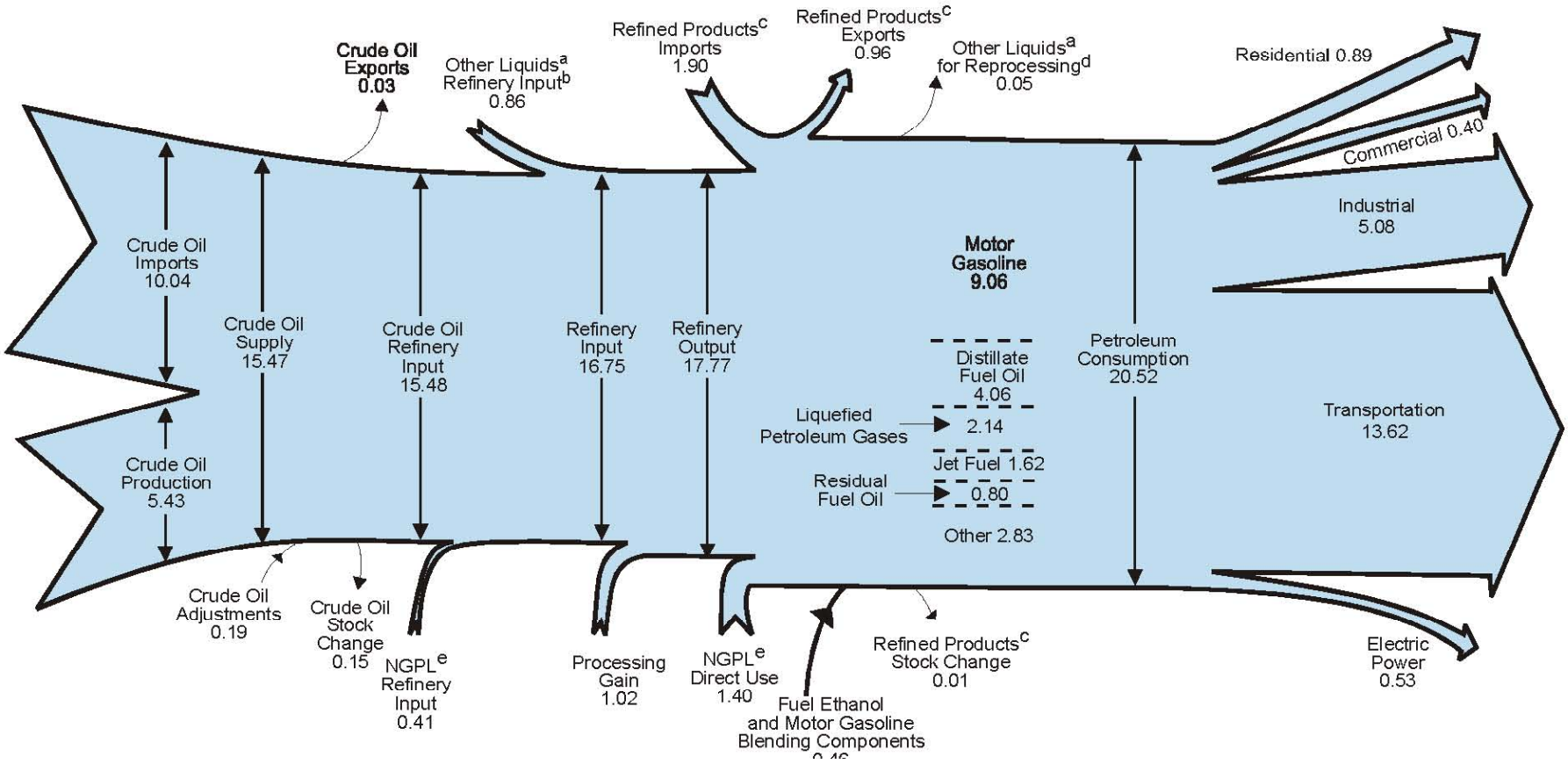
Diagram 1. Energy Flow, 2004
(Quadrillion Btu)



Source: U.S. Energy Information Administration – *Annual Energy Review* 2004

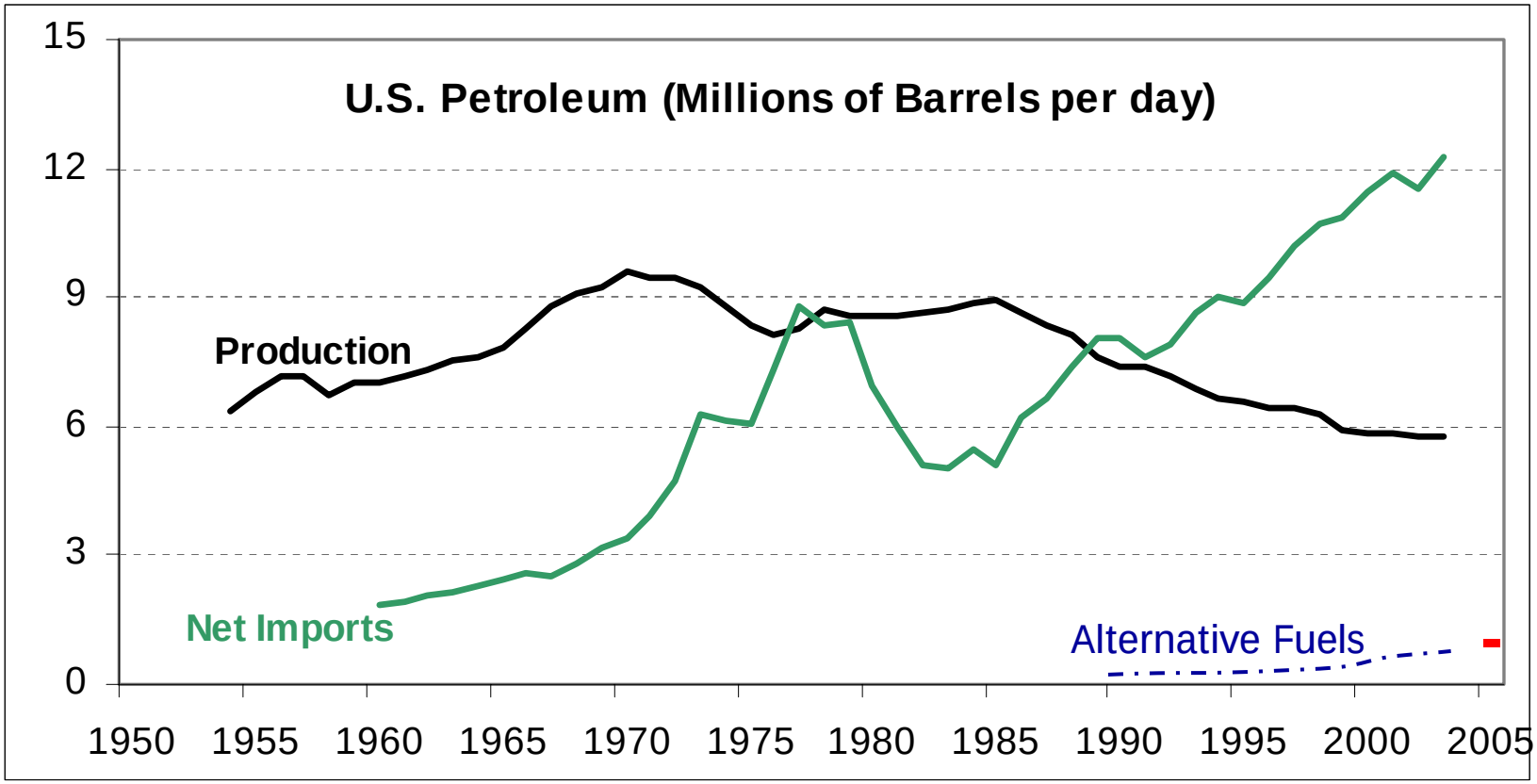
Petroleum in the U.S.

Diagram 2. Petroleum Flow, 2004
(Million Barrels per Day)



Production and Imports (2003 data)

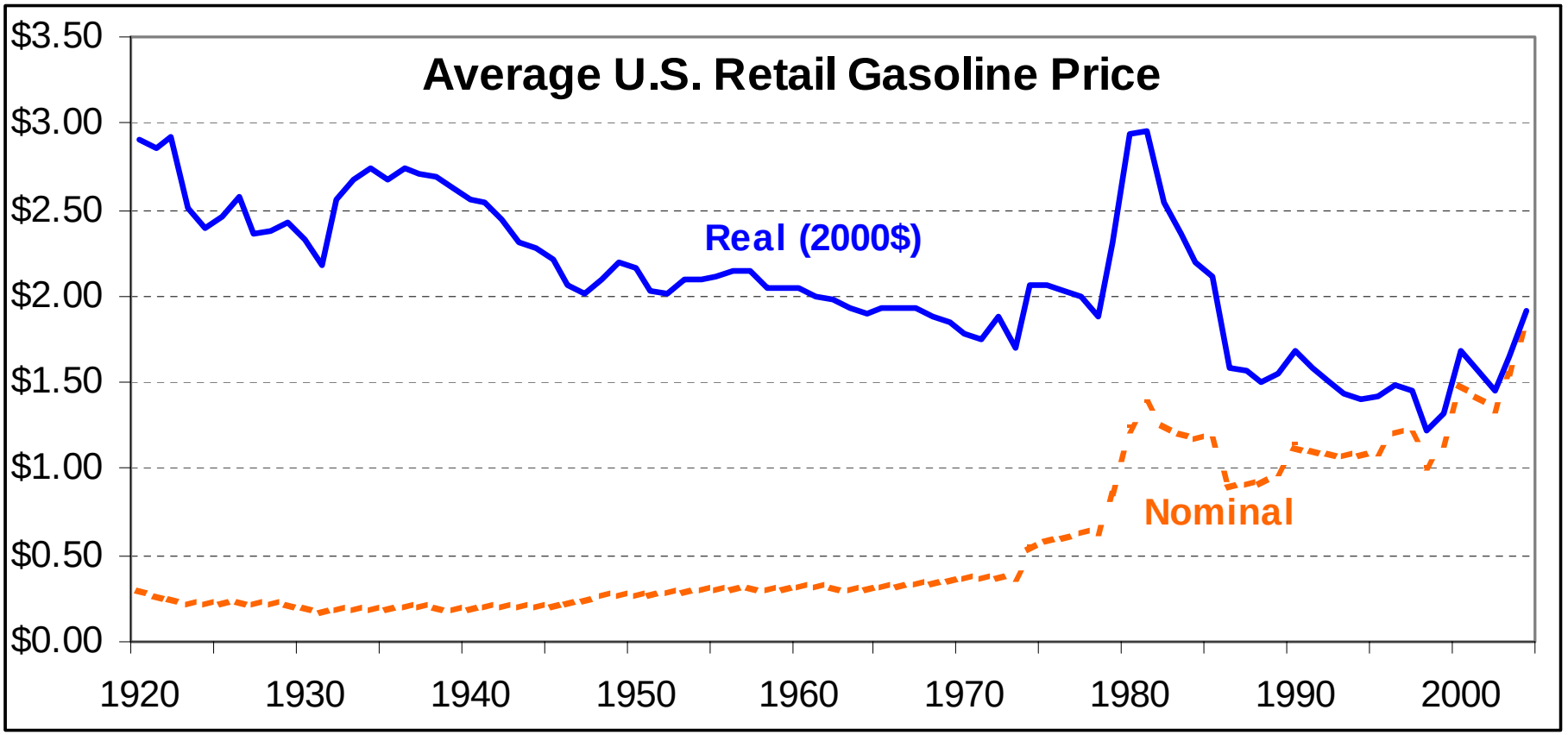
U.S. consumption ~18 mbd **X**



- Global production ~82mbd
- U.S. consumption ~24% of global production
- U.S. production ~9% of global production
- U.S. imports ~15% of global production

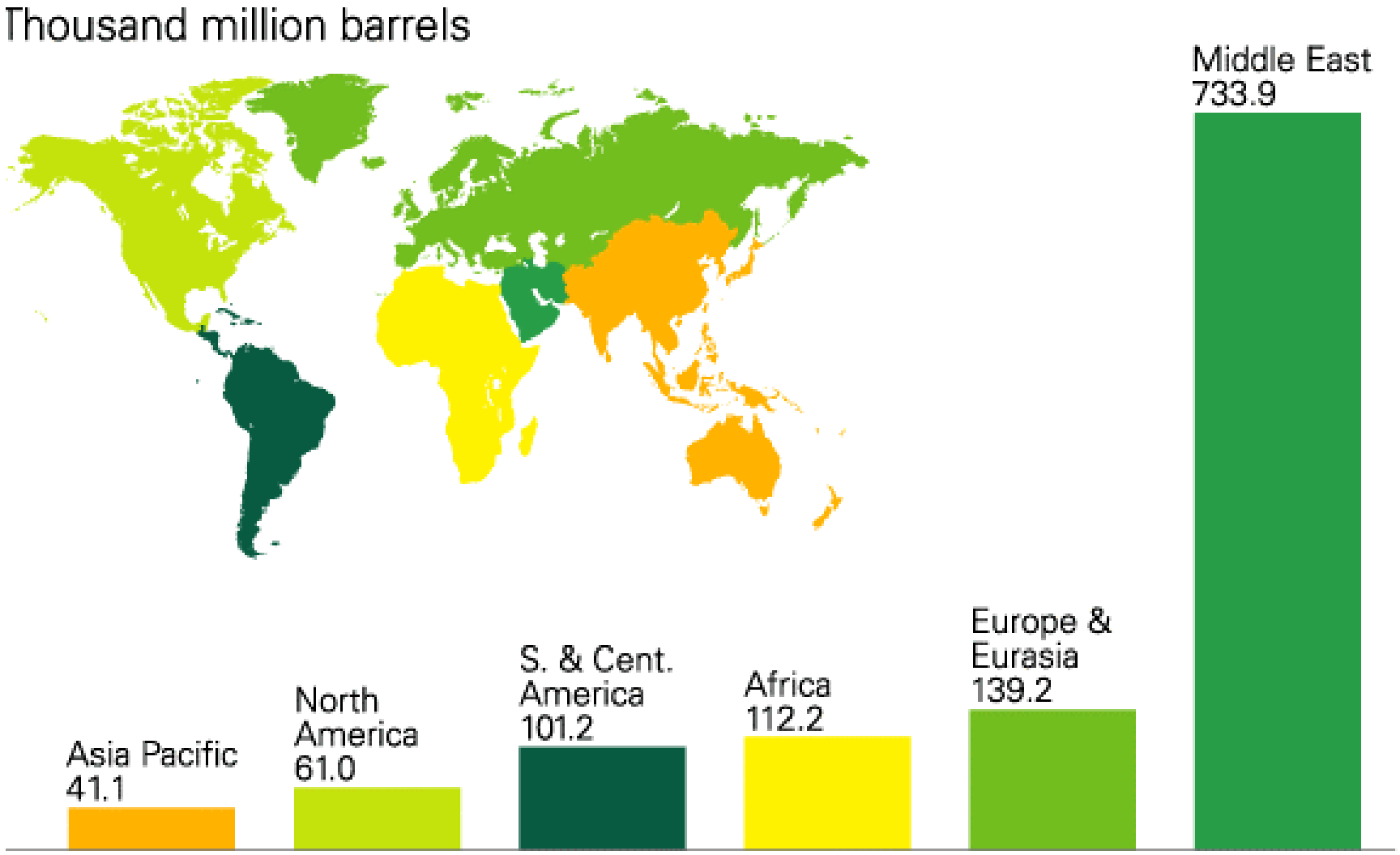
Sources: U.S. Energy Information Administration *and* BP

Long term gasoline price history



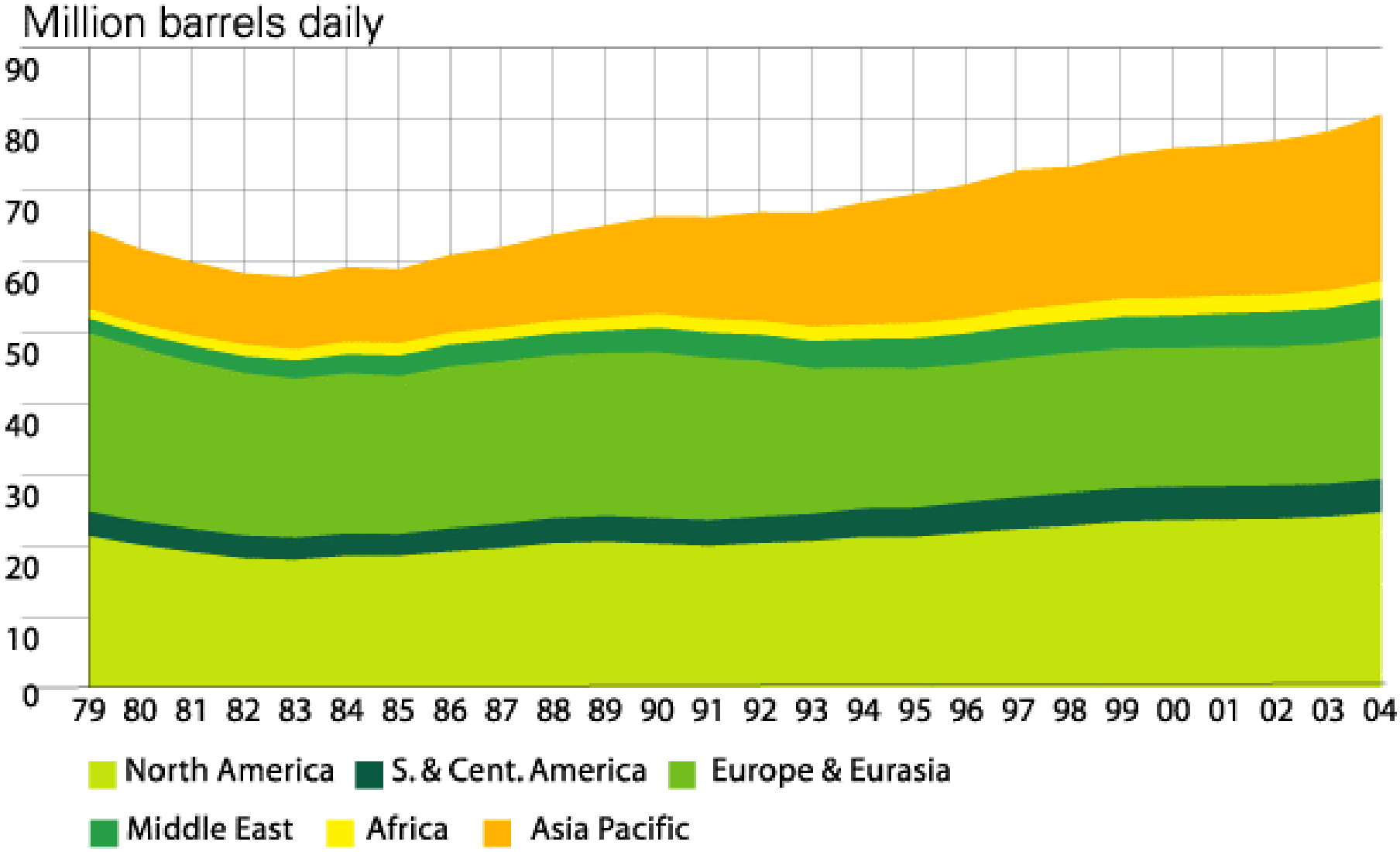
Sources: U.S. Energy Information Administration

Proved oil reserves (2004)



Source: BP

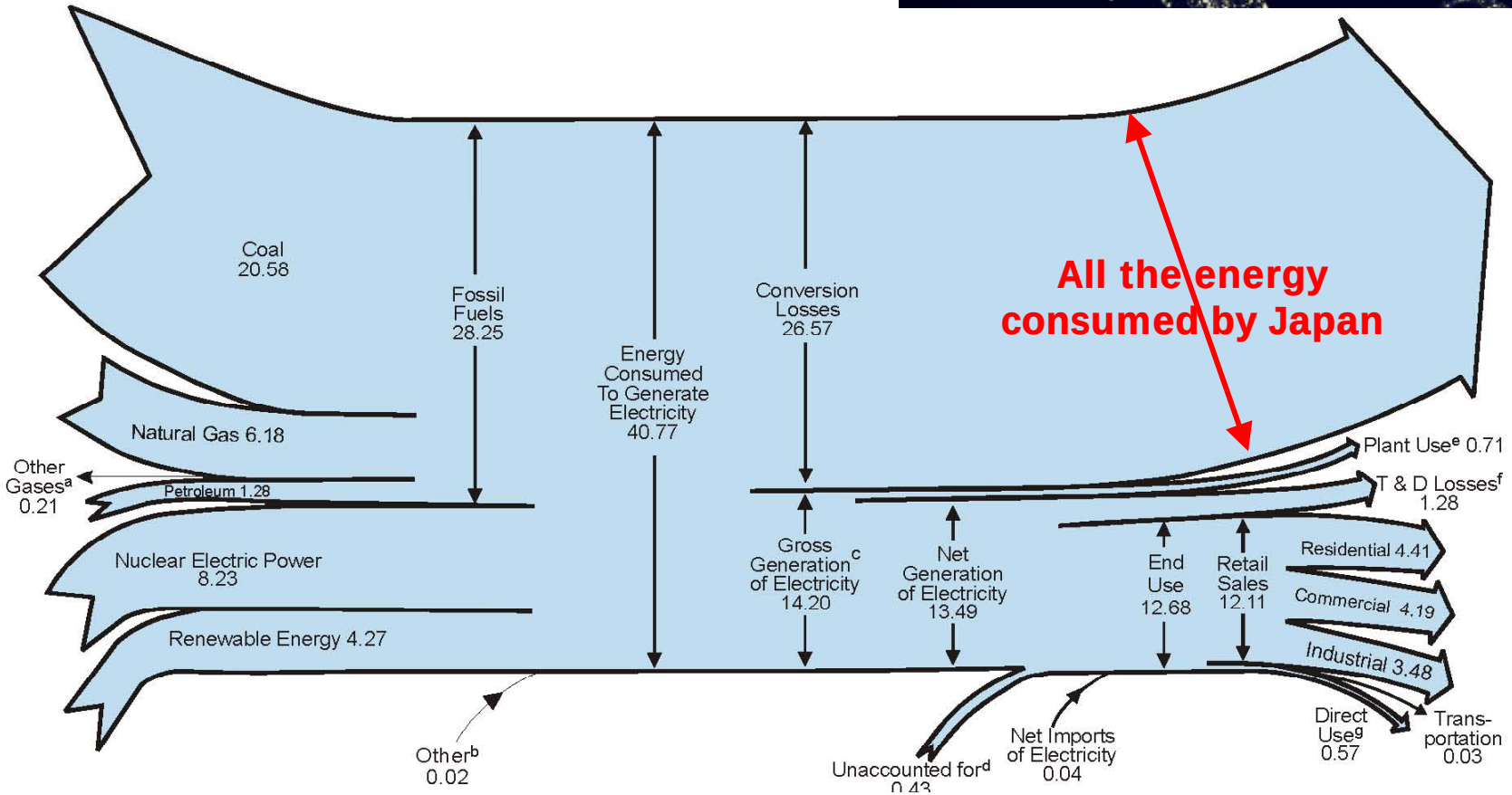
Global oil consumption



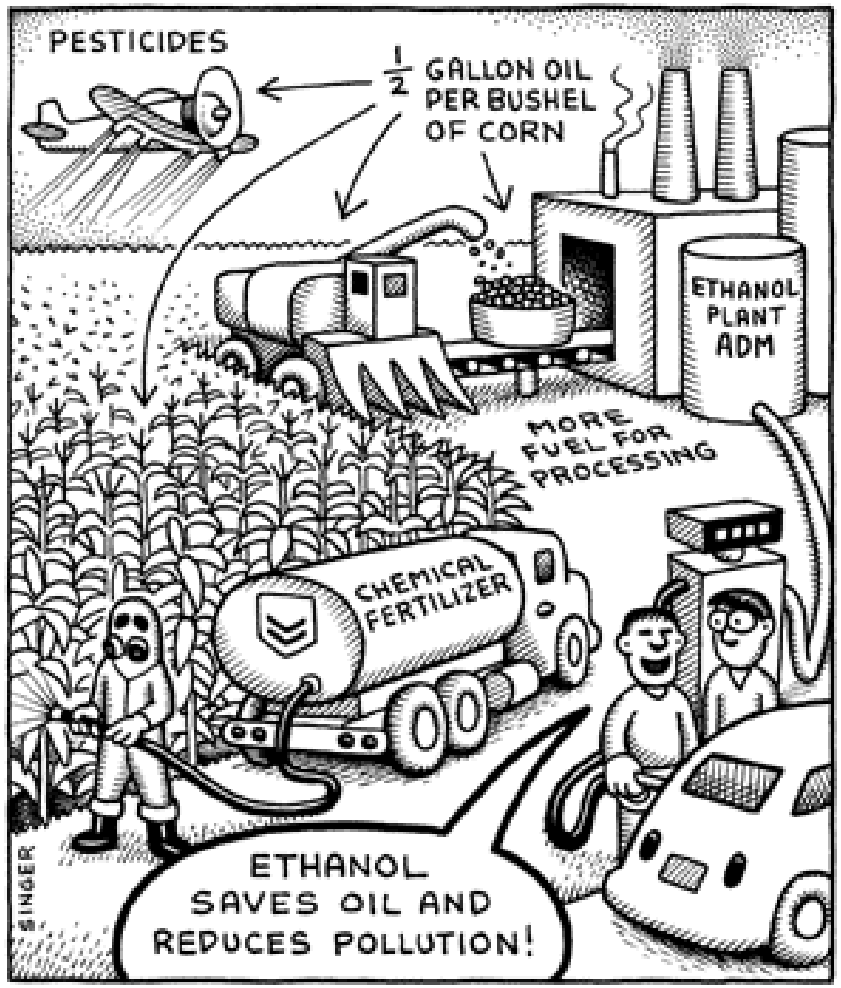
Source: BP

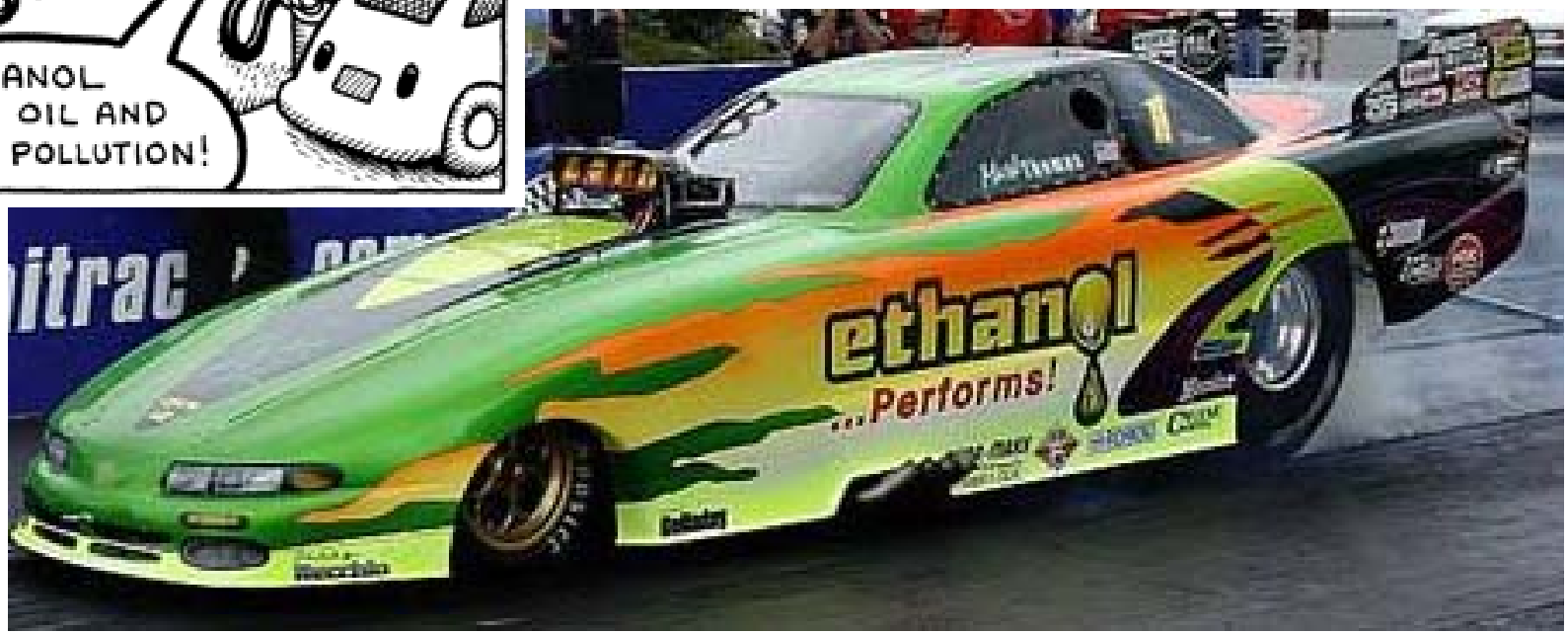
U.S. Electricity

Diagram 5. Electricity Flow, 2004
(Quadrillion Btu)



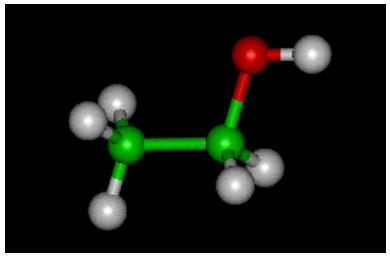
Energy and CO2 Implications of Ethanol





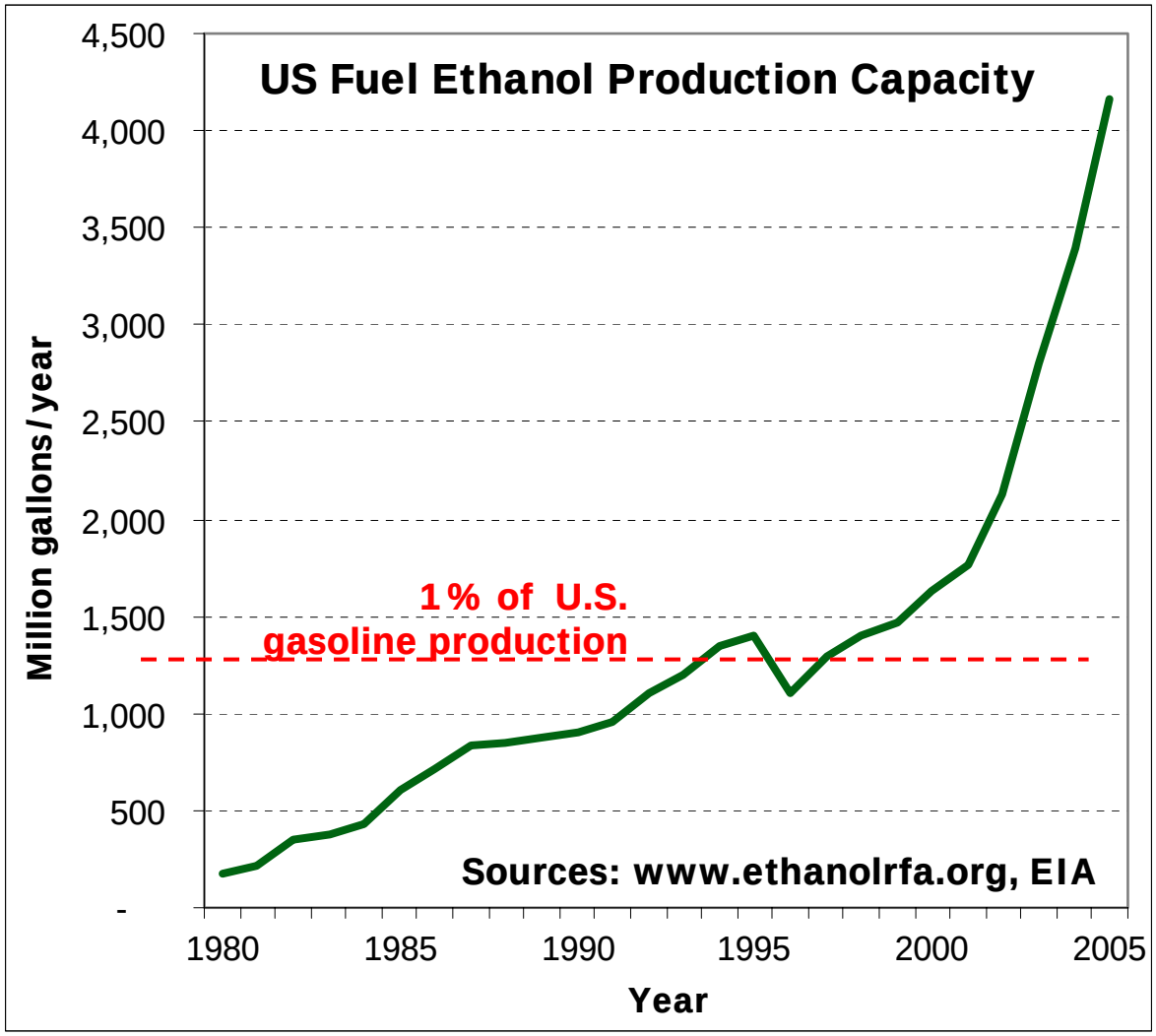
Fuel Properties

	Ethanol	**Conventional Gasoline**
Formula	C_2H_5OH	Mixture (C_8H_{18})
Boiling	78°C	varies (40°-80°C)
Sp. Gravity	0.79	0.74
LHV (MJ/L)	21	32
Octane	113	varies (85-93)



Recent Trends

- Federal subsidy for corn ethanol production
- Federal mandate for “oxygenate” in some gasoline (now ended)
- Federal mandate for “renewable” fuel”
- Almost all corn ethanol
- Cellulosic technology advances (Iogen/Shell deal)



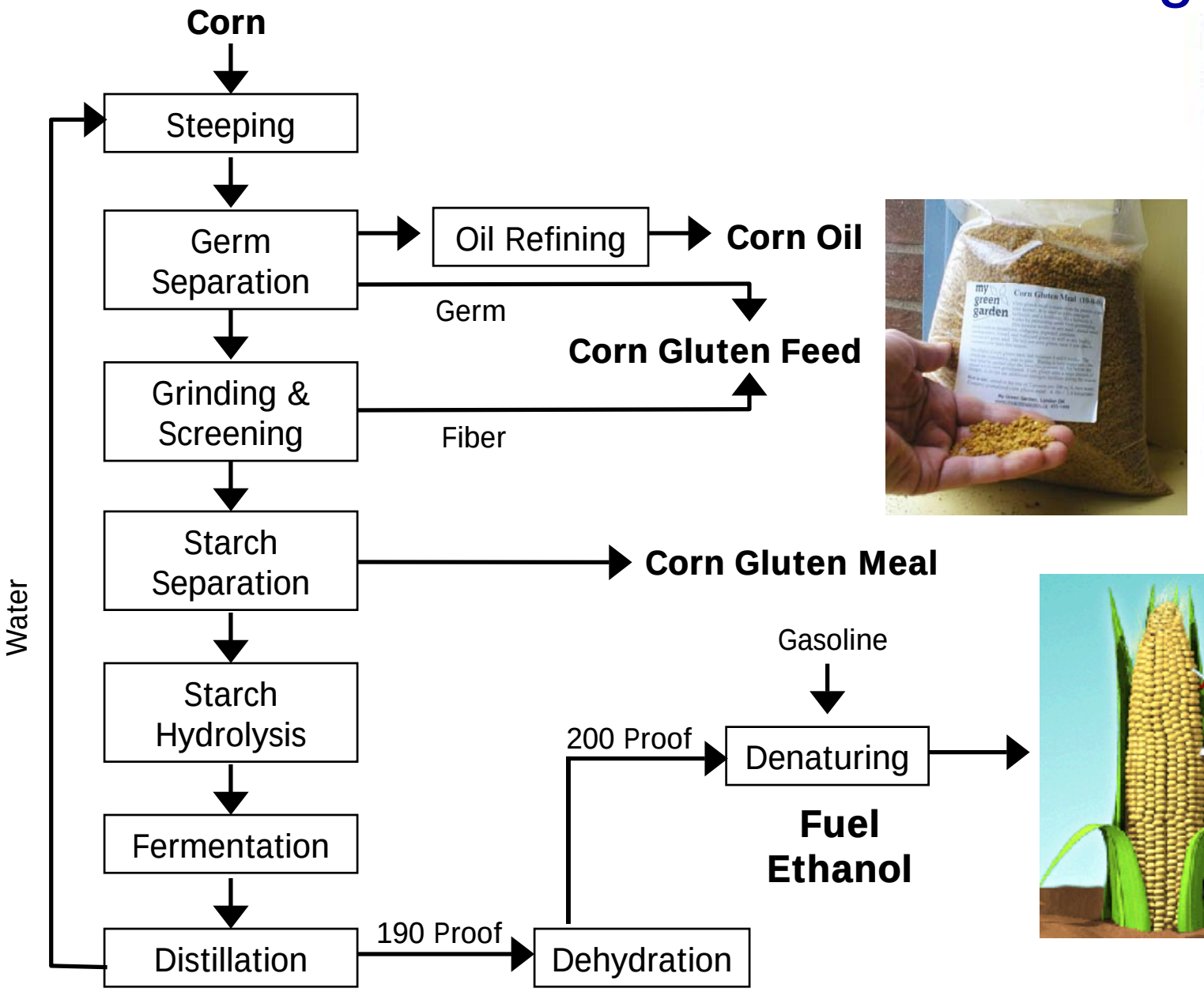
Possible feedstocks

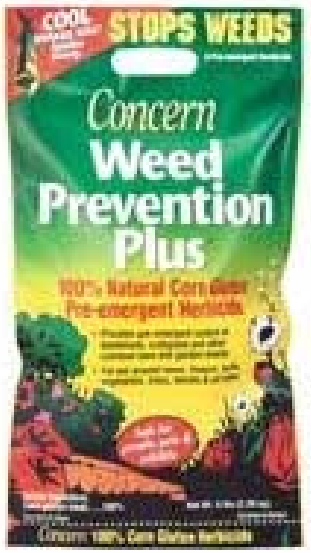
- Corn
- Stover & other residues
- Poplar
- Switchgrass
- Sugar cane
- Bagasse

Starch to ethanol – Dry milling

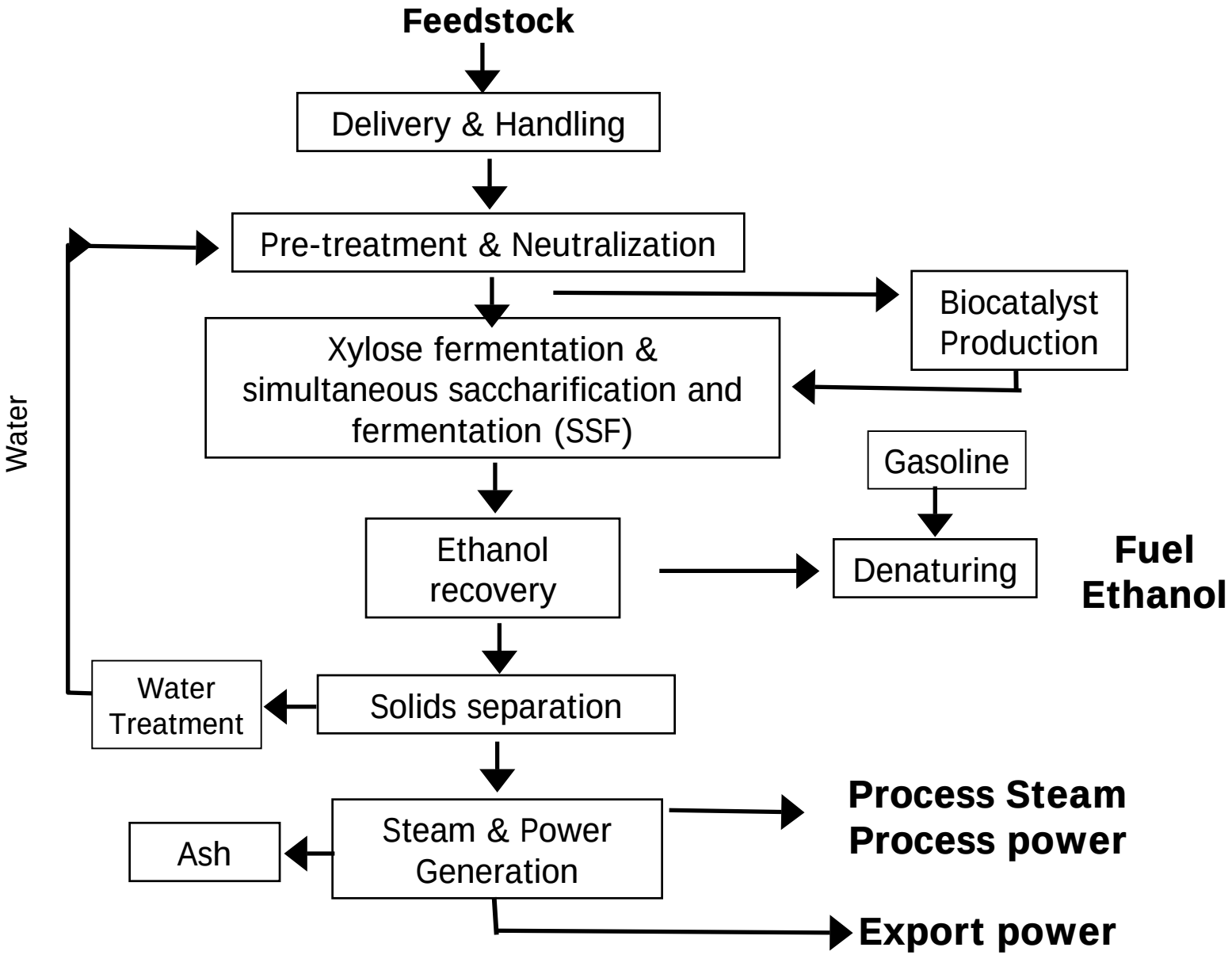
Dried Distiller's Grains and Solubles (DDGS)

Starch to ethanol – Wet milling





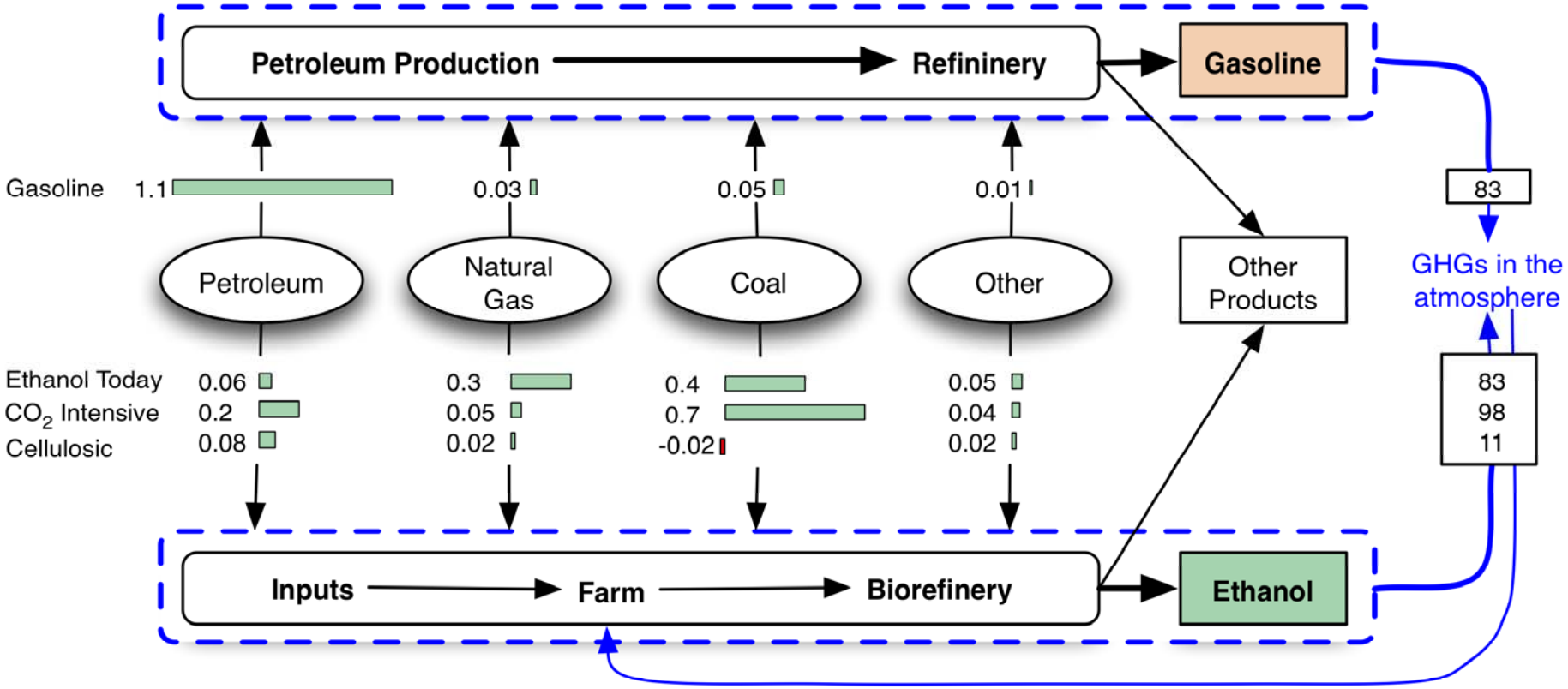
Cellulose to ethanol



The debate on “Net Energy”

- Focus
  - Corn ethanol
  - Average historical values
- Ignores
  - Differences in input energy types
  - Environmental impacts (greenhouse gases, erosion, pesticides, etc.)
  - “Energy theory of value”
- Key differences in the literature
  - Co-products ?
  - Data quality and vintage
- All studies show major reduction in petroleum use
- Best estimates (Fossil input/fuel output)
  - Gasoline: 1.2, Corn ethanol: 0.75, Cellulosic ethanol 0.08

Energy inputs and GHG emissions*



Notes:

Primary energy inputs (MJ) and net greenhouse gas emissions ($kgCO_2$-equivalent) per MJ of fuel.

*GHG emissions are highly uncertaing

"Ethanol Today" is average U.S. performance

"Cellulosic" based on recent estimates for switchgrass-based commercial production

Important environmental aspects (e.g. erosion, pesticides) ignored.

Thanks

Useful websites

- www.eia.doe.gov
- www.bp.com
- http://ist-socrates.berkeley.edu/~erg/
- http://ist-socrates.berkeley.edu/~rael/rael.html
- www.energy.ca.gov
- www.epa.gov
- www.nrel.gov