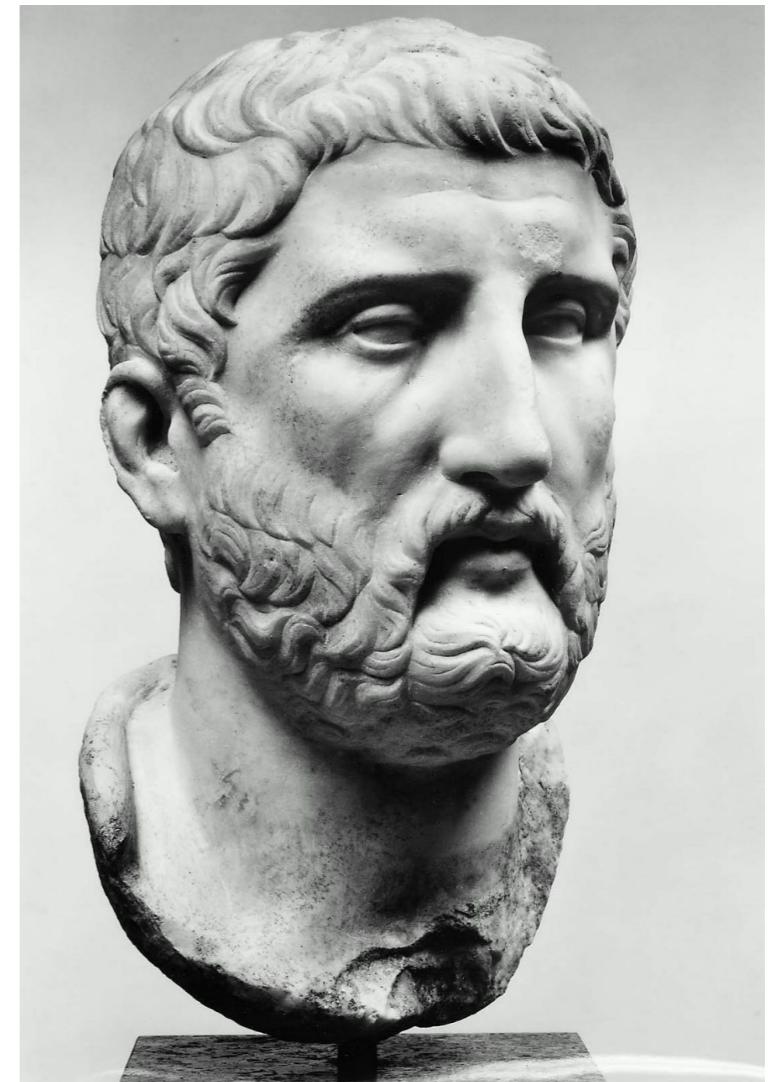


**Nothing exists except atoms and empty space;
everything else is opinion.**

Democritus



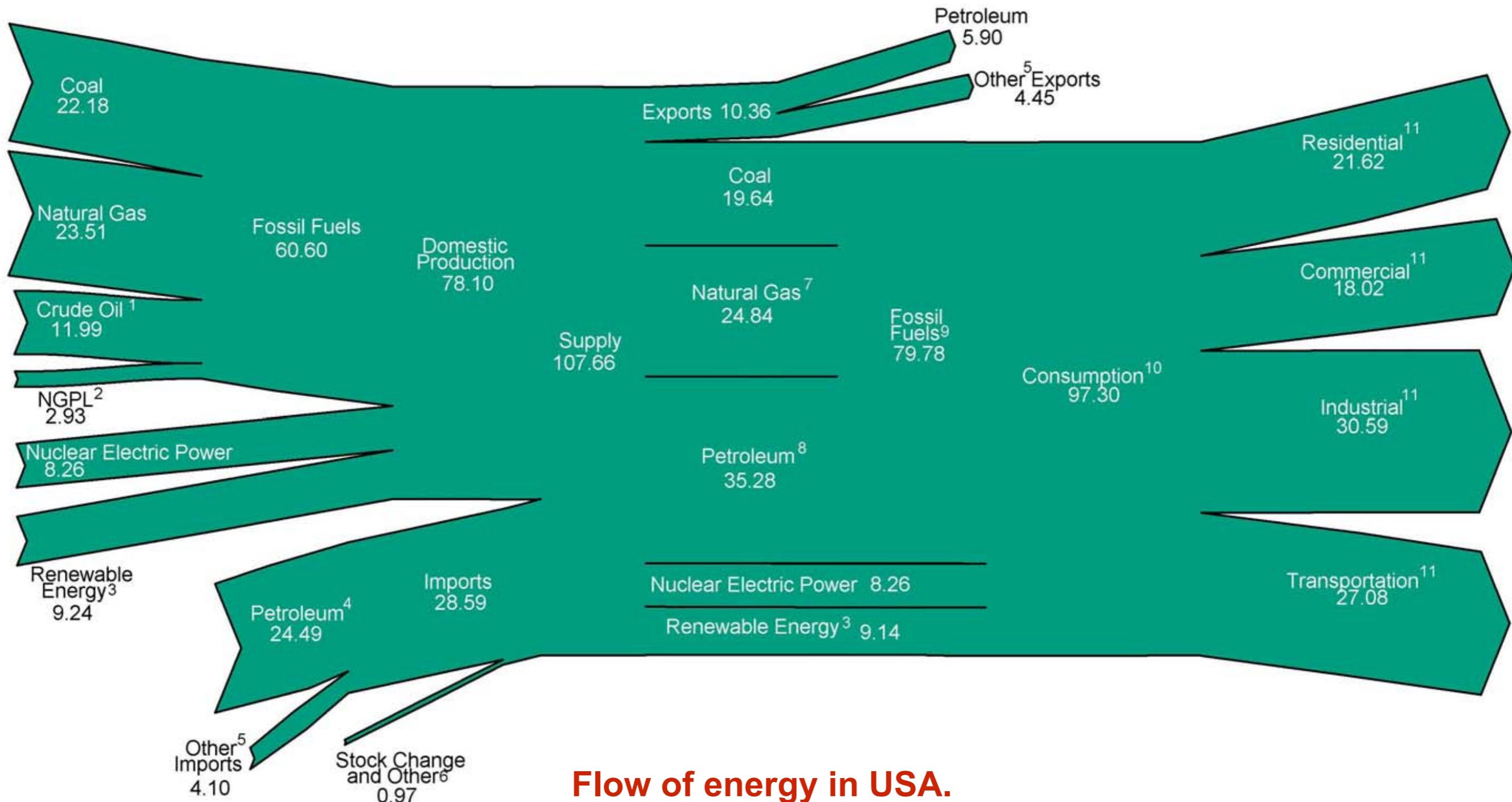
Arizona State University
SES 194

Energy in Everyday Life

Powering the Sun

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**Flow of energy in USA.
Department of Energy,
Annual Energy Review 2013.
Units are ExaJoules, 10^{18} J.**



No one knew much energy the Sun releases into space until we learned the Sun's distance from the Earth.

Once we learned the Sun's prodigious energy output, we were at a loss to explain it until Einstein opened the door by showing that mass is just a form of energy.

$$E = m c^2$$

What powers the Sun?

Wood - Ancient Greeks.
Lasts 2000 years.



Coal - Middle Ages
Lasts 4000 years.

Gravitational contraction - 1830's.
Lasts 4 million years.

Nuclear reactions - 1940's
Lasts 10 billion years.

The Sun presently shines by burning hydrogen (fuel) into helium (ash) in its core.



600 million tons of hydrogen are converted into 596 million tons of helium every second. Where did the missing mass go?

$$E = m c^2$$