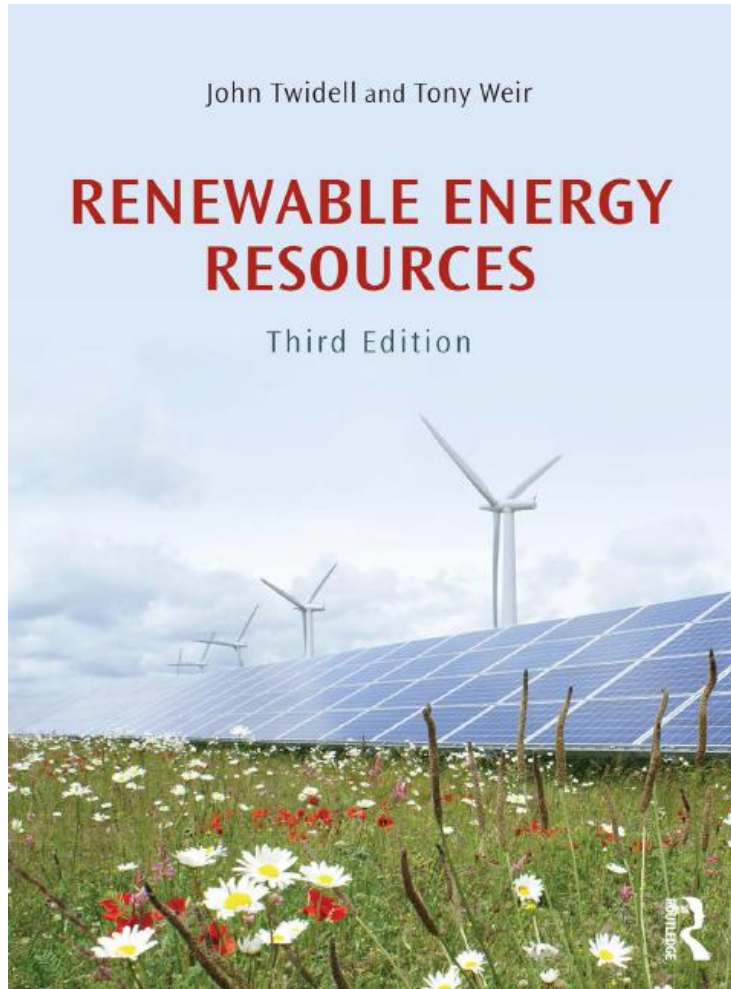


Renewable Energy Systems

EE—325



Slides are prepared from-



**John Twidell and Tony Weir—
Renewable Energy Resources**

Renewable Electric Energy Systems

What Is Power?

Power, is defined as the rate of energy change per length of time. It tells us the quantity of energy that changed during a certain period of time. Mathematically, power or rate of work can be expressed as

$$P = \frac{dU}{dt} = \frac{dw}{dt}$$

where

P is power;

U is energy;

t is time; and

w is work.

What Are the Nonrenewable Energy Resources?

Around the world, a considerable amount of electricity energy is generated based on non-renewable energy resources.

The primary non-renewable energy sources include:

- Fossil fuel
 - ❖ Coal
 - ❖ Petroleum
 - ❖ Natural gas
- Uranium

What Are the Renewable Energy Sources?

Alternative or renewable energy sources include :

- ☐ Biomass
- ☐ Geothermal energy
- ☐ Hydro power
- ☐ Solar energy
- ☐ Ocean energy and
- ☐ Wind energy.

restore (a stock or supply) to a former level or condition.

"all creatures need sleep to replenish their energies"

They are called renewable* because they are replenished or *regenerated* in a short time.

We use renewable energy sources mainly to make electricity and provide thermal heat for applications.

Advantages: Renewable Energy

In today's world, there are many reasons that support enormous interest in renewable energy e.g., :

1. Oil prices are increasing as demand exceeds supply.
2. The impact of fossil fuel usage on the environment.
3. Air pollution from power stations is hazardous to health.
4. Acid rain created when nitric oxides and sulfur oxides combine with water in clouds
5. Global warming caused by the greenhouse effect.



Pollution from the fossil fuel economy.

World Energy Consumption and Demand

Table 1.1 Total energy consumption by country for Year 2009

Country by ranking	Unit: Mtoe
China	2,234
USA	2,201
India	655
Russia	621
Japan	459
Germany	315
France	254
Canada	244
Brazil	238
South Korea	233

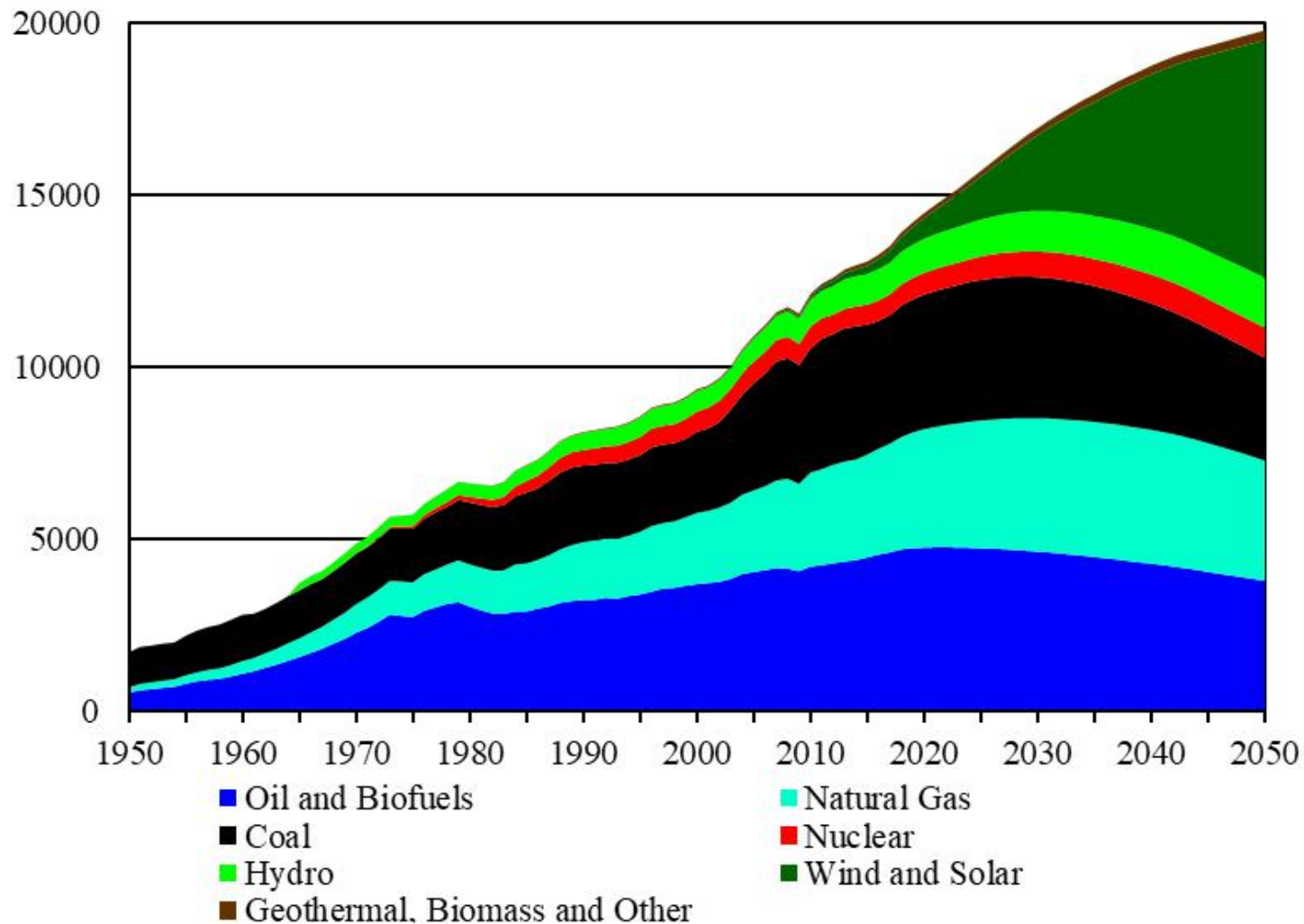
From Enerdata, 2010, Yearbook Statistical Energy Review 2010 <http://yearbook.enerdata.net/>.

The tonne of oil equivalent (toe) is a unit of energy defined as the amount of energy released by burning one tonne of crude oil.

It is approximately 42 gigajoules or 11,630 kilowatt-hours. The toe is sometimes used for large amounts of energy.

World Energy Consumption

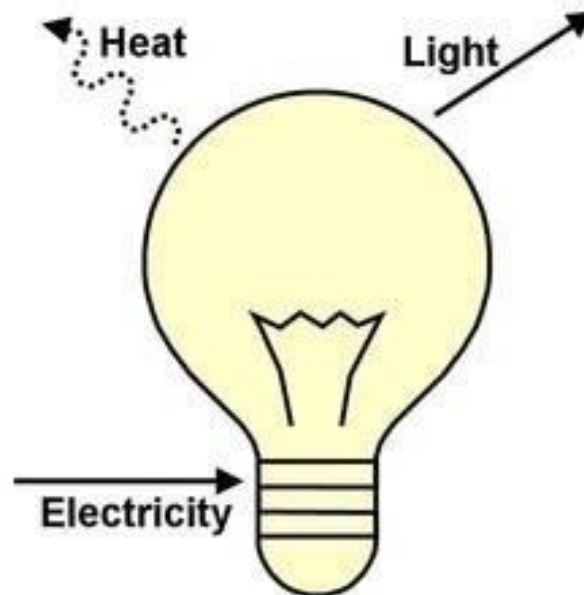
World Primary Energy Consumption
(Million Tons of Oil Equivalent, 1950-2050)



Source: World Energy 2018-2050: World Energy Annual Report

The Conservation of Energy

The conservation of energy or First Law of Thermodynamics tells us that energy changes form and it moves from place to another place but the total amount of energy in a system remains unchanged. In other words, we can say that “energy input” equals “energy stored” plus “energy output.” It tells us nothing about loss energy, idle energy or waste energy.



Revision of Extra High Energy Units

Exajoule (EJ):

$$1 \text{ EJ} = 10^{18} \text{ J}$$

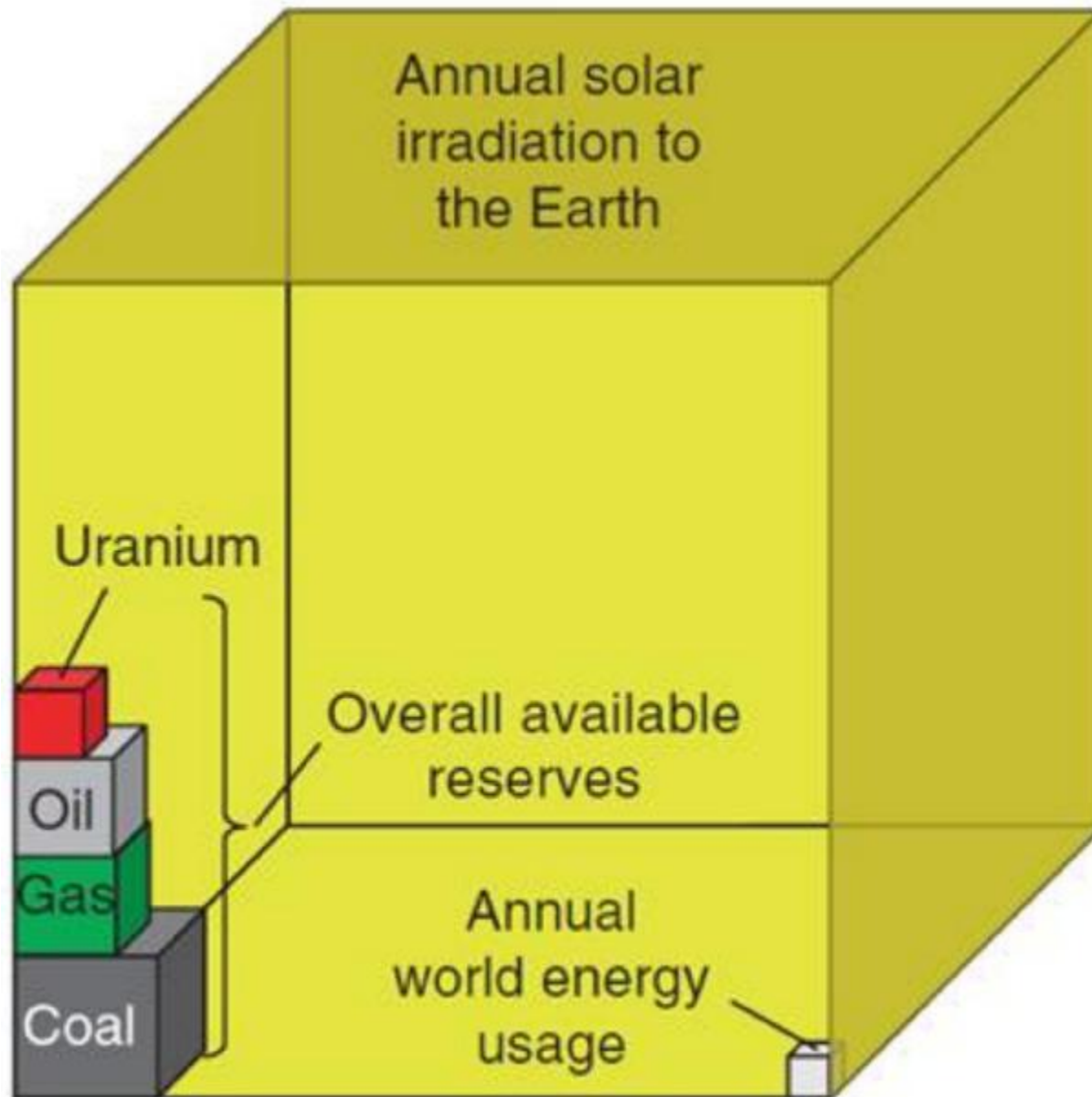
Quadrillion Btu(quad):

$$1 \text{ quad} = 10^{15} \text{ Btu} = 1.055 \text{ EJ}$$

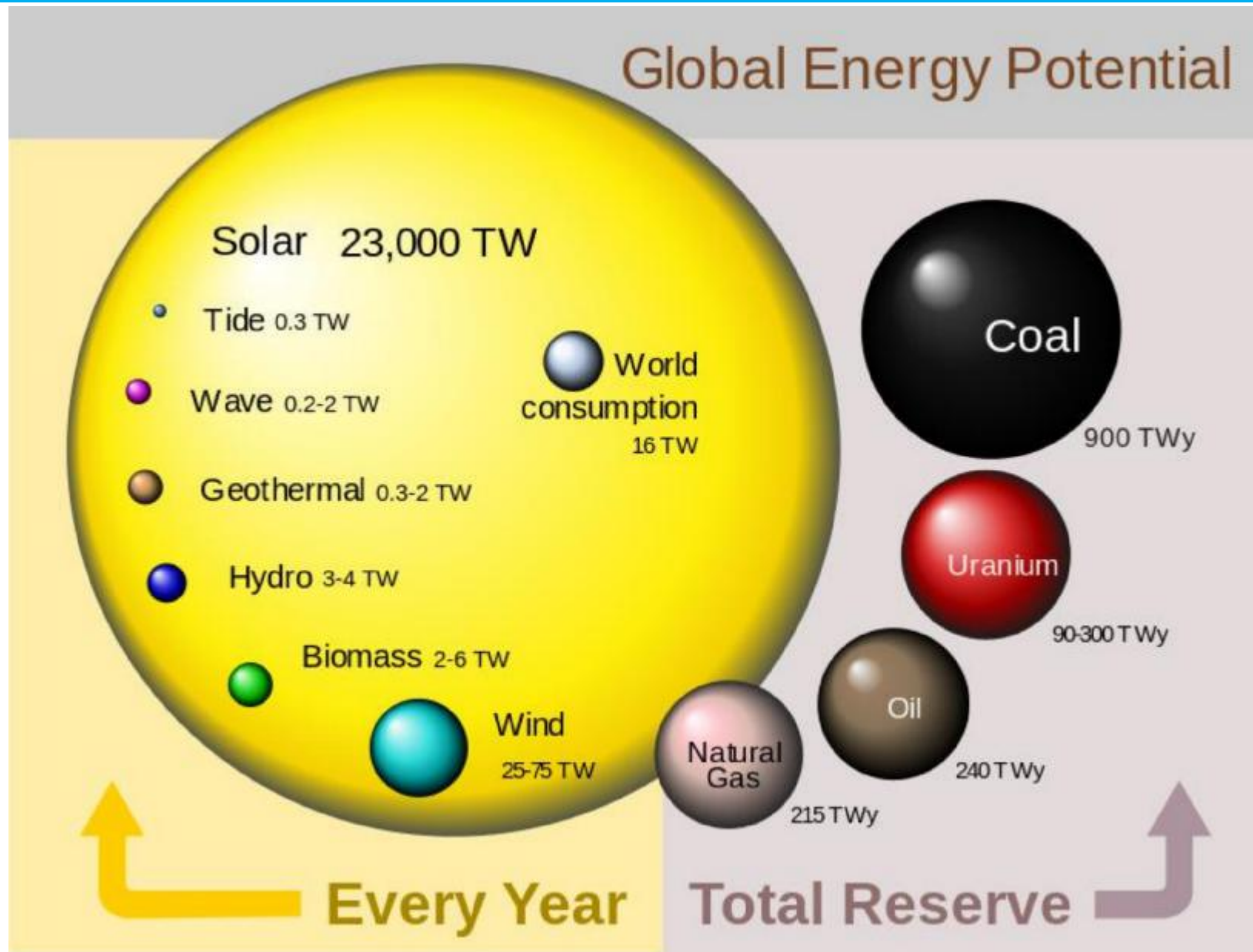
Terawatt-year (TWy):

$$1 \text{ TWy} = 8.76 \times 10^{12} \text{ kWh} = 31.54 \text{ EJ} = 29.89 \text{ quad}$$

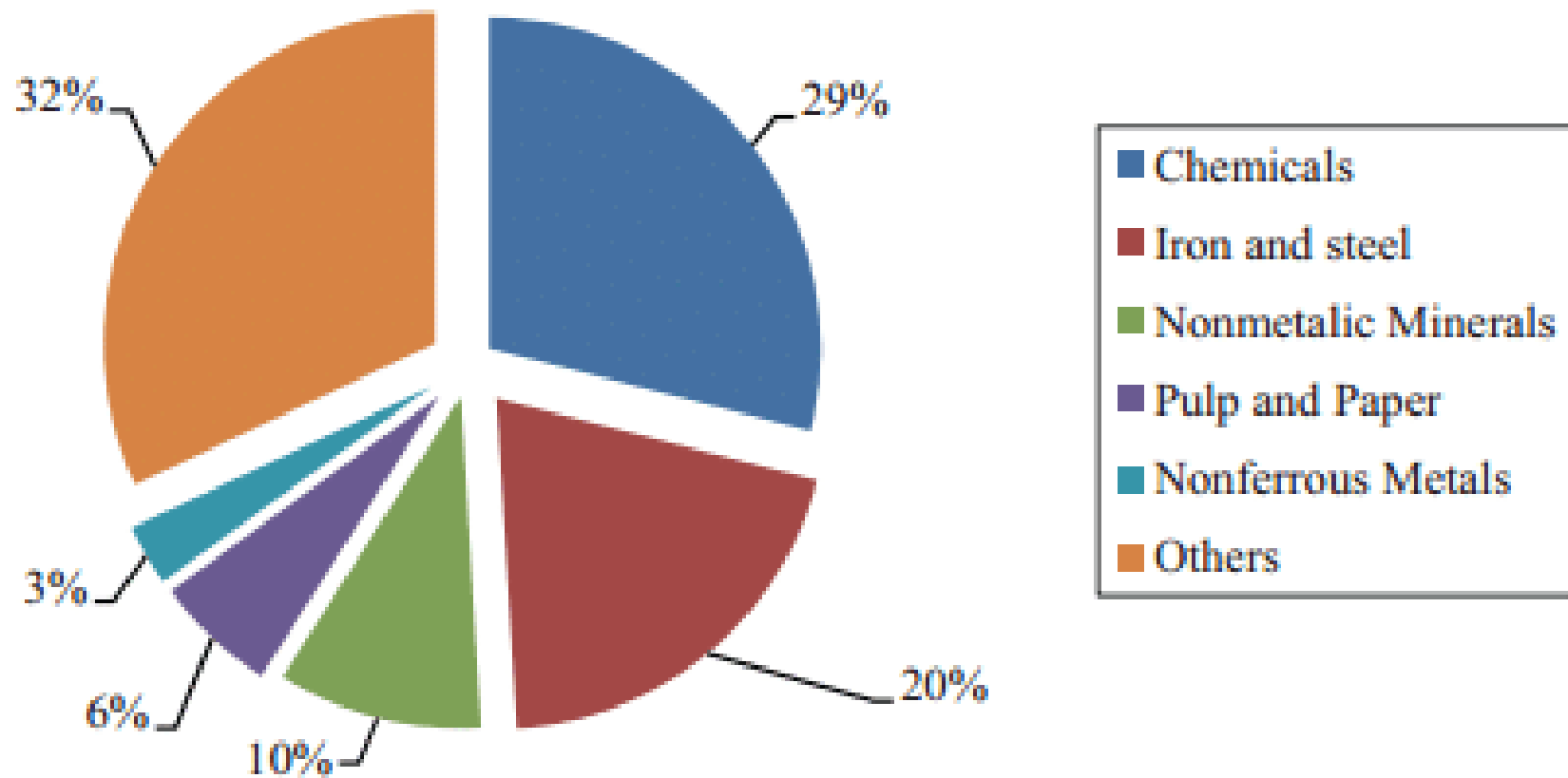
The Availability of Energy



The Availability of Global Energy per Year

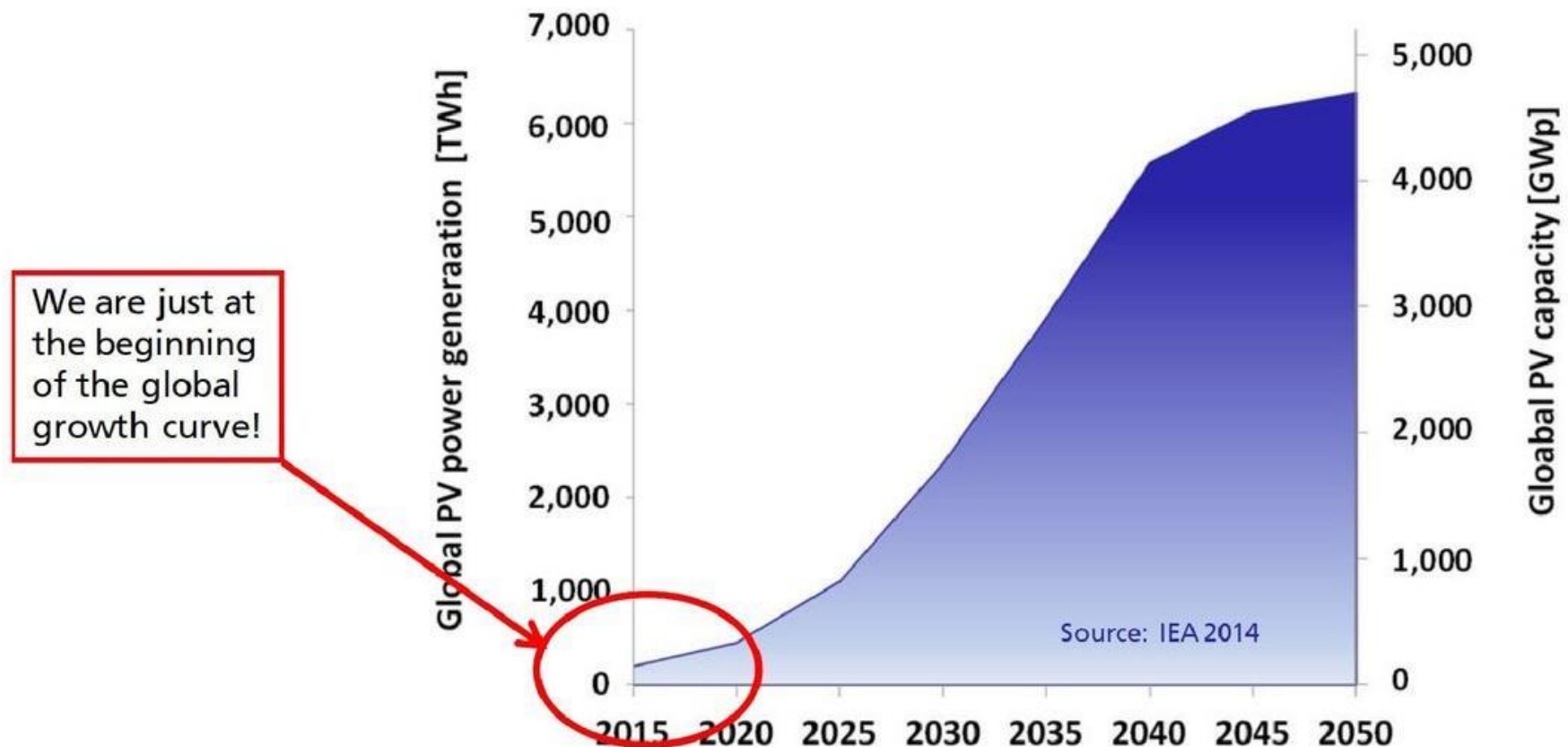


World industrial sector energy consumption by major energy-intensive industry shares in 2006



PV Heading into the Terawatt Range

- Rapid introduction of PV globally is fueled by availability of cost-competitive, distributed energy
- In 2050 or before between **4000 and 5000 GWp** PV will be installed!
- By 2016, less than 300 GW_p have been installed!





Energy Resources

