Renewable Electric Energy Systems EE—546

Chap—1 Introduction

Dr. U. T. Shami

Overview of the course:

Renewable Electric Energy Systems

EE—548: Renewable Electric Energy Systems

Lecture Schedule	Tuesday and Thursday 16:30—18:00hrs	**Course Type, Semester**	Specialization: Power Fall—2019
Credit Hours	Three	**Pre-requisites**	Graduate standing
Instructor	Umar T. Shami	**Contact**	utshami@uet.edu.pk
Office	Ground Floor, E. E. Depart., U.E.T.	**Office Hours**	Tuesday and Thursday 16:00—16:30hrs
Course Description	This master level course will cover the utilization of renewable energy systems for the generation of electrical energy. Renewable energy sources such as photovoltaic, hydro-power, fuel cells, wave energy and wind turbines, will be taught. Topics related to renewable energy including distributed generation and its interconnection will be presented. Social, economic and environmental topics associated with the renewable-energy technologies will also be studied.		

Measurable Learning Outcomes

CLOs	Description	Taxonomy Level	PLOs	Level
CLO1	**Recognize the** accessible renewable energy sources and respective conversion technologies.	C-1	PLO1	Medium
CLO2	**Show the** basic operation of wind energy and integration to grid.	C-3	PLO2	Medium
CLO3	**Outline** and analyze the operation of solar photovoltaic and integration to grid.	C-4	PLO4	Medium
CLO4	**Evaluate** environmental and Economics of renewable and hybrid systems issues of renewable energy systems.	C-5	PLO7	Medium

Textbooks

[1] J. Twidell and T. Weir, Renewable Energy Resources, 3 ed., Routledge, 2015.
[2] M. H. Rashid, Electric Renewable Energy Systems, 1 ed., Academic Press, 2015.
[3] P. Breeze, Power Generation Technologies, 3 ed. Newnes, 2019.
[4] K. Mertens, Photovoltaics: Fundamentals, Technology and Practice, 1 ed., Wiley, 2014.

Grading Policy

• Quizzes + Assignments	30%	CLO1 and CLO3
• Midterm	30%	CLO1 and CLO2
• Final	40%	CLO3 and CLO4

Tentative Lecture Plan EE—548: Renewable Electric Energy Systems
Dr Umar T. Shami (Fall—2019)

Week	Topics	CLO & Recommended Reading
1.	**Overview of the course and its future aspects**. Introduction to Renewable energy sources utilized for generating Electrical energy. Social and environmental issues including advantages and disadvantages.	CLO—1 & CLO—4; Class lectures
2.	**Hydro-power:** Introduction to Hydropower systems, Process of hydroelectricity (Hydroelectric systems), Basics of pumps and turbines (Impulse turbines, Reaction turbines), Electric generators and energy conversion schemes for hydroelectricity, Hydropower fed to grid, Social and environmental aspects	CLO—1; Textbook [1] & [2]
3.	**Fuel cells:** Fuel cell fundamentals, Modeling of ideal fuel cells, Advantages and disadvantages of fuel cell, Power applications of fuel cells.	CLO—1; Textbook [2]
4.	**Marine Power Generation:** Wave Power, Marine Current Energy, Marine Current Energy Converters, Horizontal Axis Turbines, Vertical Axis Turbines, Water Wheels and Cross-Flow Turbines, MP fed to grid.	CLO—1; Textbook [1] & [3]
5.	**Wind Power:** Global Wind Power Capacity, Wind Resources, Wind Turbine Technology, Offshore Wind Turbine Technology, Wind Farms, Environmental Effects of Wind Power, Wind Capacity Limits.	CLO—1 & CLO—2; Textbook [3]
6.	**Wind Power Conversion:** Energy Conversion at the Generator-Converter System, Idealized Operating Characteristic Curves of Wind Turbines, Wind Turbine Control Systems, Operating Management Systems for Wind Turbines, Control of the Operating Sequence of Wind Turbines, Wind Farm Control and Automation Systems, Remote Control and Monitoring.	CLO—2;
7.	**Wind Power Grid Integration:** Energy Supply Grids in Overview, Grid Control, Grid Integration of Wind Turbines, Grid Connections for Wind Turbines, Energy Storage, Switchgear circuit for Wind Turbines.	CLO—2;
8.	**Mid—of—Term Examination Week**	**Mid—Term Exam**
9.	**Solar Radiation:** Properties of Solar Radiation, Global Radiation, Calculation of the Position of the Sun, Radiation on Tilted Surfaces, Radiation Calculation with the Three-Component Model, Radiation Estimates with Diagrams and Tables, Yield Gain through Tracking.	CLO—3; Textbook [4]
10.	**Semiconductors for solar application:** Semiconductors as materials for solar cells, Carrier concentration and distribution, generation-recombination processes, Continuity Equations.	CLO—3; Textbook [4]
11.	**Consideration of the Photodiode:** Method of Function of the Solar Cell, Photocurrent, Characteristic Curve and Characteristic Dimensions, Electrical Description of Real Solar Cells, Considering Efficiency, High Efficiency Cells.	CLO—3; Textbook [4]
12.	**Photovoltaic System Technology:** DC/DC Converters, MPP-Tracking, Grid-Connected Systems, Structure of Inverters, Efficiency of Inverters, Dimensioning of Inverters, Requirements of Grid connection, Stand-Alone Systems, Batteries, Charge Controllers.	CLO—3; Textbook [4]
13.	**Photovoltaic Inverter Structures:** DC/AC Inverter Structures Derived from H-Bridge Topology, Inverter Structures Derived from NPC Topology, Multilevel Inverter for PV applications.	CLO—3; Class lectures
14.	**Interconnection of renewable energy systems into the grid:** Voltage control in power networks, Power quality and harmonics, Grid Synchronization in Three-Phase Power Converters. Islanding effect and prevention (anti-islanding circuitry).	CLO—3; Textbook [4]
15.	**Social, economic, environmental aspects and conclusion**: topics associated with the renewable-energy technologies.	CLO—4; Class lectures
16.	**End—of—Term Examination Week**	**End—Term Exam**

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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

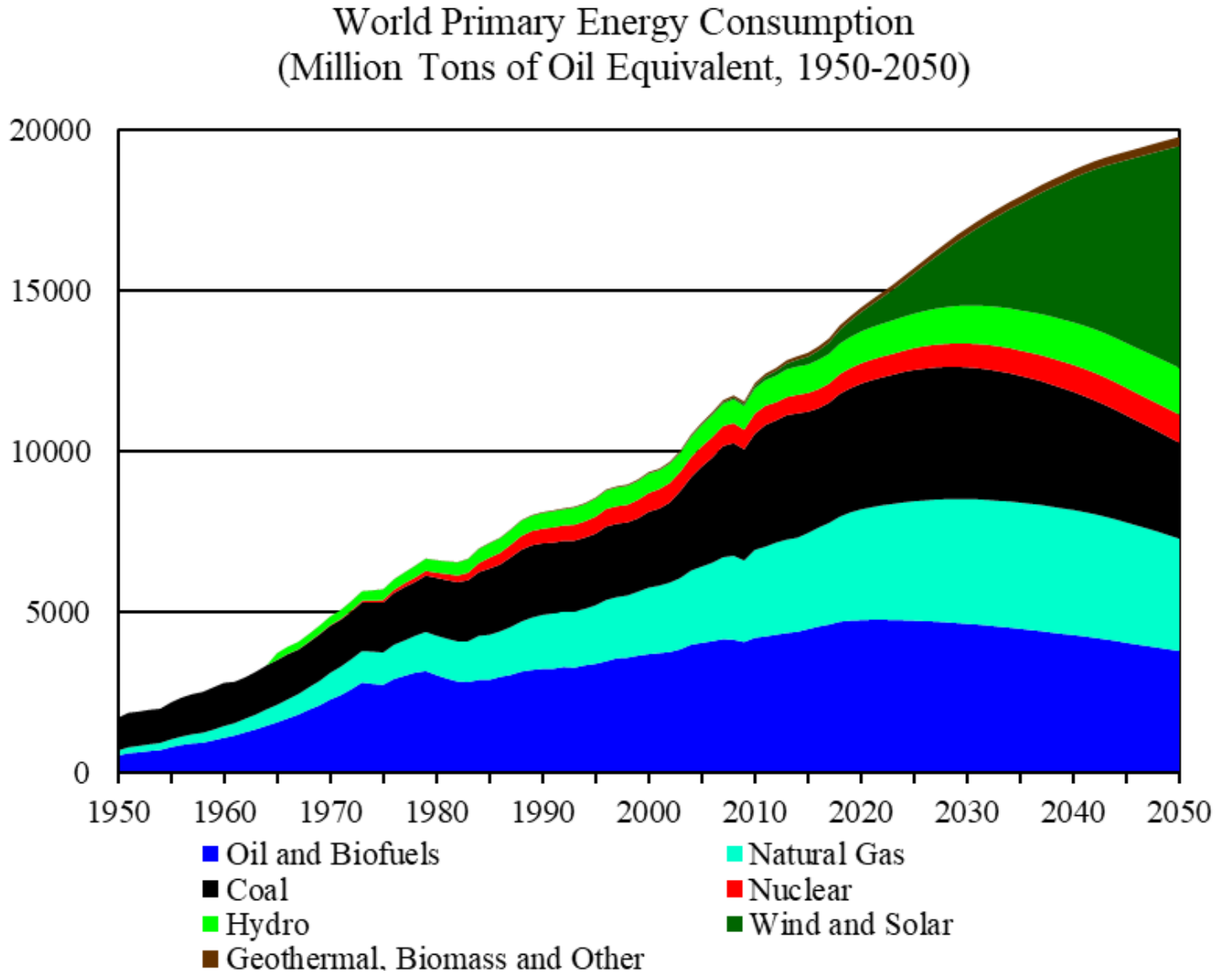
Country by ranking	Unit: Mtoe
China	2,234
USA	2,201
India	655
Russia	621
Japan	459
Germany	315
France	254
Canada	244
Brazil	238
South Korea	233

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.

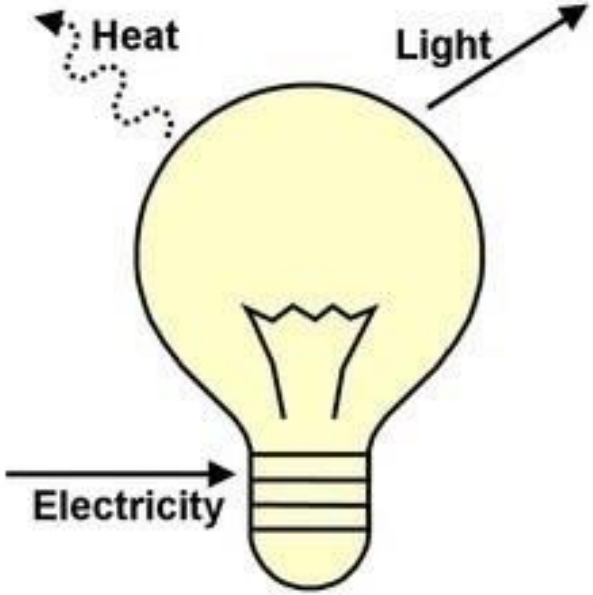
World Energy Consumption



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):

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

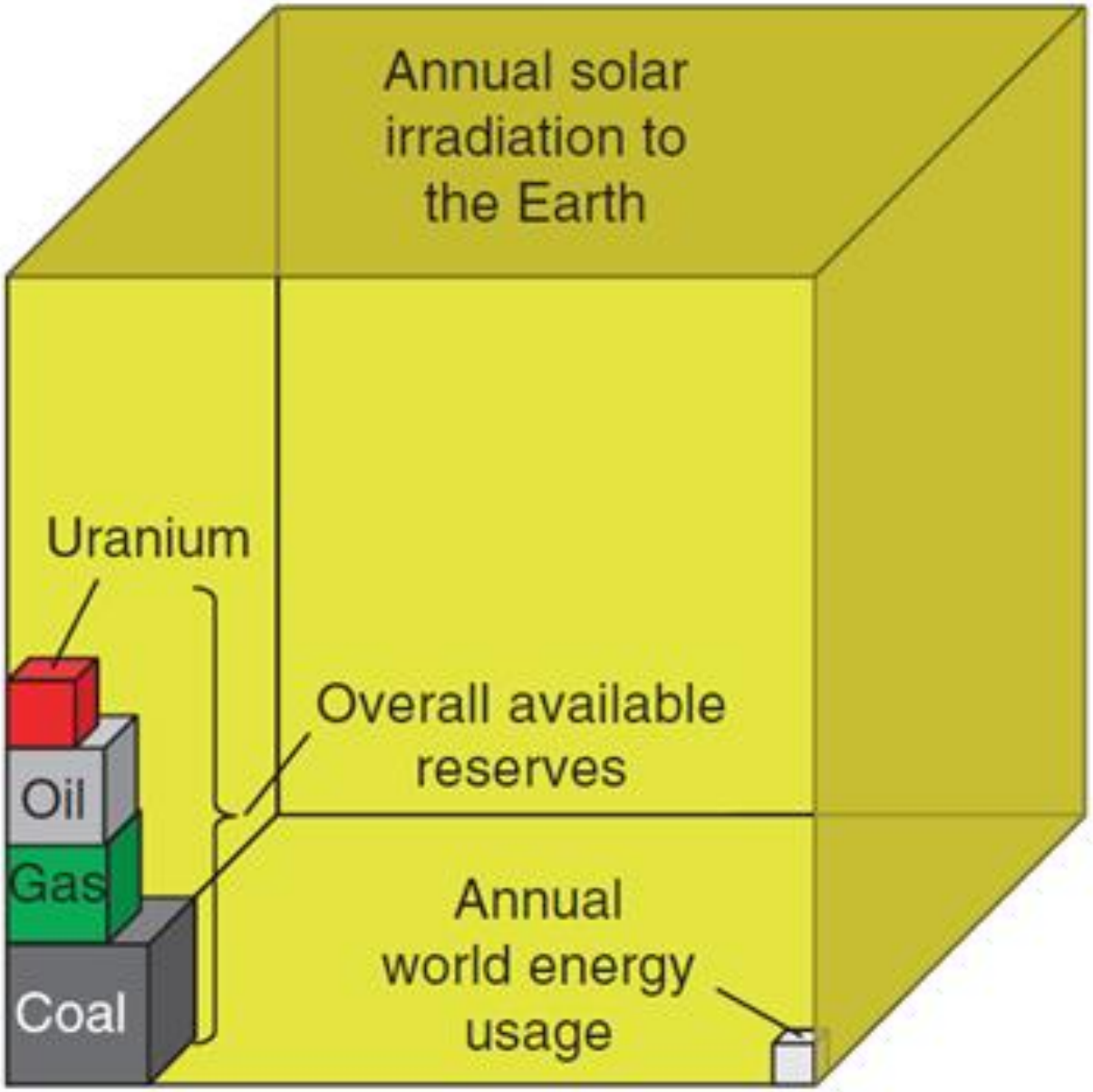
Quadrillion Btu(quad):

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

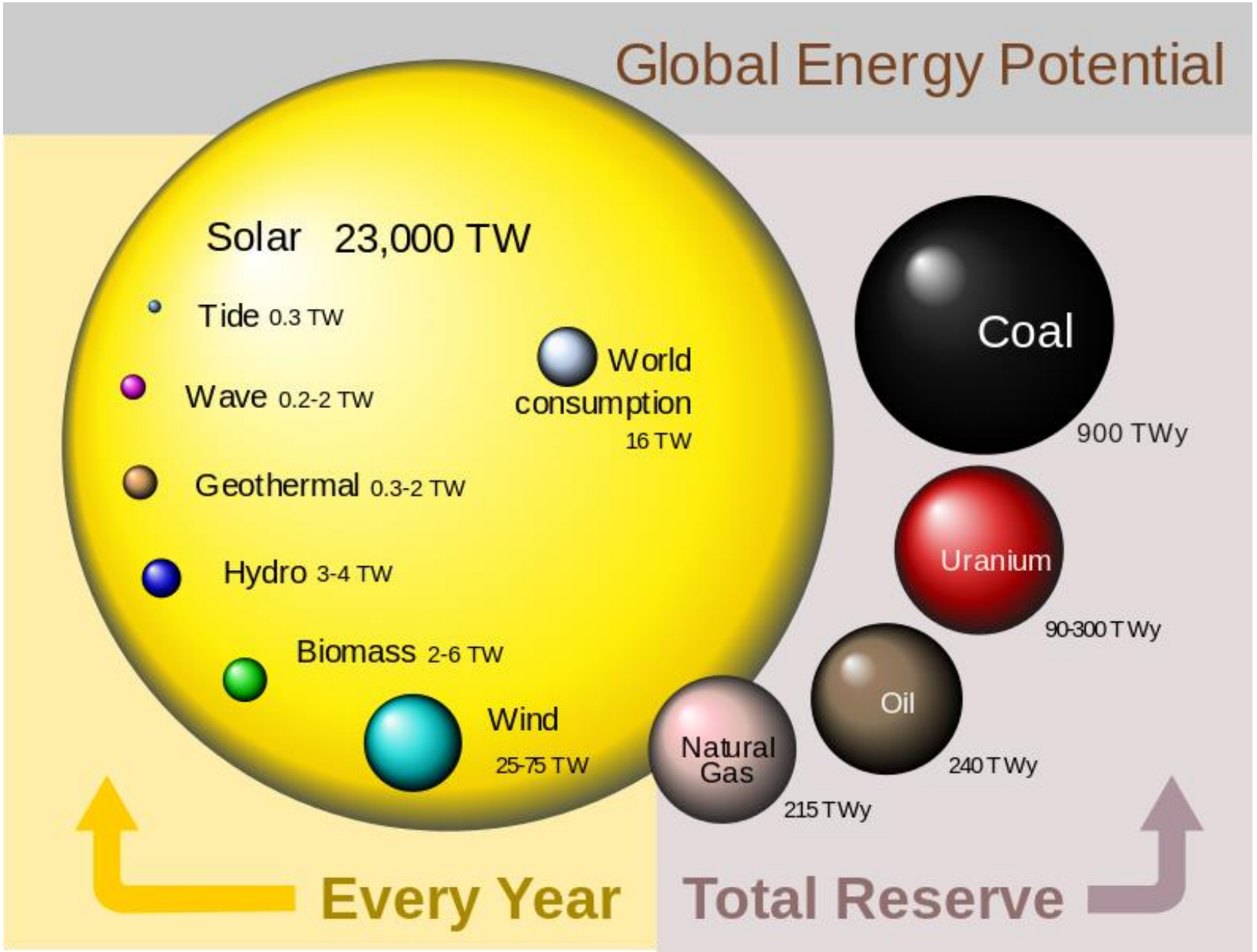
Terawatt-year (TWy):

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

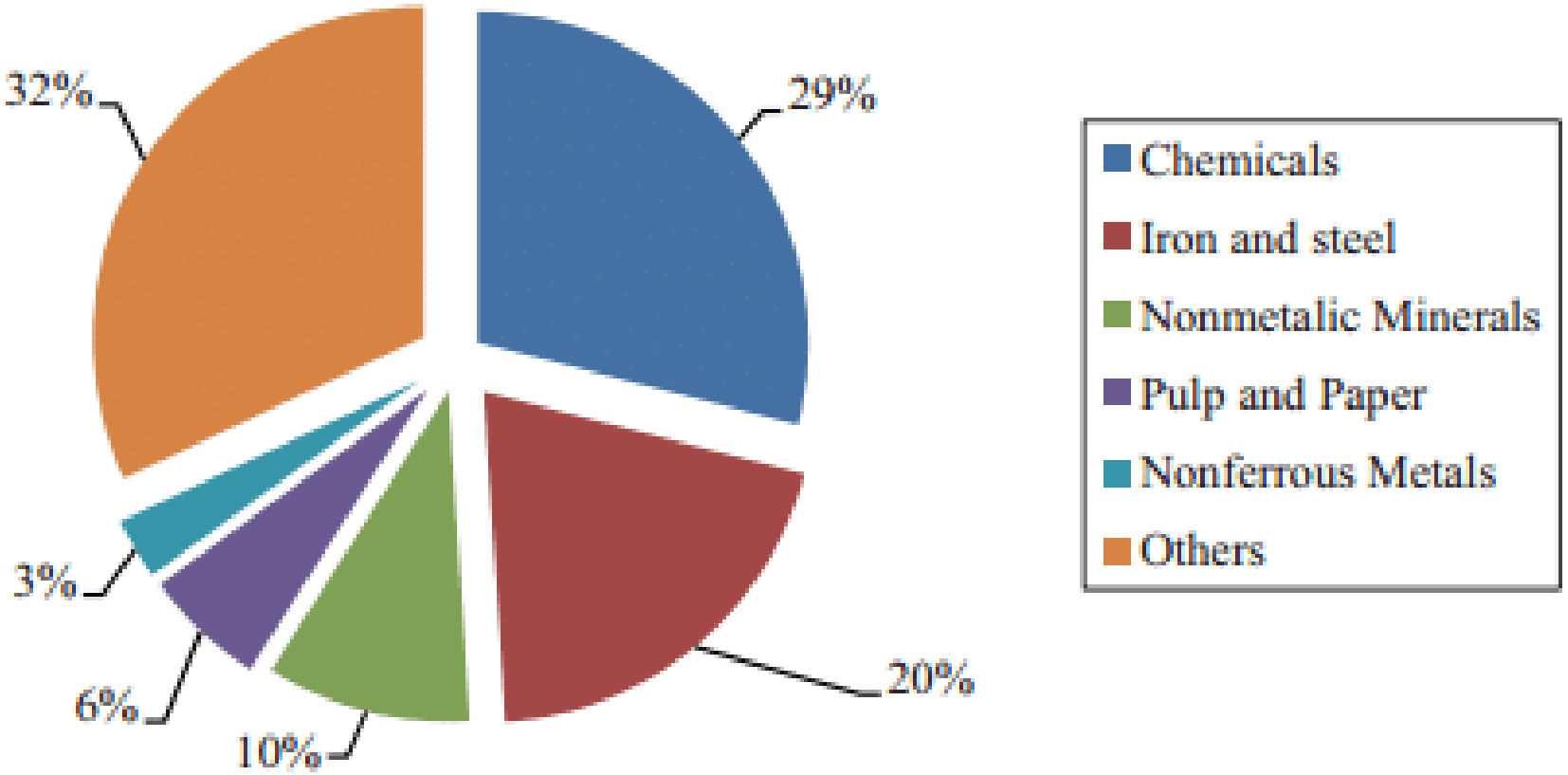
The Availability of Energy



The Availability of Global Energy per Year

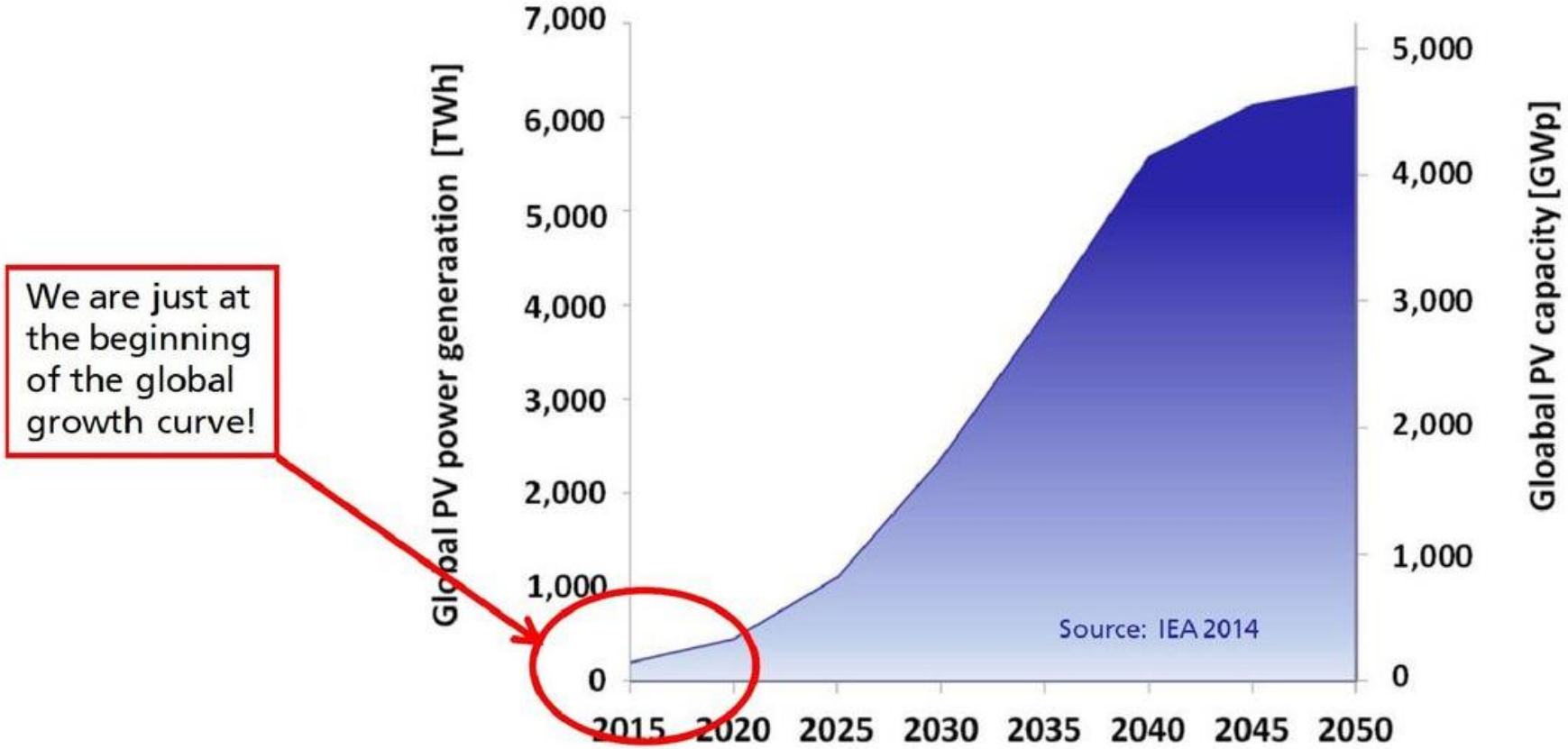


World industrial sector energy consumption by major energy-intensive industry shares in 2006

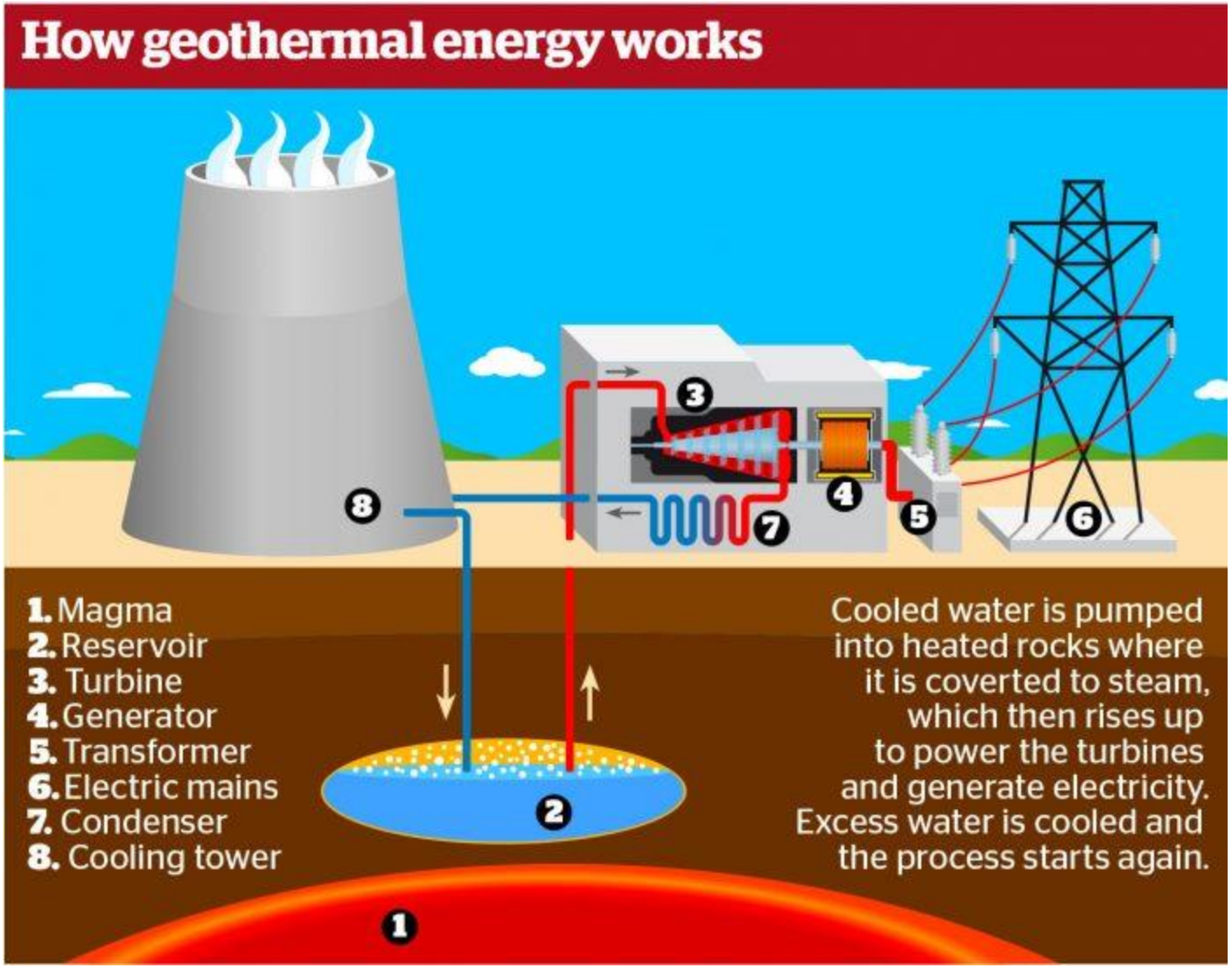


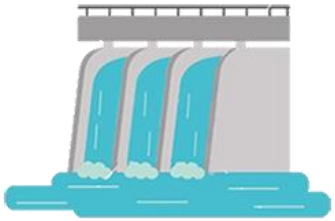
PV Heading into the Terawatt Range

- 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





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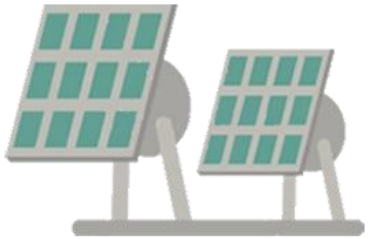

1

Hydroelectric Dam

Site C
1,100 MW

12

Natural Gas Plants

McMahon Co-Generation
120MW

990

Wind Turbines

Leitwind LTW77-1500
1.5 MW

30,000,000

m^2 of Solar Panels

Canadian Solar
500 W

EnergyBC