EE2029 Zoom Session

- Sign into the **zoom** app/ mobile before joining the zoom session.
- Use the nusnet id (exxxxxx@u.nus.edu) not the friendly email
- Please ensure that you mute your Mic when you are in the session
- Use the Raise Hand Button to ask doubts during the lecture. You can unmute yourself when I call out your name
- Use the Chat to post more detailed queries.
- This meeting will be recorded and posted to LumiNUS by the following day

EE2029: Introduction to Electrical Energy Systems

Introduction

Lecturer : Dr. Sangit Sasidhar (sangit@nus.edu.sg)
Department of Electrical and Computer Engineering

Learning Outcomes

- This module covers the fundamental principles of modern electrical energy systems; including three-phase analysis, electric generations, electric loads, and power electronic converters
- Develop a broad systems perspective and an understanding of the principal elements of electrical energy systems

EE2029 Syllabus

- Structure of Electrical Power Systems
  - Introduction to power generation, transmission and distribution systems.
- Generating sources
  - Conventional and renewable energy sources: Fossil fuel based thermal power generation, Wind Energy, Photovoltaic array: basic model, and conversion efficiencies.
- Three-Phase systems
  - Revise active power, reactive power and apparent power. Concept of harmonics and how it influences power factor. Introduction to phasor diagrams and complex power. Balanced three-phase systems and their single-phase equivalents. Power factor correction. Relationship between phase and line quantities.
- Transformers
  - Single phase and three-phase transformer, Magnetic circuits, magnetizing current and saturation, real transformers. Equivalent circuits with short-circuit and open circuit. Phasor diagram, regulation (applied to transformer) and efficiency. Three-phase transformer connection. Per unit systems.
- Transmission System
  - Three-phase-four-wire system, three-phase-three-wire system, and three-phase circuit analysis. Modelling and sizing of cables.
- Utilization of Energy
  - Static loads: Lighting, heating, resistive, and inductive. Three-phase induction machine: Operating principle, equivalent circuits, torque-speed characteristics, losses and efficiency.
- Static Power Converters
  - AC to DC conversion, ‘DC to DC conversion, DC to AC conversion, harmonics, power quality. Block diagram of power conversion

Assessments

ASSIGNMENT : (10%)

ONLINE, QUIZ &/ TUTORIAL COMPLETION: (10%)

CLASS TESTS (30%) (TAKE HOME PROBLEM SETS)

FINAL EXAMINATION (50%)

Blended Online Learning

- Online
  - Lecture Videos
  - LumiNUS/Teams Quizzes
  - Online Assignments
  - Problem Solving
- In–Class Zoom Session
  - Review and Summary
  - Tutorial Solving
  - In-class activities

❑ Weekly Schedule

- Thursday
  - ➔ Online Videos Released
- Thursday - Monday
  - ➔ Online/ Quiz/Tutorial Completion
- Tuesday/ Friday
  - ➔ In-Class Zoom Session

<table>
<tr><th colspan="5">Week (n-1)</th><th colspan="7">Week (n)</th></tr>
<tr><td>Wednesday</td><td>Thursday</td><td>Friday</td><td>Saturday</td><td>Sunday</td><td>Monday</td><td>Tuesday</td><td>Wednesday</td><td>Thursday</td><td>Friday</td><td>Saturday</td><td>Sunday</td></tr>
<tr><td></td><td></td><td>In-Class Session /Online Video Review</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Online Videos - Week (n)</td><td colspan="3">Online/ Quiz/Forum Participation - Week (n)</td><td></td><td>In-Class Session</td><td></td><td></td><td>In-Class Session /Online Video Review</td><td></td><td></td></tr>
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Admin Stuff

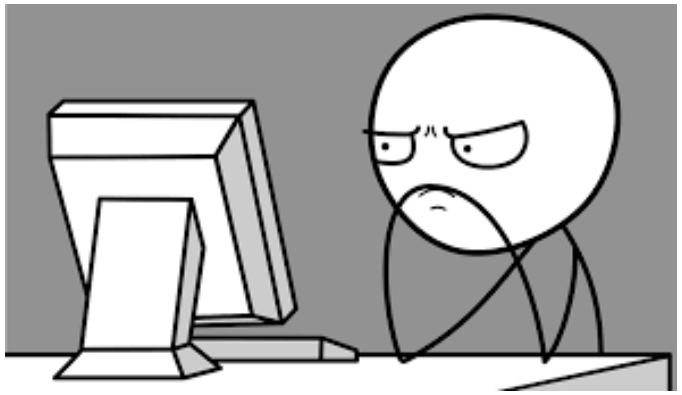
- In-Class Zoom Sessions
  - Tuesdays : 12 noon- 2 pm
  - Fridays: 4pm – 6pm
- Follow the Learning Flow, Announcements and Emails for weekly lecture schedule
- The lecture content will be released online in the form of short videos and will be available in the **Learning Flow:** View these before the in-class zoom session
- Consultation Slots: Consultation Slots will be released by this Thursday before your next lecture
- Contact Me: Forums/ Microsoft Teams/ Email (Descending Order of Preference ☺)

Detailed Schedule (upto Week 6)

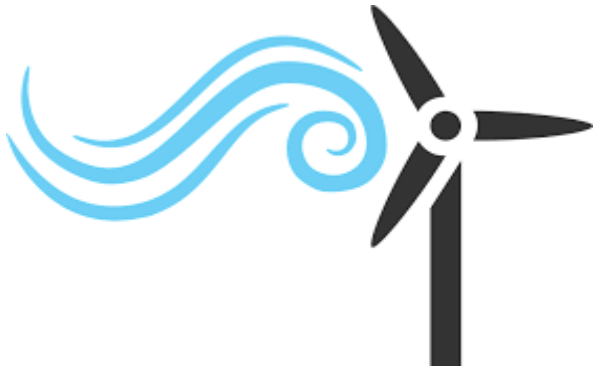
- **Week 1: Introduction and Complex Numbers**
  - Introduction to Electrical Energy Systems
  - Complex Numbers
- **Week 2: AC Fundamentals**
  - Describe a Sinusoidal Alternating Voltage
  - Sketch and Interpret a Phasor
  - Define impedance and derive it for different Circuit Components
- **Week 3: AC Power**
  - Derive the Average Power in a Resistor, Inductor, and Capacitor
  - Describe Real, Apparent, Reactive and Complex Power
  - Define Power Factor of an AC Circuit and analyse a circuit to correct its power factor
- **Week 4: Three-Phase Power**
  - Appraise the importance of three-phase over single-phase AC systems
  - Develop a way to measure and represent parameters in three-phase AC systems
  - Explain and use Delta-Wye transformations
  - Analyze a three-phase AC system and use per phase analysis to solve it
- **Week 5-6: Generators**
  - Describe the Operations of a Power Plant
  - Explain the Basic Principle of a Generator
  - Define Rotor Speed of a Generator
  - Develop the Electrical Equivalent Circuit of a Generator
  - Describe Generator Operation for Different Load Types

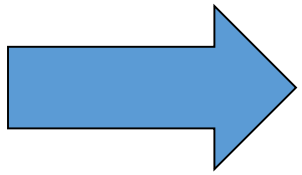
Energy

- Energy is the ability to do work

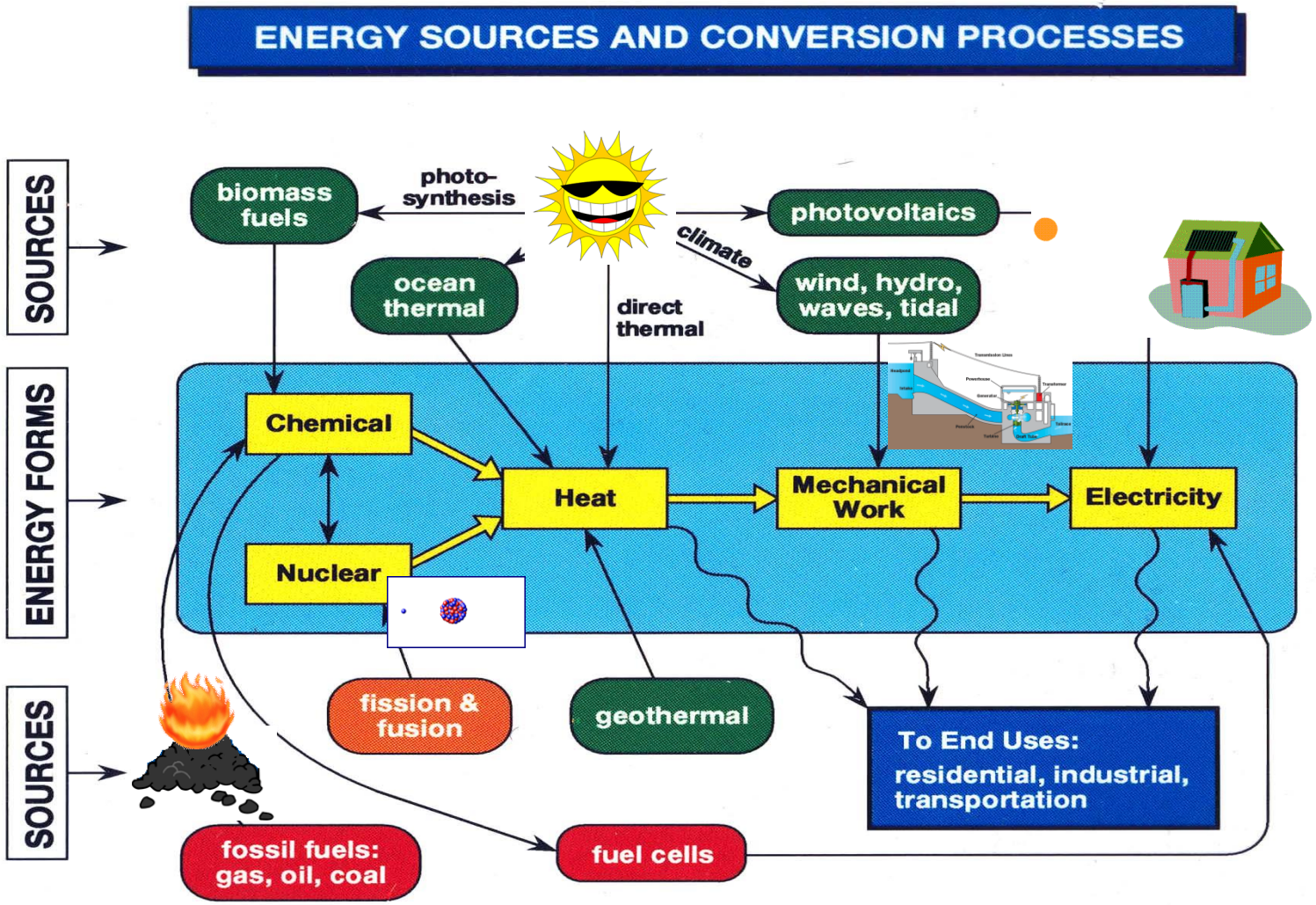


- Energy can be converted from one form to another



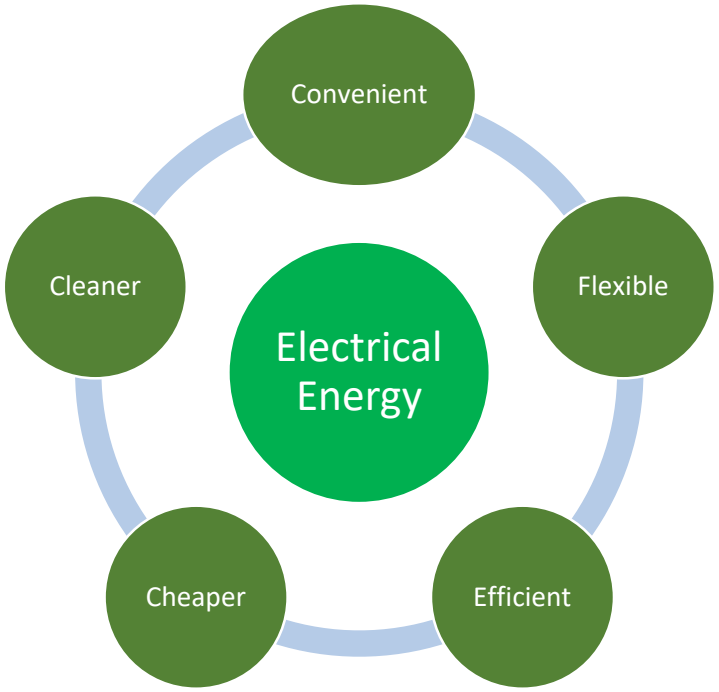


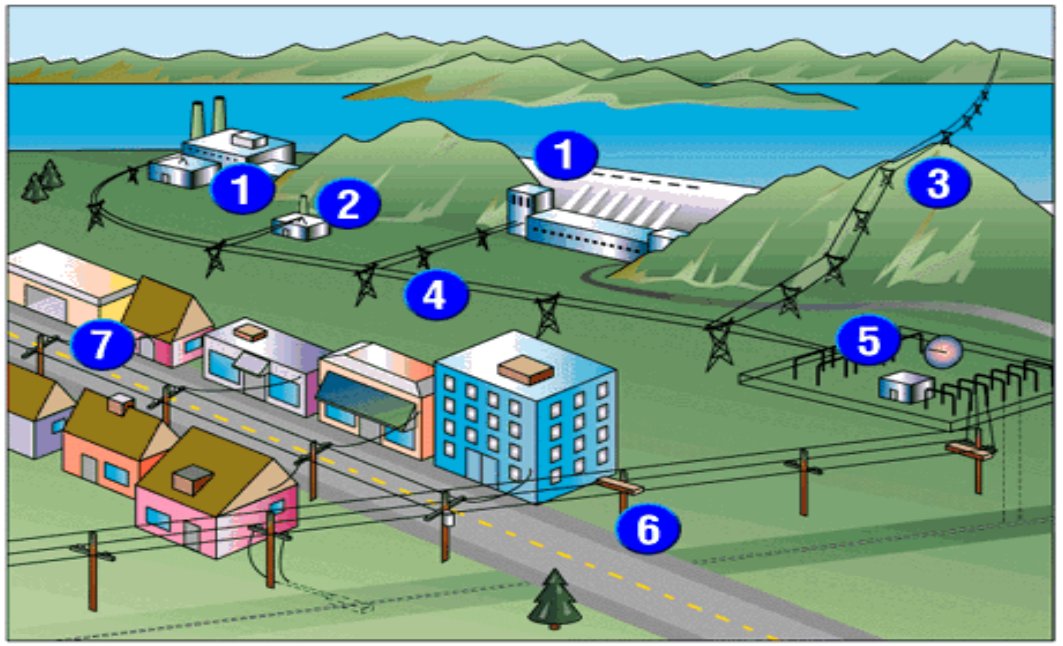
Energy Conversion



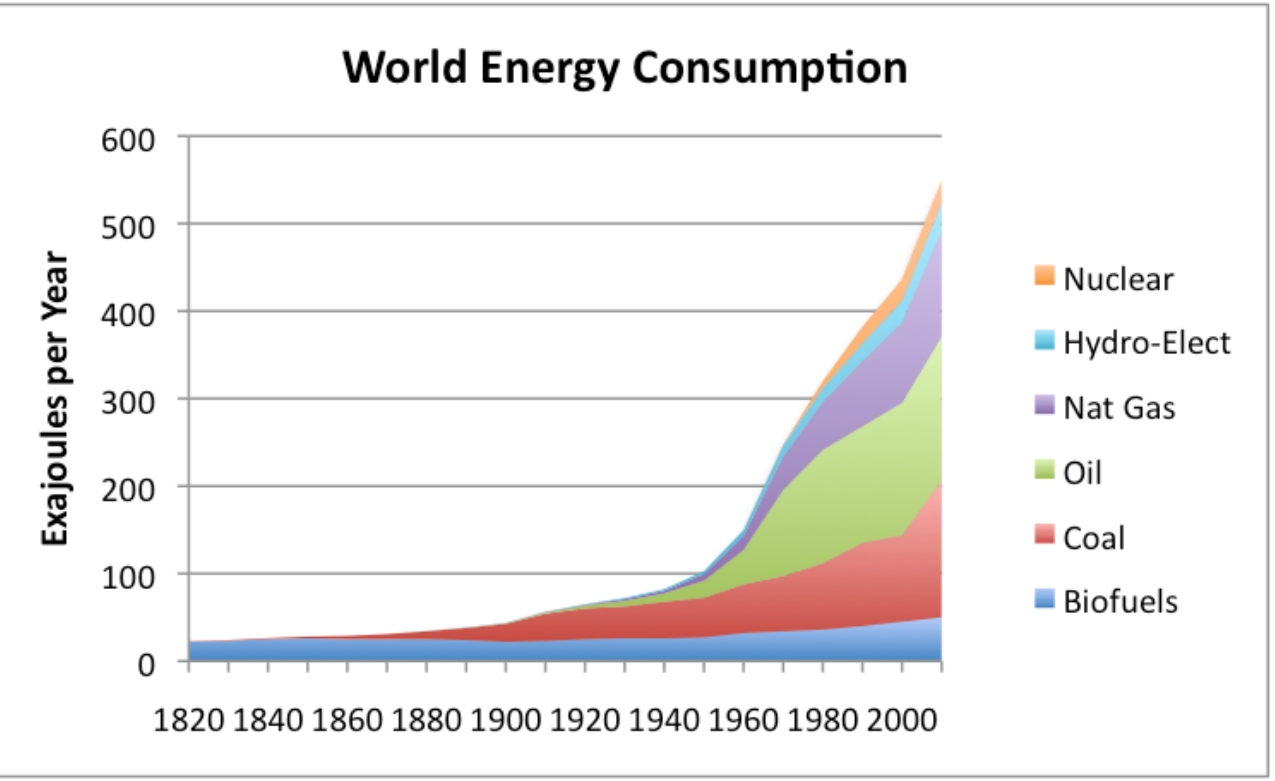
Electrical Energy

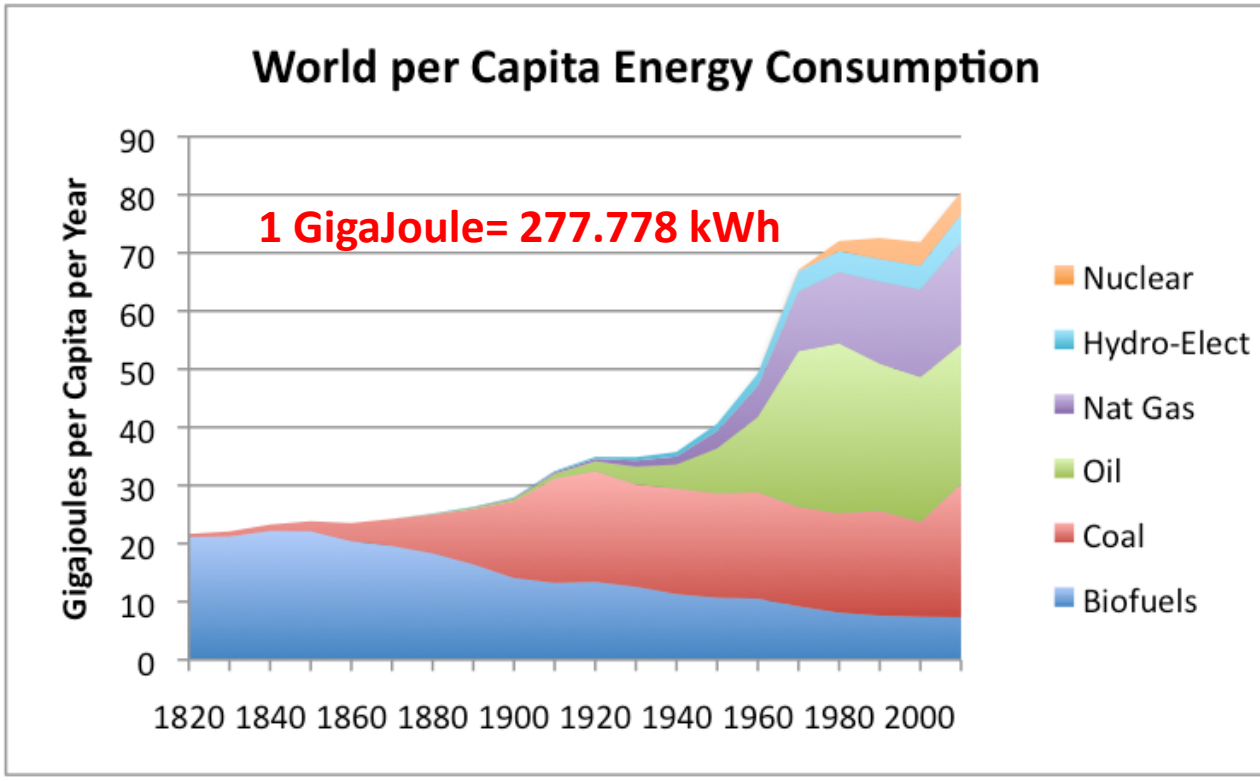
- Energy is the basic necessity for human activity, economic and social development
- Electrical Energy can be easily converted to any form of energy





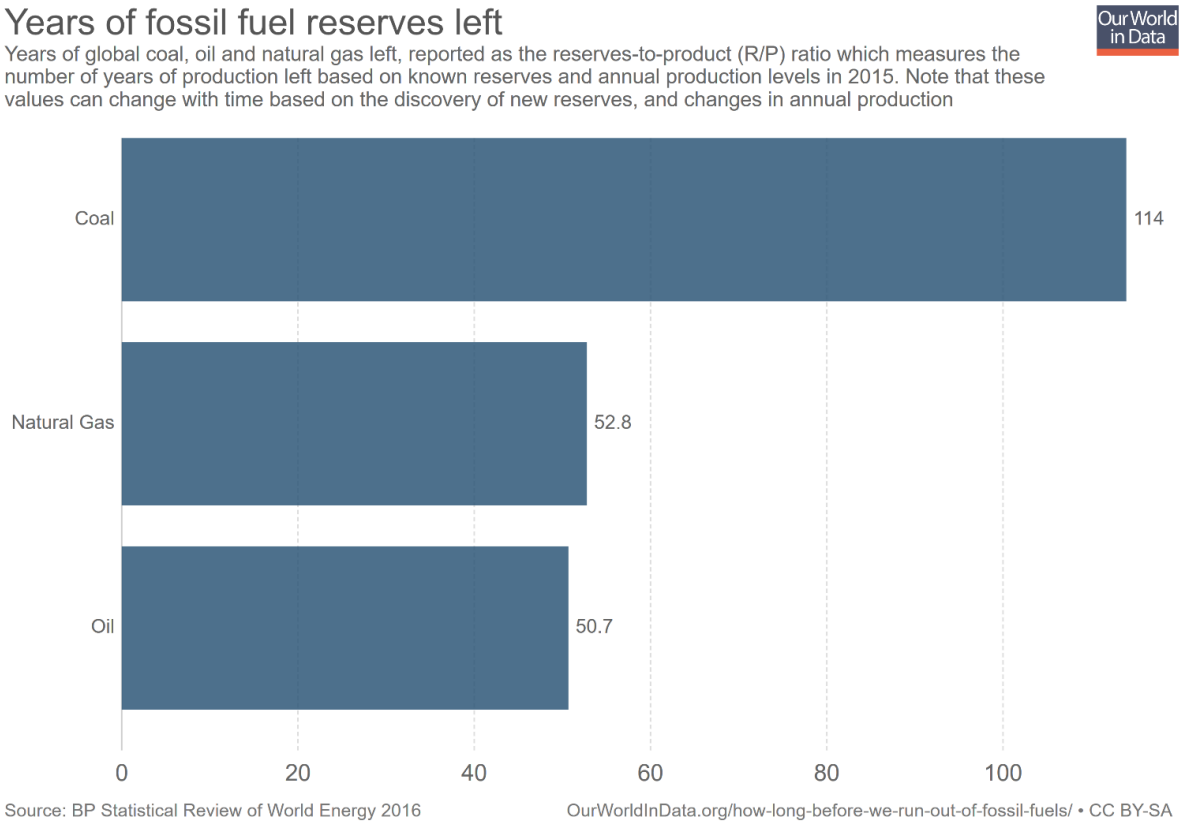
World Energy Consumption

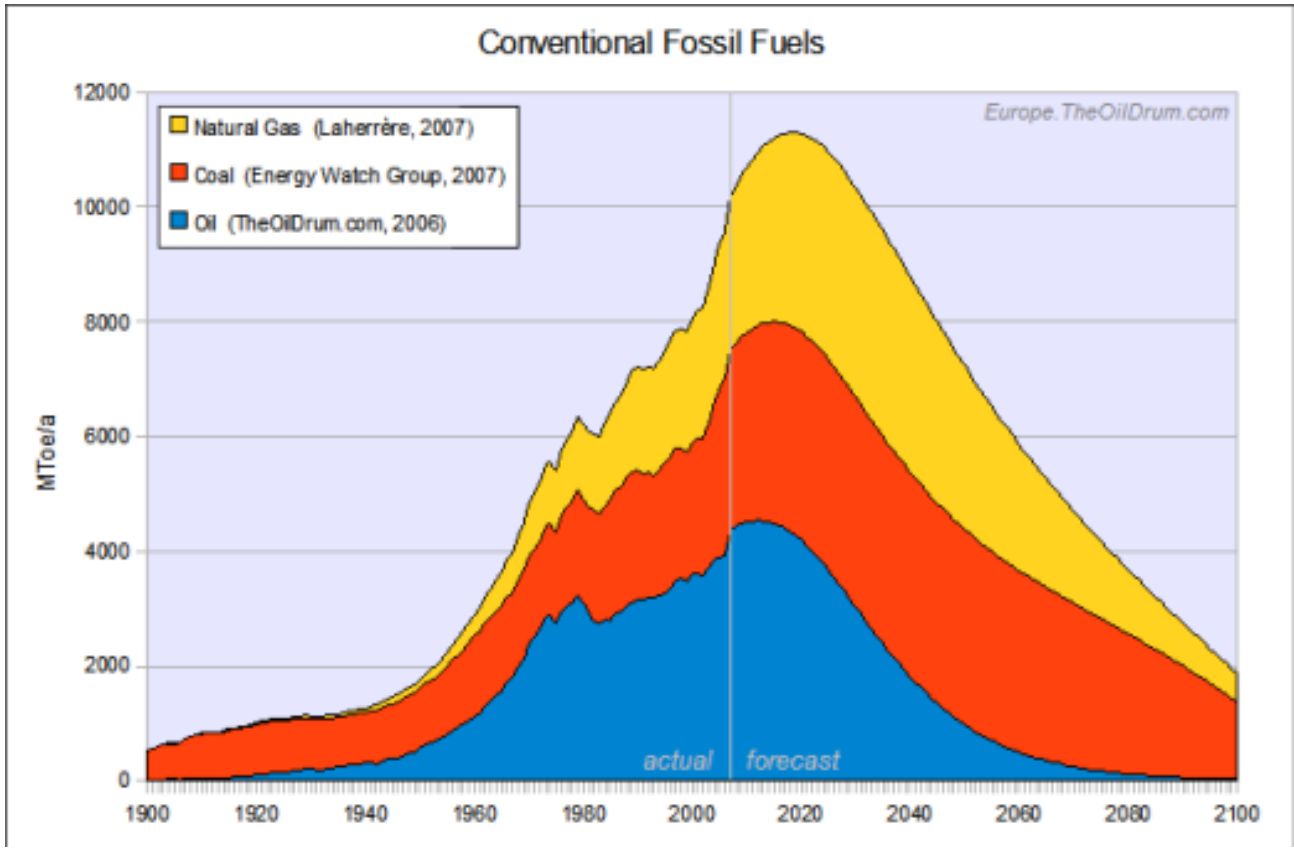




Source: https://ourfiniteworld.com/2012/03/12/world-energy-consumption-since-1820-in-charts/

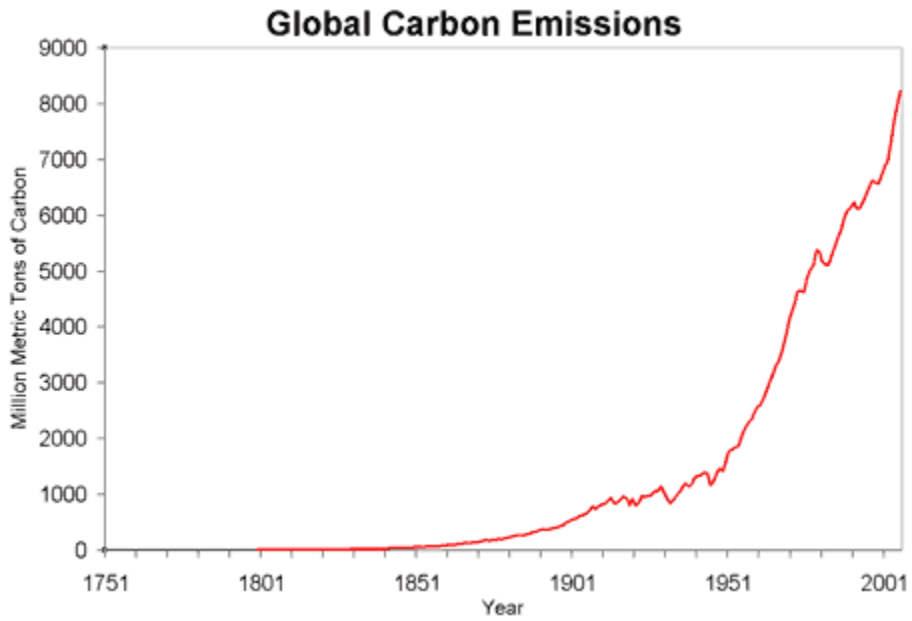
Fossil Fuels will Decline!!!!

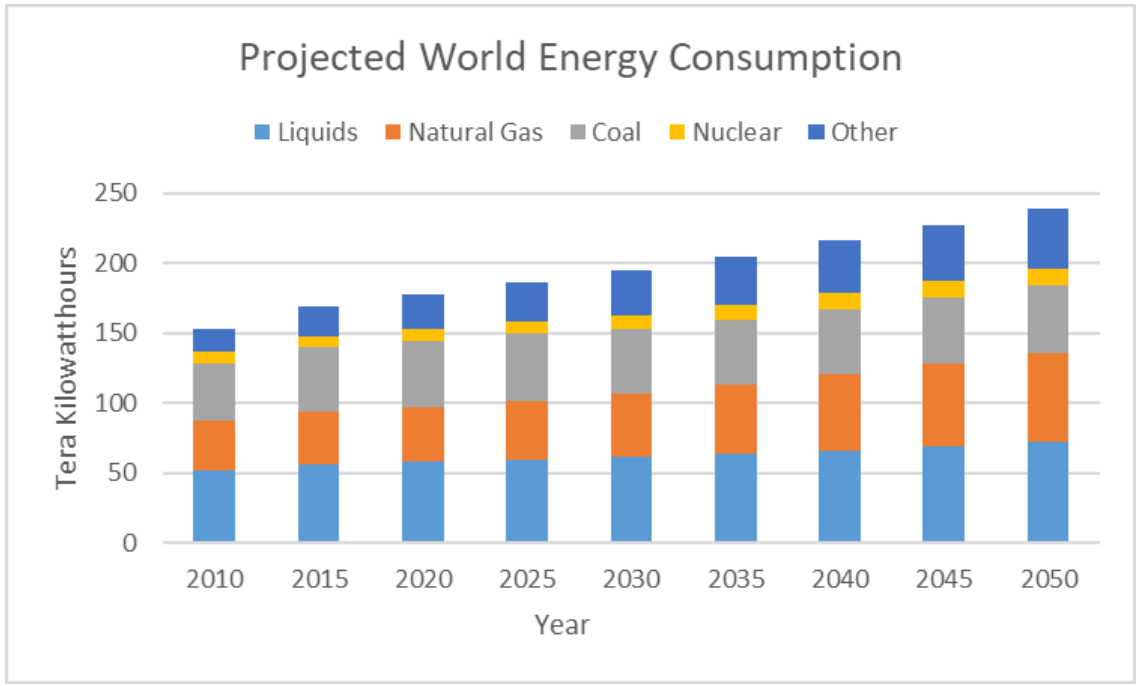




Future of Energy???

- Surge in Energy Demand
- Rising Environmental Stresses
- Declining Supply of Resources

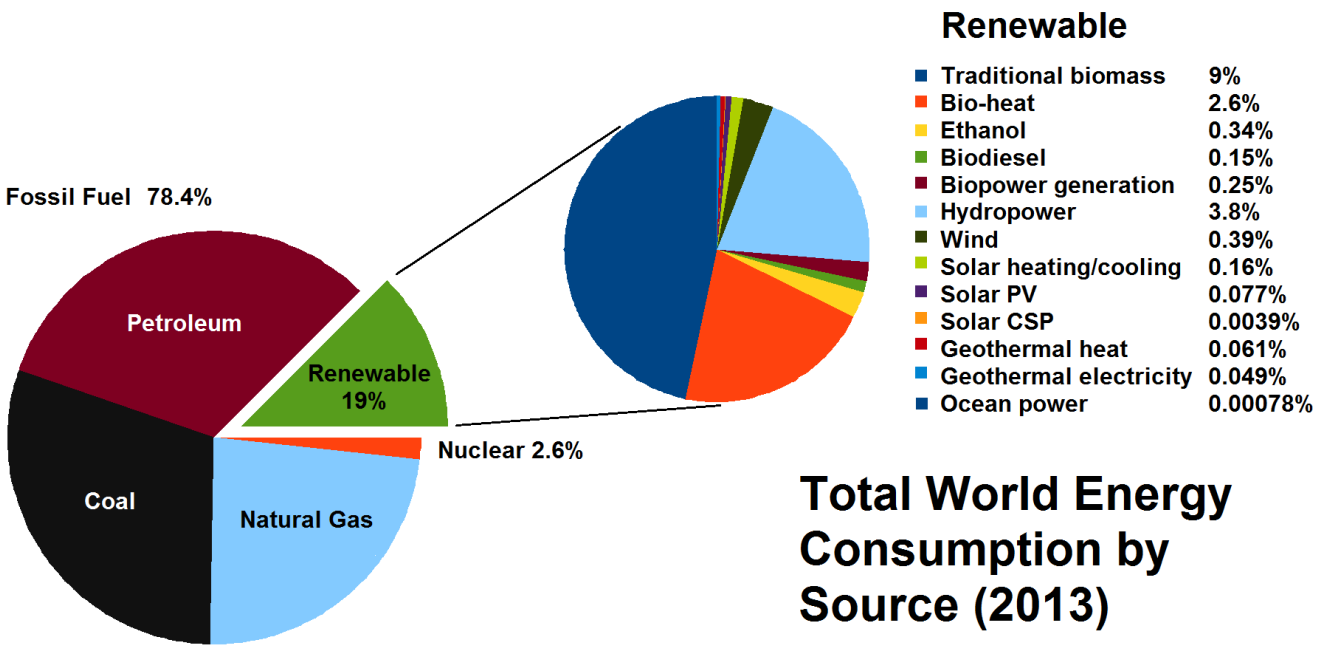




Source: US Energy Information Administration: https://www.eia.gov/

Solutions: Renewable Energy

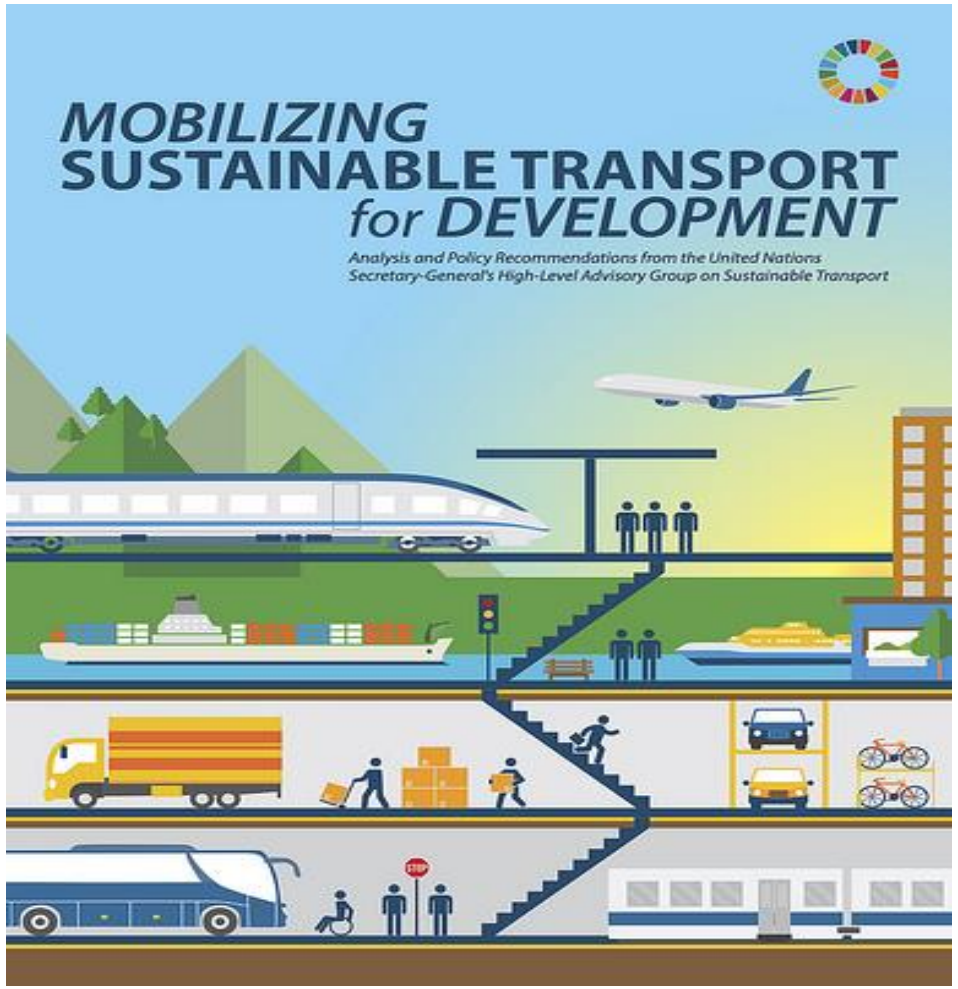
- Renewable Energies on a Large Scale

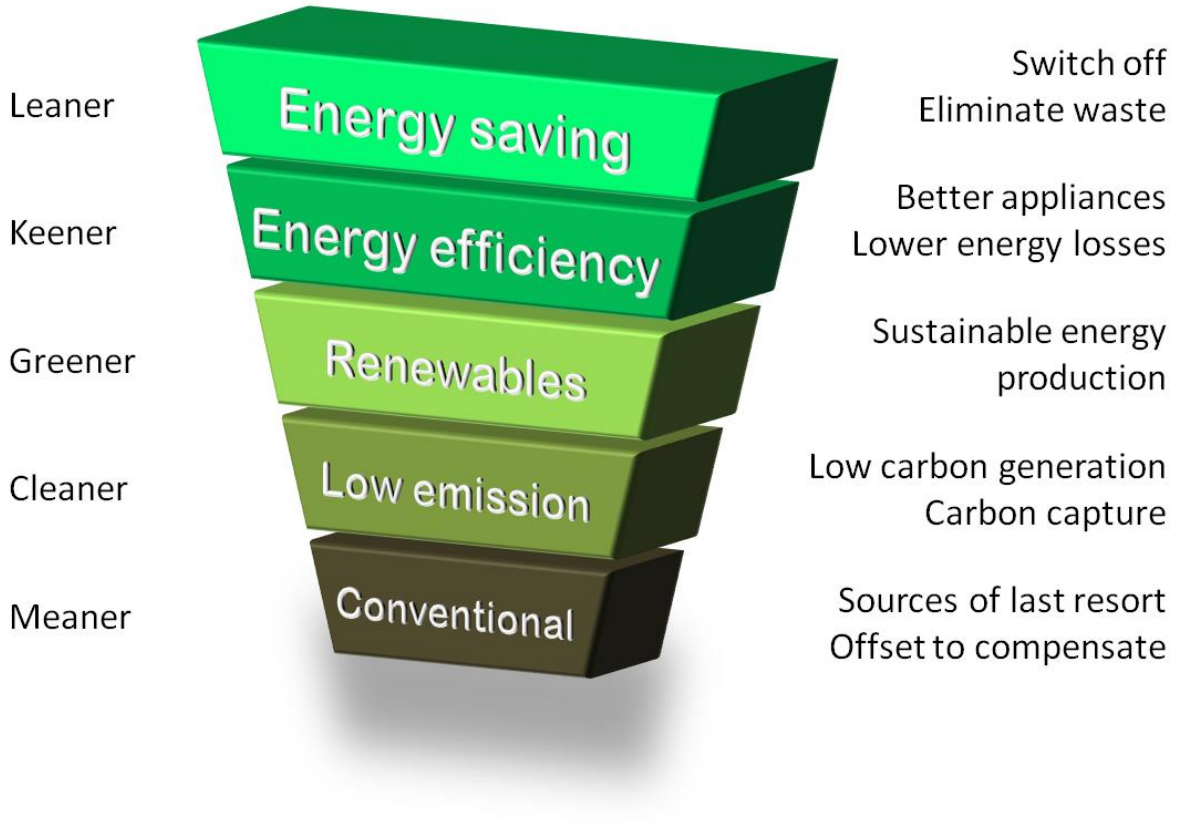


Total World Energy Consumption by Source (2013)

Solution: Sustainable Energy Systems

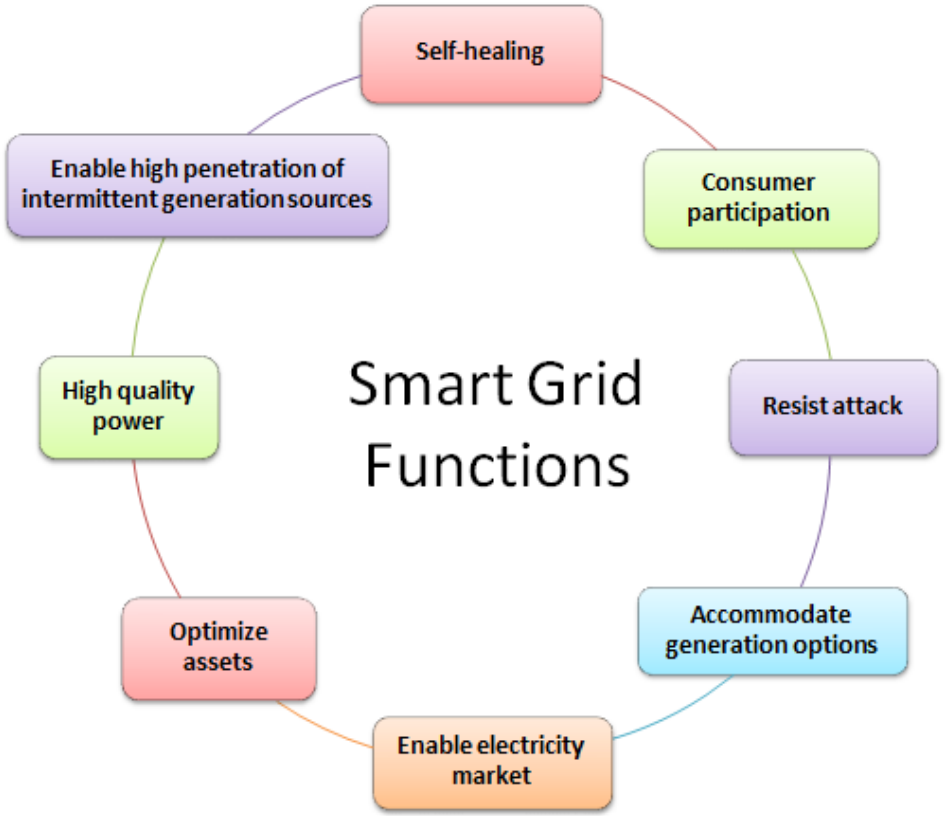
- Sustainable Transportation

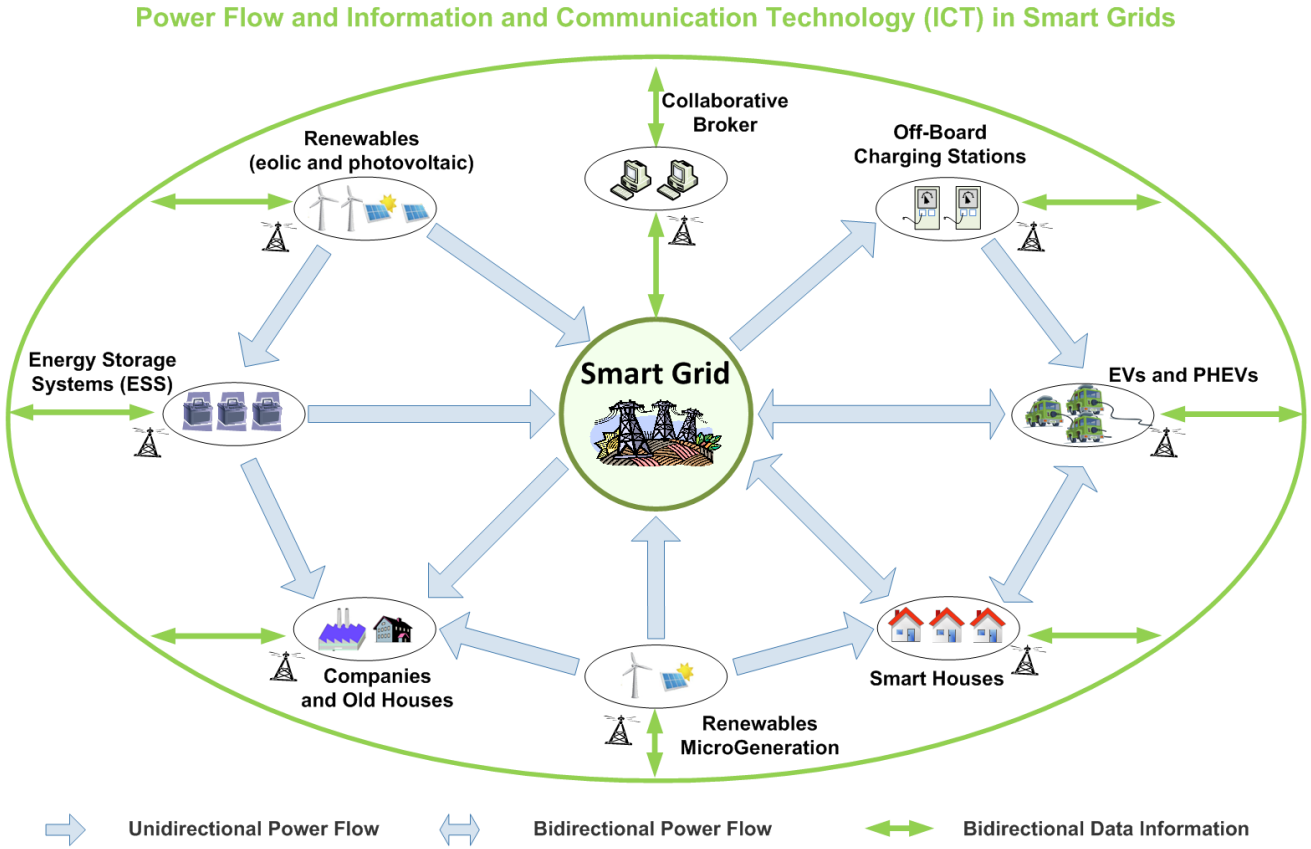




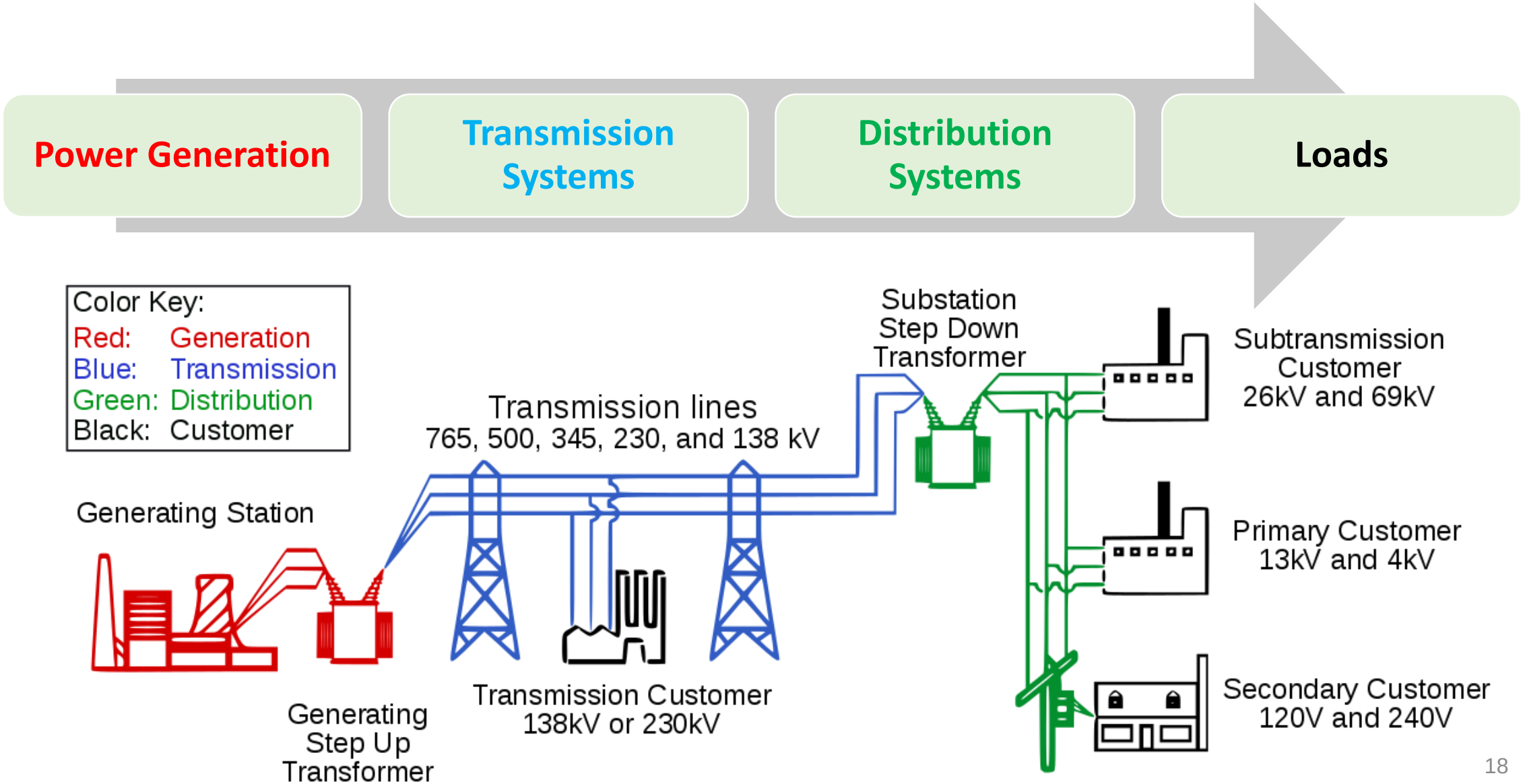
Solutions: Smart Grids

- Greater application of IT and communication technologies



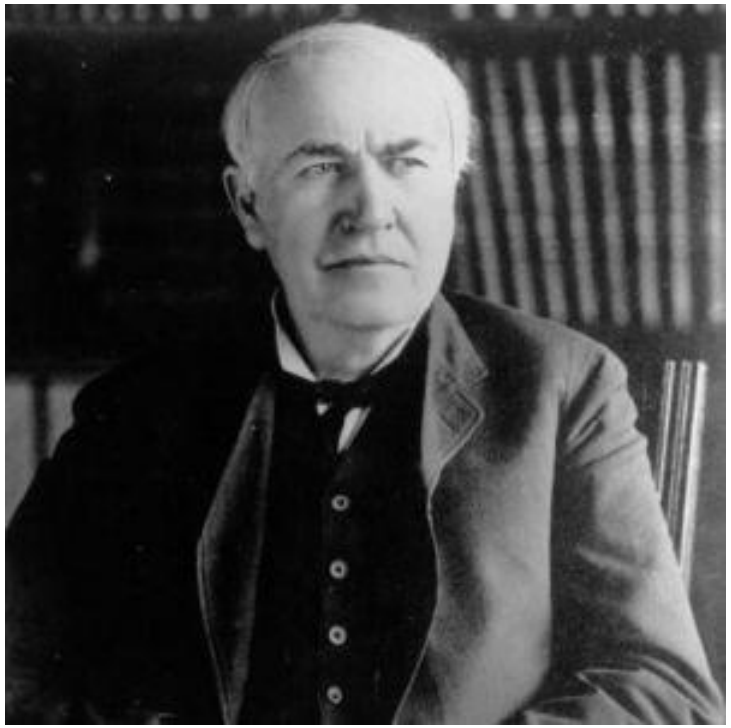


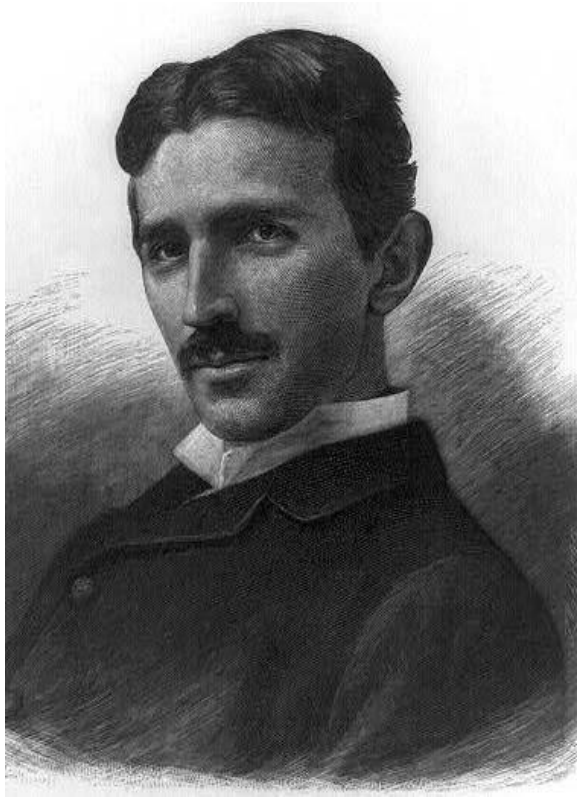
How do we get Electric Power???



War of the Currents: AC vs DC Power

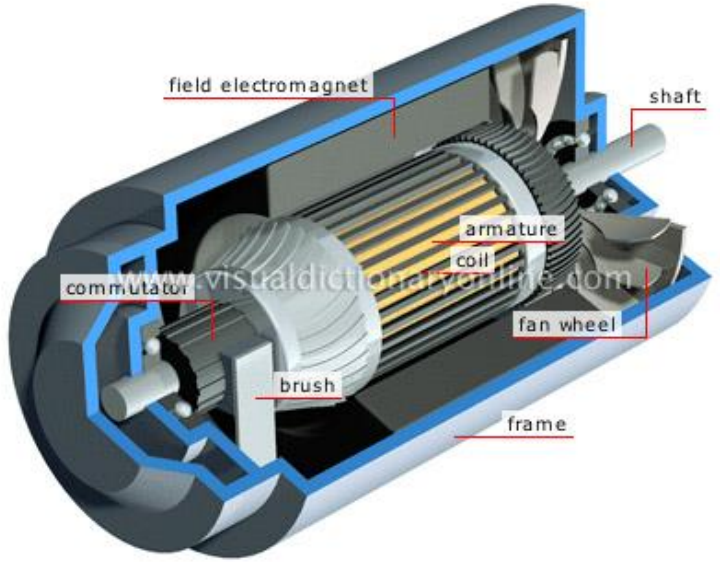
- Direct current is not easily converted to higher or lower voltages



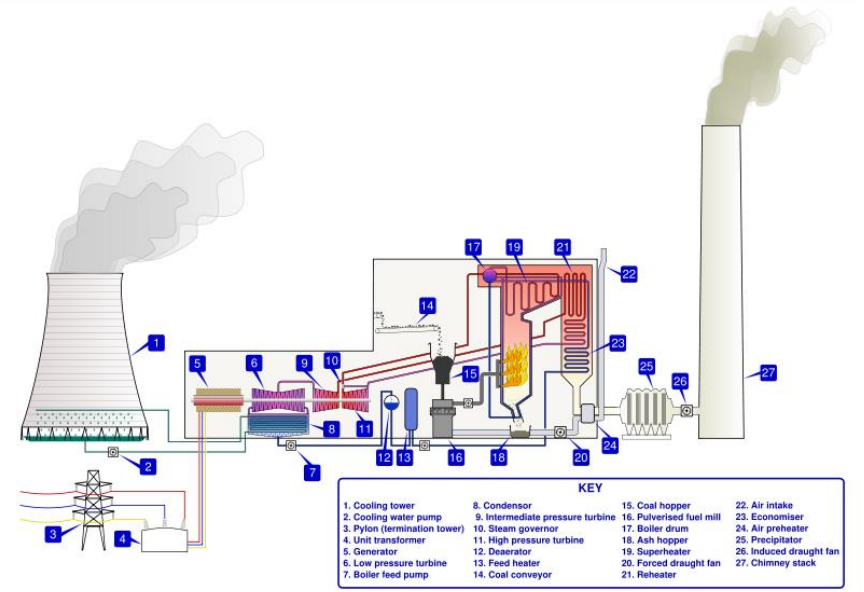


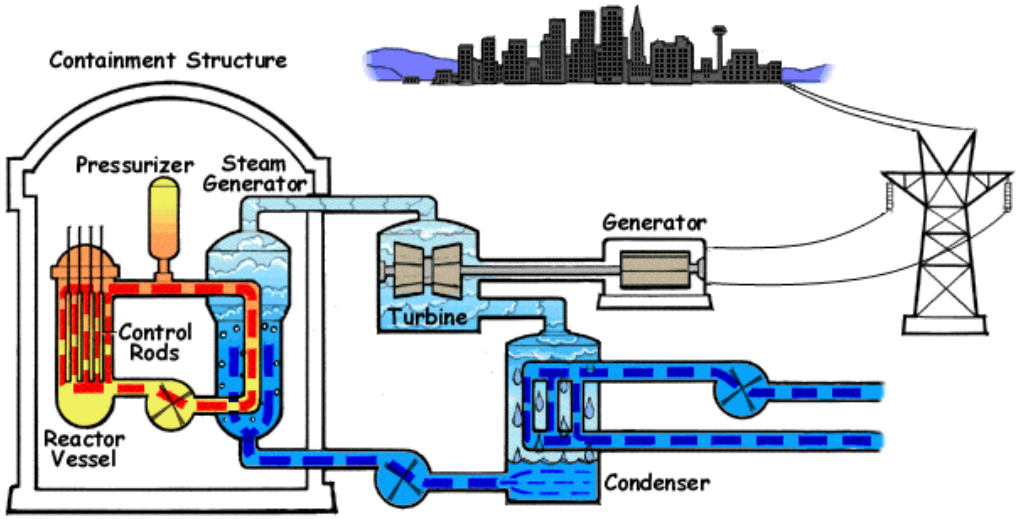
Power Generation

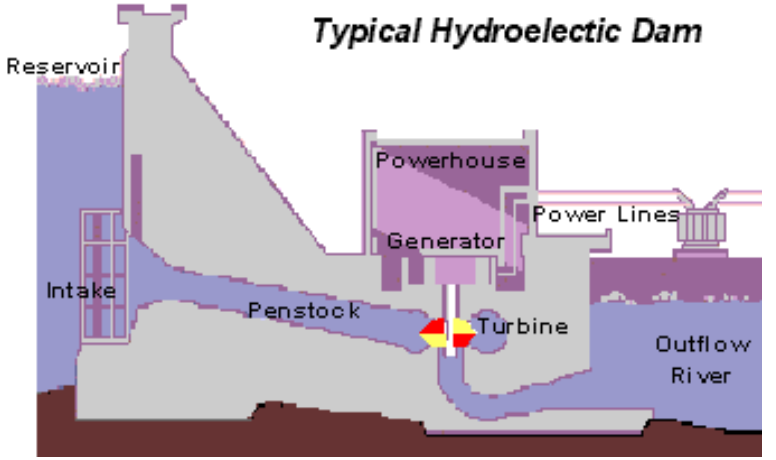
- Most of electrical power is obtained by electromechanical energy conversion, whereby mechanical energy is converted into electrical energy by means of a synchronous generator or alternator. The source of mechanical power commonly known as a Prime Mover.



Power Mover Generation Systems

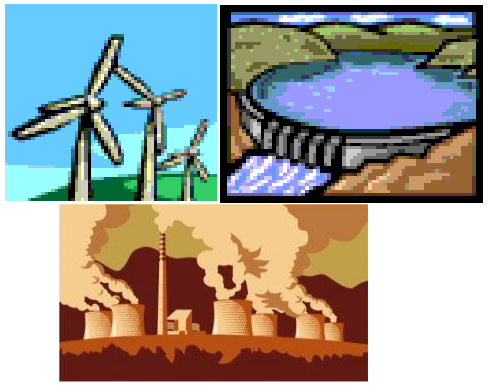






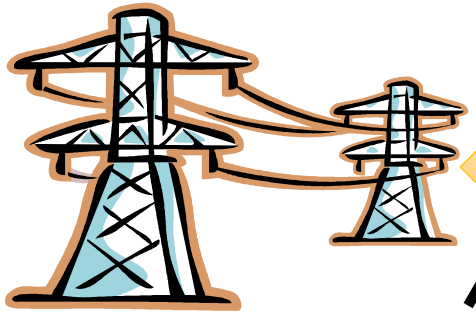
Transformers

Generation
(11 – 36 KV)

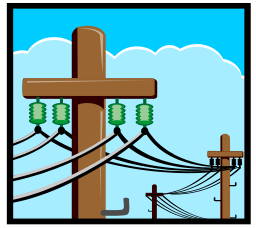


Large-Scale Power Plants:
Coal-fired, Hydro, Wind,
Solar, Nuclear

Transmission
(110 – 765 KV)



Distribution
(120/230 V – 138 KV)



Industrial customer (23 – 138 KV)
Commercial customer (4.16 – 34.5 KV)
Residential customer (120 – 240 V)

- Transformers are used to step up voltages from generation units to transmission-line and to step down voltage from transmission to end users

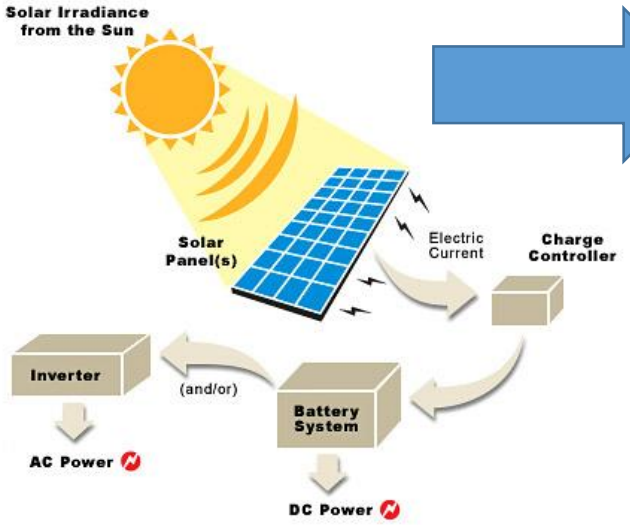
Transmission Lines

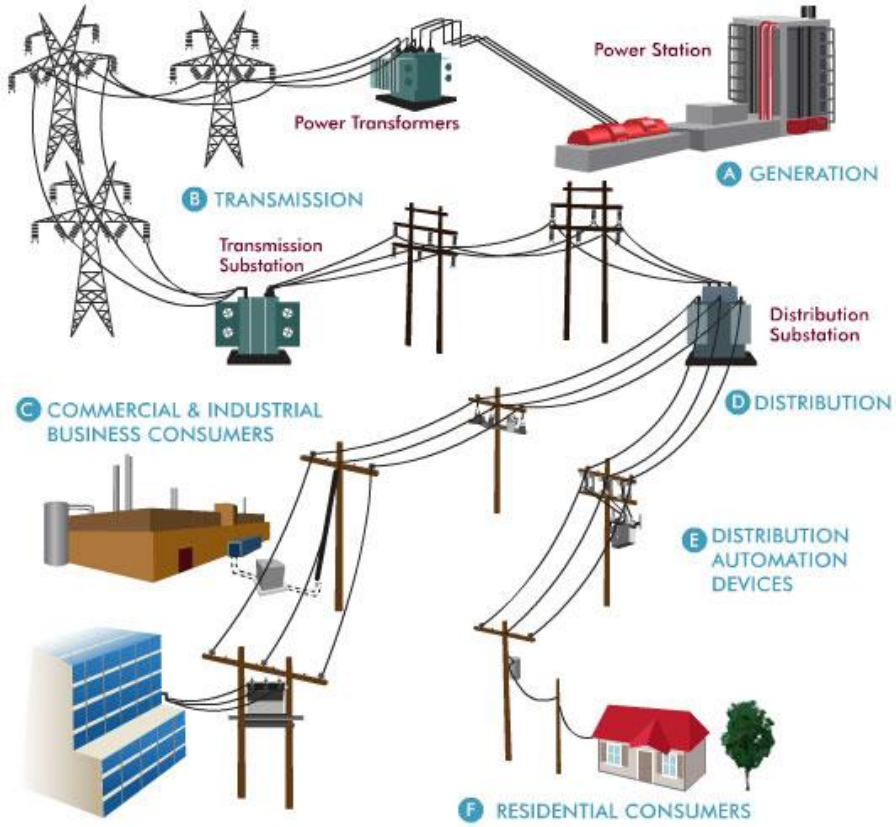
- Purpose of transmission lines is to transfer electric energy from generating units at various locations to the distribution systems
- Interconnects power systems together to enable power exchange in both directions

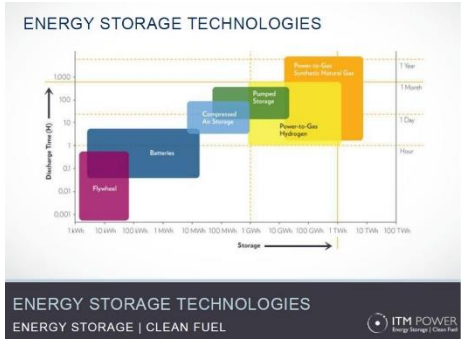
Loads

- Distribution Lines
- Residential Loads
- Commercial Loads
- Industrial Loads

How is the Power System Changing???







Multiple batteries may be installed together.

This Friday!!!

Review of Complex Numbers

(Bring your doubts and queries ☺)