Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department

4Th Year Electrical Power
1st Term

Computer Applications on Power Systems

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Introduction

In General

Total Marks:-

100 Marks

70 Marks ---- Final Exam

30 Marks ------ Midterm Exam

2nd Part

35 Marks ---- Final Exam

15 Marks ------ Midterm Exam

* Sulbus of the course & Plan :-

1- Electric Power Generation from Renewable Energy Sources.

1.1. Design of Hydro-Electric Power. **Lec. 1**

1.2. Design of Wind Energy. **Lec. 2**

1.3. Design of Solar Energy. **Lec. 2**

2- Unbalanced 3-ph circuit, Load Calculations. **Lec. 3**

3- Cables Sizing, Voltage drop calculations and Power Factor correction. **Lec. 4**

4- Transient Analysis. **Lec. 5**

4.1. RL-network **Lec. 5**

4.2. RC-network **Lec. 5**

5- Balanced Fault Analysis.

6- Symmetrical components and unbalanced fault. **Lec. 6**

Lec. 7 -------------------------------- Midterm Exam

References:-

1- Power System Analysis Third Edition, Hadi Saadat (e-book).

2- ELECTRONICS and CIRCUIT ANALYSIS using MATLAB, JOHN O. ATTIA (e-book).

3- Published papers.

4- Some data from sites of international companies.

5- Egyptian code for Electric.

6- El-Sewdy Cables Catalogue.

Lecture 1

Electric Power Generation from Renewable Energy Sources

Definition of Renewable energy

Renewable energy is energy exists freely in nature (never run out, such as sunlight, wind, rain, tides, waves, and geothermal heat.

Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, energy services.

Renewable energy

Power generation

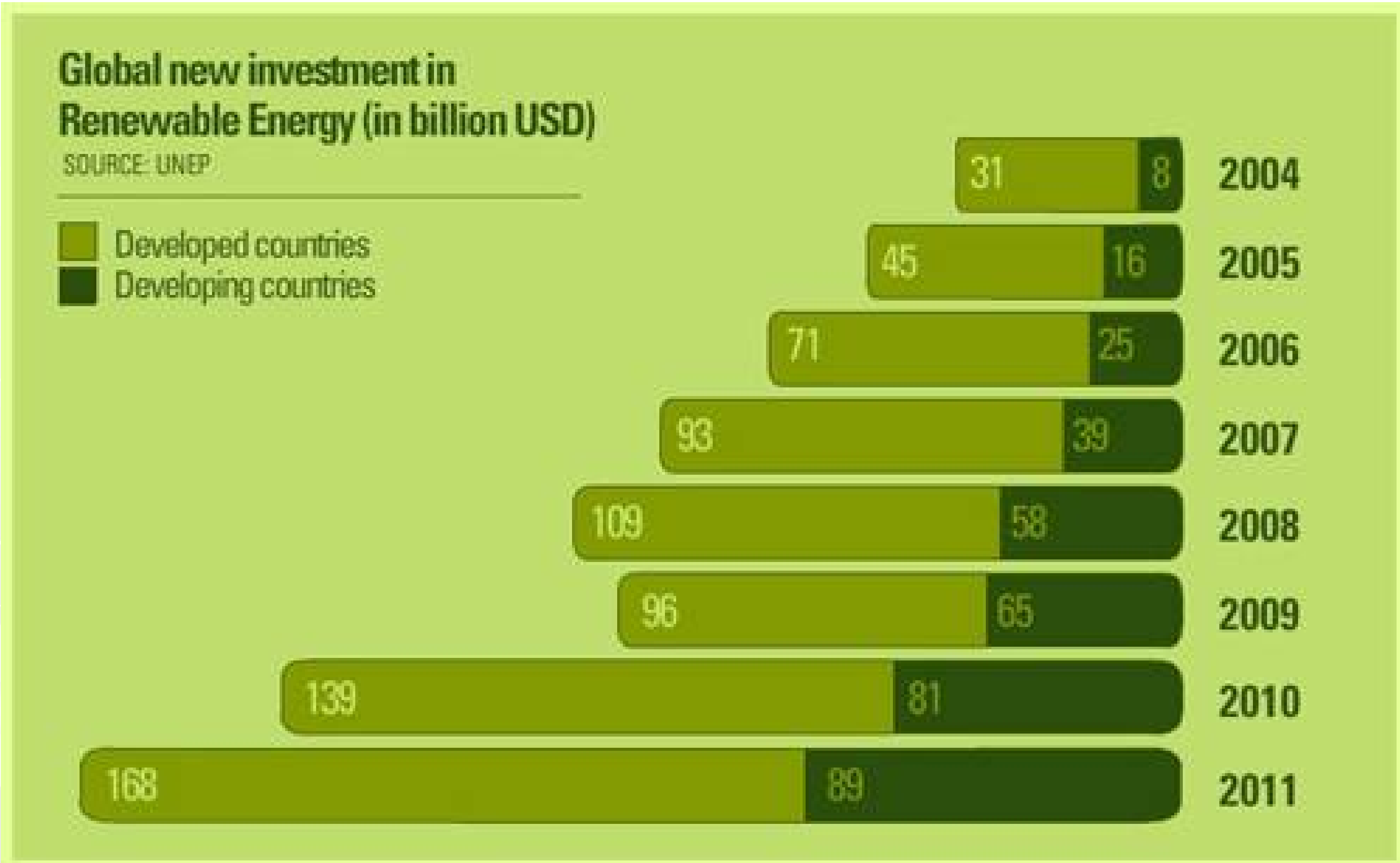
Renewable hydroelectric energy provides 16.3% of the worlds electricity.

When hydroelectric is combined with other renewables such as wind, geothermal, solar and waste: together they make the "renewables" total, 21.7% of electricity generation worldwide as of 2013.

Renewable power generators are spread across many countries, and wind power alone already provides a significant share of electricity in some areas: for example, 14% in the U.S. state of Iowa, 40% in the northern German state, and 49% in Denmark.

Some countries get most of their power from renewables, including Iceland (100%), Norway (98%), Brazil (86%), Austria (62%), New Zealand (65%), and Sweden (54%)

Illustration of Global Renewable Energy Usage



Current renewable energy capacity in Egypt

1- Hydro

Hydroelectricity has played a role in electricity generation in Egypt for decades. Projects such as the Aswan Dam produce 15,300GWh a year, or roughly five to ten percent of Egypt's annual energy needs.

2- Solar

Due to its location, topography and climate, Egypt has an average level of solar radiation of between 2,000 to 3,200kWh per square metre a year, giving it significant potential for utilising this form of renewable energy. To date, however, uptake of solar projects has been slow due to high capital costs. In 2010, Egypt's only major solar power project was commissioned in Kuraymat. The plant is a 140MW solar thermal combined cycle power plant of which 20MW is from solar energy.

the investment cost of solar power plants is currently very high in comparison with oil and gas fired power plants and it is envisaged that Egypt's strategy for developing its renewable energy capacity will be mainly directed at the wind sector.

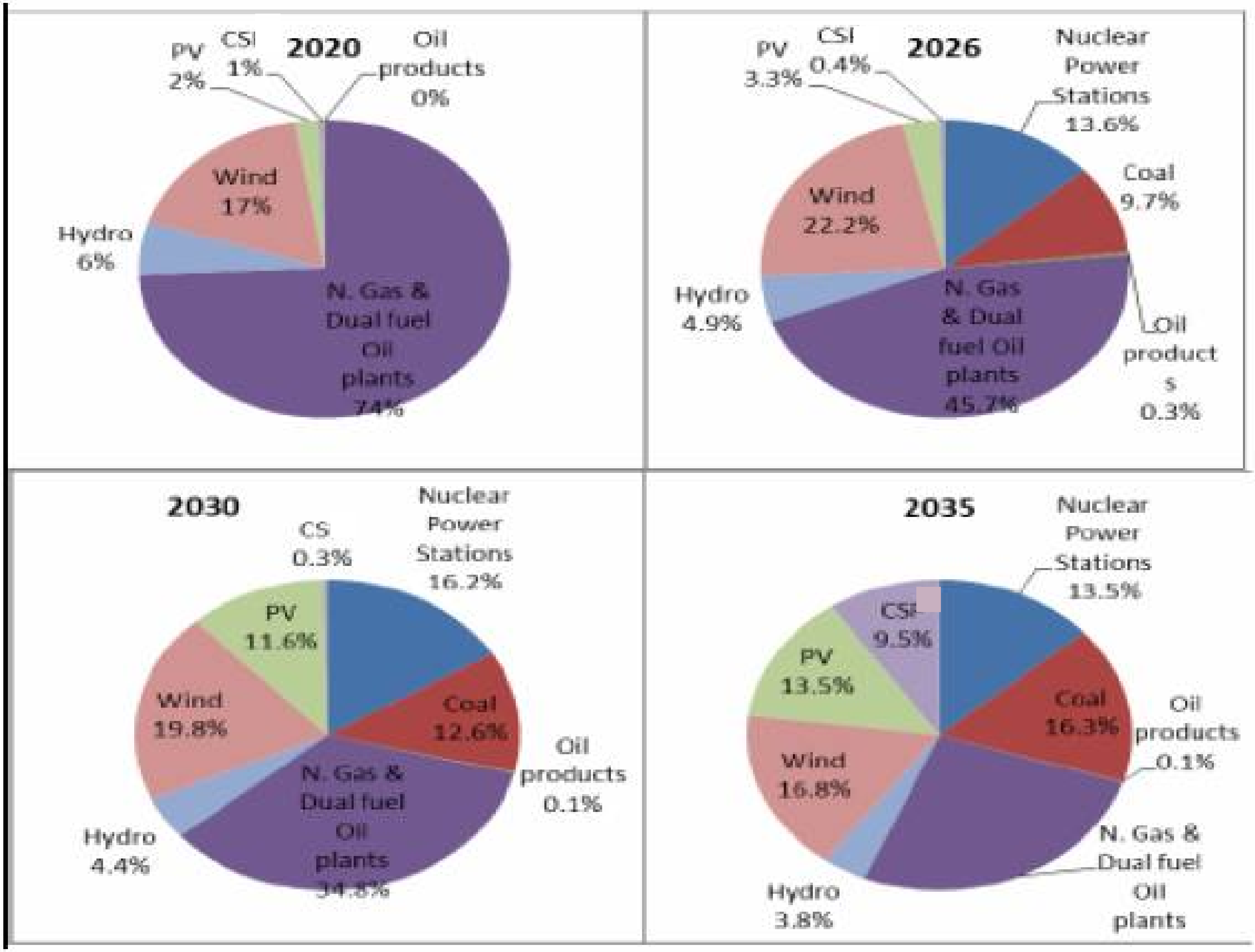
Current renewable energy capacity in Egypt

3- Wind

Egypt's best-developed wind region so far is the Zafarana district, with average wind speeds of around nine metres a second. The project (which is owned) consists of a series of linked wind farms, the first of which started construction in 2001. In 2010, Zafarana wind farm's total installed capacity reached 550MW, making it one of the largest onshore wind farms in the world.

Egypt is recognised as having some of the world's best wind resources, especially in the Gulf of Suez area, with significant additional potential along the east and west banks of the Nile. According to the Egypt Wind Energy Association, 700 square kilometres have been set aside for new wind projects in the el-Zayt area which has wind speeds of 11 metres a second.

Expected Sources of Electricity Supply in Egypt



1- HydroElectric Power Plant

Hydropower is considered to be a renewable energy source because it uses the continuous flow of water without using up the water resource. It is also nonpolluting, since it does not rely on burning fossil fuels. Hydropower is currently the leading

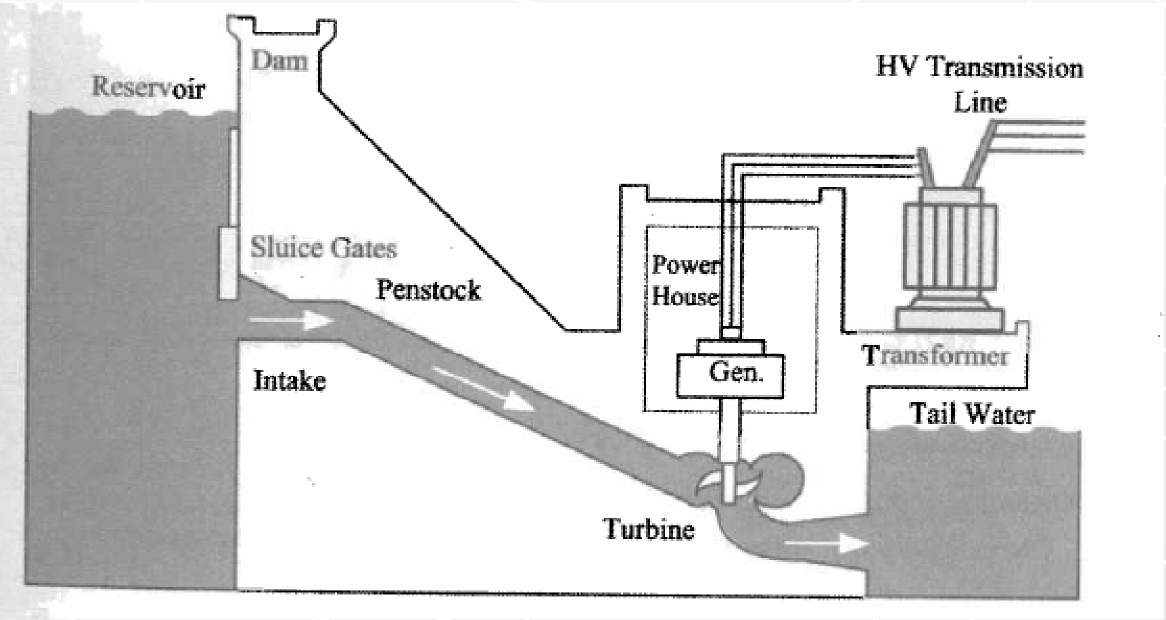
renewable energy source in the United States. In 2009, it accounted for about 63 percent of all other renewable energy sources, such as wind, solar, and biomass. Reclamation[7] is the nation's second largest producer of hydroelectric power, with 58 hydroelectric power plants and 194 generating units in operation and an installed capacity of 14,693 MW.

1- Method of Operation of HydroElectric Power Plant

- Turbines are defined as the hydraulic machines which convert hydraulic energy into mechanical energy.
- This mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine.
- Thus the mechanical energy is converted into electrical energy.

1- Method of Operation of HydroElectric Power Plant

The water from the dam is led to the water turbine through the penstock, and the potential energy of the elevated water is transformed into kinetic energy. The water turbine converts hydraulic energy into mechanical energy, and the generator converts mechanical energy into electrical energy. After passing through the turbine, the water reenters the river on the downstream side of the dam.



Schematic diagram of a hydroelectric power plant.

Classification of Turbines

1. According to type of energy at Inlet
   a) Impulse Turbine - Pelton Wheel
      Requires High Head and Low Rate of Flow
   a) Reaction Turbine - Fancis, Kaplan
      Requires Low Head and High Rate of Flow
2. According to direction of flow through runner
   a) Tangential Flow Turbine - Pelton Wheel
   b) Radial Flow Turbine - Francis Turbine
   c) Axial Flow Turbine - Kaplan Turbine
   d) Mixed Flow Turbine - Modern Francis Turbine

- **According to water head and quantity of water available**

  1. High head & small quantity of flow of water
  2. Medium head & medium flow rate
  3. Low head and large flow rate

- **According to the specific speed of the turbine**

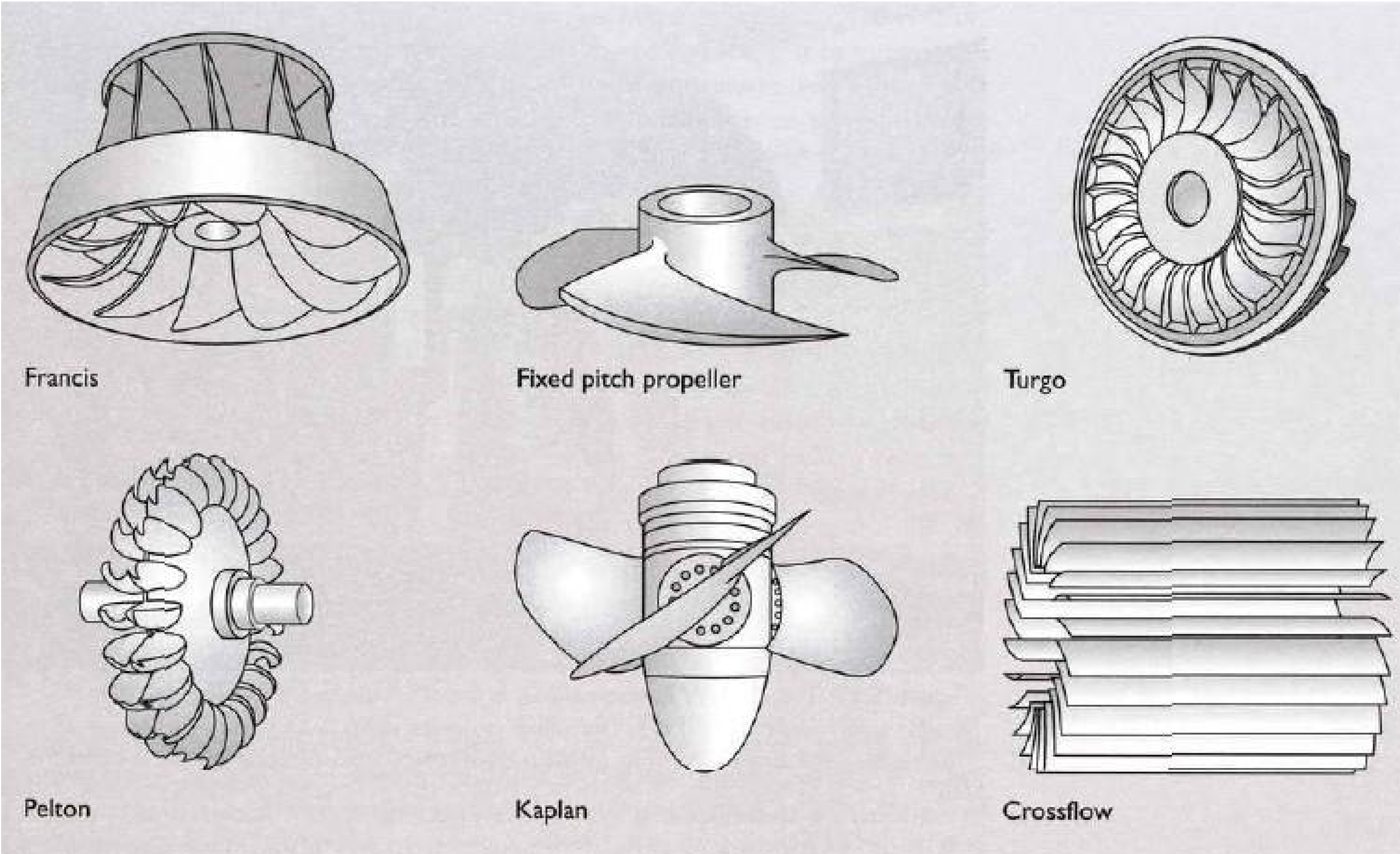
  1. Low specific speed turbine (<60)

     ex. Pelton wheel

  2. Medium specific speed turbine (60 to 400)

     ex. Francis turbine

  3. High specific speed turbine (above 400)


Francis
Fixed pitch propeller
Turgo
Pelton
Kaplan
Crossflow

O/P Power Cal. of HydroPower Plant

The potential energy of the water in the reservoir is proportional to the mass of water and the difference in height between the water impoundment and the water outflow. This height difference is called the *head* or *effective head*. That is, $P.E. = mgh$. The mass of water is its volume times its density. Therefore, $P.E. = volume \times \rho g h$ and the available hydro power becomes

$$P_w = \frac{P.E.}{t} = \frac{volume}{t} \rho g h \tag{1.2}$$

or

$$P_w = q \rho g h \quad \text{W} \tag{1.3}$$

q = rate of flow of water in m^3/s
h = effective head of water in m
ρ = density of water ≈ 1000 kg/m^3
g = acceleration of gravity = 9.81 m/s^2

O/P Power Cal. of HydoPower Plant

Given $\rho = 1000$, the available hydro power P in kW is given by

$$P = 9.81qh \quad \text{kW} \tag{1.4}$$

If η is the overall efficiency of the hydropower plant, the electrical power output in kW is

$$P_o = 9.81qh\eta \quad \text{kW} \tag{1.5}$$

where $\eta = \eta_p \eta_t \eta_g$

η_p = penstock efficiency, η_t = turbine efficiency, η_g = generator efficiency

1ft= 0.3048000m

Example

A large hydroelectric power plant has a head of 116 m and an average flow of 3100 m^3/s (Assume the following efficiencies: penstock efficiency η_p=97 percent, turbine efficiency η_t=77 percent , and the generator efficiency η_g=95 percent.

(a) Calculate the generated electric power.

(b) Assuming the average household in America uses 10,960 kWh (including all transmission and distribution losses), approximately how many homes are supplied by this hydropower plant?

(a) From (1.5) the generated electric power is

$$P = (9.81)(3100)(116)(0.97)(0.77)(0.95) = 2,503080 \text{ kW} = 2,503 \text{ MW}$$

(b) The annual energy production is

$$W = pt = 2,503080 \times 24 \times 365 = 21.926 \times 10^9 \text{ kWh}$$

Number of homes supplied is $\frac{W}{10,960} = 2 \times 10^6 = 2$ million homes.

Example 1

A large hydroelectric power plant has a head of 116 m and an average flow of 3100 m^3/s . Assume the following efficiencies: pen-stock efficiency η_p=97 percent, turbine efficiency η_t=77 percent

a) **By using matlab m-file**, write the appropriate command to find the generated power and the annual energy production ?

- **Note that:-** Ask the user for the value of head, average flow, efficiencies of pen stock, turbine only and appear the results in clear form.

b) **Then ask the user** for the average household in America uses 10,000kWh and in Egypt uses 7,000kWh. How many homes are supplied by this hydropower plant?

c) Show the results as appearing in the command window.

Sol.

```
% SOL. OF Problem of hydroelectric power plant
h=input('Enter the head of hydroelectric power plant=');        % h in meter
q=input('Enter the average flow of water=');                     % q in m3/s
eff_P=input('Enter the efficiency of pen-stock=');               % eff_P: efficiency of pen stock
eff_T=input('Enter the efficiency of Turbine=');                 % eff_T: efficiency of Turbine
eff_G=0.95;                                                      % Efficiency of generator
eff=eff_P*eff_T*eff_G;                                           % total efficiency
P=9.81*q*h*eff;                                                  % electrical power output in kW
t=365*24;                                                        % annual time =365day*24hr
W=P*t;                                                           % annual energy production in kWh
disp('The generated electric power in kW =')
disp(P)
disp('annual energy production in kWh=')
disp(W)
avg_hh_america=input('Enter avg. household in America in kWh=');
avg_hh_Egypt=input('Enter avg. household in Egypt in kWh=');
disp('Number of homes supplied by this hydropower plant in America=')
Nh_America=W/avg_hh_america;     % no. of household in America
disp(Nh_America)
disp('Number of homes supplied by this hydropower plant in Egypt=')
Nh_Egypt=W/avg_hh_Egypt;     % no. of household in Egypt
disp(Nh_Egypt)
```

Command O/P

Command Window

New to MATLAB? Watch this Video, see Demos, or read Getting Started.

```
Enter the head of hydroelectric power plant=116
Enter the average flow of water=3100
Enter the efficiency of pen-stock=0.97
Enter the efficiency of Turbine=0.77
The generated electric power in kW =
  2.5031e+006

annual energy production in kWh=
  2.1927e+010

Enter avg. household in America in kWh=10000
Enter avg. household in Egypt in kWh=7000
Number of homes supplied by this hydropower plant in America=
  2.1927e+006

Number of homes supplied by this hydropower plant in Egypt=
  3.1324e+006
```