# *ANKARA UNIVERSITY*
# *DEPARTMENT OF ENERGY ENGINEERING*

## *HYDROELECTRİC ENERGY*


*<u>INSTRUCTOR</u>*

*DR. ÖZGÜR SELİMOĞLU*

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a. History

b. Advantages and Disadvantages of Hydroelectric Energy

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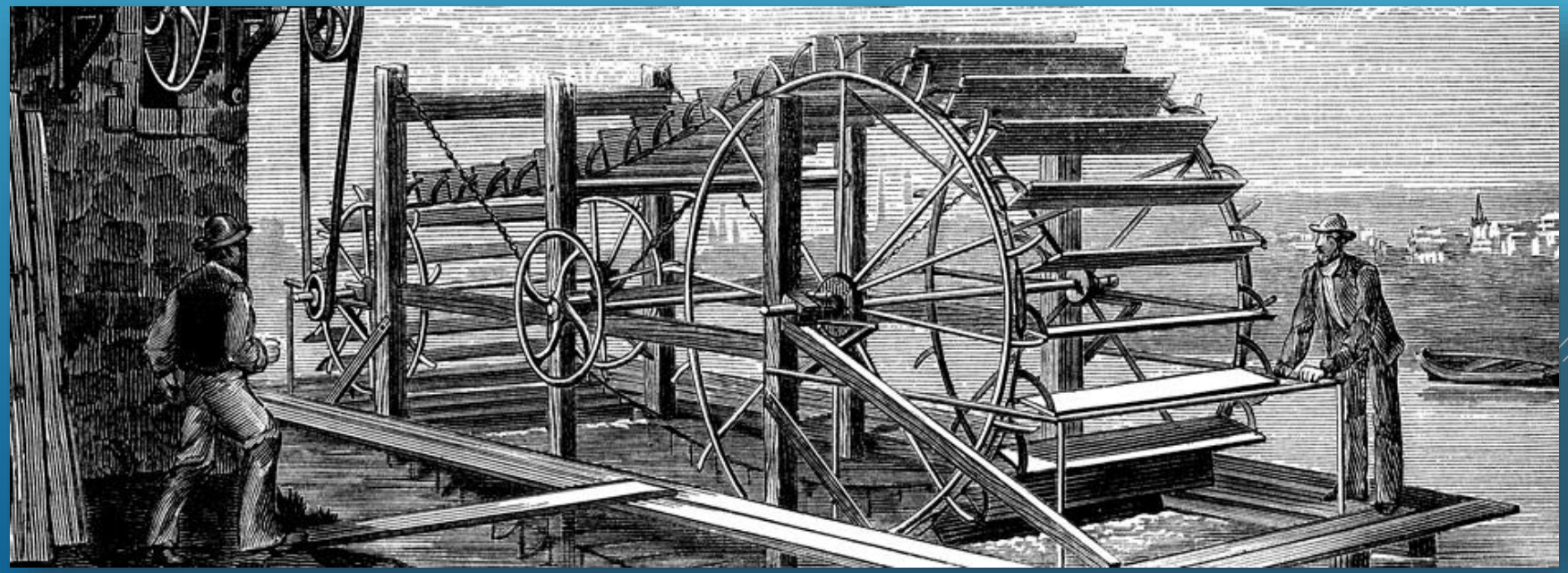
# *HYDROELECTRIC ENERGY*

***Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion such as water flowing over a waterfall to generate electricity.***

## *HISTORY*

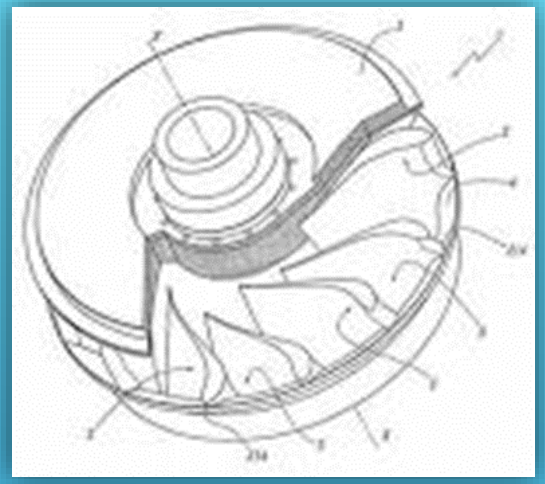
*Early uses of waterpower date back to Mesopotamia and ancient Egypt, where irrigation has been used since the 6th millennium BC and water clocks had been used since the early 2nd millennium BC. Other early examples of water power include the Qanat system in ancient Persia and the Turpan water system in ancient China.*

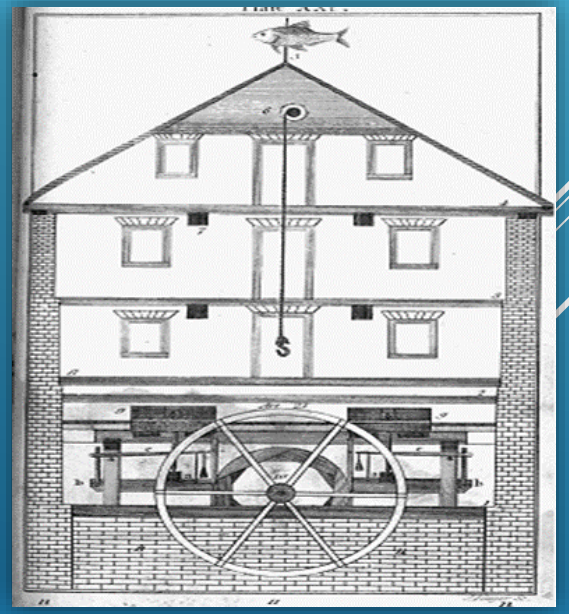


# World's First Hydropower Plant


*The dam across Fox River in Appleton, Wisconsin, the site of the first hydroelectric power plant in the world (1882).*

# HARNESSING WATER POWER





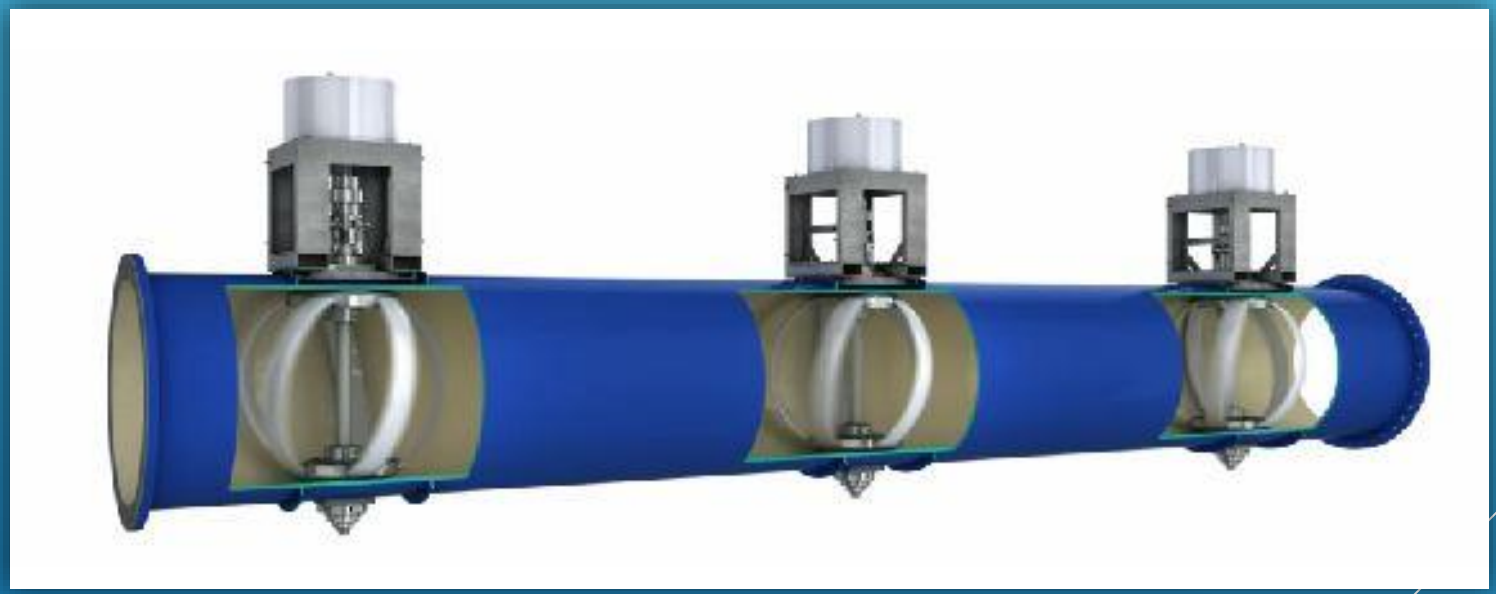
*For centuries, people used waterwheels to provide the power for needed jobs. Buckets of water poured regularly over paddles on the wheel to make it turn. These wheels were mainly used to grind flour and corn.*

## *Waterwheels and Mills*

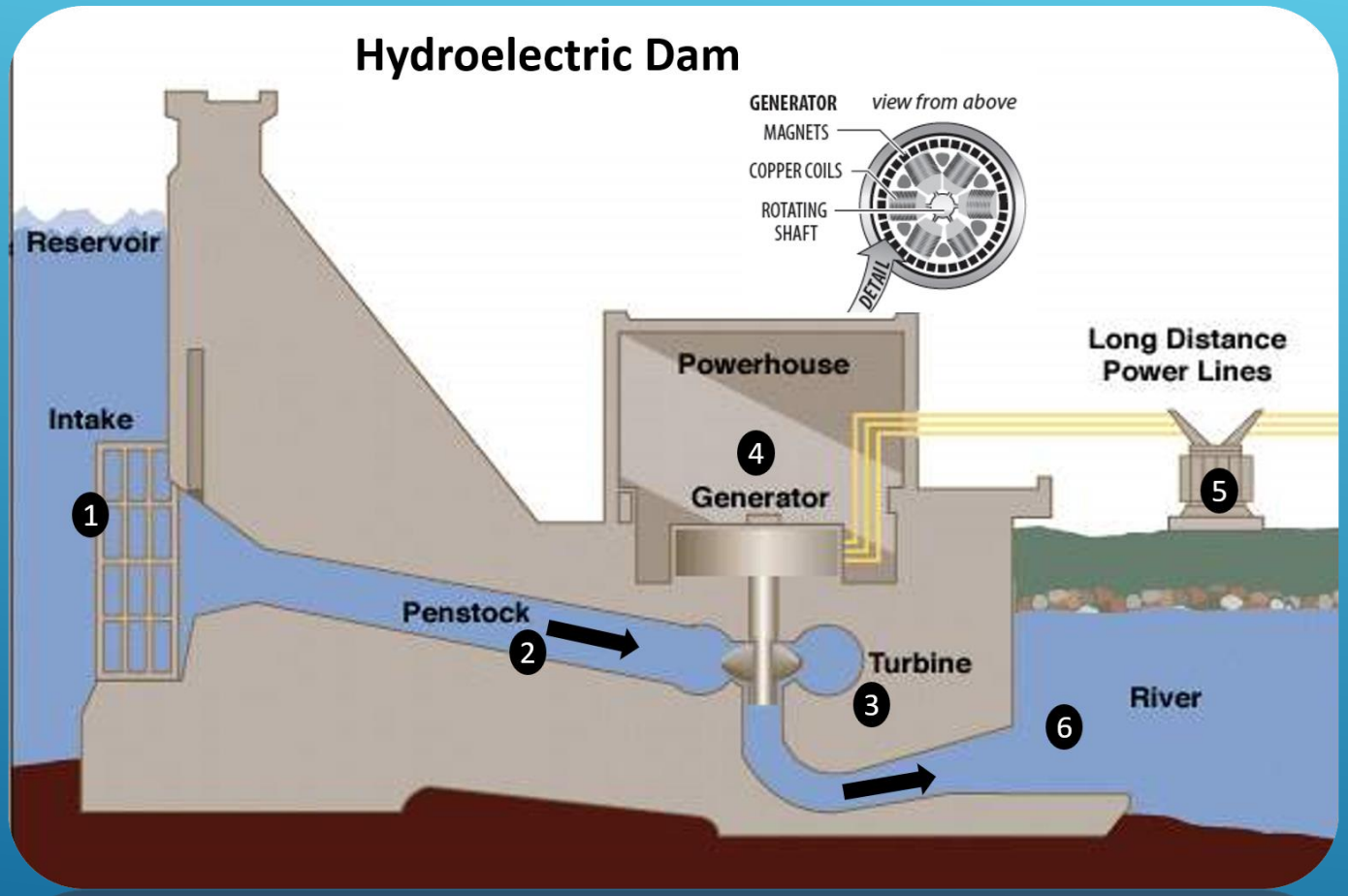
*Hydropower has been used for hundreds of years. In India, water wheels and watermills were built; in Imperial Rome, water powered mills produced flour from grain, and were also used for sawing timber and stone; in China, watermills were widely used since the Han Dynasty.*

## *Hydraulic Power Pipes*

***Hydraulic power networks also existed, using pipes carrying pressurized liquid to transmit mechanical power from a power source, such as a pump, to end users. These were extensive in Victorian cities in the United Kingdom.***



# *Modern Usage*




*There are several forms of water power currently in use or development. Some are purely mechanical but many primarily generate electricity.*

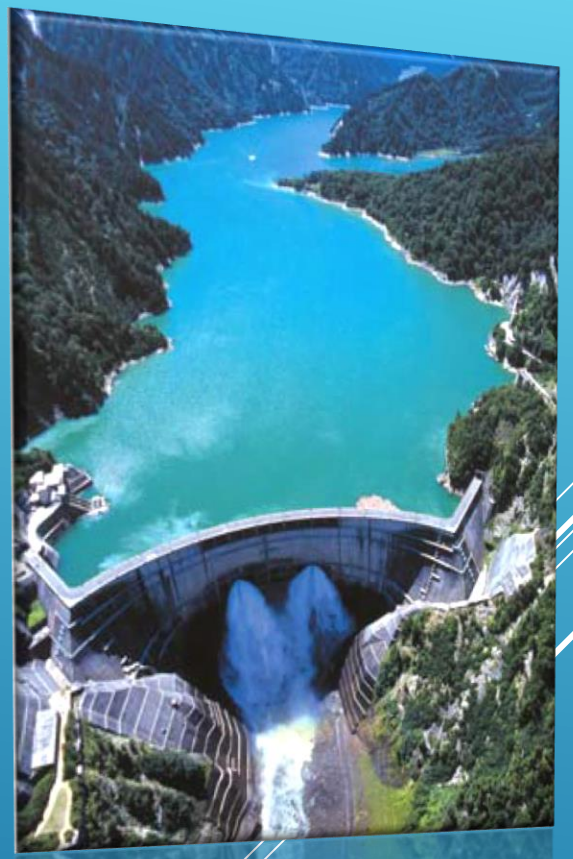
*A conventional dammed-hydro facility (hydroelectric dam) is the most common type of hydroelectric power generation.*

- *Conventional hydroelectric, referring to hydroelectric dams.*
- *Run-of-the-river hydroelectricity, which captures the kinetic energy in rivers or streams, without the use of dams.*
- *Pumped-storage hydroelectricity, to pump up water, and use its head to generate in times of demand.*
- *Tidal power, which captures energy from the tides in horizontal direction.*
  - *Tidal stream power, usage of stream generators, somewhat similar to that of a wind turbine.*
  - *Tidal barrage power, usage of a tidal dam.*
  - *Dynamic tidal power, utilizing large areas to generate head.*

# *Advantages and Disadvantages of Hydroelectric Energy*

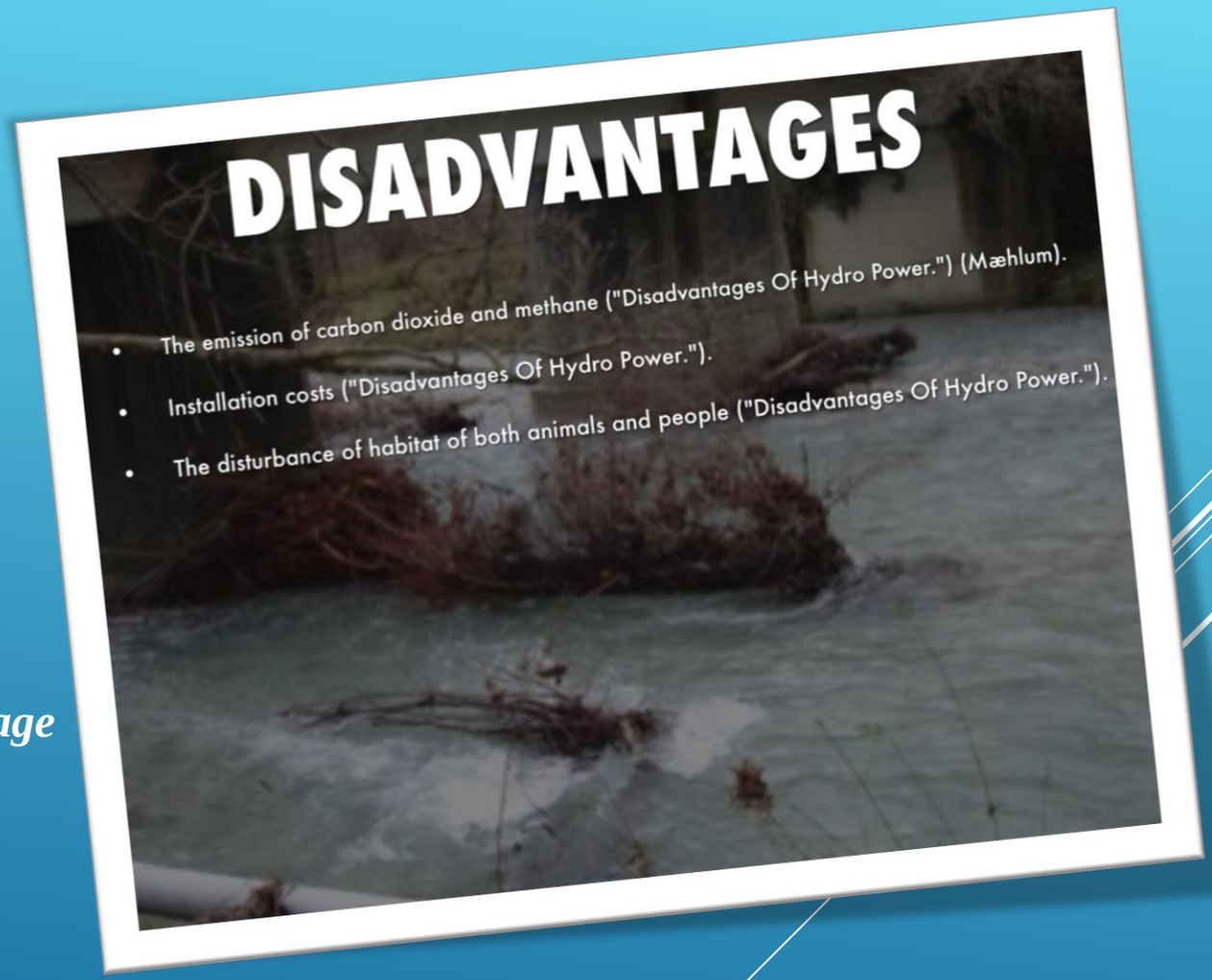
## *Advantages*

- *Fuel is not burned so there is minimal pollution*
- *Water to run the power plant is provided free by nature*
- *Reduces greenhouse gases*
- *Relatively low operations and maintenance costs*
- *It's renewable - rainfall renews the water in the reservoir, so the fuel is almost always there*



## *Disadvantages*

- *Alters the natural landscape, which could lead to habitat destruction and disruption of normal wildlife pattern*
- *Depends on precipitation, so it is not always consistent*
- *Disrupts marine life habitats, fish entrainment or passage restriction*



## *Size Classification*

*Hydropower plants are often classified based on their size or installed capacity. These classifications, which vary between countries, are used by governments as a basis for their policies to provide tax benefits, feed in tariff to the grid, subsidies, and environmental regulations.*

*The main differences in application and design of hydropower systems by size classification are as follows:*

1. Micro hydropower plants provide electricity to remote rural communities. The communities they serve are generally too remote to be supplied economically by the electricity grid.
2. Mini-hydro and small hydro projects can either supply isolated rural towns or they can be developed to supply power to the grid.
3. Small hydropower plants and some in the medium hydropower range are designed as “run of-river” projects. Projects use a weir to divert water to the intake but do not store water.

4. Large hydropower plants typically involve the construction of a dam to create a reservoir. Some reservoirs are small and are used for storing water to supply daily or weekly peak loads.

**TABLE 1.3**
**Classification of Hydropower by Size**

| Classification | Size |
|---|---|
| Micro hydropower | Up to 100 kW |
| Mini hydropower | Between 100 kW and 1000 kW |
| Small hydropower[a] | Between 1 MW and 10 MW |
| Medium hydropower | Between 10 MW and 100 MW |
| Large hydropower | Larger than 100 MW |

[a] Although 10 MW is often used as a threshold for small hydro, definitions are inconsistent across countries. For example, India and China consider small-scale hydro to be ≤25 MW and the United States <30 MW.

# *Hydroelectric Energy Used Around the World*

*Hydroelectric energy is the most commonly-used renewable source of electricity. China is the largest producer of hydroelectricity. Other top producers of hydropower around the world include the United States, Brazil, Canada, India, and Russia. Approximately 71 percent of all of the renewable electricity generated on Earth is from hydropower.*

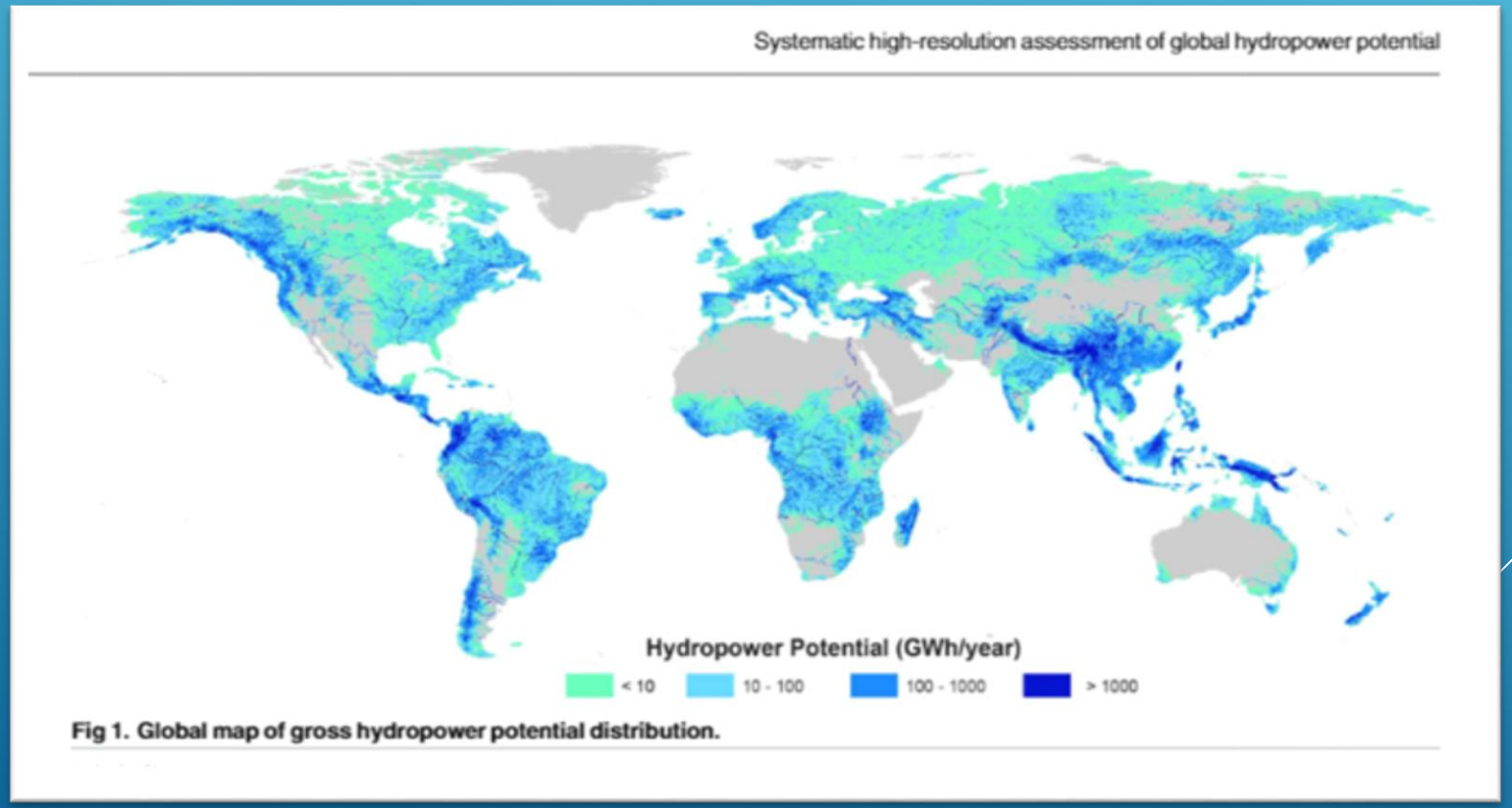


Fig 1. Global map of gross hydropower potential distribution.

*Hydropower grew dramatically all over the world with the invention of the electric generator and particularly after it became possible to generate and transmit alternating current (AC) starting around 1889. The growth in demand for electricity, improvement in turbine efficiency, rapid increase in power output of hydropower turbines, and the civil engineering know-how to build large dams all combined to tremendously expand the role of hydropower in global electricity production*

**TABLE 1.2**
**Largest Producers of Hydropower**

| | TWh/Year | % of World Generation | % Hydro in Total Domestic Power Supply |
|---|---|---|---|
| People's Republic of China | 699 | 19.6 | 14.8 |
| Brazil | 428 | 12.0 | 80.6 |
| Canada | 376 | 10.5 | 59.0 |
| United States | 345 | 9.7 | 7.9 |
| Russian Federation | 168 | 4.7 | 15.9 |
| India | 131 | 3.7 | 12.4 |
| Norway | 122 | 3.4 | 95.3 |
| Japan | 92 | 2.6 | 8.7 |
| Venezuela | 84 | 2.3 | 68.6 |
| Sweden | 67 | 1.9 | 44.3 |
| Rest of the world | 1054 | 29.6 | 13.6 |
| World | 3566 | 100 | 16.1 |

*Source:* International Energy Agency (2013) using 2011 data.

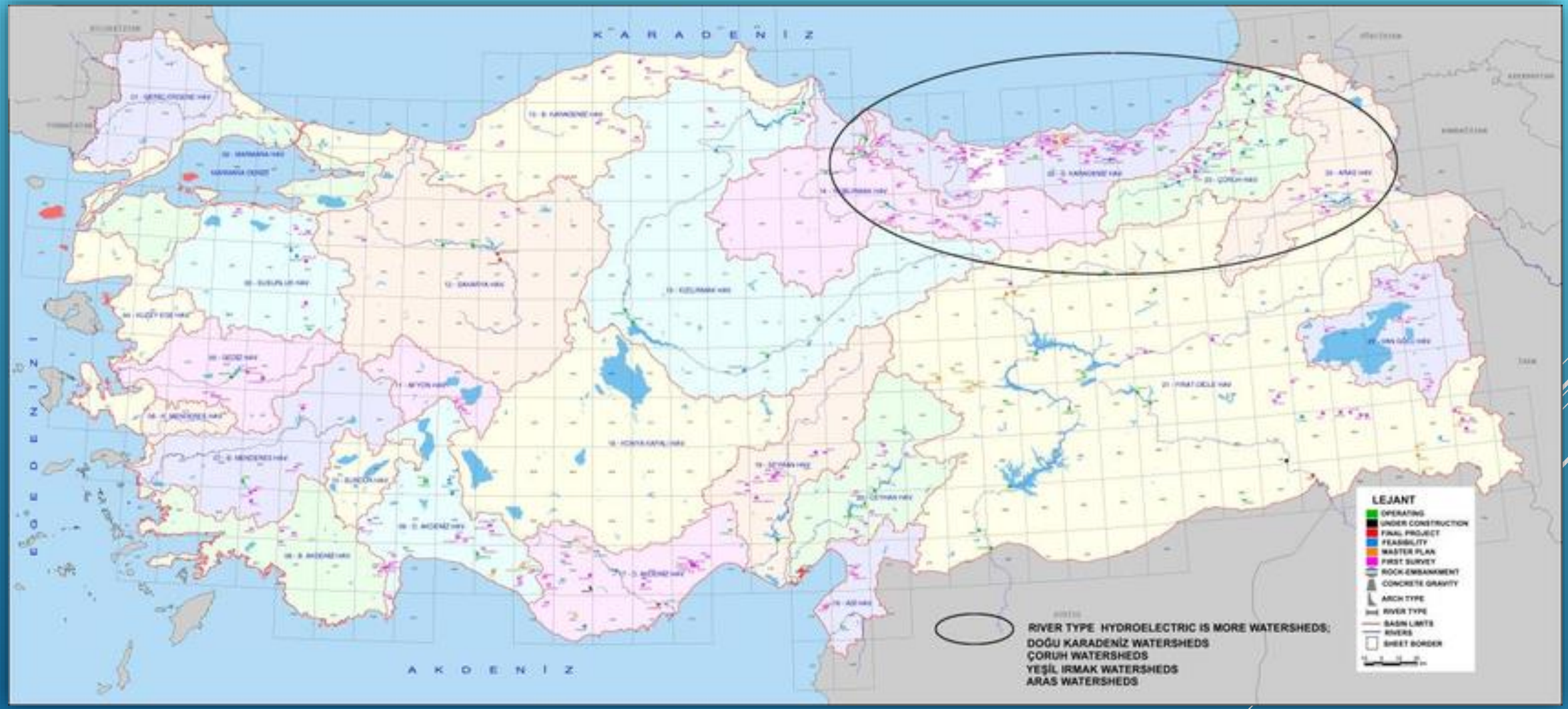
# *Hydroelectric Energy Used in The Turkey*

**Table-2:** Ongoing construction of the hydroelectric Distribution by Region and Council of Power

| | ≤10 MW | 10-50 MW | ≥50MW | Toplam |
|---|---|---|---|---|
| Marmara Region | 168 | 83 | 86 | 337 |
| Aegean Region | 75 | 100 | 61 | 236 |
| Mediterranean Region | 88 | 67 | 48 | 203 |
| Central Anatolia Region | 94 | 60 | 33 | 187 |
| Black Sea Region | 186 | 157 | 53 | 396 |
| Eastern Anatolia Region | 99 | 68 | 34 | 201 |
| Southeastern Anatolia Region | 40 | 32 | 24 | 96 |
| Total | 750 | 567 | 339 | 1656 |

## Turkey

| Turkey statistics | |
|---|---|
| Area: | 783,600 km² |
| Population: | 77,700,000 |
| Installed hydropower capacity: | 23,661 MW (2014) |
| Hydropower generation: | 39.53 TWh (2014) |


K A R A D E N İ Z
E G E D E N İ Z
A K D E N İ Z
LEJANT
OPERATING
UNDER CONSTRUCTION
FINAL PROJECT
FEASIBILITY
MASTER PLAN
FIRST SURVEY
ROCK-EMBANKMENT
CONCRETE GRAVITY
ARCH TYPE
RIVER TYPE
BASIN LIMITS
RIVERS
SHEET BORDER
RIVER TYPE HYDROELECTRIC IS MORE WATERSHEDS;
DOĞU KARADENİZ WATERSHEDS
ÇORUH WATERSHEDS
YEŞİL IRMAK WATERSHEDS
ARAS WATERSHEDS

## *The Hydropower Resource*

*On Earth, water is constantly moved around in various states, a process known as the hydrologic cycle. Water evaporates from the oceans, forming into clouds, falling out as rain and snow, gathering into streams and rivers, and flowing back to the sea. All this movement provides an enormous opportunity to harness useful energy.*

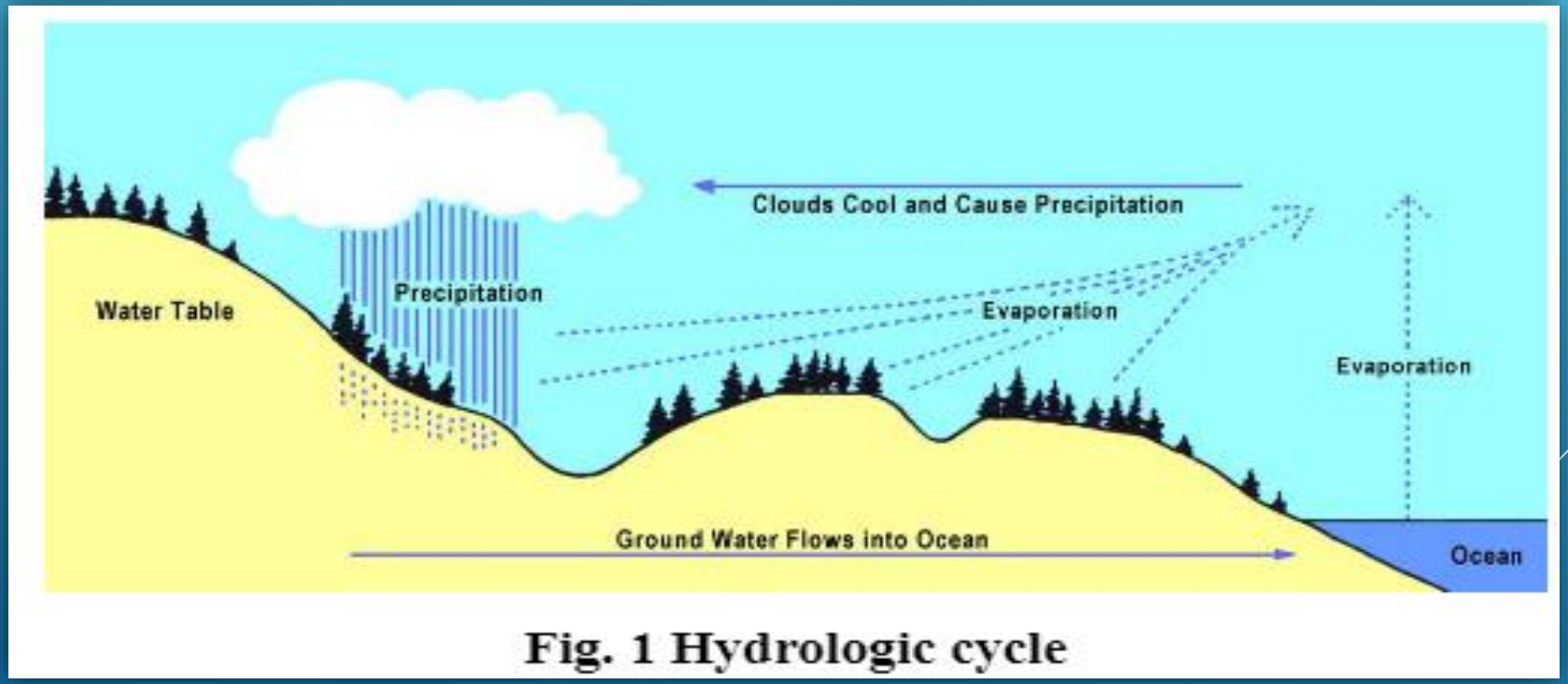
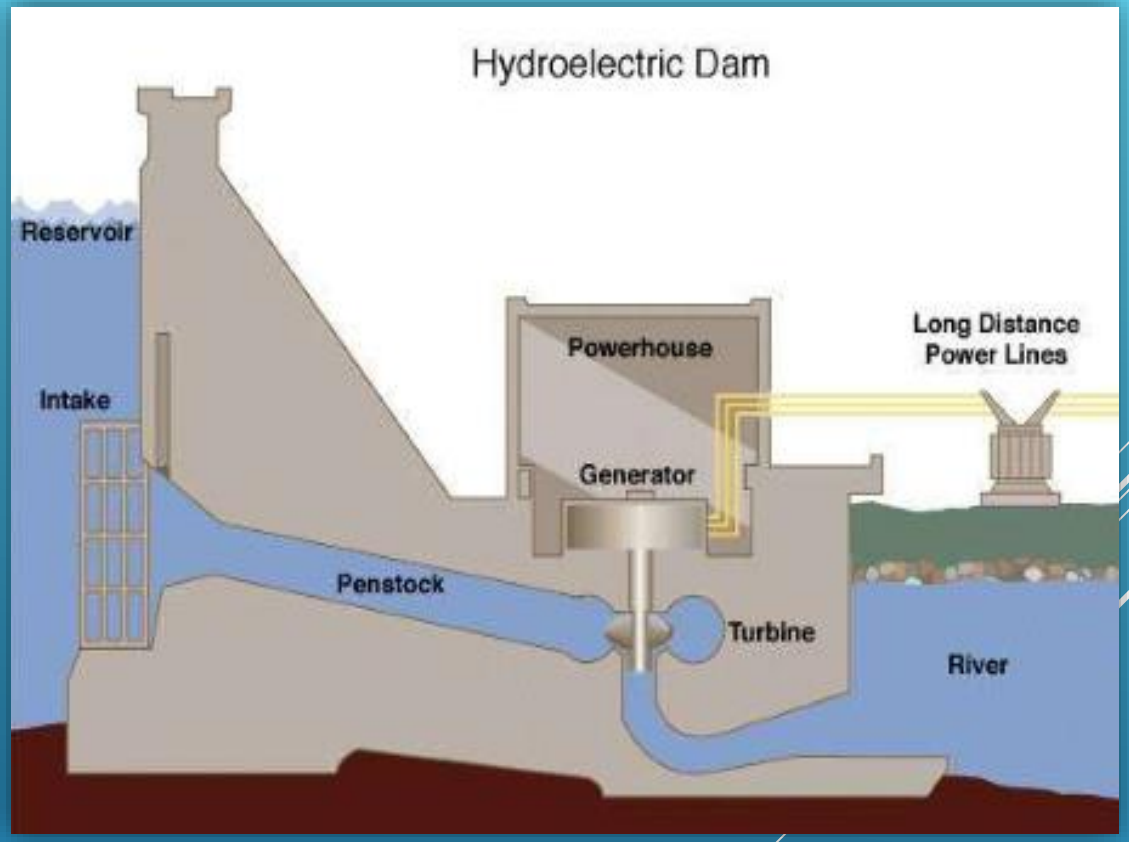



**Fig. 1 Hydrologic cycle**

# *How Hydroelectric Dams Works ?*

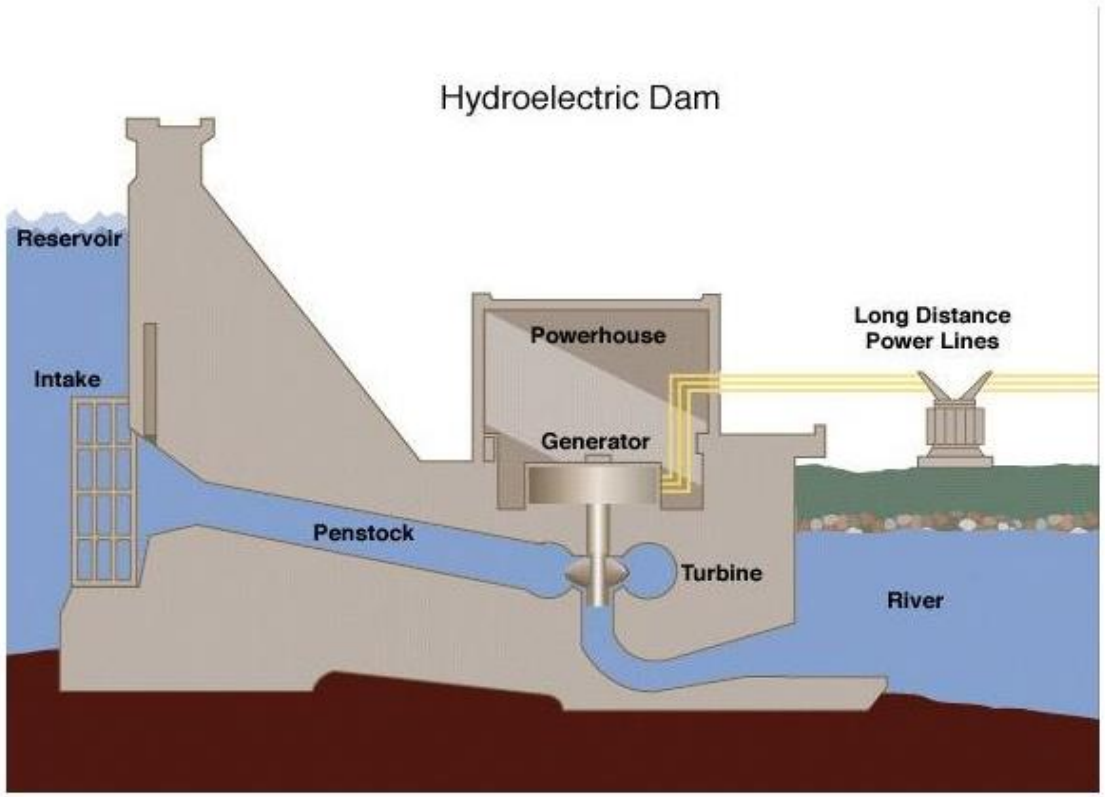
- *Large amounts of water are stored in the reservoir behind the dam*
- *Gravity causes the water to rush through the intake grill near the bottom of the dam and flow through the penstock*
- *The water, which is flowing very quickly, rushes past a turbine and spins it.*
- *The turbine powers a generator, which produces electricity and sends power to many areas via power line*




***Cross section of a conventional hydroelectric dam***

## Six Important Components of Hydroelectric Power Plants

1. Dam
2. Reserviour
3. Intake or Control Gates
4. Penstock
5. Turbine
6. Generator

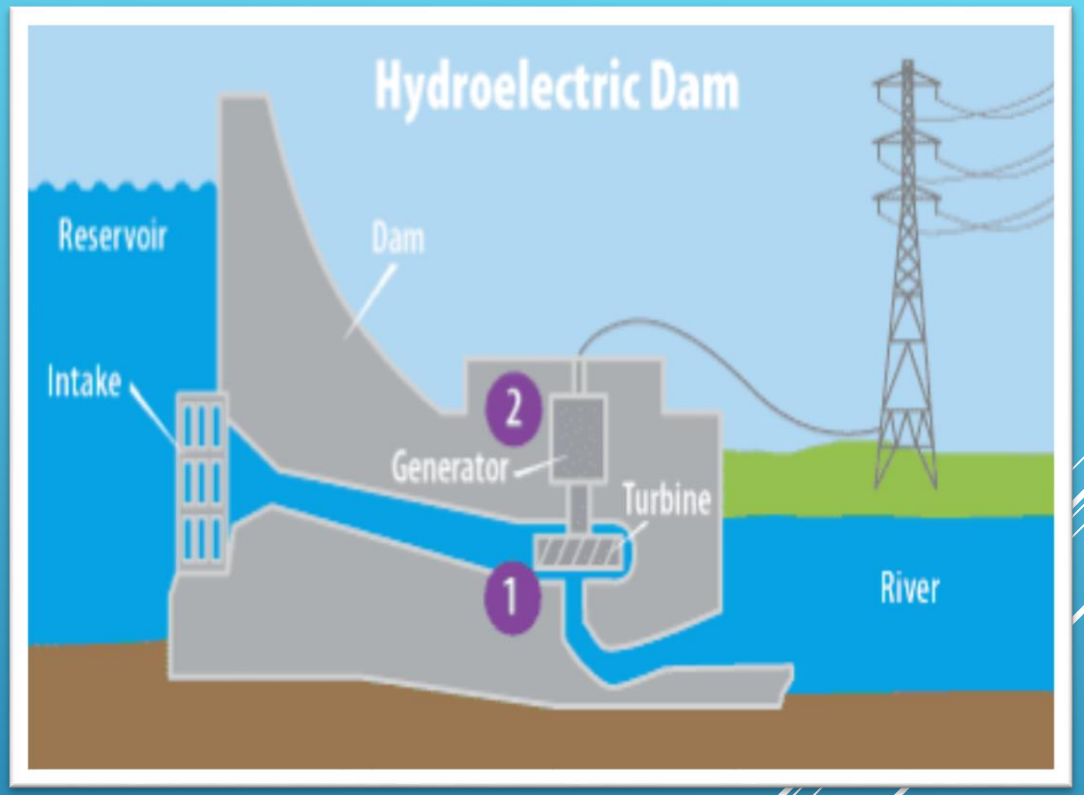



*Hydropower refers to the generation of power, either mechanical or electrical, using the energy of falling water. The power that can be available from a hydropower plant depends on the volumetric flow of water driving the turbine and its vertical drop in height. The larger the volumetric flow of water, the higher the power generation will be. There are several components of hydroelectric power plants.*

# Reservoir

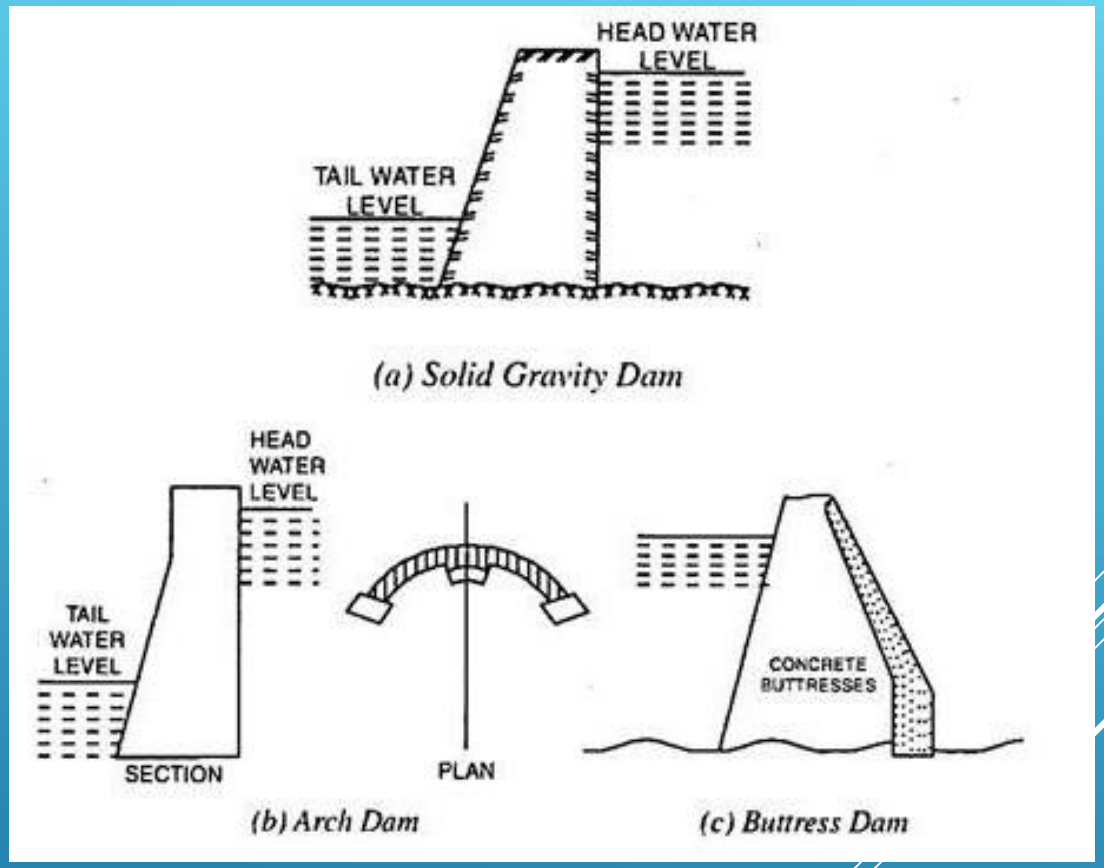
*It is the basic requirement of a hydroelectric plant. Its purpose is to store water during excess flow periods and supply the same during lean flow periods and thus it helps in supplying water to the turbines according to the load on the power plant.*

*A reservoir can be either natural or artificial. A natural reservoir is a lake in high mountains and an artificial reservoir is made by constructing a dam across the river. Low head plants require very large storage reservoir. The capacity of reservoir depends on the difference between run offs during high and lean flows.*



# Dam

*A dam is a structure built across the river to increase the water level such that the required flow volume can be diverted into the waterways of the hydropower plant for power generation. Generally, for run of river plants, the dam has a low height (as storage is not required) structure and is also referred to as a diversion weir.*



# *Intake*

***The location from which river water is initially diverted into the waterways of a hydroelectric plant is referred to as the intake. An intake in a run of river hydropower plant can be an opening along the riverbank or other types of arrangements that facilitate flow diversion into the waterways of the power plant.***

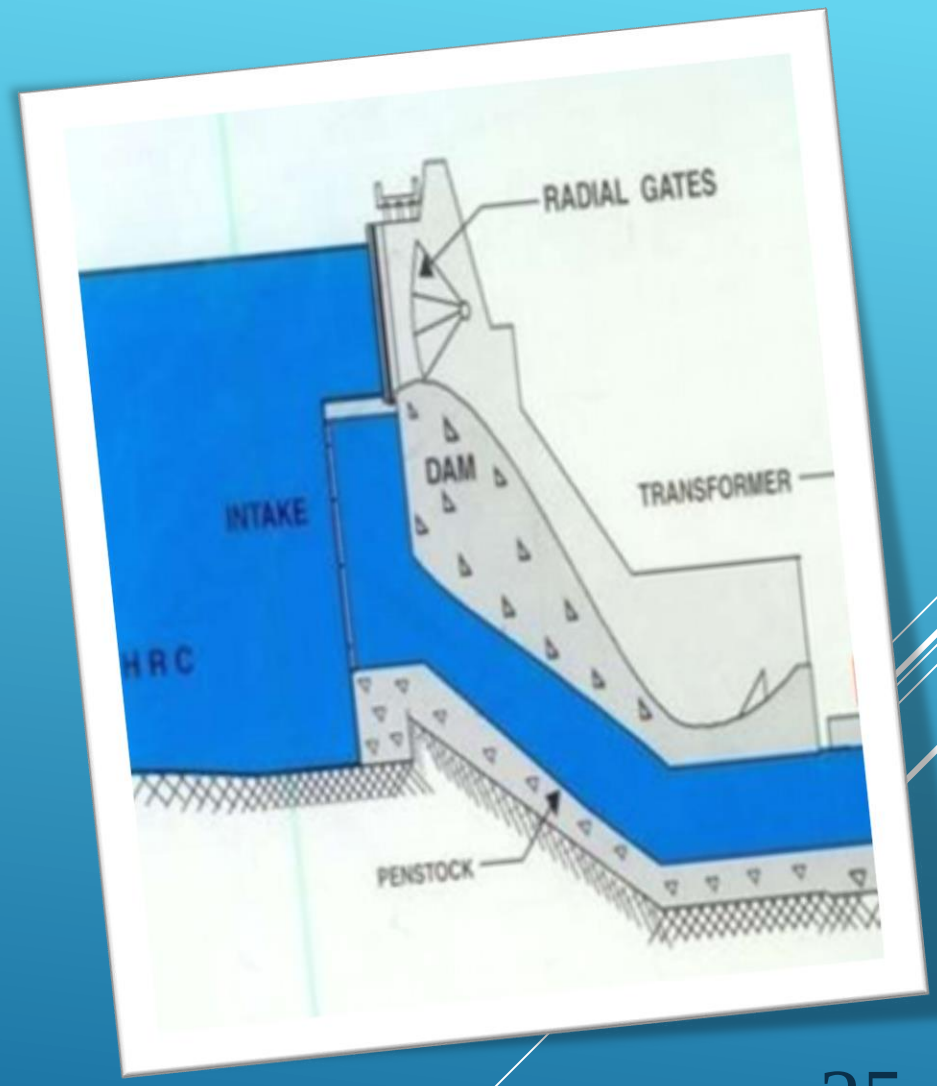
FIGURE 2.7 Typical side intake used in a small hydroelectric power plant, Nepal.

## Control Gates

*These are the gates built on the inside of the dam. The water from reservoir is released and controlled through these gates.*

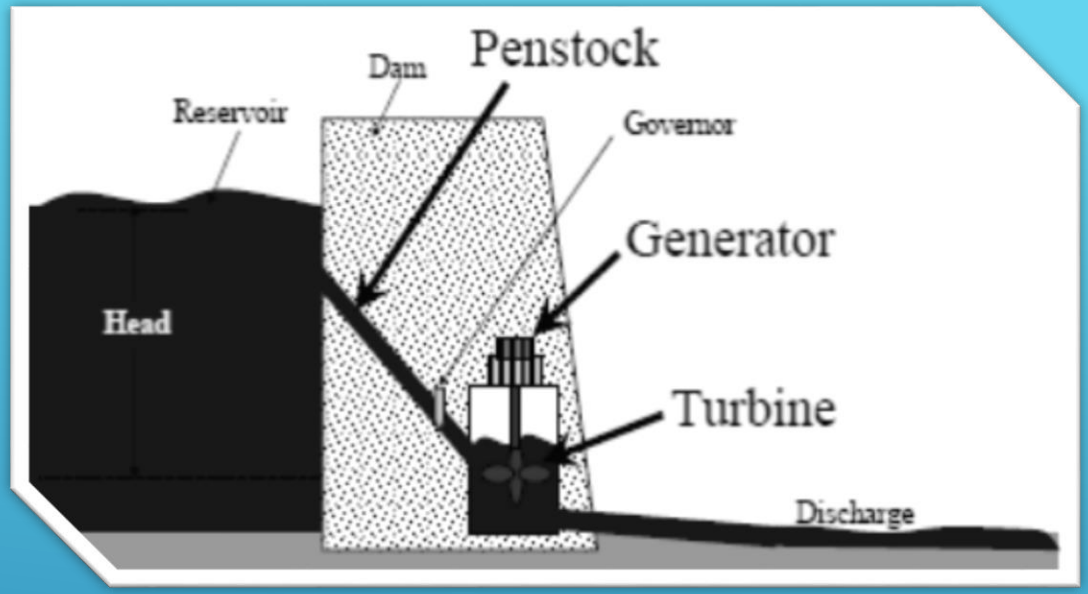
*In low head plants gates at the entrance to the turbine casing are usually all that is needed to shut off the flow and provide for unwatering the turbine for inspection and repairs.*

*The water flowing through the gates possesses potential as well as kinetic energy.*



# Penstock

*The penstock is the long pipe or the shaft that carries the water flowing from the reservoir towards the power generation unit, comprised of the turbines and generator. The water in the penstock possesses kinetic energy due to its motion and potential energy due to its height.*




# Turbine

*The turbine is a mechanical device that converts the energy of the pressure head of the water and incoming flow from the penstock into mechanical energy by rotating its mass. The type of turbine selected to be used in the power plant depends mainly on the head, volumetric flow, and the number of units that are to be installed.*

FIGURE 2.25 A 100-kW Pelton turbine in a workshop, Nepal.

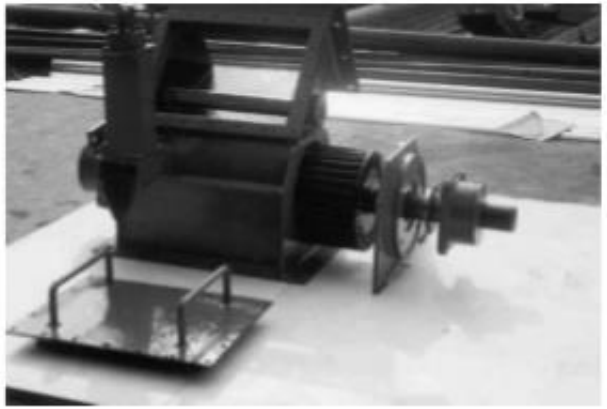
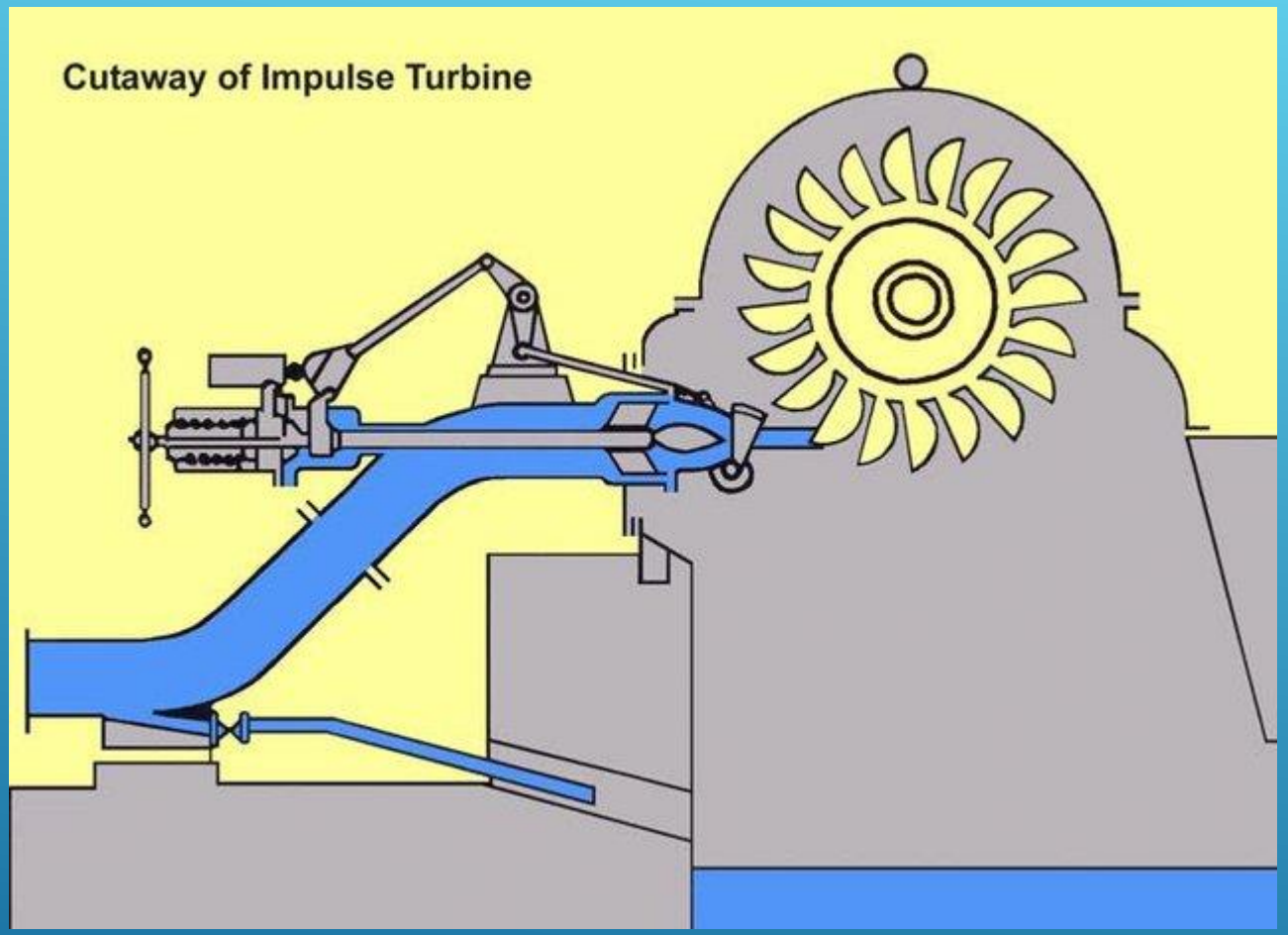


FIGURE 2.24 A cross-flow turbine used in a micro hydropower plant, Nepal.

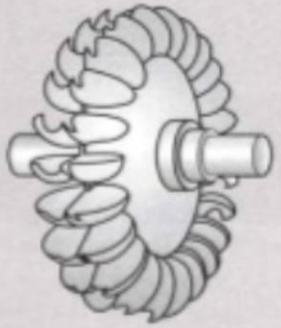

Cutaway of Impulse Turbine

# Types of Hydropower Turbines

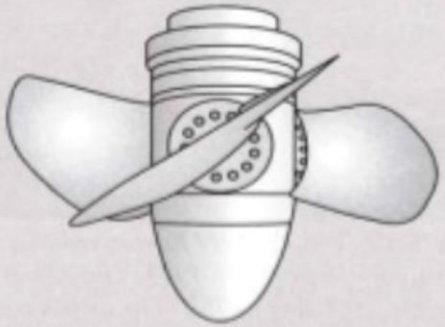
Francis

Fixed pitch propeller

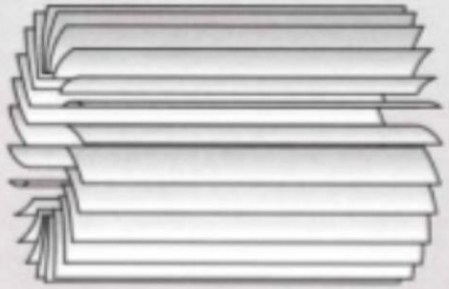
Turgo



Pelton



Kaplan



Crossflow

**Figure 5.15** Types of turbine runner

# Generator

*The generator converts the rotational mechanical energy of the turbine into electrical energy. The shaft of the rotating turbine is coupled with the generator shaft either directly or via a gear or pulley system. The two principle types of generators used are "synchronous" and "induction" or "asynchronous." The bases for selection of generator type are plant capacity, connection to the grid or isolated use, and the type of loads that are required to be powered by the generator. Both synchronous and induction generators can be single phase or three phase with larger capacity generators normally being three phase.*

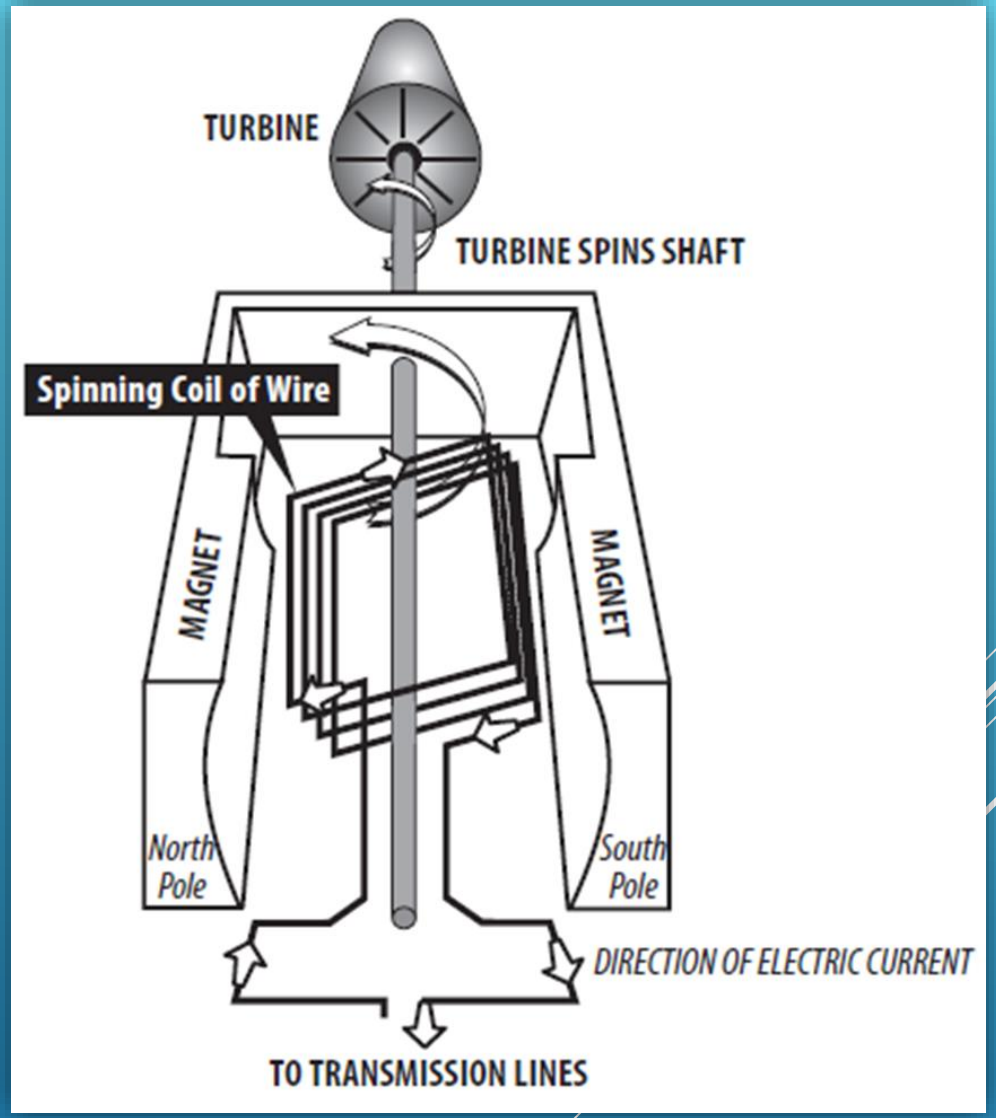
**FIGURE 2.27** An induction generator coupled with a Francis turbine in a micro hydropower plant Afghanistan.

# *How Do Generators Work ?*

***In general, the turbine converts the energy of the water into mechanical energy, which then allows the generator to produce electricity.***

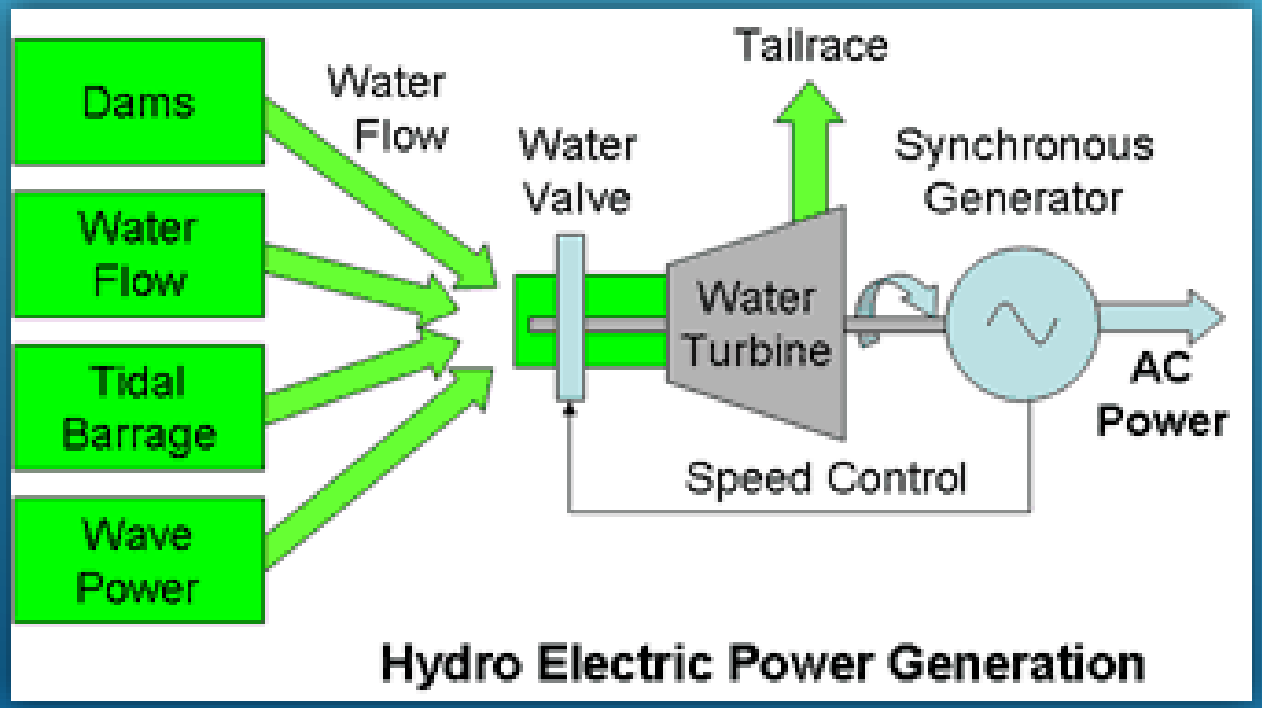
*Faraday stated that when a magnet strikes a conductor, it causes electricity to flow.*

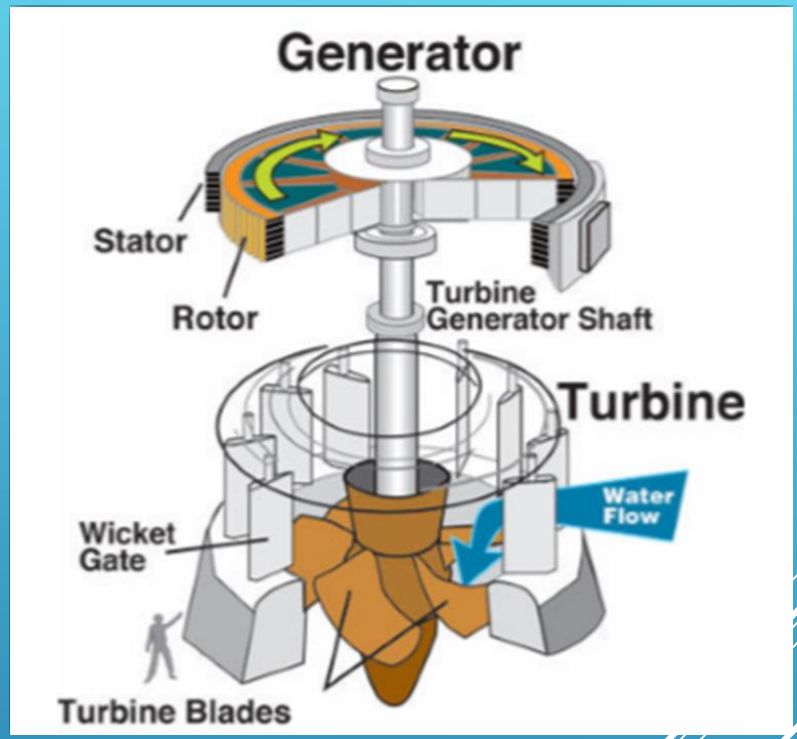
***Hydroelectric generators work off of the same principle. The turbine spins a rotor, which contains "field poles", or loops of wire wound around magnetic laminations. These field poles are electromagnets.***



*The rotor rubs against a stator, which acts as a conductor.*

*This friction between the magnet and conductor produces electricity.*




*A typical turbine and generator*

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