Department of Hydraulic and Water Resources Engineering

KOIT, Wollo University

Lecture Notes

Course Code: ***WRIE3154***
Course Title: ***Basics of Hydropower Engineering***
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Chapter 1: Introduction

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CHAPTER 1: Introduction

1.1. Sources of Energy

1.2. Merits and Demerits of Hydropower

1.3 Hydropower in Ethiopia

1.1 Sources of Energy

The following two major sources of power generation may be identified on the basis of present day importance:

a) ***Conventional sources***

i) **Thermal power**

ii) **Hydropower**

iii) **Thermo-nuclear power**

b) ***Unconventional sources***

i) **Tidal power**

ii) **Solar power**

iii) **Geothermal power**

iV) **Wind power**

V) **Wave power**

Vi) **Depression (solar) power**

Sources of Energy

- **Energy can be described as potential for work, which may be withdrawn if needed. The source for any kind of energy on earth is the sun. This is also valid for nuclear and fossil fuel when taking into account the genesis of the earth.**

THE SUN

- **The Sun is the primary sources energy .The energy radiated by the sun in the form of electro- magnetic waves can be utilized for the generation of power It can be observed in solar collectors to provide space or water heating Buildings can be designed with solar features that allow solar energy to their space heating requirements. It can be concentrated by parabolic mirror to provide heat up to several thousands forge Celsius and this high temperature may then be used either for heating purposed or to generate electricity**.

THE WIND

- **Winds have sufficient energy which can be utilized in wind turbines to derive small generators. Wind turbines make use of the aerodynamic force generated by aerofoil to extract power from the wind the method is unreliable as the production of electrical energy depends largely up on the availability of wind pressure.**

GEOTHERMAL

- **The earth has a molten core. During volcanic action, the material comes out from the bowels of earth to form volcanic explosions also produces steam vents and hot springs. This steam can be used for the generation of electric power and space heating.**

BIOGAS

- **Biogas is derived from biological sources such as dung or sewage. These biological materials are fed in to a purpose- built digester as slurry with up to 95% Water.**
- **The resulting gas is a mixture consisting mainly of methane and can be used to generate power using gas or Steam turbines.**

OCEAN TIDES

- There is a tremendous energy in ocean tides and waves but it is very difficult to harness this power. Only a few favorable points exist where the geography of the inlet to a stury favors the electrical energy.
- In this case, a small dam or weir with large gates can be built across the mouth of a stury and low head hydraulic turbines are installed in the dam. At the time of high tide the gates are opened & Water is stored in the tidal basin and then the gates are closed. After the tide has reseeded, there is working hydraulic head between the basin Water and the open-ocean and the stored water is now allowed to flow back to the ocean through hydraulic turbines installed in the dam.

FUELS: THERMAL POWER

- **Fuels such as coal. Oil, and natural gases the most commonly used sources of energy coal is available in huge quantities in many steam so produced is utilized in steam turbines coupled to generators and therefore, for generation of electric power, oil, acing costly ,is used for power production only where small power is required, for instance, as stand- by power stations Natural gooses available in large quantities can be used to run gas engines or turbines or can be burnt to produce steam and steam turbines can there after to produce power.**

Radio Active Substances: Nuclear power

- **Tremendous amount of heat energy can be by fission of nuclear disintegration of uranium and other similar fissionable materials the heat energy so librated in atomic reactors is extracted by pumping fluid or molten metal like like liquid sodium or gas through the pile The heated exchanger by circulation On the heat exchanger the gas is heated or steam is generated which is utilized to derive gas or steam turbines coupled with generators there by generating electrical energy .**

In our country (Ethiopia)

- **Natural gases :-** are found in ogaden, Borena
- **Coal: -** North shwa, Welega, Gonder,South Wello etc
- **Uranium :-** Ogaden, Borena, West Wellega
- **Geothermal Energy :-** lake langano, Afar/Asayita

WATER POWER (HYDROPOWER)

- **Water at high pressure or flowing with a high velocity can be used to run turbines or water wheels coupled to generators, and therefore, for generation of electric power. This method of generating electric power is well established as one of the principal energy producing technologies around the world. It is widely acclaimed as the cleanest and cheapest of all energy forms.**
- 90% of total energy is generated from water

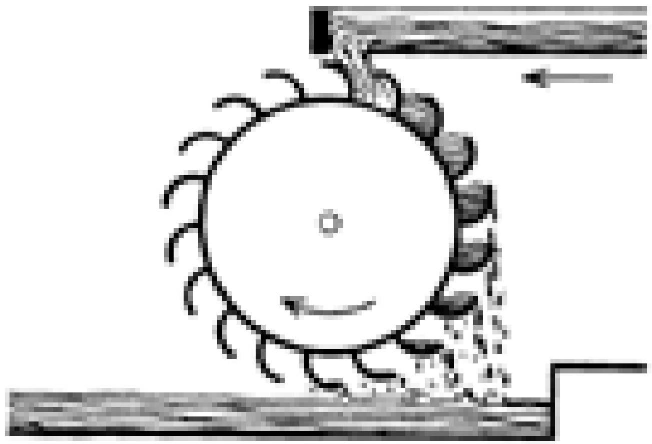
Definition:

- **Hydropower Engineering refers to the technology involved in converting the pressure energy and kinetic energy of water into more easily used electrical energy.**
- **The prime mover in the case of hydropower is a water wheel or hydraulic turbine which transforms the energy of the water into mechanical energy.**

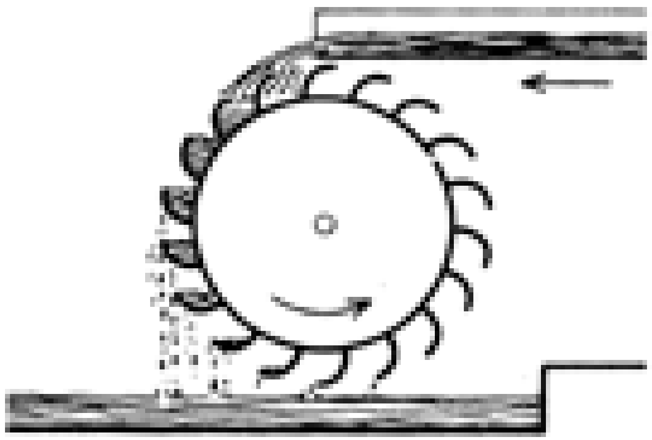
Water Wheels

- **Types of water wheels are based upon where the water strikes it**
  - **Pitch back – water drops from top and is deflected backwards to fall back towards the dam/river**
  - **Overshot – shoots over the top onto the wheel; the usual kind**
  - **Breast shot – strikes about 50% to 80% of height of the near side of the wheel**
  - **Undershot – pushes underneath and need not be more than immersed in a stream**
- **Waterwheels turn slowly compared with turbines**
  - **one to fifty rpm**

Pitchback



PitchBack (90%)



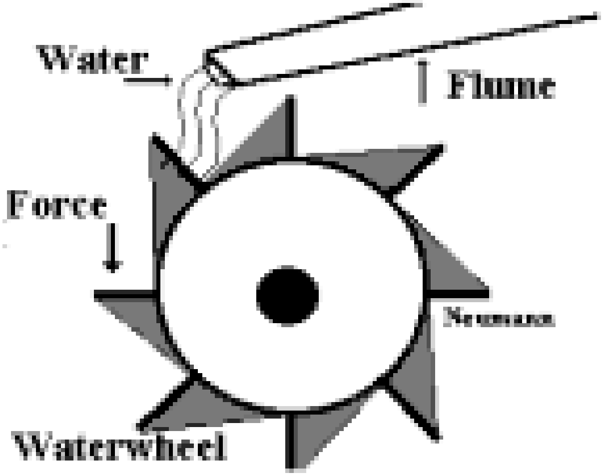
OverShot (70%)

- Note the difference in direction of the water flow
- A containing surround structure could force the water against the wheel as it falls and increase the weight of the water in the wheel

Overshot

- The water flows across the top of the wheel, pushing it forward, but also partially filling the buckets so that the weight pushes downward to turn the wheel
- The inertia of the water helps turn the wheel only slightly since it doesn’t flow very fast
  - A very fast flow would be needed to get kinetic energy

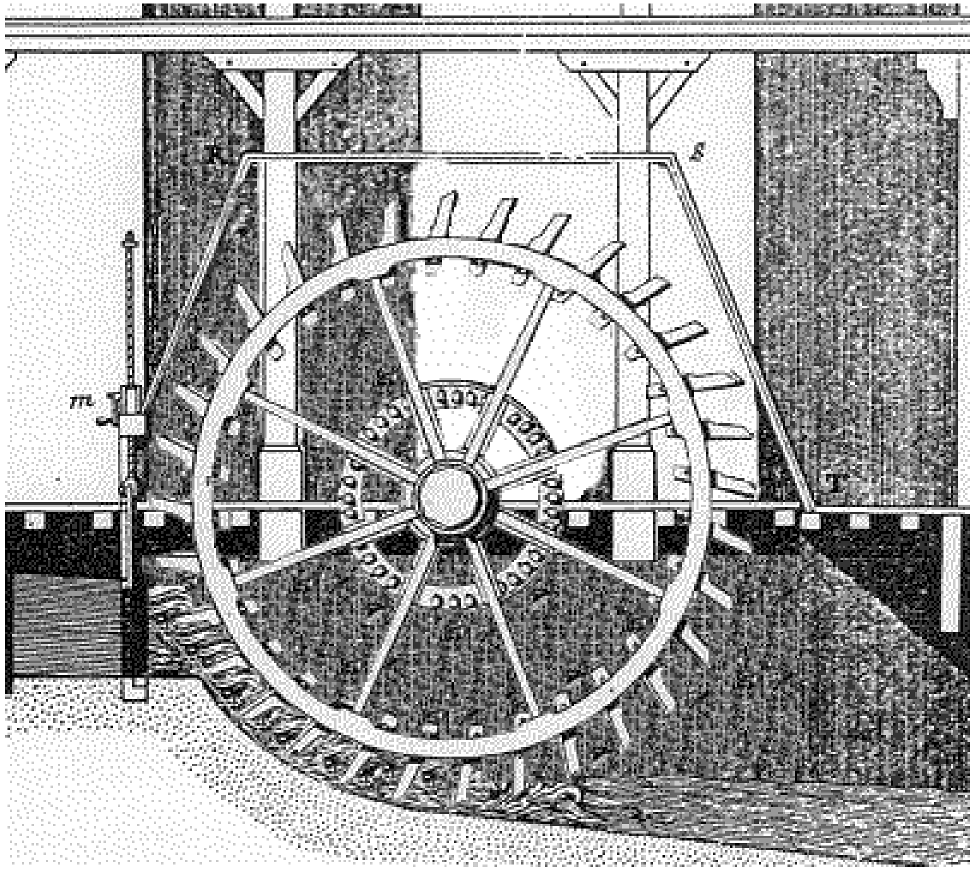
Figure 5



Overshot Waterwheel

Breast shot

- Note the contoured channel or surround at the bottom of the wheel that holds the water into the wheel



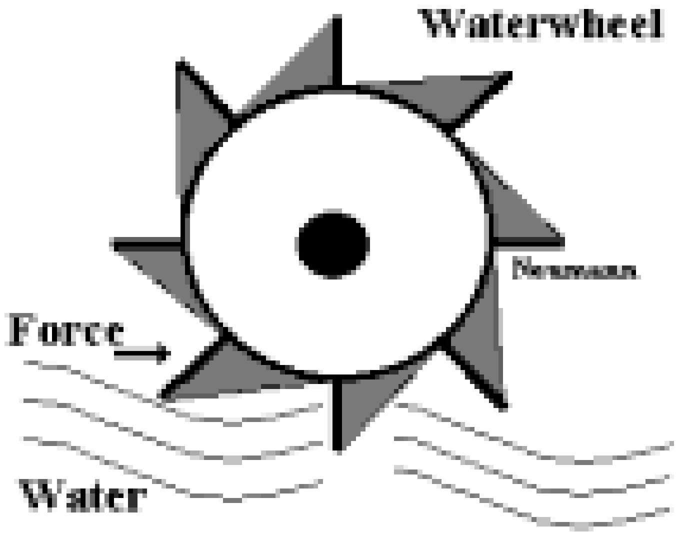
Water Flow

- The water strikes the wheel about mid-way up so the inertia and the weight of the water push the wheel around

Undershot

- The undershot wheel is simply placed in a stream with the bottom of the wheel pushed by the current
- Works well where there is little depth and no head
- Inefficient, but works where others won't
- Can be on a small boat anchored in a stream

Figure 4



Undershot Waterwheel

Turbines:

- The turbine is made to convert hydraulic energy (potential and kinetic) into rotational mechanical energy on the turbine shaft.
- The flow discharge is controlled by an aperture mechanism just in front of the turbine runner.
- The rotating part of the turbine or water wheel is often referred to as the *runner*.
- The shaft is directly connected to an electric generator that further converts the mechanical energy into electric energy.

  - Impulse turbines
  - Reaction turbines

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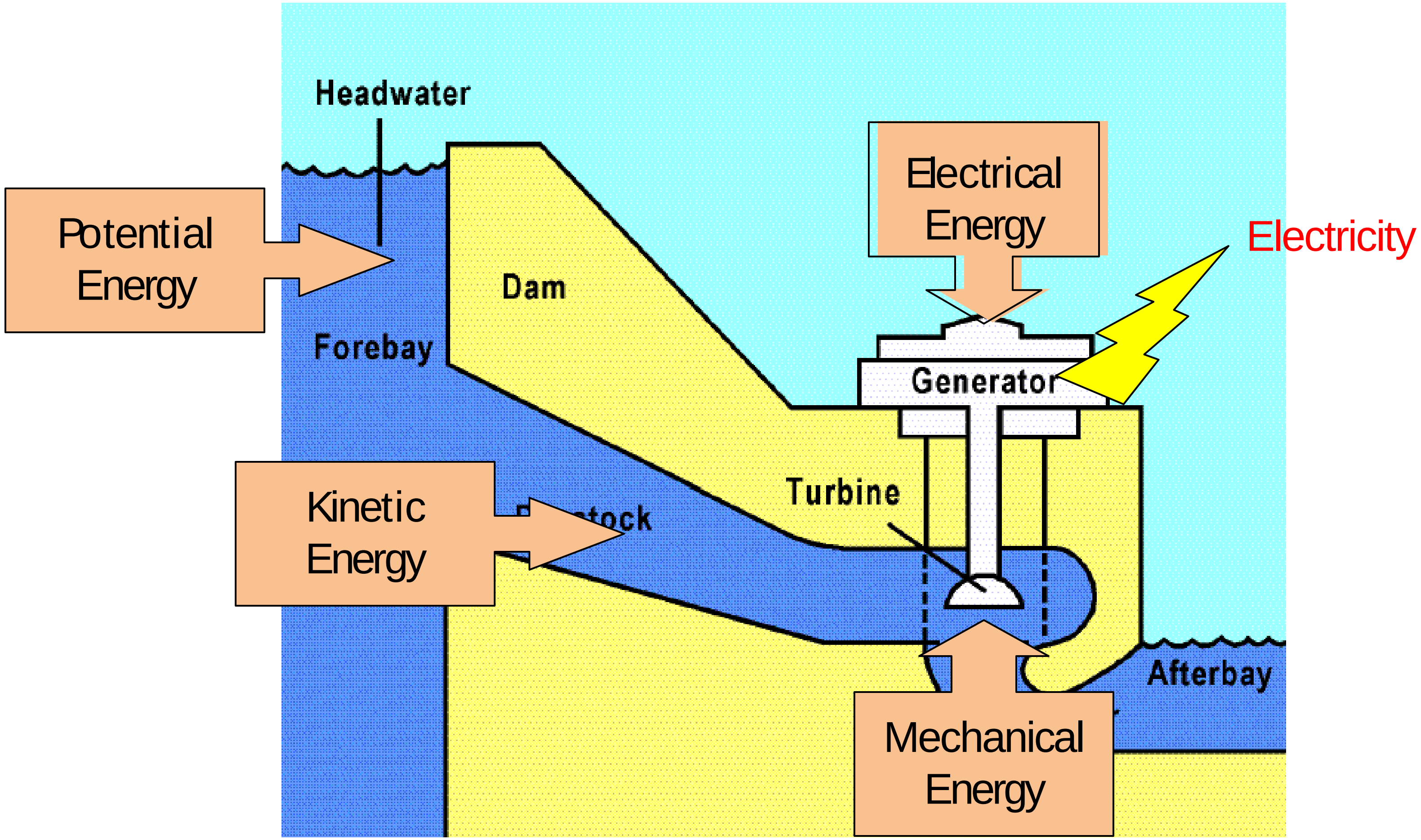


1.2 Merits and Demerits of Hydropower

MERITS

- Hydropower plants do not require fuel, as water is the Source of energy Hence operating costs are and there are no problems of handling and storage of fuel and disposal of as h
- In Hydropower plants the hydraulic turbines can be pit off and on in a matter of minutes and the rapidly changing load demands can be met without any difficult. Hence it is well suited for peaking
- Hydropower plants are highly reliable, robust, and have higher life expectancy and nuclear less maintenance

  - Thermal & nuclear - 25-30 years
  - Hydropower 50-100 years
- Hydropower is clean and free of environmental pollutions. There is no danger of radiation, hazards and no nuisance of smoke and as has
- Hydropower has by far the highest energy conversion efficiency, at 80-90% (Thermal & nuclear 30-60 %)

Merits and Demerits of Hydropower

Hydropower has the following *advantages* over other sources:

- Hydropower has a '***continuous***' source of energy, while thermal power has a depletable fossil fuel source. Besides hydropower doesn't consume the water.
- Running cost of hydropower plant is very low compared to thermal and nuclear plant.
- Hydropower plants can be brought in to operation in few minutes while thermal & nuclear power plants lack this capability

- Thus hydropower plants are particularly useful in taking up short period peak loads in a power grid system.
- Efficiency of hydropower system is very high (85-95%), while thermal power plants have low efficiency, as low as 40%.
- Hydropower development also provides secondary benefit such as recreation, fishing, flood control etc, where storage is contemplated.

DEMERITS

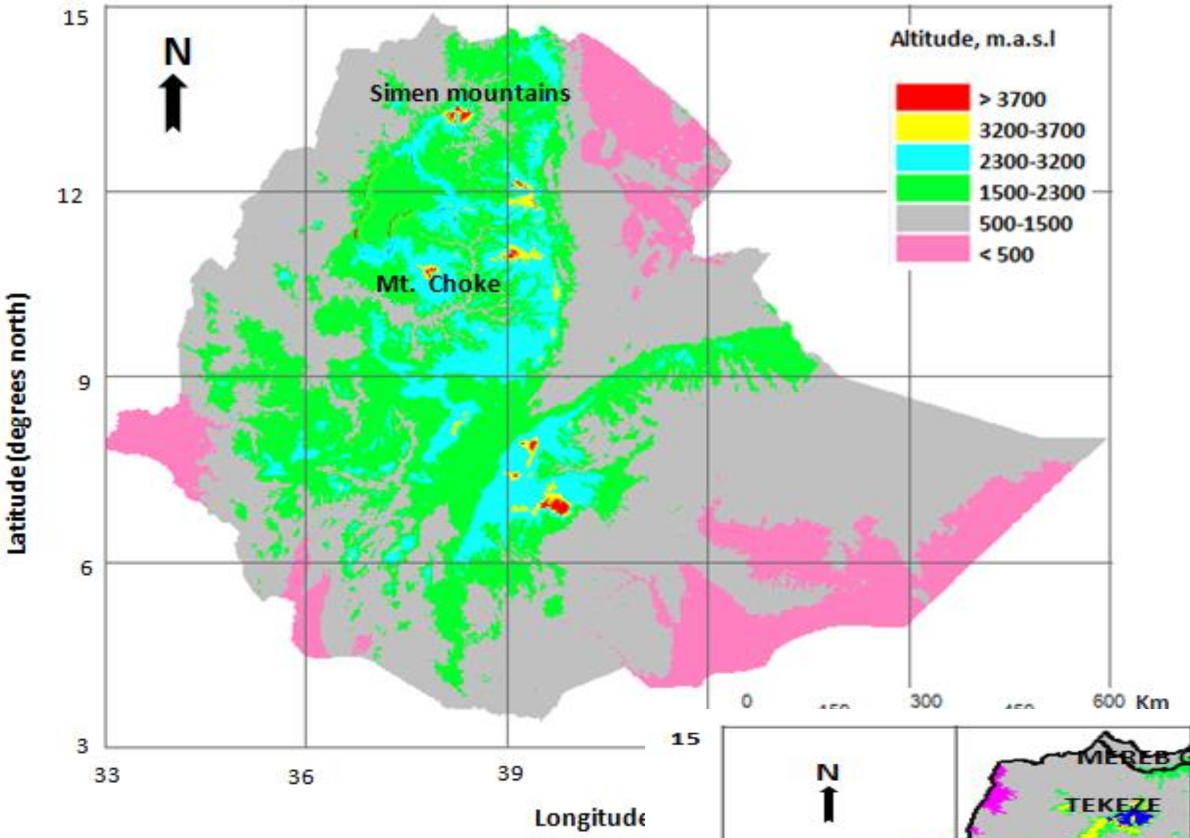
- **The initial cost of hydropower plant is high due to the longer gestation period and the involvement of huge civil and hydraulic engineering works.**
- **The reservoir (if any) submerges huge areas of land, uproots large number of population and creates social & other problems.**
- **Long transmission lines are required as the plants are located in hilly areas, which are quite far from load centers.**

  - **Some of the disadvantages of hydropower development are:**
    - It is capital intensive & therefore rate of return is low.
    - The development period is long. This period is low for thermal power plants.
    - Hydropower is dependent on natural flow of streams. Since this is very variable the dependable or firm power is considerably low compared to total capacity.

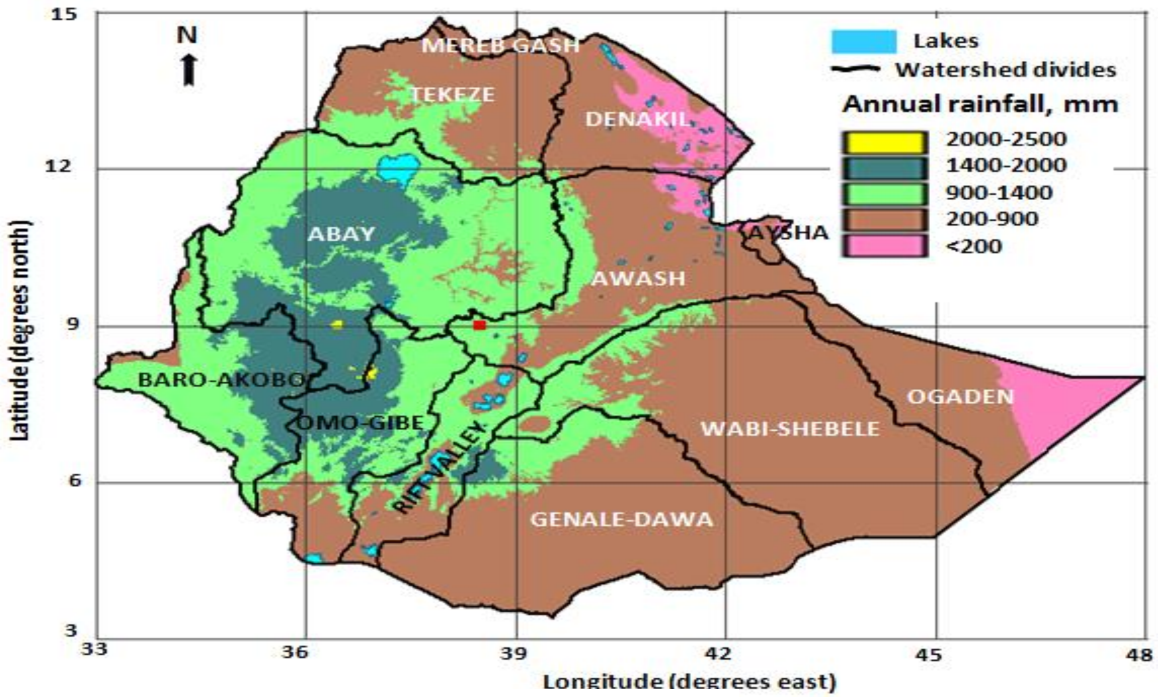
1.3 Hydropower in Ethiopia

Presently there are **two different** power supply systems,

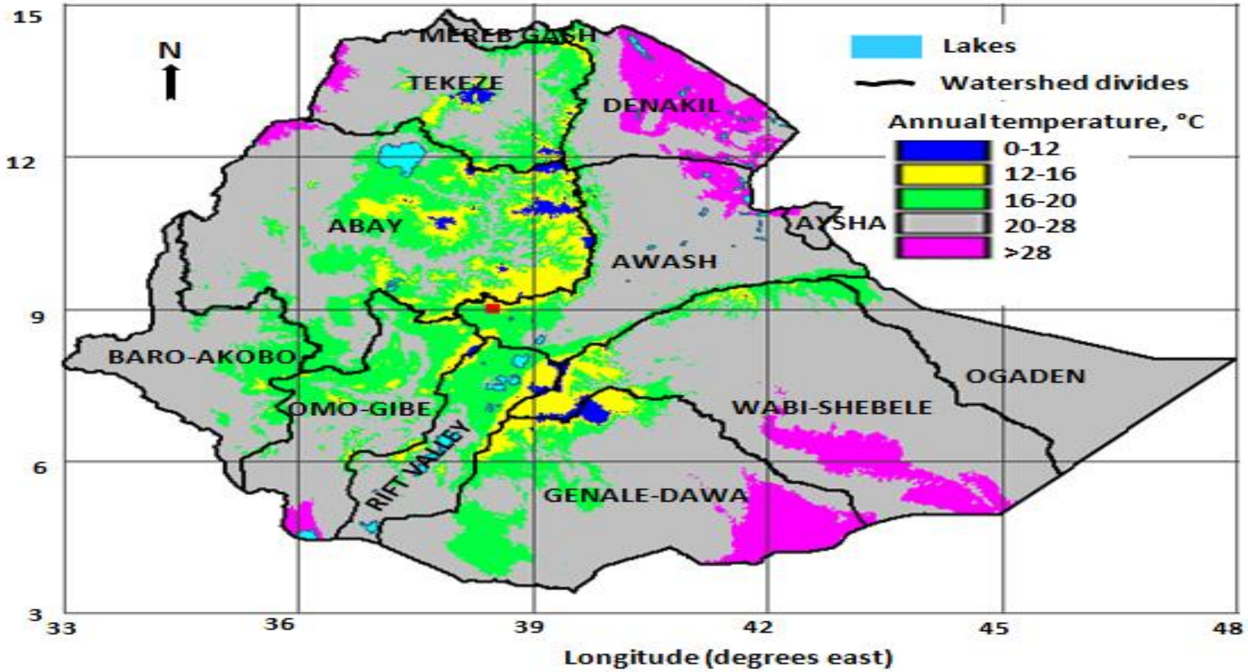
- The Interconnected System **(ICS),** which is mainly supplied from hydropower plants,
- The Self-Contained System **(SCS),** which consists of mini hydropower plants and a number of isolated diesel generating units that are widely spread over the country.
- The ICS has a total installed generation capacity of about **1,963 MW** (Table 1) and an average energy capability of about 9019.6 GWh/yr.
- The SCS has a total installed generation capacity of about 45.7 MW.
- Currently (as of 2010), the total installed capacity from both systems is **2008.7 MW**



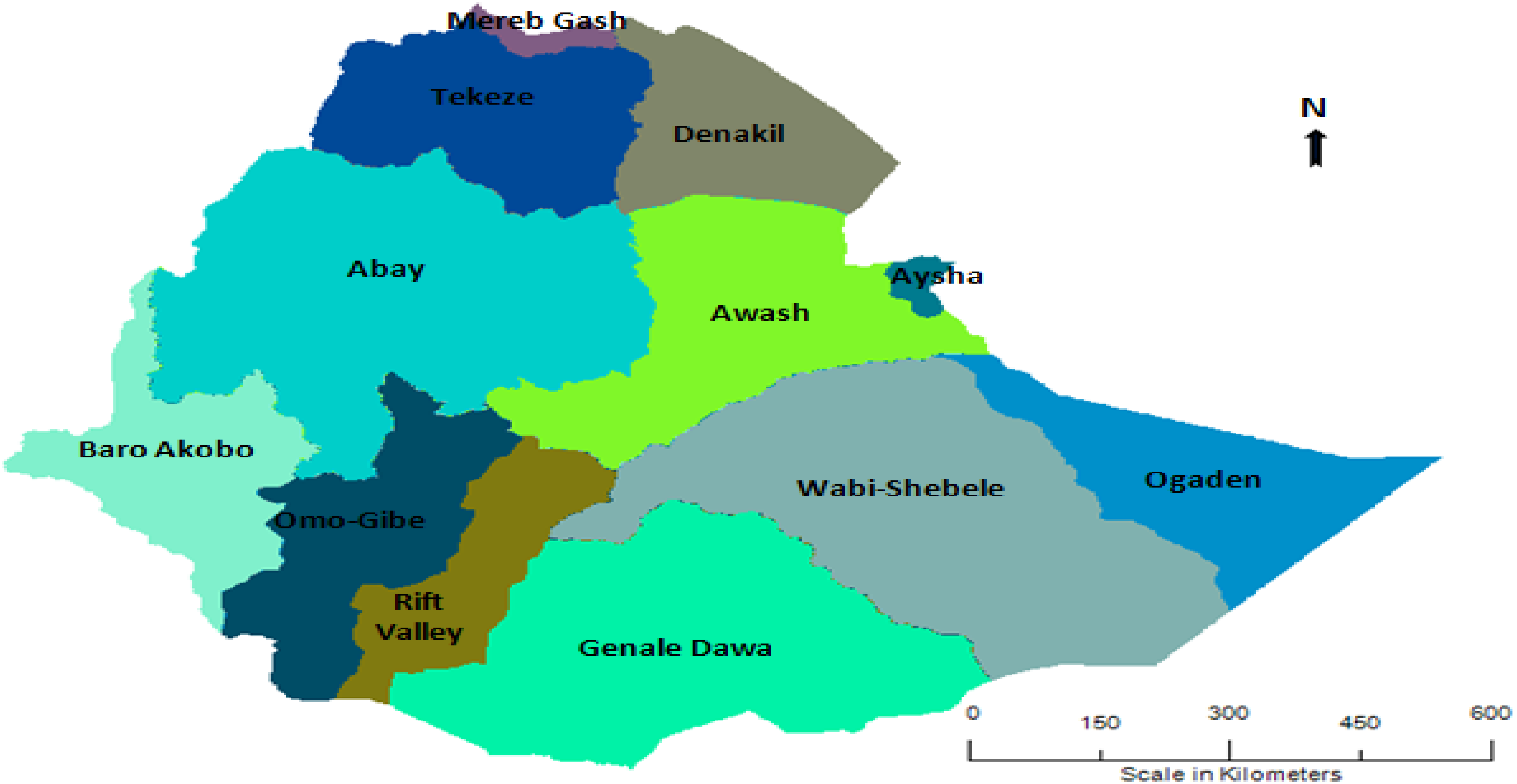
TOPOGRAPHY



RAINFALL



TEMPRATURE



RIVER BASINS OF ETHIOPIA

No.	Basin Name	Type	Source	Area (km^2)	Terminal	Water Resource Potential (Billion m^3)
1	Wabishebele	R	Bale Highland	202220	Indian Ocean	3.4
2	Abay	R	West, Southwest Highland	199912	Mediterranean Sea	54.4
3	Genale Dawa	R	Bale Highland	172259	Indian Ocean	6.0
4	Awash	R	North Wollo Highland	110000	Terminal Lakes (Internal)	4.9
5	Tekeze	R	North Wollo Highland	82350	Mediterranean Sea	8.2
6	Denakil	D	No flow	64380	Internal	0.86
7	Ogaden	D	Central, Western Highland	77120	Internal	0
8	Omo-Gibe	R	Western Highland	79000	Rudolph Lake (Internal)	16.6
9	Baro-Akobo	R	Western Highland	75912	Mediterranean Sea	23.23
10	Rift Valley Lakes	L	Arsi and Central Highland	52000	Chew Bahir	5.64
11	Mereb	R	Adigrat Highland	5900	Swamp in Sudan	0.72
12	Aysha	D	No flow	2223	Intenal	0

#	Generation plant	Installed capacity (MW)	Average energy production (GWh/yr)	In-service Year
1	Koka	43.2	131.12	1960
2	Awash II	32	161.68	1966
3	Awash III	32	174.81	1971
4	Finchaa	134	912.29	1973,2003
5	Melka Wakena	153	559.63	1988
6	Tis Abbay I	11.4	48	1964
7	Tis Abbay II	73	496.69	2001
8	Gilgel Gibe I	184	884.46	2004
9	Gilgel Gibe II	420	1886	2010
10	Tekeze	300	1069	2010
11	Beles	460	2050	2010
	ICS Hydro	**1,842.6**	**8,423.73**	

#	Generation plant	Installed capacity (MW)	Average energy production (GWh/yr)	In-service Year
12	ICS diesel - aggregate	113.1	582	Na
13	Aluto Langano geothermal	7.3	13.87	1999
	Total ICS	**1,963**	**9019.6**	
	Total SCS	**45.7**	**45**	
	Total: ICS & SCS	**2008.7**	**9,064.6**	

#	Name of the project	Capacity		Construction		Status
		MW	GWh	Launched	Completion	
1	Gibe III	1870	5300	2008	2014	Under construction
2	Fincha–Amerti Neshe	97	215	2008	2011	Under construction
3	Chemoga Yeda	278	1348	2011	2015	New
4	Geba	336	1787	2011	2015	New
5	Halele Werabesa	422	2030	2011	2015	New
6	Genale Dawa III	258	1600	2011	2015	New
7	Genale Dawa VI	256	1475	2011	2015	New
8	Millennium	5250	15177	2011	2015	Under construction
	Total	**8767**	**28932**			

Thank you!!