Department of Hydraulic and Water Resources Engineering

KOIT, Wollo University

Lecture Notes

Course Code: ***WRIE3154***
Course Title: ***Basics of Hydropower Engineering***
Target Group: ***G3_WRIE***
2020

Chapter 1: Reading and Summarizing Assignment

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Reading and Summary Assignment

Write a summery note about this lecture Note. Your assignment should be approximately 1-2 pages.

- The first page should summarize the lecture note.
- The second page should write what you understand of the lecture note (including chapter 1 and this reading lecture note) .

Successful assignments will be typed and double-spaced, with one-inch margins and 12 point font. The assignment will count toward your final “Section Assignments Grade”.

- ***Current and potential Sources of Energy from Ethiopian Context***
  - Most of the domestic energy needs in Ethiopia are met from renewable bio-fuels.
  - In 1994, the total amount of energy consumed in the country was 698.84 Terra Joules, out of which
    - 95.1 percent was covered by bio-fuels.
  - The share of energy generated from
    - Petroleum 4.3 percent
    - electricity was 0.60 percent
  - The total annual hydropower potential of Ethiopia is estimated at about 650 TW

- The deposits of natural gas and geothermal resources in Ethiopia are estimated
  - in the order of 30-50 billion m3 and
  - 700 MW respectively
- Alternative renewable energy resources:
    - Solar-about 2.3 TWH and
    - Wind-4.8 million terra calories
- Biomass potential: about 14 million terra calories
  - Out of this, the share of forest products, 79 percent
  - animal dung ,13 percent
  - crop residue is, 8 percent

- ***Energy resources utilization***
  - About 77% of energy needs of the country is met from fuel wood
  - Animal dung, crop residues, liquid petroleum gas (LPG), coal, petroleum and oil cover 7.7 percent, 8.7 percent, 0.06 percent, 1.55 percent, and 4.8 percent of the energy requirements of the country, respectively.
  - This shows that 95 percent of the energy consumed in the country originates from **BIOMASS** energy sources.
  - **Hydropower – 1%**

Table 1.1: Predicted Energy Demands by sources (2005 and 2010)

Energy Source	2005		2010		Annual Average Growth (%)
	Terra Joule	%	Terra Joule	%	
Bio-mass	862,552	**91.0**	974,464	**88.5**	**2.6**
Fuel wood	47,986		53,932		2.5
Coal	805		1,113		6.4
Crop residue	4,755		5,316		2.4
Dung	5,340		5,988		2.4
Petroleum	76,514	**8.1**	113,859	**10.3**	**8.7**
Electricity	9,132	**1.0**	13,365	**1.2**	**7.9**
Total	**948,198**	**100**	**1,101,688**	**100**	**3.0**

- ***Energy resources utilization and environmental problems***
- Although the country is known to have the potential to produce substantial amounts of energy from its various sources, currently most of the energy consumed comes from **biomass**. As a result:
  - The water holding capacity of catchments and reservoirs is decreasing
  - The heavy dependence on biomass resources reduced soil fertility
  - The biomass resources being depleted fast due to low income majority to use alternative energy sources

- Apart from the environmental problems mentioned above, there are other factors that **directly affect the energy resources** utilization in the country. These are:
  - Inefficient in **energy utilization** which results in a high degree of energy resources wastage in the country
  - Lack of **capacity** to effectively develop the country's energy resources such as hydropower, solar and other renewable energy sources
  - The fact that **climate change** is causing erratic rainfall, both in amount and distribution and consequent fluctuations in hydropower energy supply in the country

- ***Efforts made to tackle the problem associated with energy resources development and utilization***
  - A national energy policy has been issued
  - Even though insignificant compared to the vast potential, some attempts to utilize renewable energy resources have been made
  - Some steps to promote charcoal and other biomass energy efficient cooking stoves have been taken
  - An investment code that encourages the involvement of the private sector in energy generation has been prepared

- Survey, design and construction are being done to develop the country's huge hydropower potential
- There are ongoing initiatives in the agricultural sector designed to encourage the participation of rural communities in the development of forest for firewood
- In order to enhance energy development for rural areas, a Rural Energy Development Promotion Centre has been established as an independent entity by the Federal Government and by some Regional States, and
- A Rural Electrification Fund has been established

- Hydropower status in the World
  - Worldwide, only 15.2% of the technically possible hydroelectric energy was developed by 1990. The following table gives hydroelectric generation in 1990

Table 1.2: Hydroelectric Generation in 1990 (in TWh/year)

Continent	Technical Potential (1)	Generated in 1990 (2)	(2) as % of (1)
Africa	**1344**	**50**	**3.7**
Asia	**4212**	**387**	**9.2**
Australia/Oceania	203	**38**	**18.7**
Europe	836	**483**	**57.8**
North America	969	**573**	**59.1**
Latin America	**3486**	380	10.9
USSR	**2950**	223	7.6
World	14000	2134	15.2

Table 1.3: Hydropower Potential in GWh of Ethiopia by Basin and Generation Type

Basin	Generation Type			
	With flow Regulation	Small slope plants	River plain plants	Total
Awash	16,770	1,574	4,010	22,354
Tekezze	23,150	-	12,720	35,870
Blue Nile	221,930	8,197	51,017	281,144
Baro	58,700	2,553	18,050	79,303
Chamo	73,850	2,961	27,430	104,241
Bilate, segen and Dawa	47,050	1,910	-	48,960
Genale	31,500	2,641	11,360	45,501
Gistro	4,400	133	-	4,533
Wabi Shebelle	14,500	1,490	8,780	24,770
Total	**491,850**	**21,459**	**133,367**	**646,676**

Table 1.4: Total installed electricity generation capacity in 2005 (MW)

ICS (Inter Connected System)			SCS (Self Contained System)		
Hydro	662.6	95.5	Hydro	6.33	31
Diesel	22.5	3.4	Diesel	13.8	69
Geothermal	7.3	1.1	Geothermal	0	0
Total	692.4	100	Total	20.13	100

Table1.5: Electric power potential and actual production of the hydropower generation plants (MW)

Power Station	Production	Actual Production in Billion KW/h			
		1995/96	1996/97	1997/98	1998/99
Koka	43.20	84.80	129.30	59.30	120.10
Soar (SCS)	5.00	10.50	11.50	11.99	11.30
Awash2	32.00	106.60	159.10	97.80	114.80
Awash 3	32.00	106.80	183.50	113.40	175.50
Denbi (SCS)	0.80 ***(0.71)***	1.00	1.80	2.10	1.86
Fincha	134.00	771.10	624.40	843.30	671.50
Yadot (SCS)	0.35	0.84	0.88	0.79	0.95
Melka Wakena	153.00	381.60	436.30	438.90	510.10
Tis Abay1	11.40 ***(12.00)***	28.30	19.60	11.90	11.30
Tis Aby 2	73.00	-	-	-	-
Gilgel Gibe I Sire (SCS) Yaye (SCS)	184.00 0.0055 0.17	-	-	-	-
Total	668.93 ***(669.44)***	1,491.54	1,566.38	1,579.48	1,617.41

- Achievements
  - The ICS consists of **8 hydro, 10 diesel** and **one geothermal** power plants with total installed capacity of 662.6 MW, 22.2 MW and 7.3 MW respectively. However, due to aging of the plants the dependable total capacity is only 456.4 MW excluding the newly commissioned Gilgel Gibe hydroelectric power plant and the peak demand is 391.15? MW. Over 98% of the total generation in the country comes from the ICS and of the total (ICS and SCS) supply system 99% is from hydro.

Indicators	1956	1974	1984	1996	1999	2002
Installed Capacity (MW)						
ICS-Predominantly hydro	-	213.3	213.7	371	384	502
SCS-Predominantly diesel	9.7	35.6	35.6	38	41	20
Actual Generation (GWh)						
ICS	-	322	670	1495	1619	1976
SCS	33	61.5	83	53	32	33
Per capita Generation (ICS+SCS (KWh/head))	**1.6**	**11.6**	**17.7**	**26.3**	**26.7**	**31**
Per capita Consumption (ICS+SCS (KWh/head))	-	-	-	-	-	**25**
Part of the population which has access to electricity	-	-	-	-	-	**13.99%**

Table 1.7: Hydropower Plants under construction and committed

Station name	Installed Capacity (MW)	Number of Units	Dependable Capability (MW)	Scheduled Commissioning date
Under Construction				
Gilgel Gibe-II.III	420,870	3?6	425?	2007?
Tekeze Beles	300 460	3 ?	225 ?	2006 ?
Committed?? Suspended due to environmental Reason				
Gojeb Geba I & II	102 ?	2 ?	102 ?	? ?

In the last 60 years, local capacity has been built in some major areas of hydropower development. Full self-reliance has been developed in:

- Reconnaissance level studies of small to large hydropower development projects
- Operation of all sizes of hydropower plants and transmission lines
- Study, design and construction of transmission and distribution lines of 0.4 kv – 1 32kv

DEVELOPMENT OF HYDROPOWER

2.1 Hydropower Status in the world

- The status of hydropower with respect to the total power generation varies considerably from country to country. Developing countries need affordable energy to:
- increase agricultural productivity;
- deliver basic educational and medical services;
- establish adequate water supply and sanitation facilities, and
- build and power new job-creating industries
- Worldwide, only 15.2% of the technically possible hydroelectric energy was developed by 1990. The following table gives hydroelectric generation in 1990.

2.1 Hydropower Status in the world

Continent	Available Technical Potential (Twh/year)	Exploited until 1990	Utilization percentage
Africa	**1344**	**50**	**3.7**
Asia	**4212**	**387**	**9.2**
Australia/Oceania	**203**	**38**	**18.7**
Europe	**836**	**483**	**57.8**
North America	**969**	**573**	**59.1**
Latin America	**3486**	**380**	**10.9**
USSR	**2950**	**223**	**7.6**
World	**14000**	**2134**	**15.2**

2.1 Hydropower Status in the world

Country	Installed capacity of Hydro (MW)	percentage of Hydro in the power system (%)
USA	90000	16
USSR	73000	19
Canada	59000	66
Brazil	57000	-
Japan	26000	27
Noraway	25000	99.9
India	23000	34
France	21000	38
Italy	20000	—
Sewden	15000	—
Spian	15000	—
Switzerland	12000	—
Australia	7000	—
Ethiopia	200	90

Estimated 80's

Annual per capital consumption of electrical energy for various counstries.

(Estimate made in the 80's)

Country	per capital Consumption (KWH)	country	per capital consumption (kWh)
Norway	21,500	UK	5,400
Canada	16,900	France	4,500
Saweden	16,000	Italy	3, 700
USA	10,900	China	425
Germany	6.800	India	175
USSR	5,600	LDCS	100
Japan	5,500	Ethiopa	20

2.1 Hydropower Status in Ethiopia

Although there is no recorded history, the use of waterpower in Ethiopia in its non-electric form is estimated to exist since long period of time. It has been used in the water mills, and such practice is still under use in some rural areas of the country. The water power use in its more effective form, i.e. electricity generation, came to existence in the beginning of 1930's, when Abasamuel hydropower scheme is commissioned in 1932. This station was capable of generating 6MW and operational up to 1970. In Ethiopia, by 1990, about 94% of the energy requirement satisfied through the traditional energy sources, and the remaining 6% through modern sources such as fuel oil, gas and electricity.

Cont'd

- According to Ministry of Mines and Energy, in 1990 the energy total requirement in Ethiopia was estimated at 177.6 TWh per year of which 76.1% from wood, 16.1% agricultural by-product, 5.3% from fuel oil and 1.1% from electricity, 0.8% from charcoal and 0.6% through others. The energy is used in the sectors of domestic in the town and rural areas, industry, service, agriculture and transport.

- Ethiopia is naturally endowed with quite a substantial amount of water resource potential, even though its distribution and occurrence through time & space is erratic .Despite its abound ant water resources, the section .In particular the exploitation of the hydropower potential was not noticeably successful inspire of being give priority as a major filed of nation development.
- The hydropower potential of Ethiopia is very considerable such an abundant potential is attributed to the high rainfall regimes & steep slopes of the meters natural landscape. Most of the rivers generally drop hundreds of meters in relative short distances, especially at plateau escarpments, making them attractive to hydropower development Estimated energy potential of the country is about 160,000GWH per year Nevertheless, this resource is distributed unevenly with about 85%of the total covered by the Blue Nile, Ome-Gibe & Baro basins

Hydropower Potential of Ethiopia

River basin	Estimated potential (GWh / year)	share of the total (%)
Awash	4,500	2.8
Baro-Akobo	19,000	12.0
Blue-Nile	79,000	49.5
Generale-Dawa	9,500	6.0
Omo-Gibe	35,000	22.0
Riftvally lakes	1,000	0.6
Tekeze	6,000	3.8
Wabi-shebele	5,500	3.4
Total	159,000	100

The Ethiopian electric supply system is characterized by two distinct divisions: Inter connected system (ICS) and a number of self contained system (SCS). The ICS receives most if its energy from relatively large hydrogenating stations and supplies the almost 80% of the total energy produced in the country and supplies the main demand centers

Existing Hydropower Plant

Plant	Type	system Catagagory	installed capacity, (Mw)	Film energy production (Gwh/year.	year of Commission.
KoKa	storage.....	.....ICS	43.2	80	1960
Tis- Abay I	RoR	.....ICS	11.5	55	1964
Awash II	RoR	.....ICS	32	135	1966
Awash III	RoR	.....ICS	32	135	1971
Fincha	stprage	.....ICs	100	618	1973
Melka-Wakena..	stprage	.....ICS	153	560	1988
Yadot	ROR	.....SCS	0.35	1.2	1991
Sor	ROR	.....SCS	5.0	47	1992
Demi	ROR	.....SCS	0.8	2.8	1994
Tis-Abay II	RoR	.....ICS	73	331	2000
Gilgel Gibe					
			---	---	
			440.85	1965	