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Ethiopia: An Emerging Renewable Energy Power Hub of Africa

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ABSTRACT

This study examines the emergence of Ethiopia as a renewable energy power hub in Africa by analyzing trends, patterns, changes, and continuities in the development of hydropower. Methodologically, the study used a qualitative research approach supported by a historical and geopolitical lens. The data used in this study was collected from 50 key informants from government institutions, regional organizations, academic institutions, research institutes, power sector advisors, and independent consultants. The study identifies three interrelated and mutually reinforcing factors that contribute to the repositioning of Ethiopia as an emerging renewable energy power hub of Africa. The vast renewable energy potential, water-based development attempts across successive regimes, and the booming of hydropower have transformed hydropower potential into 'real power' since 2000. The strategic location of the country specifically its hydrological, geological, and topographical characteristics have enabled the country to become a powerhouse and battery of the Horn of Africa. Additionally, the massive post-2000 hydropower development has simultaneously made the country heavily dependent on its hydropower as it generates more than 90 percent of the electricity from water. The study identified four patterns from hydropower development: the entanglement of domestic and international politics as the underlying factor for the country's hydropower development, the strong correlation between political stability and hydropower development, the role of hydropower in foreign policy orientation and power balance, and the state-led nature of hydropower development. The study also find outs common barriers to hydropower development across the hydropower epochs, including the transboundary nature of the rivers, geopolitical factors, lack of finance, climate change, and political instability. Overall, the study reveals how Ethiopia's unique position combines abundant hydropower resources, development ambition, and strategic planning, allowing the country to become a major player and actor in the emerging world order that heavily relies upon renewable and green energy resources.

Keywords: Ethiopia, hydropower, renewable energy, hydropower potential

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INTRODUCTION

Ethiopia has the largest hydropower potential (45,000 MW) in Africa, which is the second largest next to the Democratic Republic of Congo (Ethiopian Electric Power Corporation [EEPCo], 2014; International Hydropower Association [IHA], 2018; Ashebir, 2022; Dereje *et al.*, 2011). In addition, the country has unique geographical, topographical, geological, and climatic features that are ideal for exploiting its hydropower potential. However, the development of hydropower since1912 has undergone a slow process until it boomed with the turn of the millennium.

Before 1991, the total installed capacity was 370 MW (EEP, 2017:3). Hydropower projects constructed during this period included Aba Samuel, Koka, Ourso, Tis Abbay, Awash I and II, Fincha and Melka Wakena. In the post-1991 period, however, hydropower entered its booming period owing to the construction of large-scale hydropower projects such as Tekeze, Gilgel Gibe I, Gibe II, Gibe III, Beles, Amerti Neshi, Genale Dawa III, GERD and Koyisha. With this hydropower development, the total installed capacity of the country was raised from around 370 MW in 1991 to 5, 256.5 MW in 2023 (Ethiopia Electric Power [EEP], 2023:11). Of the installed capacity, 4,820.2 MW came from hydropower sources (EEP, 2023:11), which accounted for over 90% of the total electricity produced in the country. This suggested that Ethiopia heavily depended on hydropower. Additionally, with the massive hydropower development over the past two decades, hydropower has become an exportable commodity to Djibouti, Sudan, and Kenya.

Despite such changes, the pace of hydropower development has been a slow process except over the past two decades. In addition, compared to the country's hydropower potential, hydropower development is at its initial stage. Only 4,820 MW is harnessed from 45,000 MW potential. However, the existing literature fails to suggest the megatrends of hydropower development in Ethiopia across periods using a historical and geopolitical lens. Rather, the focus of existing literature is largely limited to the hydropower potential of the country without showing its strategic implications in geopolitical terms (Solomon, 1998; Ashebir and Desta, 2020; Dagmawi *et al.*, 2015; Dessalegn, 2018). Others also studied the hydropower potential and its development in specific river basins (Dereje *et al.*, 2011; Ashebir, 2020), climate change aspect of hydropower development (Block and Kenneth, 2012) and different aspects of specific hydropower projects (Abebe, 2000; Eldardiry and Faisal, 2021; Annys *et al.*, 2020; Annys *et al.*, 2018; Beirne, 2014).

Furthermore, the existing literature has overlooked the implications of the country's hydropower potential to its development and benefits to the region at large specifically from a geopolitical point of view. This study therefore intends to examine how hydropower development is repositioning Ethiopia as a regional anchor state by exploring the strategic importance of its hydropower potential as well as the historical evolution of hydropower development, including the mega trends, changes, and continuities. The research also tried to meet the following objectives:

- To assess the hydropower potential of Ethiopia by mapping its key features.
- To analyze the historical evolution of hydropower development in Ethiopia, identifying the major trends, patterns, changes, and continuities.
- To examine the massive expansion of hydropower development that occurred in the post-1991 period.
- To show the strategic importance and implications of Ethiopia's hydropower potential and its development.

RESEARCH METHOD

The study employs a qualitative research approach specifically a historical and geopolitical perspective to analyze Ethiopia's emergence as a renewable energy power hub. Data was gathered through key informant interviews with 50 purposively selected individuals from the Ministry of Water and Energy, the Ministry of Foreign Affairs, Ethiopian Electric Power, Ethiopia Electric Utility, the Eastern Nile Technical Regional Office, the Environment Protection Authority, the Ministry of Agriculture, Ministry of Irrigation and Lowland, Ministry of Finance, Project Offices, universities, and research institutes. The names of the key informants were coded to maintain confidentiality and anonymity. Documents such as river basin studies, policies, strategies, programs, project feasibility studies, and environmental and social impact assessments were consulted. Pertinent secondary sources were also used. The data were analyzed using thematic analysis.

Hydropower: Ethiopia's White Oil

Ethiopia has abundant renewable energy sources such as hydro, wind, geothermal, solar, and biomass. The availability of these diverse renewable energy sources is largely attributed to the strategic location of the country, including its diverse and complex geographical, topography, and climatic features. According to different sources, economically feasible hydropower potential ranges from 15, 000 to 30,000 MW (Ethiopian Panel on Climate Change, 2015: 26; Solomon, 1998; KII-35, April 2022). Hence, hydropower is often described as Ethiopia's "blue gold" (Verhoeven, 2011) and "white oil" (Addisu, 2021) that could position it to become a clean energy "powerhouse of Africa" (Ashebir *et al.*, 2020:4).

In addition to its hydropower potential, as presented in Table 1, the country possesses untapped reserves of natural gas (113 billion m^3), solar, wind, geothermal (7,000 MW), coal (300 million tons), oil shale (253 million tons), and agricultural waste. Particularly, the untapped renewable energy potential in the country is a valuable resource that has the potential to enhance its geopolitical position in the global transition towards a renewable-based energy system. However, as depicted in Table 1, the country faces various challenges such as technological, financial, technical, and geopolitical barriers (KII-2, April 2023; KII-35, April 2022), which have hindered the full utilization of these resources.

Table 1: Energy Potential of Ethiopia

Sources		**Unit**	**Exploitable reserve**	**Exploited %**
Hydropower		MW	45,000	< 11
Solar/day		kWh/m^2	Avg. 5.5	< 1
Wind	power	GW	1,350	
	speed	m/s	> 6.5	
Geothermal		MW	7,000	< 1
Wood		Million tones	1,120	50
Agricultural waste		Million tones	15-20	30
Natural gas		Billion m^3	113	0
Coal		Million tons	300	0
Oil shale		Million tons	253	0

Source: Adapted from EEPC, 2014; FDRE, 2019; Gordon, 2018; KI-43, 20 November 2023

Concerning hydropower, Ethiopia has not only abundant hydropower potential but also suitable sites for generating electricity from hydropower sources. The country's diverse and complex geographical, geological, hydrological, and topographical features contribute to the availability of ideal sites for harnessing hydropower. First, in terms of hydrology, Ethiopia has eight river basins such as Abbay, Baro-Akobo, Tekezze, Awash, Omo-Gibe, Genale-Dawa, Mereb, and Wabishebelle. It has also one lake basin (Rift Valley Lakes), and three dry basins (Aysha, Dinakle, and Ogaden) (KII-1, June 2023). These river basins have an estimated surface runoff water of nearly 122 billion cubic meters every year, which is ideal for hydropower generation (Ministry of Water Resources, 2002:2). However, only eight of these river basins have been recognized to have hydropower potential, as shown in Table-2.

Solomon (1998) identified 300 potential hydropower sites with an estimated exploitable potential of 158,700 gigawatt hours per year (GWh/yr) from the various river basin master plans in eight river basins. However, a report by UNIDO and ICSHP (2013:16) suggests that there are over 600 potential sites for hydropower generation in the country, indicating a lack of accurate information about the exact number of suitable locations for this type of energy production in the country. The 1990s national water resources development master plan of the People's Democratic Republic of Ethiopia (PDRE) government, prepared by the Indian Water and Power Consultancy Service, identified 314 hydropower sites across ten river basins, including the Mereb-Gash and Barka-Anseba rivers. Besides, the hydropower potential from small streams, which are relatively small and dispersed, do not require reservoirs (Getahun, 1993 E.C.:286), is also estimated to be 173 hydropower sites (Solomon, 1998).

Second, Ethiopia also has topographical (Meles, 2011) and geological advantages for harnessing water power for development purposes. Though the country's mountainous terrain, steep slopes, and deep gorges may pose challenges for irrigation (Alem-meta *et al.*, 2019: 49), they are highly suitable for various types of hydropower generation such as run-of-river, storage, high head, medium, and low head power plants. Noting the topographical suitability for hydropower, a senior diplomat and energy expert expressed as follows:

> Ethiopian rivers originate in high mountains and flow rapidly downhill towards lower elevations. These rivers flow through steep slopes and gorges, which make them attractive for hydropower generation. Except for the Genale Dawa and

> Wabishebele, there are no rivers that flow directly on the flat plains (KII-21, April 2022).

The mountains' headwaters, numerous waterfalls, and the flow of water through steep slopes provide ideal sites for harnessing the natural flow of rivers and streams to generate electricity from falling water without requiring large reservoirs. For instance, the Tis Abay I Hydroelectric Plant which started to operate in 1964 with an installed capacity of 11.4 MW used the naturally created Tis Abbay Fall (Abebe, 2000).

Table 2: Hydropower Potential of Ethiopian River Basins

River Basin	Number of Potential Sites				Hydropower Potential (GWh/year)	Percentage Share of the Total (%)
	Small scale <40 MW	**Medium scale 40-60 MW**	**Large scale <60 MW**	**Total**		
Abbay	74	11	44	129	78,800	48.9
Awash	33	2	--	35	4,500	2.8
Baro-Akobo	17	3	21	41	18,900	11.7
Genale-Dawa	18	4	9	31	9,300	5.8
Omo-Gibe	4	--	16	20	35,000	22.7
Rift Valley Lakes	7	--	1	8	800	0.5
Tekezze-Angereb	11	1	8	20	6,000	4.2
Wabishebelle	9	4	3	16	5,400	3.4
Total	173	25	102*	300	158,700*	100

Source: Solomon, 1998

Furthermore, the rugged terrain and rocks make the country well-suited for storage hydropower because the reservoir has to be built on a suitable reservoir rock type that can store water and has less vulnerability to geological hazards and problems like earthquakes, and leakage (Knowles, 2014:29). The headwaters of the mountains, numerous waterfalls, and the flow of water through steep slopes provide ideal sites for harnessing the natural flow of rivers and streams to generate electricity from falling water without requiring large reservoirs. Particularly the topography, hydrological and geological features of the Abbay and Omo-Gibe rivers provide ideal sites for generating electricity from water power. The Abbay River was appraised as one of the "ideal sites for economic hydropower development" in the national water resources master plan owing to the availability of good reservoirs "on the upper plateau at the head of steep incised ravines" (PDRE, 1989:32). The Ethiopian Electric Light and Power Authority (1997) concluded in its environmental impact assessment report that the Gilgel Gibe Project is "one of the most attractive" hydropower development sites in the country because of its topographical and geological features. Gilgel Gibe III is one of the hydropower projects that take advantage of the country's topography and geography. The dam is located in a deep gorge with sub-vertical walls, making it one of the tallest dams in Africa[1].

However, hydropower should not be taken as a mere resource but rather as one that defines and shapes Ethiopia's geopolitical opportunity and limits. In other words, geopolitics refers to how geographical features _water resources and their developments_ determine the fate of a country (Owens, 2015: 2)

Therefore, water resources and hydropower potential of the country are important elements of its national and regional power matrix. Meaning, natural resources and geographical features such as topography and climate are among the natural determinants of national power (Strategic Studies Institute, 2008: 148). Noting this, a diplomat in the Ministry of Foreign Affairs asserts that Ethiopia has a natural leverage over its water resources, particularly in hydropower, owing to its geographical location (KII-13, June 2021). Besides, Ethiopia has more advantage in producing electricity from hydropower resources than other energy sources at lower prices because of its hydrological, topographical, and geological advantages (KII-38, April 2022).

It also has a comparative advantage at the regional level to produce power from hydropower sources at lower costs (KII-24, May 2022; KII-2, 5 January 2023). The generation cost for 1 kWh from hydro in Ethiopia is $0.09 (ESI-Africa, 2021) on average, whereas the same amount of energy from non-hydropower sources is produced at $0.32 and $0.70 in Djibouti (Guelleh *et al*, 2023:215) and South Sudan (ICED, 2018:2), respectively. Djibouti relies heavily on imported oil for electricity generation (World Bank, 2009:1; Guelleh *et al*, 2023:215). South Sudan relies on fossil fuels, particularly diesel generators, for electricity generations (Africa Development

[1] Gibe III Hydroelectric Power Project Environmental and Social Impact Assessment. Accessed January 2022 from https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and Operations/Gibe%20III_EIA_%20Executive%20Summary%20EBJK%2006-08-08.pdf

Bank Group, 2013:209; U.S. Energy Information Administration, 2022: 8). Half of the installed capacity of electricity generation in Sudan also comes from fossil fuels (U.S. Energy Information Administration, 2022: 8). The dependence of these countries on expensive diesel generators contributes to higher costs and carbon emissions in contrast to Ethiopia. Nevertheless, Ethiopia is more advantageous in attracting investment and entering regional power markets with its low-cost hydropower. In addition to the cost competitiveness, the renewability and reliability of hydro further increases its competitive advantage. As a result, hydropower is a reliable power source to provide electricity on demand (KII-21, April 2022). It is also a clean and green energy with 'no' carbon emissions (KII-38, 21 April 2022; KII-10, 15 July 2023; KII-38, 21 April 2022). Realizing the benefits, Djibouti is now replacing diesel with hydroelectricity imported from Ethiopia, which constitutes 80 to 100% of Djibouti's total electricity (KII-1, July 2023). Ethiopia also exports electricity generated from hydro to Sudan and Kenya serving as a water tower and powerhouse of Northeast Africa. Thus, water and hydropower are strategic resources for the country, linked with national power.

On the other hand, hydropower endowment can also be a geopolitical curse. The transboundary nature of river basins where hydropower resources are found can generate geopolitical tensions with other water users, particularly downstream countries. Except the Awash River, all other river basins flow into neighboring countries. This implies that Ethiopia's geographical location as a "water tower" of the region may be seen as a source of power. However, downstream countries may see Ethiopia as a perceived threat because of the downstream impacts of its water resources development_ hydropower. The Abbay River, which accounts for nearly 49% of the hydro potential of the country (Assefa *et al.*, 2014:111; Casimir, 2005: 7), is a good example of this[2]. Owing to its downstream position, Egypt historically views Ethiopia's water resource plans and

[2] Different studies have reported varying estimates of the hydropower potential share of the Abbay River basin. According to the Ministry of Water, Irrigation and Energy, the hydro potential of Abbay River is estimated to be 13,500 MW, which represents 33.7 percent of the total energy potential of the country. In contrast, the Nile basin capacity building Network's hydropower development research cluster has estimated the hydropower potential of Abbay to be 79,000 GWh/yr, covering 49 percent of the country's total hydropower potential. For more see Casimir, Museruka, Sibilike K. Makhanu, D. Mahauri, D.J. Chambega, C.F. Mhilu, F. Matalo, Ntungumburanye Gerard, Kizza Michael, Keneth Muniina, Zelalem Hailu, David Negula, James L. Ngeleja, I.S.N. Mkilaha, Leonard Kassana, Leonard R. Masanja, and Bela petry (2005). Nile basin capacity building Network hydropower development research cluster: Group 1 Small Scale Hydropower for Rural Development; Ministry of Water, Irrigation and Energy (2013). Water Resources of Ethiopia: The National and International Perspectives [Paper Presentation]. Awareness Creation Program Prepared for Public Relation Officials, August 2013, Addis Ababa, Ethiopia

developments on the Abbay River as "an existential threat", which is neither an actual nor a perceived security threat but rather securitization by imagination. Egypt's fear and anxiety, which emanates from its downstream geographical feature, has been an obstacle to Ethiopia’s monetary demands from international financial institutions and donors who are reluctant to provide loans to such contested projects (KII-25 July 2023; KII-27 May 2022). This has rendered Egypt a "veto power" status over external loans for Ethiopia's water projects (KII-13, June 2021). Furthermore, the Abay River along with the Red Sea are the two water systems that make Ethiopia and Egypt adversarial/rival powers of the Northeast Africa geopolitical region (KII-13, June 2021). Hence, the geopolitical adversarial stand of the rivals may continue, Ethiopia being the source of the water and Egypt the furthest riparian. This implies that the strategic location of Ethiopia as a water source and hydropower hub of the region is both an opportunity and a limitation.

Moreover, the country’s vulnerability to climate change such as droughts and El Nino could affect the electricity generation capacity of its hydropower plants. For instance, in 2002/3, frequent power disruptions were caused by drought-induced water shortages that affected the power generation capacity of the existing hydropower plants (WB, 2006: xiv). It was estimated that each day of power interruption resulted in a loss of 10-15% of that particular day's Gross Domestic Product (GDP) (WB, 2006: xiv). Similarly, power interruptions in 2009 forced the government to install 60 MW of diesel in Adama, which was observed by the former Ethiopia Electric Utility (EEU) leadership as a costly source of energy (KII-1, July 2023). Thus, the country's hydro dependency and vulnerability to climate change presents a significant challenge that arises from its geographical features. Therefore, it is essential to understand that hydropower development in Ethiopia could have both geopolitical limitations and opportunities. It is a geopolitical opportunity since Ethiopia has geopolitical leverage over hydropower generation, with the potential to become a regional renewable energy power hub. However, certain factors such as the transboundary nature of the rivers and the geopolitical impact of the country's hydropower development may ignite geopolitical tensions with downstream countries, notably Egypt.

Harnessing Water Power for Development

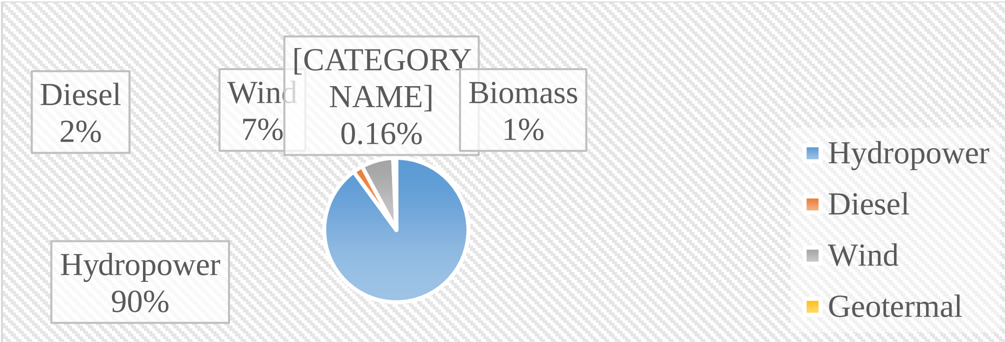
Hydropower is a strategic resource for Ethiopia as it has the potential to boost economic growth and bring about structural transformation. At the same time, hydropower can be an important source of foreign currency through power export to neighboring countries. As stated in the various policy documents of the FDRE government, the generation of electricity from hydropower is a key means to realize the national objectives ranging from poverty reduction to building of climate-resilient green economy, and ultimately becoming a clean energy hub. However, investment in the hydropower sector, which dates back to the early 20th century, was slow until the early 2000s, when it entered a booming period that coincided with the global hydropower re-booming period in developing countries of the global south.

Hence, over the preceding two decades, the country has made significant steps in hydropower generation, transmission infrastructure, and access to electricity. Though the national energy demand is not yet met, the progress in hydropower generation has increased by more than tenfold (KII-1, July 2023; KII-27, May 2022). In 1991, the country installed capacity of 370 MW (EEP, 2017:3), but by 2023 this figure rose to 5,256.5 MW (EEP, 2023:11). 4, 820.2 MW of the installed capacity is from hydropower sources (EEP, 2023:11). Hence, as shown in figure-3, hydropower accounts for over 90 percent of the total energy produced in the country, making Ethiopia hydropower dependent country (Amsalu, 2022:1). The country has also seen significant changes in its transmission lines and substations, with high electric transmission lines increasing from 5,000 km to 20,634 km over the past three decades (KI-53, November 2023). Moreover, more than 192 substations with varying voltage levels ranging from 132kv to 500kv have been constructed (KI-53, November 2023). These developments have led to increased access to electricity, which has risen to 56% (EEP, 2017:3). However, the number is a contested one and varies across different sources. According to the revised National Electrification Program, access to electricity is 44 percent (FDRE, 2019: xiii). In addition to this, a senior energy expert pointed out that per capital electricity consumption in Ethiopia is one of the lowest in the world which is 130kwh, and according to him access to electricity in the country is 51 percent (KII-1, July 2023). Both the key informant and the updated version of the electrification program confirmed that nearly 57 million people do not have access to electricity (FDRE, 2019: xiii; KII-1, July 2023). However, per capita electricity consumption has increased from 100 kWh in 2017 to 130kWh in 2019 (Ashebir and Desta, 2020:5). The country also exports power to Sudan, Djibouti, and Kenya.

These changes are largely owing to changes in the policy and ideological orientations of the post-1991 regime. Among the notable policies, strategies, and programs that encouraged the production of electricity from hydropower included the Climate Resilient Green Economy strategy, Growth and Transformation Plans, National Electrification Program, Power Purchase Agreement, and Digital Ethiopia 2025 strategy. Despite significant progress in hydroelectric power generation, Ethiopia's per capita electricity consumption was the lowest in the world. The challenges included limited access, high costs for construction and new connections, and drought disruptions in hydropower generation.

Institutionally, the two state-dominated enterprises, Ethiopia Electric Power and Ethiopian Electric Utility, are mandated for the power generation and transmission, and power distribution respectively. Other stakeholders included the Ministry of Water and Energy responsible for managing water resources of the country at the national level. With this, the country has two power supply system namely: an interconnected system (ICS) and a Self-contained system (SCS). The ICS is managed by Ethiopia Electric Power. As shown in Table-3, the ICS is mainly supplied by 16 hydropower plants, but also has 4 wind, 1 geothermal and 1 biomass power plants (EEP, 2021:4). There are also 6 diesel power plants. Currently, ICS installed generation capacity amounted to 5,256.5 MW (EEP, 2023:11). Whereas, the SCS is supplied by mini hydropower, thermal plants and isolated diesels.

Figure 1: Power Generation Capacity by Energy



Source: Adapted from EEP, 2021

Moreover, hydropower plants in Ethiopia are classified by their capacity, ranging from large (>30 MW) to pico (≤10 kW) (Meder, 2011:9). Medium power plants have a capacity ranging from 10 to 30 MW whereas small and mini power plants have a capacity ranging from 1 to 10 MW, 501 to 1,000 kW respectively. Micropower plants have a capacity ranging from 11 to 500 kW. However, the classification of hydropower in terms of installed capacity varies from institution to institution. For instance, in the Water Sector Development Program of the Ministry of Water Resources, small-scale hydropower schemes are classified as micro (< 100 kW), mini (100–1,000 kW), and small (1–10MW) schemes (Ministry of Water Resources, 2002: 19). The absence of a nationally defined classification of hydropower according to this size may be explained by the lack of inter-agency coordination study and planning of hydropower development between the stakeholders notably the Ministry of Water and Energy, and Ethiopian Electric Power. According to an informant in the Ministry of Water and Energy, Ethiopia has no clear classification of hydropower in terms of their installed capacity except that in ICS and SCS (KII-27, May 2022). However, another informant disclosed that the classification is done in view of pico, micro, mini, medium, and large scale (KI-43, 20 November 2023).

As clearly shown in the preceding session, the post 2000 period is a hydraulic era that repositioned Ethiopia as an emerging regional renewable energy power hub with a focus on hydropower. However, the development of water power for electrifying Ethiopia and the region has undergone several distinct stages. These can be categorized into two periods: early rapid development (1912-2000) and the hydraulic era (post 2000). Early rapid development can be further divided into three periods: early development (1912-1960), hydropower era (1960-1974) and stagnation (1974-2000). Given this, the following section briefly explores the evolution of hydropower development in Ethiopia and the drastic shift in the pace of hydropower investment since 1991.

Table 3: Interconnected System Installed Capacity by Energy Source Type in MW in 2023

No.	**Power Plant**	**Installed Capacity (MW)**					
		Hydro	**Geothermal**	**Biomass**	**Wind**	**Total**	**Operation Year**
1	Koka	43.2	-		-	43.2	1960
2	Awash II	32	-		-	32	1966
3	Awash III	32	-		-	32	1971
4	Finchaa	134	-		-	134	1973/2003
5	Meleka Wakena	153	-		-	153	1988
6	Tis Aby I	11.4	-		-	11.4	1964
7	Tis Abay II	73	-		-	72	2001
8	Gilgel Gibe I	184	-		-	184	2004
9	Aluto Langano	-	7.5*		-	7.5*	1999
10	Tekeze	300	-		-	300	2009
11	Gilgel Gibe II	420	-		-	420	2010
12	Beles	460	-		-	460	2010
13	Amerti Neshi	97	-		-	97	2011
14	Gilgel Gibe III	1,870	-		-	1870	2015
15	Abasamuel	6.6	-		-	6.6	2016
16	Adama I	-	-		51	51	2012
17	Ashegoda	-	-		120	120	2012
18	Adama II	-	-		153	153	2014
19	Rappie Waste			25		25	2019
20	Genale Dawa	254				254	2020
21	GERD	750				750	2022
22	Ayisha wind				80	80	2022
Total		4,820.20	7.5		404	5,255.70	

Source: Filed Data and EEP: 2018 and 2023

*EEP Fact sheet of 2023; the installed capacity declined to 7.3

Early Rapid Development (1912-2000)

The harnessing of water power for energy generation in Ethiopia began in the early 20th century as part of the country's modernization and industrialization drive under the imperial regime. However, it is important to note that electricity was first introduced in 1898 during the reign of Emperor Menelik II and was supplied by diesel generators, though its service was limited (Ministry of Water, Irrigation and Energy, 2006: 43; Yirgu, 2017:4; Ethiopian Electric Utility, 2022). Electricity generated from hydropower sources was also introduced in 1912 with the construction of a power plant on the Akaka River (Carr, 2017; 23; Yirgu, 2017:4; Getahun, 1993:290; Ministry of Water, Irrigation and Energy, 2006: 43), while others differ in their public knowledge of the plant's history referring to the operation of Aba Samuel Dam with an installed capacity of 6.6 MW in 1941 (EEP, 2018:18).

Emperor Haile Selassie I, following his coronation in 1930, continued in harnessing water power for electrifying and powering Ethiopia, and in 1932, revitalization and redevelopment of the Akaki River were initiated (Carr, 2017; 23). Regrettably, these plans were interrupted by the Italian invasion and subsequent occupation. The Italians expanded the power supply through diesel generators and began the construction of Aba Samuel Hydroelectric Power Plant. During this period, the Italian company Coneil ran the generation, distribution, and sale of electricity having taken over the electric power-related property of the Ethiopian government (Getahun, 1993:290; Yirgu, 2017:4).

The Aba Samuel Hydroelectric Power Plant, commissioned in 1941 with an installed capacity of 6.6 MW, served the post-liberation modernization and industrialization drive of the imperial regime. It supplied electricity to the capital city but was out of service from 1974 to 2016 due to 'reservoir problems and defect" (PDRE, 1989:2), and high silt accumulation from the Akaki River[3]. The plant has since been revitalized through a rehabilitation project funded by the Ethiopian and Chinese governments, with Power China Huadong Engineering Corporation handling the rehabilitation. The revitalized power plant, which was completed in

[3] Clean Rivers Trust. Aba Samuel Reservior. Accessed January 2022 from https://www.cleanriverstrust.co.uk/aba-samuel-reservoir/

2016, has an installed capacity of 6.6 MW[4] (EEP, 2018:18). However, it has to be recalled that a rehabilitation and redevelopment study on the Aba Samuel Power Plant was conducted by UNDP and ENEL in 1983 and 1987, respectively. The finding suggested that redeveloping the power plant "to a total installed peak load capacity of 36 MW' was economically feasible (PDRE, 1989:2). Simultaneously, the study by ENEL showed that only 16-20 MW would be generated from the rehabilitated power plant (PDRE, 1989:2)

In addition to Aba Samuel, another hydropower plant with an installed capacity of 120kW operated in Jimma town (Getahun, 1993:288). The development process covering the period from 1912 to 1952 can be referred to as a slow hydropower development phase.

The second period, which covers the years from 1960 to 1974, was the hydropower era. During this period, major achievements were made specifically the construction of significant hydropower projects such as Koka (43.2 MW), Ourso (0.42 MW), Tis Abbay (7.6 MW), Awash I and II (64), and Fincha (100 MW) (Getahun, 1993:288-289). Additionally, the Ethiopian Light and Electric Authority, currently the Ethiopia Electric Power, was established during this period (World Bank (WB), 1964). Furthermore, a joint study between the US Bureau of Reclamation and the Ministry of Public Works and Communication of Ethiopia led to the identification of potential single and multipurpose hydropower sites on the Abbay River.

Table 4: Hydropower Plants Built from 1941 to 1974

Power Plant	**Installed Capacity in MW**	**River**	**Operation Year**
Aba Samuel	6.6	Akaka River, Awash Basin	1941
Koka	43.2	Awash	1960
Ourso	0.42	---	1953
Tis Abbay	7.68	Abbay	1964
Awash I	32	Awash	1966
Awash III	32	Awash	1971
Fincha	100	Fincha River, Abbay Basin	1973/4
Small Plants	0.43 (*Isolated	----	---

[4] AidData. Chinese Government provides RMB 95 million grant for Aba-Samuel Hydropower Plant Rehabilitation Project [Project ID: 59178]. Accessed January 2022 from https://china.aiddata.org/projects/59178/

	system)

Source: Compiled from World Bank, 1964; EEP, 2021; Getahun, 1993

As in Table 4, the second hydropower plant in the country's hydropower development history was initiated two decades after the operation of Aba Samuel Power Plant. Except Tis Abbay hydroelectric power which supplies electricity to Bahirdar and a textile factory, all hydropower plants feed the main grid (WB, 1964:3; Getahun, 1993). Moreover, there was also mini hydropower that served small towns across the country.

Another salient feature of this hydropower era was the birth of hydraulic bureaucracy and the centralization of planning, generating, and selling of electricity. Ethiopian Light and Electric Authority (ELEA) was the first state-owned hydraulic institution established by the Imperial Charter in 1956 (WB, 1964:1). Other includes the Awash Valley Authority (AVA), Water Resources Department, and National Water Resource Commission[5]. While the AVA was a basin level water management institution responsible for the utilization and management of Awash River, the rest two were national institutions.

ELEA was responsible for the overall power development particularly the production, transmission, distribution, and sale of electricity throughout the country. However, an Italian company granted a concession in 1953 for 44 years supplied electricity to the northern province of Eritrea was by that was (Bureau of Reclamation, 1964a:96-102; WB, 1964:1). While the northern province of Eritrea particularly Asmara and Massawa load centers were mainly supplied by Società Dell' Africa Orientale (SEDAO), isolated towns and villages were provided by other four utilities such as Public Works Department of Eritrea, CONIEL, SAIBO, and SAET (Bureau of Reclamation, 1964a: 102).

However, southern parts of Eritrea were supplied by ELEA which operates both the interconnected system and self-contained system. The Interconnected system mainly serves the fast-growing industrial and commercial centers of the Addis Ababa-Dire Dawa-Harar corridor through a high-voltage transmission line connected to Koka Hydroelectric Power Plant while the isolated system serves small towns such as Jima, Ambo, Dessie, Debre Berahan, Woliso, Yirgalem, Jijiga, Negele, Bahirdar, and factories (Bureau of Reclamation, 1964: 96-100). While

[5] For more see, Yacob Arsano (2007). Ethiopia and the Nile: Dilemmas of National and Regional Hydropolitics. Dissertation, University of Zurich, Zurich

off-peak power was supplied to industries in Addis Ababa, Tis Abba hydroelectric power plant provided power to the Textile Factory in Bahirdar (WB, 1964:5). To address the shortage of skilled manpower, ELEA established its Training Institute in 1960 (ELEA, 1973).

Another breakthrough in the pace of hydropower development of the country during this period was the water resource studies and plans undertaken by the Imperial regime. The 1955 water resource survey and the Ethiopia-US Cooperative Program for the Study of Blue Nile Basin (1958-1964) had far-reaching geopolitical implication to the water resource development of the country. The former undertaken by the imperial regime identified 5,226 MW economically feasible hydropower potential, most of which was located within a 500 km radius of the capital city (WB, 1964:7). In this survey, the annual hydropower production potential from Awash River was estimated to be 1,287 million kWh.

In addition to hydropower potential of Awash, its strategic importance made it a key site for hydropower extraction during the imperial regime. Firstly, Awash is geographically close to the largest load center, the Addis Ababa complex. Most of the suitable hydropower sites in the country are in remote areas and peripheries, but the Awash River is located near the fast-growing industrial and commercial centers of the Addis Ababa-Dire Dawa-Harara corridor and the railway connecting Ethiopia with the Djibouti port. Meeting the energy demands of this political, economic, and commercial corridor was of great strategic importance to the country. Secondly, Awash is an inland river that does not cross the international border of Ethiopia. This means that water resource development would not involve geopolitical tensions. Obtaining finance for projects on the Awash River from international financial institutions may also be easier than for projects planned on transboundary rivers such as Abbay. These factors made Awash River the site for hydropower generation during the imperial regime. While Awash I and II were constructed with funds from the World Bank, the Koka Hydroelectric Power Plant was built using finance obtained from Italy as war reparation (Carr, 2017: 26-27).

Another study with significant geopolitical implications for Ethiopia's hydropower development was the Ethiopia-US Cooperative Program for the Study of the Blue Nile Basin (1958-1964). The program aimed to investigate land and water resources of the Abbay River basin, establish an appropriate water resources management organization capable of continuing the investigation in other river basins, and provide training to Ethiopian personnel in administering this organization (Bureau of Reclamation, 1964a: I; 1961d: 1). The study began in early 1958 and was completed in 1964. The final report, titled "The Blue Nile Land and Water Resources in Ethiopia," consisted of one volume and six appendices specifically plan and estimates, hydrology, geology, land classification, power, agriculture, and economics.

The study identified 33 potential hydropower and irrigation sites, particularly their productive potential and costs, and four mega hydropower projects: Karadobi (5,835 million kWh per year), Mendaia (7,800 million kWh per year), Mabil (5,314 million kWh per year), and Border (6,200 million kWh per year). Although Fincha Hydroelectric Power was reported to have been completed, the GERD was identified as being currently under-construction. The report also listed several hydropower and irrigation sites that were considered less feasible due to inaccessibility, remoteness from the grid, and less desirable dam and reservoir sites (US Bureau of Reclamation, 1964c: 253). The electricity generation capacity was estimated for 10 promising hydropower sites. Furthermore, the study concluded that Abbay River Basin is less feasible for irrigation, and its potential is largely restricted to hydropower. The construction of the identified hydropower projects, according to the study report, would benefit downstream countries by regulating the water flow and retaining sediments.

Table 5: Identified Hydropower and Irrigation Projects on Abbay by Bureau of Reclamation, 1964

Identified Project	Project Purpose	Reservoir		Irrigable Area (ha)	Installed Capacity (kW)
		River	Installed Capacity (Million cubic meter)		
Megech Gravity	Irrigation	Megech	225.3	6,940	
Ribb	Irrigation	Ribb	312.6	15,270	
Gumara	Irrigation	Gumara	236.7	12,920	
West Megech Pump	Irrigation	Lake Tana	12,987.0	7,080	
East Megech Pump	Irrigation	Lake Tana	12,987.0	5,890	
Northern Tana Pump	Irrigation	Lake Tana	12,987.0	5,000	

Identified Project	Project Purpose	Reservoir		Irrigable Area (ha)	Installed Capacity (kW)
		River	Installed Capacity (Million cubic meter)		
Upper Beles	Multipurpose	Lake Tana	12,987.0	63,200	200,000
Middle Beles	Hydropower	Beles	3,974.0	---	168 000
Upper Birr	Irrigation	Birr	537.4	24,350	
Debohila	Irrigation	Debohila	50.1	4,200	
Lower Birr	Irrigation	Birr	Run of River	6,600	
Giamma	Hydropower	Giamma	3,169.0		60,000
Muger	Hydropower	Muger	300.7		26,000
Upper Guder	Irrigation	Bello	70.6	5,100	
Lower Guder	Hydropower	Guder	2,557.0		50,000
Fincha	Multipurpose	Fincha	464.0	15,000	80,000
Amarti-Neshe	Multipurpose	Amarti and Neshe	847.6	8,490	80,000
Arjo Diddessa	Multipurpose	Diddessa	2,130.0	16,800	30,000
Dabana	Multipurpose	Dabana	1,617.0	6,100	85,000
Angar	Multipurpose	Angar	3,572.0	30,200	185,000
Lower Diddessa	Hydropower	Diddessa	4,862.0		320,000
Dabus	Irrigation	Dabus	Direct Diversion	15,000	
Dabus	Power	Dabus	---	---	7,500
Dindir	Multipurpose	Dindir	3,690.0	58,300	40,0000
Galegu	Irrigation	Galegu	798.8	11,600	
Rahad	Irrigation	Rahad	1,902.0	53,100	
Karadobi	Hydropower	Abbay	32,500.0		1,350,000
Mabil	Hydropower	Abbay	13,600.0		1,200,000
Mendaia	Hydropower	Abbay	15,930.0		1,620,000
Border	Hydropower	Abbay	11,074.0		1,400,000
Addi, Ababa-Asab Trans	Hydropower	---	---		
Jiga Spring Pilot	Irrigation	Turkar Spring	Direct Diversion	224	
German Gilgel Abbay	Multipurpose	Jema, Koga, Gilgel Abbay	1,017.0	62,390	63,665
Sum			118,427.8	433,754	6,965,165

Source: United States Department of the Interior Bureau of Reclamation, 1964a

However, the joint study program on the Abbay River by Ethiopia and the US was not without criticism. Critics argue that the cooperative program for the study of the Blue Nile Basin was largely motivated by Cold War geopolitics rather than a pragmatic need. Firstly, the lack of implementation was associated with the US's reluctance to provide finance for the identified projects. Waterbury (2002:69) argued that the study was not "a blueprint for Blue Nile development" but rather it clearly implied Cold War geopolitics.

Secondly, some claim that the study was not driven by demand but it was a geopolitical response by Addis Ababa and Washington to Cairo's High Aswan Dam and the Cairo-Moscow alliance, respectively. A senior water expert questioned the very intention of the study program and asserted that the rationale behind the 1958-64 Abbay River Basin study needs to be questioned whether it was driven by development needs to meet national energy demand or a response to Cold War geopolitics:

> the study was initiated suddenly, and no preparations were made. If it was driven by development needs, we would have seen some implementations. However, there was no finance available for these projects, and even the regime faced problems obtaining finance for Fincha. During that time, energy-demanding sectors such as urbanization and industrialization were in their infancy stages, and the majority of the population was agrarian, can rely on annual rainfall which was sufficient (KII-28, May 2022).

The absence of high energy demand at the national level seems more convincing which is also further supported by the personal experience of a senior energy expert who held top leadership positions in the energy sector:

> during the 1970s, there was surplus electricity generated from different sources, but the community was unable to use this surplus energy because most of the population was agrarian, and there was no urbanization. The EEPA had to find a solution and applied various incentive packages to encourage the community to use electricity. One of the incentive packages was a low tariff for users who consumed more energy. The logic behind this was that the more electricity you use, the less you pay per unit, while those who used less electricity paid a higher tariff. Secondly, the EEPA began producing and selling electric pans (KII-1, July 2023).

Another view by an experienced energy specialist adds weight to this issue. According to him, during the pre-1991 era, power usage remained relatively low. He explained this by comparing the past energy surplus with the present energy crisis: “elderly people who were customers of EEPA in the 1970s and 1980s told us that “in those days, we didn't experience power outages [ድሮ መብራት አይጠፋም ነበር]. However, there have been times since 1991 when the country faced energy shortages and even crises” (KII-9, May 2022). Another key informant also noted that the study was unrealistic because it was conducted in the absence of geopolitical conditions necessary to proceed with the construction of hydropower dams (KII-31, April 2022). Furthermore, there was a lack of finance, transmission and substation infrastructure, and ultimately, no users (KII-31, April 2022).

In order to fully understand the potential geopolitical motivations behind the joint study program on the Abbay River by Ethiopia and the US, it was necessary to examine the geopolitical landscape of Northeast Africa during the Cold War and post-Cold War periods. Major geopolitical events during the 1950 and 1960 are this time contributed to a realignment of interests between Ethiopia and the US. One such event was the antagonism between Gamal Abdel Nasser and the US was attributed to the withdrawal of US from financing the High Aswan Dam. In response, Nasser nationalized the Suez Canal and constructed the dam with Soviet funds and technical support (Zewude, 2006: 9-18; Teferi, 2004:135-136). This created a crisis in the West (Erlich, 2002:132), and geopolitical fear in the US owing to the potential spread of communism following the Egypt-USSR alliance. On the other hand, Ethiopia was irritated by Egypt's monopolization of the Nile water through bilateral agreements which excluded upstream countries like Ethiopia.

The Ethiopian imperial regime's immediate countermeasure to the High Aswan Dam was to construct water controlling infrastructure on Lake Tana, built by Italian and French companies (Zewude, 2006:12). Playing Sudan against Egypt was also another countermeasure that was considered (Erlich, 2002:133). However, in opposition to Egypt's alliance with the USSR and the unfeasibility of constructing a dam on Lake Tana, the imperial regime invited the US, to undertake a joint preliminary study on the Abbay River (Zewude, 2006:12-23). This common geopolitical interest led Ethiopia and the US to conduct a joint study program on the Abbay River.

The involvement of the US in the study program was a tactical alliance, which was contrary to its current opposition to the construction of the GERD. It was recalled that the US in the 1950s and 1960s had expressed its concerns about the negative impacts of Egypt's unilateral water resources development on Ethiopia and other riparian countries (US National Security Council, 1960). The US aimed to systematically alienate Egypt from the USSR and send a clear message that if Egypt threatened US interests, then the US would help Ethiopia construct the identified projects on the Abbay River (KII-11, November 2021). In 1956 the U.S also formally assured Ethiopia that “no action in derogation of Ethiopia’s legitimate rights [to the Nile water] should be taken without Ethiopia’s consent” (US National Security Council, 1960). However, the US's policy shifted after the Camp David Accords, resulting in a shift from protecting Ethiopia's water rights to shielding Egypt's water security.

In contrast to this, for Ethiopia, the joint study is a tactical-cum-strategic move. It is tactical in the sense that it is a countermeasure to the unilateral move of Egypt. It is strategic because the study is a continuation of the country’s hydropower development, and the construction of hydraulic infrastructure in accordance with the study could reposition the State as the powerhouse of the region in the long run.

Hence, the joint study program on the Abbay River by Ethiopia and the US had significant geopolitical implications. Firstly, the program played a crucial role in increasing the structural and expert power of Ethiopia in terms of water resources development and management. Structurally, the study program led to the establishment of the Water Resources Department in 1959 (US Bureau of Reclamation, 1964a: II). In terms of expert power, 71 Ethiopians participated in the study program, gaining the skills and experience needed to manage, study and utilize the country's water resources (Water Resource Department, 1952/1960). This served as the foundation for the country's journey towards having a well-equipped hydraulic human power. Secondly, the study served as a baseline for the river basin master plan and hydropower master plan undertaken by the Ministry of Water and Energy and Ethiopia Electric Power, respectively. Lastly, as knowledge is a crucial element of power, the study program could be used as a reference in water resources study and related negotiations. This knowledge can be leveraged in future negotiations to ensure that Ethiopia's interests are well-represented and protected.

Besides, Ethiopia's interest to electrifyAfrica through continental power grid was also entertained during the imperial regime. The country hosted the first African Electric Power Conference under the auspices of the Economic commission for Africa in Addis Ababa, from October 21-31, 1963[6]. The conference was attended by delegates from 21 African countries, 14 observers from non-Africa countries, and 7 representatives from international financial and energy institutions. In this meeting, Ethiopia emphasized the importance of the untapped energy potential of Africa including hydro for realizing African unity through establishing African electric power grid.

In sum, the last two decades of the imperial regime witnessed high progress in the energy sector in general, and hydropower in particular. Globally, the period from 1930s to the 1970s was also a 'high dam era' particularly in the North America, and Europe[7]. As it was the case in the global north, the drivers for hydropower development in Ethiopia during the imperial regime was also largely linked to modernization and industrialization drive of the State. The taming of rivers for generating electricity was also limited to rivers proximate to the center, Addis Ababa, and the major commercial center along the Djibouti-Addis Ababa Railway, the Addis Ababa-Dire Dawa-Harar corridor. This shows that the generation, transmission, and distribution of electricity were largely determined by the energy demand from the growing industrial and commercial centers. The regime was also successful in obtaining technical and financial support from international financial institutions by instrumenting the geopolitical position of the State, and at times by playing one power against the other (KII-21, April 2022).

The final sub-development phase of the early hydropower development stage (1912-2000) was the stagnation period (1974-2000), which coincided with the global decline and stagnation of hydropower (1970-2000). During this period, only one hydropower project, Melka Wakena with an installed capacity of 153 MW, was operational in 1988. The construction of the Gibe I Hydroelectric Project was initiated by North Korea during this period (KII-1, June 2023). On top of the slowing down of hydropower development, some power plants, such as Aba Samuel, were out of service. Regrettably, Melka Wakena, constructed on the Wabishebelle River, was unable

[6] Minute of report of the African Electric Meeting, E/CN.14/INR/32, 27 November 1963

[7] Lee, Gabriel (n.d). The Big Dam Era, Energy History, Yale University. Accessed on February 2022 from https://energyhistory.yale.edu/units/big-dam-era

to produce its full installed capacity because of reduced inflow of water to the reservoir and water loss owing to evaporation. Simulation studies revealed that Melka Wakena generates only 12.21% of its installed capacity (Bosona and Gebresenbet, 2010:87; Brook and Teshale, 2022: 3). Except for the year 2022, overflow had never been recorded in the history of this dam (KII-28, May 2022).

The factors that contributed to the stagnation of hydropower development during this period were financial constraints, geopolitical factors, political instability, policy and institutional barriers. First, internally the energy sector faced problems such as unchanged electricity tariff rate, increased operation costs, and absence of manpower and management organized under the principle of meritocracy (Getahun, 1993:313). A senior dam operation expert also noted that one of the problems in the energy sector was that there was "no professional autonomy and freedom, projects were led by cadres" (KII-2, January 2023). These problems hindered the capability of ELEA to construct new hydraulic infrastructure by covering its costs, even to maintain and rehabilitate existing ones (Getahun, 1993:313). Hydropower plants that were out of service like Aba Samuel had to wait for the hydraulic era. Second, the government policy prohibited private producers and suppliers. This had made ELEA the only electric utility.

Third, factors such as political instability, severe drought, civil war, and external war with Somalia forced the regime to shift resources to war zones and drought response measures. The political instability, civil war, and the external war with Somalia had also a direct link with the water resources development plan of Ethiopia. Owing to the far-reaching geopolitical implication of the Ethio-US Abbay River study and the overall water resources development plan of Ethiopia to Northeast Africa, Egypt pursued a policy of destabilization aimed at weakening Ethiopia, and creating political and security crisis so as to impede water resources development. To secure its monopolization of the Nile water, Egypt supported subversive activities against the Ethiopian government, indirectly through supporting insurgencies in Northern Ethiopia, EPLF and TPLF, and Somalia's irredentist movement in the East. The study by Teferi (2018) revealed that during the Ethio-Somalia war, Egypt provided military support for the invading forces of Somalia, which was nearly 30 million dollars (p. 281). Quoted in Teferi (2018: 278), the former president of the PDRE government also disclosed the strategy Egypt used against Ethiopia to prevent

Ethiopian leaders and future generations from constructing hydraulic infrastructure on the Abbay River by instigating proxy war. This shows that political instability in Ethiopia best serves the interest of Egypt because resources will be spent on war rather than water-intensive hydraulic developments. Thus, because of the 17 years of political instability, the Derge regime's main focus was on 'extinguishing fires' rather than promoting development (KII-11, November 2021). The regime's motto was also not centered on 'development' but rather 'all to the front' [ሁሉም ወደ ግንባር]" (KII-21, April 2022).

Fourth, the lack of external financial support for hydropower projects due to the shift in the global hydropower financing landscape was also another factor that affected the pace of hydropower development during the Derge regime. Globally, in the 1980s and 1990s, international financial institutions such as the World Bank declined to provide funds to large-scale hydropower projects over the adverse socio-environmental impacts of these infrastructures. For instance, in the 1990s, the World Bank withdrew or reduced its funding for hydropower projects around the world (World Bank, 1989:6; WCD, 2000: 19). International financial institutions lack of interest on large-scale water resource development had thus affected the hydropower development of the Derge regime.

Despite these constraints, the PDRE regime through Ethiopia's Valleys Development Studies Authority undertook a 'preliminary country-wide water resources development master plan'. The study was conducted by the Indian Water and Power Consultancy Service (WAPCOS) from April 1988 to June 1990. The study aimed to assess the water resources of the country, including their availability, location, and characteristics (PDRE, 1990a). The study was directed to determine the present and future water requirements of the country and identify its hydropower potential. Moreover, the study aimed to propose a framework for the fair distribution of water resources to all areas and suggested measures for preserving the environment. Furthermore, the study targeted to identifying projects, prioritizing them, and establishing an implementation schedule within a given time frame.

Table 6: Hydropower Projects Identified Under the PDRE Master Plan

Rivers	Number of sites	Technical hydropower potential Gwh/yr
Abbay	132	78,820
Awash	43	4470
Baro-Akobo	39	18,880
Genale-Dawa	31	9270
Omo-Gibe	23	36,560
Rift Valley Lakes	6	800
Tekezze	15	5980
Wabishebelle	18	5440
Mereb-Gash	10	760
Barka-Anseba	6	80

Source: PDRE, 1990a

The final report of the study comprises 11 volumes, along with 19 annexes that cover various topics such as topography, hydrology, agronomy, hydrogeology, geology, environment, seismology, and irrigation and hydropower project sites. As shown in Table 6, the study identified a total of 314 hydropower projects, 60 major irrigation and multipurpose projects, and 26 medium projects. These projects were ranked based on their financial feasibility and development priorities.

According to the master plan, the gross hydropower potential of the country was estimated to be 212,810 Gwh/yr, whereas the technical potential amounted to 145,610 Gwh/yr (PDRE, 1990a). The identified hydropower projects had been prioritized based on their development needs to meet the energy demand for the next 50 years. Furthermore, the government had a plan to construct 'one dam every five years' (KII-2, January 2023). With these two initiatives as a breakthrough, some argue that this period was characterized by a strong interest in constructing hydraulic infrastructure on a massive scale (KII-2, January 2023).

The Hydraulic Era (post-2000)

Hydropower development in Ethiopia had been booming since the post-2000 period, marking the hydraulic decades that spanned from 2000 to the present. This era was dubbed the 'big dam era' owing to the boom in hydroelectric power infrastructures, installed and generation capacities, transmission lines, and substations. Furthermore, it was a period in which the water and energy sector had witnessed structural changes which could be explained by the promulgation of the first water management policy, the establishment of the first Ministry of Water Resources, the splitting of the former EELA into Ethiopia Electric Power and Ethiopia Electric Utility, and establishment of water and energy-related regulatory authorities and agencies, and the introduction of various policies, strategies and programs that incentivized and encouraged water resources development including hydropower. Furthermore, it was a period that witnessed a strategic shift in the consideration of hydropower as a means to multiple ends simultaneously.

This 'hydraulic decade' also occurred concurrently with the global restoration and booming period of hydropower development in the global south such as China, Brazil, India, Laos, and Turkey. Ethiopia was among the new big dam builders of the post-2000. After a period of decline and stagnation in the 1970s and 1980s, large-scale hydropower projects returned to the development agenda of developing countries and funding agencies. Suspended projects owing to alleged environmental and social concerns like Arun-III were constructed (Saklani, 2021). In Ethiopia too, delayed and planned projects like Gibe I, and Border Dam, and Amerti Nesh respectively had become a reality. Rivers in the global south such as Amazon, Mekong, Abbay, Omo-Gibe, and Congo had also become the new hydropower sites for the new dam builders and financiers.

The major factors that drove hydropower booming after its stagnation in the 1980s were the emergence of new dam builders and financiers like China, and the return of traditional financial institutions to finance hydropower projects due to its strategic importance to attain global environmental and developmental goals like MDGs, SDGs, net-zero emission, and the just transition to low-carbon and climate-resilient economy. Particularly, the rise of China as an infrastructure financer was 'an emblematic shift' in the hydropower investment landscape of Ethiopia (Casco, 2009:260). Ethiopia got an alternative source of finance other than the traditional Western donors who were reluctant to finance upstream countries' projects without the consent of downstream countries (Institute of Development Studies, 2013:2; Casco, 2009:260). Furthermore, China involved in Ethiopia's hydropower sector when international financial institutions like the World Bank drastically reduced their investment in hydropower projects because of the alleged negative socio-ecological impacts of the dams (Wang, 2012). For instance, by 1999, the World Bank had not approved any loans for hydropower worldwide.

It is in this global context that China became "a strategic technical and financial partner for the Ethiopian power sector" (Alao *et al.*, 2019:14). Without Chinese involvement, some of the hydropower projects in Ethiopia having both national and regional significance could not have been realized. The Gibe III hydropower project was a good example. When international and regional financial institutions like the World Bank, Africa Development Bank, and European Investment Bank retreated from financing Gibe III due to their concern about the negative social and environmental impacts of the dam (Killoh *et al.*, 2020:415), Chinese financial institutions provided the funds for the construction of the project.

Apart from changes at global level, new geopolitical developments in the Nile and East Africa region served as regional incentives that favored hydropower development. This required the establishment of NBI, EAPP, and the signing of the Nile River Basin Cooperative Framework Agreement. Nationally, because of the relative political stability and double-digit economic growth since 2000, the country was in a better position than in the distant past to run a water resources development. GERD, for example, is currently being constructed by mobilizing domestic resources, government bonds and private donations. Moreover, since the early 2000s, the regime has introduced new policy and institutional frameworks that further accelerated development in the hydropower sector. The major policy measures included: the First National Energy Policy, Water Resources Management Policy, the 2001 water sector policy and strategy, Environmental Policy, the Agriculture Development-Led Industrialization Strategy (ADLI), the Sustainable Development and Poverty Reduction Program (SDPRP) from 2002/03-2004/05, the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) from 2005/06-2009/10, GTP I and II, the Ten-year Development Plan (2021-2030), the Climate-Resilient Green Economy strategy, the Industry Development Strategy, City and Industry Development Strategy, the Ethiopian Power System Expansion Master Plan (EPSEMP), River Basin Integrated Resources Development Master Plans, and the National Electrification Program. All these policy reforms created a conducive environment for massive public investment in the hydropower sector.

With these changes at three levels, development in the hydropower sector boomed substantially. The installed capacity of the country generated from hydropower sources increased from 370 MW in 1991 to 5,256.5 MW in 2023 (EEP, 2023:11). Besides, massive hydraulic infrastructure construction was undertaken: Gilgel Gibe I (184 MW), Gilgel Gibe II (420 MW), Gilge Gibe III (1,830 MW), Genale Dawa (254 MW), Tekeze (300 MW), Amarti Nesh (95 MW), Beles (460 MW), and the GERD (6000 MW), and Koyisha (2160 MW). Rehabilitation of existing hydropower plants (the Fincha, Tis Abbay I, and Aba Samuel hydropower projects) was also completed. .

Table 7: Hydropower Plants Built During the Big Dam Era (2000 to Present)

Power Plant	Installed Capacity in MW	River	Operation Year	Notes
Finchaa	134	Finchaa, Abbay River	1973 (Rehabilitated in 2003)	
Tis Abay II	73	Lake Tana/Abbay	2001	
Gilgel Gibe I	184	Gibe	2004	
Tekeze	300	Tekeze	2009	Cascaded with Gibe II
Gilgel Gibe II	420	Gibe-Omo	2010	Cascaded with Gibe I
Beles	460	Lake Tana	2010	
Amerti Neshi	95	Neshi	2011	
Gilgel Gibe III	1,870	Gibe-Omo	2015	Cascaded with Gibe IV (Koyisha)
Aba Samuel	6.6	Akaki	1941/ (Rehabilitated in 2016)	
Genale Dawa 3	254	Genale Dawa	2020	Cascaded with Dawa Iv
Sor	5			2014
GERD		Abbay		Under construction
Koyisha				Under

				construction, Cascaded with Gibe III

Source: Adapted from EEP, 2021

The Amarti Nesh and the GERD projects were among the 33 identified projects by the Bureau of Reclamation study as part of the Ethiopia-US study program for the Abbay River. Gilgel Gibe I initiated during the Derge regime was completed during the EPRDF reign. In addition to generation, substantial progress was made in the construction of transmission lines and substations, and linking of electric power to the national grid which varied between 132 and 500 kv high voltage transmission lines covering 20,634 km (KI-53, November 2023). Moreover, more than 192 substations with varying voltages had been constructed (KI-53, November 2023).

Moreover, the incumbent government was running hydropower projects that would meet the energy generation goal as set in the ten-year development plan. In this plan, power generation capacity was planned to increase from 4,478 MW to 19,900 MW, transmission line length from 18,400 to 29,900 km, and energy export volume from 2,803 to 7,184 GWH (Planning and Development Commission, 2021:55). These goals were set to meet the growing energy demand both at national and regional levels. Furthermore, in the post-2000 hydraulic era hydropower development was perceived as a *sin quo non* for attaining the policy objectives by 2025 in terms of attaining a regional energy hub, poverty reduction, climate-resilient green economy, and regional integration.

Table 8: Generation Planning

Name of the Project	Installed Capacity (MW)	Notes
Beko Abo	935	
Chemoga Yeda I & II*	280	Under consideration for construction by Public-Private Partnership
Genji	214	
Upper Mendaya	1700	
Genale 6	246	Under review, in the process of bidding to be built by Public-Private Partnership
Karadobi	1600	

Name of the Project	Installed Capacity (MW)	Notes
Upper Dabus	326	
Geba 1 + Geba 2	372	
Sor 2	5	
Gibe IV + V	2132	Gibe IV is under construction
Birbir R	467	
Baro 1 + Baro 2	645	
Genale 5	100	Prequalification stage for PPP
Werabesa + Halele	436	Under review, in the process of bidding to be built by Public-Private Partnership
Tams**	1700	
Gojeb	150	
Lower Didessa	550	
Tekeze II	450	
Aleltu East	189	
Aleltu West	265	
Lower Dabus	250	
Wabi Shebele	88	

Source: Compiled by the Author from the EAEPP and EEP master plans, and FDRE, Public Private Partnership, Directorate General. 2021

*In 2009, a construction agreement was signed with SinoHydro Company. However, in 2014, the agreement was canceled owing to opposition from the International Water Rights Institute on the claim that the project did not meet pre-qualification requirements. Despite this setback, the project was listed as a candidate project for GTP II to be constructed through a public-private partnership.

**Tams will be considered after completing Baro 1 and 2. The installed capacity in the EEP master plan was 1700 whereas in the EAPP, it was 1700 MW

CONCLUSION

Through the analysis of various trends, patterns, changes, and continuities, the study aimed to understand how Ethiopia was emerging as a regional renewable energy power hub focusing on hydropower. The primary reason was associated with three key factors: vast hydropower potential, the consideration of hydropower development as a priority across the regimes, and hydropower booming since 2000. The first factor that contributed to Ethiopia's potential to become a regional renewable energy power hub was its geographical advantage. The country's hydrological, geological, and topographical features made it suitable for hydropower development. This would render Ethiopia the potential to reposition itself as a powerhouse and battery of the Horn of Africa, highlighting the country's strategic importance in the region's energy landscape.

Second, the country had a good historical precedent for harnessing water power. This was indicated in the basin-wide studies, master plans, and the hydropower development ambition of the three successive regimes. These envisaged the country's hydropower potential as a means to attain national and regional goals, build a hydraulic state, and make the country a regional renewable energy power hub.

Since the turn of the millennium, Ethiopia has experienced rapid growth in its hydropower industry. Installed capacity increased nearly tenfold in just two decades, reaching 5,256.5 MW in 2023. As a result, hydropower contributes over 90% of the country's overall electricity production. The change in the hydropower sector has also enabled the country to export power to Kenya, Djibouti, and Sudan.

Furthermore, the pace of hydropower development has also four distinct patterns. The first pattern is the entanglement of domestic and international politics which has been a significant factor in the boom and stagnation of hydropower development. When the domestic and international environment is conducive, hydropower tends to boom, but it declines and stagnates when international geopolitical developments become barriers. This was evident during the period of massive hydraulic infrastructure construction from 1960 to 1974, which coincided with the global hydraulic era. The stagnation of hydropower development between 1974 and 2000 corresponded to the global hydropower decline period of the 1970s and 1980s because of global anti-dam movements. The boom in hydropower since 2000 has also coincided with the global restoration and re-booming period of hydropower in the global south such as China, Brazil, and India.

The second pattern is the strong correlation between political stability and hydropower booming. The relative political stability of the post-liberation period of the Imperial regime and the post-2000 EPRDF reign witnessed the construction of massive hydraulic infrastructure. Conversely, the war period of the military regime experienced the decline and stagnation of hydropower development. Between 1974 and 2000, only the Melka Wakena Hydropower project was operational. However, Koka, Tis Abbay, Awash I and III, and Fincha were constructed and operated between 1960 and 1974. Since 2000, several hydropower projects, such as Tekeze, Gilgel Gibe I, Gibe II, Gibe III, Beles, Amerti Neshi, and Genale Dawa 3 have been completed. Still, other projects such as the GERD and Koyisha are under construction and many others are in the pipeline.

The third pattern is the hydropower sector's role as an exemplary showcase of the regime's foreign policy orientation, power balance, and alliance. Each regime tried to gain technical and financial support from its international allies. For instance, the US-Ethiopia joint program for the study of the Abbay River Basin was a result of the allied interests of the US and Ethiopia during the Cold War. North Korea and the USSR were also involved in the construction of Gilgel Gibe Hydropower Projects and basin-wide studies of the Derge regime, respectively. China has been a major player in the post-2000 hydropower development of the EPRDF era as a dam builder and financier. Furthermore, across the three regimes, the country's hydropower resources were considered strategic in achieving domestic and regional goals, including regional integration. While power trade is a recent phenomenon, the intention of electricity trade has been an element of continuity. The fourth pattern is that hydropower development was state-led although some water resources development studies were in response to rival powers, notably Egypt.

Some of the changes witnessed in the post-2000 hydraulic era included the establishment of the first Ministry of Water Resources and the promulgation of water and energy policies that transformed the water and energy sector structurally. Second, the introduction of policies, strategies, and programs that incentivized and encouraged the generation of electricity from hydropower sources further contributed to the booming of hydropower. Third, hydropower development shifted from rivers close to the center to the peripheries. Fourth, new dam builders and financial institutions have been involved in the hydropower industry development. Finally, the regime's attempt to mainstream and integrate global development and environmental agendas and goals helped legitimize hydropower development as an instrument not only to achieve domestic ends but also global goals.

Barriers to hydropower development across regimes also included the transboundary nature of rivers, lack of finance, geopolitics, political instability, lack of technology and manpower, project delays, lack of private investors, and weak water institutions. Political instability and lack of finance were major constraints during the Derge regime, while the geopolitical context of the rivers was a major factor constraining hydropower development on the Abbay across all regimes.

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