Effects of the variability in reservoir inflow on the Grand Ethiopian Renaissance Dam (GERD) hydropower generation

Tewodros Walle[a*], Mark Howells[b] , Ioannis Pappis[b]

[a] **Addis Ababa Institute of Technology, Addis Ababa University, Ethiopia** teddymec2@gmail.com

[b] **KTH – Royal Institute of Technology, division of Energy Systems Analysis, Stockholm, Sweden**

1. Introduction

The aim of this policy brief is to investigate the effect of the reservoir inflow patters of the Nile River on the Grand Ethiopian Renaissance Dam (GERD) hydropower generation in Ethiopia the period 2022-2037. To do so, the OSeMOSYS modelling system for medium to long-run integrated assessment and energy planning was used [1][2]. The results of this study show a summary of projected power development indicators and policy recommendations for risks associated with estimated droughts in the future in Ethiopia.

The power system of Ethiopia is mainly based on hydropower (3.8 GW installed capacity). Ethiopia has the second largest hydropower potential in Africa, with less than 10% developed to date. In the future, it is expected that the country will increase its hydro capacity. The Ethiopian government has awarded contracts for mega plants. In addition, 90% of the future installed capacity will be from hydropower [3]. However, the country is vulnerable to droughts[4][5]. The first large hydropower plant in Ethiopia, the Tekeze dam, was out of production for most of the time during its first year of commission because of drought. That means that the coming climate change could limit the role of GERD (a dam 74 BCM[1] storage capacity) which will produce 6000 MW electric generation in the country´s power system[6]

2. Problem definition

The Ethiopian power system is experiencing load shedding with a frequency that now has reached every other day. The power outage is already taking its toll on some of the households and major industries like cement, metal and grinding mills which had to operate fewer shifts. That shift is threatening the overall economy in terms of exacerbating the already built-up inflationary pressure and deteriorating industry sector. These load-shedding are a direct result of water shortages in hydropower dams. The rationale comes from near and longer-term urgency in the energy sector of tacking load-shedding. In the study, specific policy portfolios to eliminate the intermittency are addressed.

[1] BCM= billion cubic meters

3. Methodology and Scenario development

In this study, the open-source modeling system OSeMOSYS for medium to long-run integrated assessment and energy planning was used. The objective of this system is to identify the least-cost energy supply mix which meets the electric services demands. The data for energy demand projections, primary energy resources and transmission and distribution system were collected from 18 different offices under MoWIE[2], MoMNG[3] and literature survey. In this study, the "Drought" scenario takes into consideration the effect of the lower inflow of the Nile River on the future power generation of GERD. Under this study, the trend of 40 years reservoir inflow patterns data were used to determine the flow of the river in each time slice.

4. Results

Overall, our results demonstrate a strong effect of drought that led the reservoir water inflow amount decrease GERD's water requirement to generate electricity throughout the year. Figure 1 indicates that the GERD could generate 1-17% less power than its generating capacity between the two scenarios. To compensate the load shedding as a result of this, the Ethiopian government should expand other renewable energy power plants.

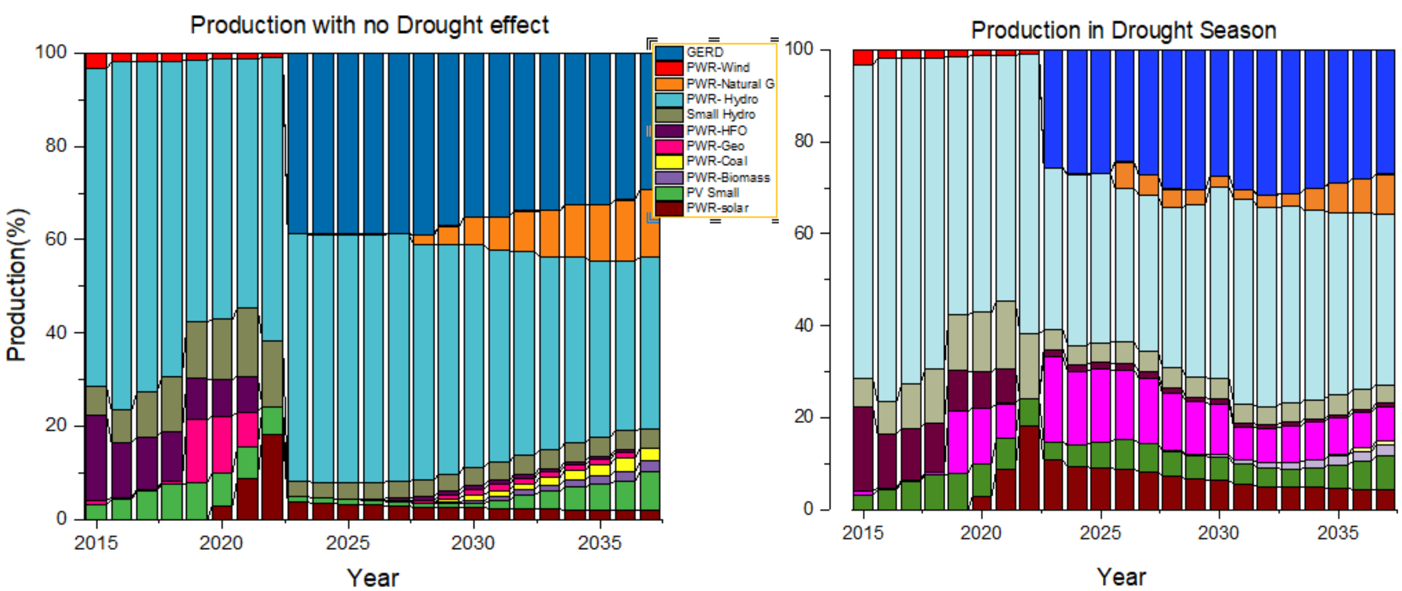

Figure 1: Effect of drought in the Ethiopian power system (2020-2037)

The following table shows, the drought effect on emission level, electricity per capita, electricity exports, energy production, and power system compared to the "no drought" season

Table 1. Summary of projected Ethiopian energy development indicators in Drought season

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[2] MoWIE: Ministry of Water Irrigation and Energy

[3] MoMNG: Ministry of mine and Natural Gas

Effects	Season	2022	2028	2035	Results
CO2 emissions (Mt)	BAU	11.3	13.9	18.3	Average 16.3% increase CO2 emissions each year
	Drought season	13	16	23	
Electricity per capita (kWh/Cap)	BAU	101	152	204	17.9% average decrease Electricity per capita each year
	Drought season	86	131	158	
Electricity Exports (Million $)	BAU	310	445	574	22.34 % of electricity exported to Sudan, Djibouti, Kenya, and Tanzania could be decreased b/c of shortage of electricity to be exported
	Drought season	264	332	436	
Import of crude oil	Drought season				Increase by 17.3%
Energy production	Drought season				Decreased by 21.7%
Emitter power plants capacity	Drought season				Increased by 13.4 %
Load Shedding	Drought season				There would be forced load shedding 13.1 % time of the year. Specifically in the month June, July and August would be worst

5. Limitations

Some of the techno-economic assumptions are based on international sources and the rest on estimated values for east Africa and Ethiopia. Therefore, further data collection mainly national one is required to better determine and capture national changes. In addition, a sencitivity analysis on fuel or technology costs should be conducted to limit the model uncertainties.

6. Policy implications and recommendations

The broad implications of the present study do not impose that the Ethiopian government should stop pursuing its current ambitious national hydropower development plan because of the coming drought seasons. However, the government could increase the share of other renewables (wind, solar, biomass) in the power generation mix to harmonize with the capability to manage load shedding during drought seasons and reduce the dependency on hydropower. Therefore, the policy should encourage to adequately internalizing an extensive range of factors such as:

i) In the energy mix to include environmental serves
ii) Addressing the sustainability of multipurpose hydropower reservoirs in Hydro-Electric Scheme development,
iii) Investment in energy efficiency (in the energy sector, i.e., power infrastructure refurbishment and power plant rehabilitation; and across other sectors of the economy) and saving,
iv) Polling investments in non-hydro renewable energy sources

v) Setting standards and best practice and
vi) Private sector participation in power generation and co-generation.

All these factors have the potential to contribute to a reduction in electricity demand which could potentially ease the pressure on hydro and reduce the intermittency.

Reference

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