Policy Brief: Pathways to an Electrified Ethiopia

July 2021

How can Ethiopia meet future energy demands? We provide insights drawn from the Energy system development pathways for Ethiopia (PATHWAYS) Project, based on modelling of the Ethiopian energy system and spatial electrification pathways.

Key messages and recommendations

Future energy demands are projected to increase dramatically as a consequence of Ethiopia's rapid growth in population, the economy and urbanisation together with ambitious targets for universal electricity access.

- Ethiopia's ambitious electrification targets can be achieved at lower cost with off-grid technologies
- Aside from hydropower, there are significant roles for solar, wind, geothermal & natural gas generation
- Investing in interconnection to neighbouring countries would unlock revenue potential from energy trade, covering up to 30% of the costs of new electricity capacity in Ethiopia between 2015 and 2065
- Policy makers must manage climate risks associated with the large expansion of hydropower

Background

Two major Ethiopian energy policy programmes are currently in place. First, the National Electrification Programme (NEP II) aims to achieve universal access to electricity by 2025, up from 44% in 2018. The programme stipulates that 65% of the population should be grid connected by 2025, with the remainder of the population relying on off-grid electricity. Five year later, in 2030, 95% of the population – everyone within 25km of the existing transmission network – should be grid connected. Second, the Power Sector Reform bill outlines key challenges of low energy access, large debt and high load-shedding. It identifies solutions including the strengthening of institutions, regulatory frameworks, restructuring of the sector and development of a contractual framework to reform tariffs.

Ethiopia's large hydropower resource represents the cornerstone of its low-carbon energy system. Ethiopia also has a broad range of untapped alternative renewable and fossil resources, including solar, wind, geothermal and natural gas. Significant challenges to exploiting these substantial resources remain and, if not tackled, run the risk of preventing the country from achieving its goals. Climate change will increase the vulnerability of hydropower dependent countries, underlining the importance of a diverse generation mix that includes integration of other renewables. The challenges identified in the Power Sector Reform Bill, including weak institutional capacity and insufficient human capacity, must be overcome to enable the rapid growth of energy supply that is required.

Methods The project co-developed plausible scenarios for electrification and development of the energy system, through stakeholder workshops held in Addis Ababa in 2018 and 2019. The OSeMOSYS and OnSSET modelling frameworks were coupled to compute a cost-optimal technology mix and spatial electrification pathways. New Policies and High Ambition achieve NEPII and explore medium and high demand growth. Big Business and Slow Down miss NEPII targets and explore high and low demand growth, the former emphasises industrial demand.

Electrification targets can be achieved at lower cost with off-grid technologies

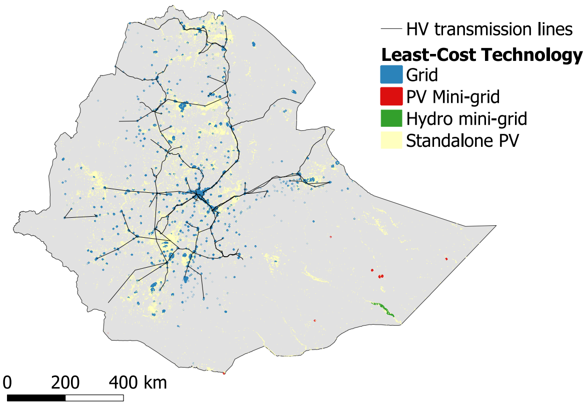

Figure 1 Pattern of electrification in 2030 under high demand growth with home-solar and hydro mini-grids

For residential demands, a higher reliance on off-grid technologies could lower investment costs before 2030 by slowing the near-term expansion of the grid. Following the NEP II targets under medium demand growth, our analysis shows that US$16B are required for providing access to every household in Ethiopia by 2030 (in line with NEP II estimates of US$15B). Under higher demand growth ('high ambition' in our scenario analysis), investments for residential electrification can be reduced from US$18B to US$11B by deviating from the NEP II targets and focusing grid-extension on high-demand areas, while using off-grid technologies in remote and low-demand areas (Figure 1). This delays capital intensive investment to later years. Ultimately, connections to an expanded transmission grid will be needed to meet higher electricity demands. However, the timing of these connections could be dictated by the rate of demand growth, reducing financial pressure in the near term.

Rapid growth in supply capacity is needed

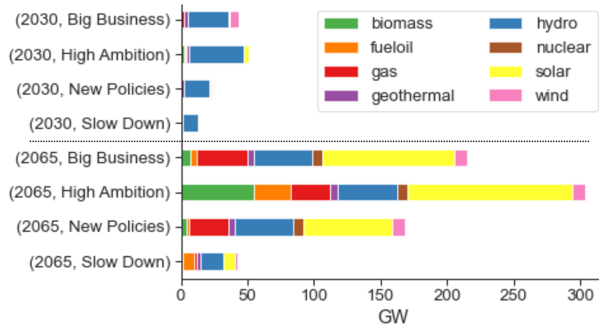

Figure 2 Power generation capacity split by scenarios for key years 2030 and 2065

A large investment push is required to meet the increase in electricity demands under all but the most pessimistic ‘Slow Down’ scenario.

The results (Figure 2) show that electricity generation capacity increases to between 14GW and 50GW in 2030 from 3GW today, delivering between 60TWh and 184TWh of electricity. In the long term, the range becomes much wider with 50GW to 300GW delivering 170TWh to 1,000TWh of electricity in 2065. Supply capacities vary widely due to the adoption of cost-effective, but low capacity-factor, renewable technologies and the rate of demand growth.

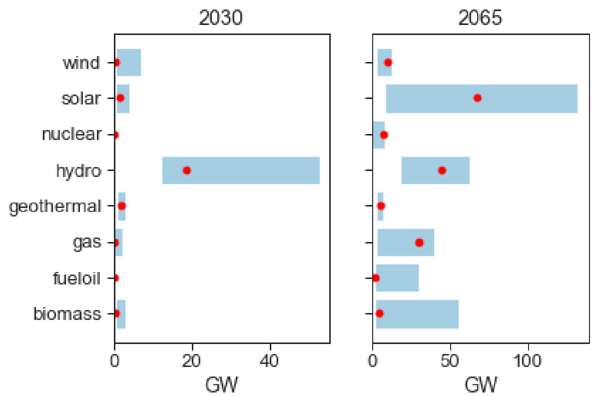

Figure 3 Ranges of technology capacity in 2030 and 2065

Before 2030, there is a clear role for the expansion of hydropower (12-45GW by 2030) across the range of scenarios explored, with a smaller role for wind, solar, geothermal and natural gas, depending on assumptions for relative costs and availability of these technologies. Beyond 2030, the hydroelectric resource is fully connected and grid-connected solar generation technologies (photovoltaics and concentrating solar power) experience rapid growth to become the second largest source of electricity. The results (Figure 3) show that there is also a potential role for nuclear, natural gas and oil (due to limited natural gas resource), albeit with practical, political and environmental implications. These results are sensitive to future technological developments.

Large investment will be needed to unlock export revenues

Under medium demand growth, total capital expenditure required is $535B for the period 2020–2065 (85% grid connected capacity, 6% off-grid technologies, 9% other (interconnectors and grid expansion)). Capital expenditure is $48B for the period 2020-2025 (79% grid, 5% off-grid, 15% other), $30B for the period 2026-2030 (60% grid, 7% off-grid, 33% other) and $459B for the period 2031-2065 (88% grid, 6% off-grid, 6% other).

Ethiopia could play a key regional role as an energy hub, importing and exporting electricity to neighbouring countries with benefits including both improved energy security and income from export revenues. Total electricity export revenues range from $48B to $280B depending on the size of the energy system, interconnector capacity and export price. Annual revenues grow over time, doubling following investments in interconnector capacity in the mid-2030s.

Policy makers need to manage risks

The results highlight potential risks. Ethiopia’s large hydropower capacity presents an increased vulnerability to droughts, which should be mitigated through diversification of the power sector. This presents a risk to future export revenues as well as to system security. Under conditions of very high demands, electricity from biomass becomes the generator of last resort, raising questions around sustainability of the resource.

About the author Dr. Will Usher is an Assistant Professor of Integrated Systems Analysis for Sustainable Development at KTH Royal Institute of Technology. Further reading: Pappis, I.; Sahlberg, A.; Walle, T.; Broad, O.; Eludoyin, E.; Howells, M.; Usher, W. *Influence of Electrification Pathways in the Electricity Sector of Ethiopia—Policy Implications Linking Spatial Electrification Analysis and Medium to Long-Term Energy Planning*. Energies 2021, 14, 1209. https://doi.org/10.3390/en14041209. Contact: wusher@kth.se