United Nations University
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WATER, SOIL AND WASTE
DRESDEN NEXUS CONFERENCE

POLICYBRIEF

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ENERGY RESOURCE USE OPTIONS FOR IMPROVED ENERGY SECURITY IN ETHIOPIA

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HIGHLIGHTS

- Investigated Ethiopia's least cost investment for integrated energy source diversification
- Assessed impacts of drought expected from future climate change on hydroelectric generation
- The country would need to invest in the development of alternative energy resources
- This would enhance the sustainability and reliability of energy generation, but also increase costs
- A greater rates of technological and efficiency innovations improve electricity diversification and reduce production costs; and are thus key for enhancing energy security

THE CHALLENGE

Ethiopia's energy sector faces critical challenges to meet a steadily increasing energy demand. This is due to the low development of electric restructure, the countries strong dependence on imported oil, and drought vulnerable hydroelectric power. Likewise, Engidawork et al. (2009) indicated that shortage of electricity during 2007–2009 brought a 3% GDP loss.

An overwhelming share of energy consumed by Ethiopia in 2009 (92%) was derived from biomass sources, fossil fuels accounted for 7%, and other forms of electricity generation were only 1% (See Figure 1). High economic growth for the past decade had a high correlation with the increased fossil fuel demand. The report of the Ethiopian petroleum enterprise (2011) indicated that fossil fuel import doubled during 1998/99–2009/10. The challenge in the electricity sector is mainly caused by the high electric transmission rates and heavy losses in its distribution, and homogeneous mix of electricity (World Energy Trilemma, 2013). Heavy reliance on hydropower poses energy security concerns due to vulnerability to frequent and persistent drought that is characteristic of the region. The concern is also related to trade-offs with potable, industrial, and agricultural water needs; the effects of siltation and sedimentation on dams and reservoirs; and conflicts over water rights.

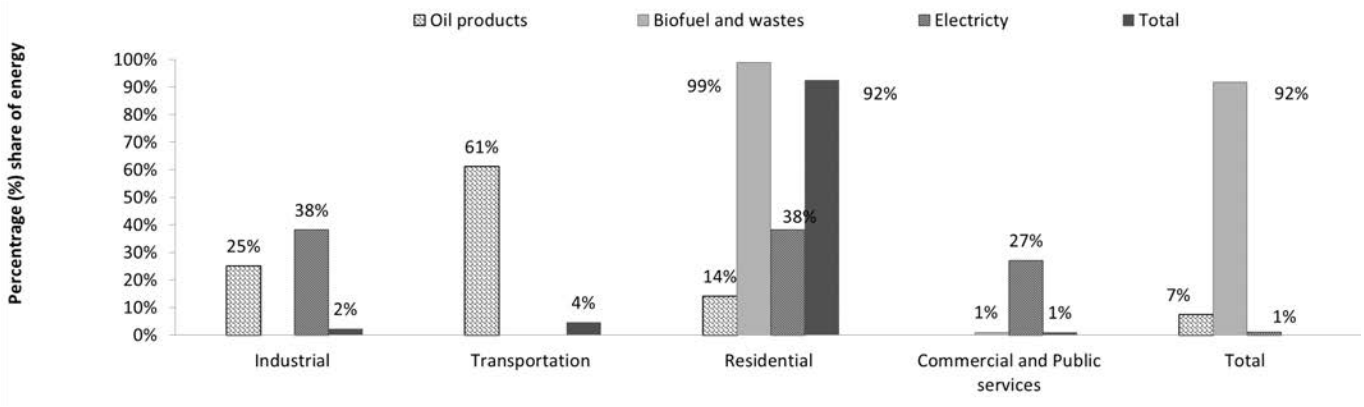

Figure 1: Distribution of energy consumption in Ethiopia by end-user, 2009 (Source: International Energy Agency, 2009)

RENEWABLE ENERGY POTENTIAL

Despite this challenge, Ethiopia could dramatically improve its situation by becoming a renewable energy producer. Located in the tropics, the country has a considerable potential for production of green energy in terms of diversity (see Table 1). The presence of several large rivers draining the highlands and the Great East African Rift Valley (GEARV) could be respectively used for hydroelectric, wind, and solar power production.

THE NEED FOR ENERGY SOURCE DIVERSIFICATION

The primary challenge of Ethiopia's energy sector is the low performance in developing renewable energy resources that ensures competitive advantages as well as energy security. The country needs to invest in sustainable energy to keep pace with the unprecedented growth in energy demand. Correspondingly, this study aspired to investigate the optimal least cost investment decisions for integrated energy source diversification. Particular attention was given to relevant literature on the cost of investment decisions, role of public policy in renewable energy, and underlining evidences of uncertainties implication on the country's future energy security.

ELECTRICITY DEMAND GROWTH RATE

The electricity demand growth rate varies, in the long term, due to future uncertainty in the electricity market; which was assumed in this article as a function of the economic and population growth. The annual demand growth rate varied between 6% to 9% in the period 2010–2045 and assumed to grow only of 2.5% due to the expected stabilisation of economic and population growth between 2045 and 2110.

POWER GENERATION BASELINE SCENARIOS

The outcomes of the model indicate that hydroelectric power continue to dominate the country's energy mix without intervention with respect to technological progress and efficiency innovations. Under high electricity demand growth, Ethiopia would generate about 388 Terawatt hours (TWh) by 2110, compared to 183 TWh under low growth. Under low electricity demand growth, Ethiopia continues to heavily rely on hydroelectric power. In the high demand growth, alternative energy sources (geothermal, wind, solar and biomass) will be exploited after fully exploiting hydroelectric sources.

Table 1: Ethiopia's current and potential or projected renewable energy resource capacity (Source: Ministry of water and energy, 2013; Global Methane Initiative, 2011)

Energy source	Unit	Potential reserve	Exploited as of 2010	
			Amount	%
Hydroelectric	MW	45,000	2,100	5%
Solar	kWh/m²/day	4–6		
Wind	GW	1,350	268MW	<3%
Geothermal	MW	5,000–7,000	7.3	<1%
Woody biomass	t (millions)	1,120	560	50%
Agricultural waste	t (millions)	15–20	≈6	30%
Municipal solid waste	t (millions)	2.8–8.8	50 MW (under construction)	

IMPACT OF EXPECTED FUTURE CLIMATE CHANGE ON POWER GENERATION AND ADAPTION MEASURES

In the short and mid-term, climate change is likely to have negligible effects on Ethiopian's hydroelectric energy production. However, it is predicted that the adverse effects of droughts on the reliability of hydroelectric energy are more likely to manifest in the long term; and consequently the cost of energy will increase. This prediction calls for investing in expensive alternative renewable energy sources.

Costs are projected to rise above the baseline model by about 0.1% under a 0.11 standard deviation of water availability, 2.5% under a 0.25 standard deviation and 7% under a 0.40 standard deviation. There is great uncertainty about how future climatic change will affect energy production in Ethiopia. Ethiopian highlands' precipitation may increase rather than decrease, thus increasing water availability for hydroelectric power generation. However, the increase of precipitation might not always result in a benefit for the country unless it occurs during the dry season. Likely, the increases in the intensity of precipitation in the rainy season may increase the risk of flooding, siltation, and sedimentation, which directly affect the capacity of hydroelectric reservoirs adversely.

It is expected that the construction of small-scale hydroelectric projects would allow the country to mitigate the risks of climate change or drought. On one side the construction of small hydroelectric plants could increase the country's capacity to adapt to the effects of climate change. On the other side, according to the statistics of the Ethiopian Electric Power Corporation (EEPCO) (2011) on selected existing plants, the cost of power generation per unit of power is significantly higher than in large hydroelectric plants. However, small hydroelectric plants designed as decentralised power providers for rural communities require less transmission and distribution networks and therefore less related costs and electricity loss.

All in all, the primary adaptation measure for shortage electricity during dry years in Ethiopia is the increased use of fossil thermal, to cope with power rationing or blackouts. National statistics revealed that when the country faces shortfalls in electricity in dry years, private and governmental organisations increase their use of diesel generators (EEPCO, 2011).

IMPLICATION OF TECHNOLOGICAL PROGRESS AND EFFICIENCY INNOVATION

To cope with the expected effects of climate change on hydroelectric power generation, the country needs to invest more in alternative renewable energy resources. Newer energy technologies were expected to have greater advantages and innovation rates than more mature (hydroelectric and geothermal) technologies (Winkler et al., 2009). In terms of energy security this would not only improve both sustainability and resilience, but also increase production costs. A study indicated that promoting adaptive research and development and supporting technological transfer could be especially valuable for developing countries, as new markets emerge for renewable energy technologies (Popp, 2011).

Innovations that improve the technology and efficiency of alternative energy sources, especially solar energy, would increase energy resource diversity and reduce production costs, shadow prices, and thus resource scarcity. Technology and efficiency innovations are therefore key for mitigating the expected effects of future climate change and improving energy security, and thus would likely serve as an engine of economic growth. Greater rates of cost reduction resulting from technological and efficiency innovation were found to promote substitution of new energy resources for hydroelectric energy sources.

Adoption of technology and efficiency related innovation are useful to diversify energy sources and reduce cost of energy production. Under the "best innovation scenario", Ethiopia was projected to undergo a massive shift from hydroelectric power sources to alternative sources such as wind, biomass, and solar energy. Moreover, relative to the "baseline scenario", it is projected that the discounted minimized cost of energy production would decline by about 10% (US$ 0.08 billion) and 18% (US$ 0.42 billion) under high and low electricity demand growth rates respectively. The mean shadow price of energy resources would declines from US$ 0.003/kWh in the "baseline scenario" to US$ 0.001/kWh in the best-case scenario. In a world of constrained resource availability, technological and efficiency innovations can thus clearly contribute to growth by reducing resource scarcity.

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POLICY RECOMMENDATIONS

Ethiopia needs to invest in renewable energy resources to ensure green energy development, achieve poverty alleviation and improve energy security; however, such an effort is hindered due to the high capital costs of these alternative energy resources. The following policy measures are recommended:

- Introduce policy measures that support innovation through research & development.
- Create a secure environment for private investors or decentralized renewable energy investment.
- Support for renewable technologies should be directed at closing technical, financial, and efficiency gaps that exist in the country's energy sector.
- Use tools such as capital subsidies that enhance the competitiveness of alternative energy sources.
- Provide incentives for integrated natural resource (forest, land/soil, ecosystem) and river basins management programmes, to cope with impact of drought and various risks (flooding, siltation, and sedimentation) which affect the capacity of hydroelectric reservoirs.

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