Alternative Future Pathways for Household Biomass Use in Ethiopia

Overview

Traditional biomass (wood, charcoal, dung) in households accounts for roughly 90% of total primary energy use in Ethiopia; about 84% and 99% of urban and rural households, respectively, rely on biomass as their primary cooking fuel.

Using the LEAP model, two alternative household energy scenarios in Ethiopia were designed and investigated: moderate shift and high shift towards efficient biomass use. Under the moderate shift scenario, the primary effect is that urban households shift significantly towards electricity and away from charcoal, while rural households switch to improved wood cookstoves.

In the high shift scenario, more households switch to efficient stoves and there is also some use of biogas in rural areas and bioethanol in urban areas.

In the baseline scenario, biomass demand doubles by 2030 compared with 2010. In the moderate and high shift scenarios, biomass use decreases by 53% and 67%, respectively, compared to the baseline case.

Significant health and environment benefits can be achieved if these scenarios are realized. Estimated GHG savings in 2030 from avoided land use change is 33–44 million tonnes CO_2-equivalent, or 13-18% of the government's targeted GHG reductions.

Introduction

Wood, charcoal, agricultural residues and animal dung are the most common cooking fuels in Ethiopia, as is common in sub-Saharan Africa. Traditional biomass accounts for 90% of energy consumption in Ethiopia, due to the low rate of electrification and the low level of commercial energy use in combination with increasing population. In rural areas, three-stone fires are commonly used, and the low efficiency results in high demand for fuelwood and has contributed to biomass scarcity. This, in turn, means longer distances for wood collection and increased drudgery (hardship) for women.

Charcoal is often made with traditional earth mound kilns that incur considerable losses, requiring four to five times as much energy input compared with fuelwood that is burned directly. However, since charcoal has nearly twice the final energy content per unit weight as fuelwood, it is a tradable commodity that is shipped from rural areas to urban and peri-urban areas in large bags. Increasing population has led to over-exploitation in some regions and thus contributed to deforestation, forest degradation and GHG emissions from land use change. Biomass burning also contributes to indoor air pollution and emissions of black carbon (soot), a short-lived climate forcer.

Household cooking and biomass in Ethiopia

Ethiopian households depend overwhelmingly on biomass for cooking in rural areas and even in most urban areas, as shown in Table 1, but a few significant shifts have occurred in the past 15 years. First, both urban and rural households have upgraded their biomass use, from low-quality residues and dung, to wood and charcoal. In urban areas, a small but growing share of households now use electricity for cooking. At the same time, in urban areas, there has also been a shift "down the energy ladder" from kerosene to charcoal or wood, due to rising kerosene prices.

Meanwhile, the urban population has more than doubled, driven to a large extent by migration from rural areas. The increase of 44% in rural households has been more modest, but nevertheless significant. Smaller households use proportionately more energy for cooking per person than larger ones,

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Corn bread bakes on a clay plate over a wood fire in Hawassa, southern Ethiopia.

and since urban households have fewer members on average than rural households, per capita energy use for cooking has increased with urbanization. Putting all of these trends together, there is now considerable pressure on forest and land resources in Ethiopia.

Are households willing to change stoves?

Rural households are extremely sensitive to any additional cash expenditures; consequently, for people who now collect firewood for cooking, at no cash cost, it is more feasible to switch to improved wood stoves than to switch both the fuel and the stove they use, especially if that will require recurring expenditures. There can be some opportunities for fuel-switching to biogas in rural areas where animal dung is available in sufficient quantity, although such shifts are also quite constrained.

Most urban households do not have access to "free" biomass and must purchase their fuel, and thus are sensitive to fuel price changes. There are also some cultural factors that favour cooking with charcoal, and – like their rural counterparts – urban households find it easier to switch to an improved stove using their current fuel than to switch both fuel and stove type. Consequently, improved charcoal stoves are the most likely feasible option for improving the overall efficiency of urban

Table 1: Primary cooking fuel/stove shares in Ethiopia
Source: Government of Ethiopia, Central Statistics Agency, Welfare Monitoring Surveys, 1996–2011

	Urban			Rural		
	1996	2004	2011	1996	2004	2011
Wood	61.7%	65.3%	63.3%	75.5%	84.5%	90.9%
Charcoal	4.3%	7.7%	17.5%	0.1%	0.2%	0.2%
Electricity	2.7%	2.4%	6.2%	0.0%	0.1%	0.0%
Kerosene	18.9%	13.8%	4.9%	0.2%	0.2%	0.2%
LPG	1.0%	2.7%	1.1%	0.0%	0.1%	0.0%
Biogas	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dung, sawdust, crop residues	11.4%	6.1%	3.4%	24.2%	15.0%	8.6%
None/other	0.0%	2.0%	3.6%	0.0%	0.0%	0.1%
Number of Households (thousands)	1,583	2,113	3,437	8,856	11,325	12,707
Change in number households (since 1996)		34%	117%		28%	44%

and peri-urban biomass use. Urban users may be willing to switch fuels where there is some compatibility or experience; for example, switching from kerosene to bioethanol. However, urban households prefer electricity, which is cheaper than other options in terms of actual energy expenditures once stove efficiencies are taken into account. As a result of discussions with stakeholders, it was assumed that biogas stoves would only be feasible in rural areas, and bioethanol stoves would only be feasible in urban areas.

Bioenergy shift scenarios

In order to investigate future pathways for bioenergy use in Ethiopia, we formulated three scenarios for 2013–2030. The baseline scenario assumes that current energy practices and policies continue without significant change. Two alternative scenarios – moderate shift and high shift – consider future shifts to more modern and efficient household energy use. The moderate shift scenario assumes parameters/targets that are viewed as being achievable through efforts to promote improved cookstoves, especially in rural areas, along with fuel-switching away from wood and charcoal in urban areas. The high shift scenario considers more optimistic parameters/targets and thus assumes more aggressive policy design and implementation.

The market penetration of improved stoves and related assumptions for the two scenarios were based on discussions with stakeholders, as well as Ethiopia's Green Economy Strategy and National Cooking Investment Plan, and the author's own expertise. Population and GDP projections for the moderate and high shift scenarios were based on the Ethiopian Green Economy Strategy, whereas the baseline scenario is equivalent to the business-as-usual case. In the baseline scenario, the population would increase from 87 million to 133 million in 2030, whereas in the alternative scenarios, the population is 120 million in 2030. In the baseline scenario, there is an annual GDP growth rate of 8.4%, whereas it is assumed to be 10% and 11% in the moderate and high shift scenarios. The average useful energy per year and household for cooking was estimated at 5.6 GJ and was assumed to be constant.

Results of the scenario analyses

The moderate and high shift scenarios were investigated using SEI's Long-range Energy Alternatives Planning (LEAP) system, with gradual penetration of improved wood and charcoal cookstoves from 2013 to 2030, along with the fuel-switching options discussed above. The resulting shares of different cookstove options in 2030 are shown in Table 2, along with the assumed parameters for the different types of stoves. Improved wood and charcoal stoves were assumed to have zero market shares at present, since their availability is currently constrained. Improved charcoal stoves are more cost-effective and have short payback times, so traditional charcoal stoves are assumed to disappear in urban areas. Furthermore, urban households that have the opportunity to switch to cooking with electricity, do so. Traditional wood stoves nearly disappear in rural areas in the high shift scenario. Biogas and bioethanol play a small role in rural and urban areas, respectively.

The shift to improved stoves, along with fuel-switching would significantly reduce wood consumption. The annual wood savings in the scenarios for 2015 and 2030 are shown in Table 3. The high shift scenario results in savings of more than 50% of all wood consumption by 2030, relative to the reference or baseline case.

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Charcoal is made in rural areas and shipped to cities. Above, a charcoal stand in the Bahir Dar market.

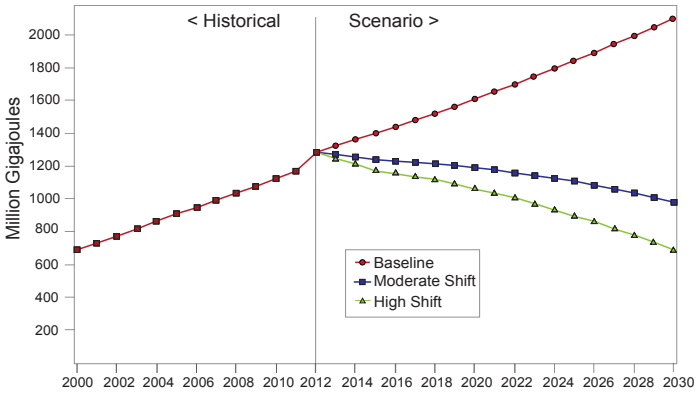

Figure 1: Wood energy demand for cooking under the three scenarios in Ethiopia

Table 2: Energy parameters for cookstove options and projected market shares in 2030

	Efficiency	Annual Energy Use	Market share in 2030			
			urban		rural	
	Energy out/ energy in	GJ/HH	Moderate Shift	High shift	Moderate Shift	High shift
Traditional wood stoves	7.5%	74.7	26.6%	16.0%	31.1%	8.4%
Improved wood stoves	21.5%	26.1	3.8%	5.0%	60.0%	80.0%
Traditional charcoal stoves	10.0%	56.1	0.0%	0.0%	0.1%	0.1%
Improved charcoal stoves	25.0%	22.4	25.0%	20.0%	0.4%	0.6%
Electric stoves	75.0%	7.5	39.7%	53.0%	3.8%	5.0%
Kerosene stoves	35.0%	15.9	0.0%	0.0%	0.0%	0.0%
LPG stoves	65.0%	8.5	0.0%	0.0%	0.0%	0.0%
Biogas stoves	55.0%	10.2	0.0%	0.0%	3.8%	5.0%
Bioethanol stoves	55.0%	10.2	3.0%	4.0%	0.0%	0.0%
Other stoves/fuels	7.5%	74.7	2.0%	2.0%	1.0%	0.9%

Figure 1 shows wood demand over time, as households adopt improved stoves or switch fuels; the figure shows the total wood input requirement needed for fuelwood and charcoal use in the household sector. In the baseline case, wood demand reaches 2.1 Exajoules (135 million tonnes), by 2030 whereas demand in the moderate and high shift scenarios is 0.98 EJ (63 million tonnes) and 0.7 Exajoules (45 million tonnes), respectively. As given in Table 3, improved stoves account for about 64% of the savings, while fuel-switching accounts for 36% of he savings in the two scenarios.

Figure 2 shows the rapid increase in urban electricity use in the two shift scenarios: whereas rural households adopt improved stoves, urban households switch from charcoal and other fuels to electricity. Since households tend to prioritize electricity for lighting, a shift to electricity for cooking requires additional disposable income, and thus the expected growth in the coming years in GDP – growth which is overwhelmingly concentrated in urban areas – accelerates the shift. The increase in electricity demand in the high shift scenario amounts to roughly 7,500 GWh, which is nearly twice the current level of total electricity use in Ethiopia (as of 2010). However, there are ambitious power expansion plans underway in Ethiopia that will considerably expand production and widen access.

The moderate and high shift scenarios offer savings in GHG emissions through improved energy efficiency and reduced land use change. The estimated potential savings in 2015 and 2030 for each type of measure (improved stoves and fuel-switching) is shown in Table 4. The GHG savings amount to more than 10% of the projected baseline GHG emissions in 2030. Ethiopia's climate policy targets a reduction of 250 million tonnes in annual GHG emissions by 2030; thus, the savings estimated here from the moderate and high shift scenarios would account for 13% and 18% of the national target, respectively. Consequently, improved stoves and household fuel-switching support climate mitigation and offer higher quality energy services. Urban households will save on fuel expenditures, while rural households can avoid the drudgery and drain on productivity associated with fuelwood collection.

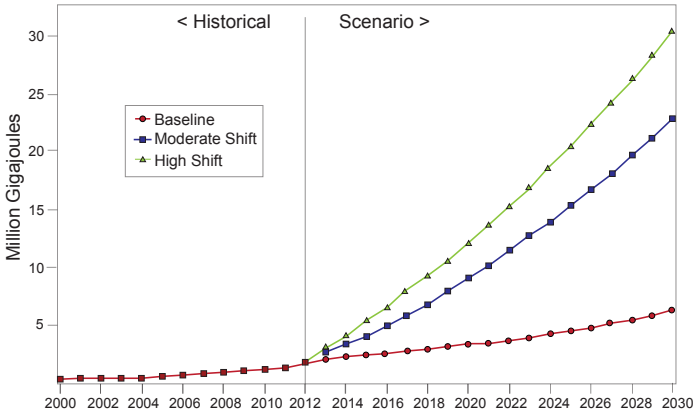

Figure 2: Electricity demand for cooking under the three scenarios in Ethiopia

Table 3: Estimated annual wood savings for the scenarios (million tonnes of wood)

	Savings in 2015			Savings in 2030		
Measure/scenario	Baseline	Moderate Shift	High Shift	Baseline	Moderate Shift	High Shift
Improved cook stoves	0	6.67	8.89	0	33.08	44.10
Fuel-switching	1.54	3.35	4.48	3.95	18.78	25.06
Total	1.54	10.02	13.37	3.95	51.86	69.16

Table 4: Estimated annual GHG savings for the scenarios (million tonnes of CO_2 equivalent)

	Savings in 2015			Savings in 2030		
Measure/scenario	Baseline	Moderate Shift	High Shift	Baseline	Moderate Shift	High Shift
Savings from improved cook stoves	0.0	4.9	6.5	0.0	24.3	32.3
Savings from fuel-switching	0.7	1.5	2.1	1.8	8.6	11.5
Total	0.7	6.4	8.6	1.8	32.9	43.8

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Policy implications

Realizing these bioenergy shift scenarios would require rather aggressive policy actions, due to the income constraints of all but the wealthiest households, the uneven availability of electricity and improved cookstoves, and the lack of physical infrastructure and supporting institutions. Electricity access and affordability will have to be rapidly expanded and/or improved in urban areas, while improved stoves will need to be made widely available in rural areas. In peri-urban areas, other solutions may be appropriate, including off-grid electricity access and wider distribution options for alternative fuels.

The analysis summarized here has focused on the resource implications of bioenergy shifts but has not analysed or simulated in detail the implementation of specific policy mechanisms to achieve these shifts. However, given that there are significant potential economic savings as well as environmental benefits, there seems to be wide scope for inducing a major shift away from inefficient uses of biomass. The following issues can be highlighted:

- Awareness creation at all levels (household, community, national) can articulate the benefits of improved stoves and modern fuels, including the value of reducing female drudgery, reducing and pollution and saving valuable biomass resources.
- Local production of improved stoves should be encouraged in order to offer new economic opportunities in rural areas, through measures, to stimulate innovative designs and offering operational, financial and marketing training.
- Incentive schemes for improved stoves and fuel-switching can be based on micro-finance, carbon credits and competitive procurement; markets need support in early phases when unit costs are high.
- Supply chain and infrastructure development for modern biomass supply options (such as pellets) along with logistical systems for improved stove delivery are crucial for upscaling and will generally require local distribution centres or coordinators.
- Establishing decentralized institutional capacity is needed to match the wide variation in demand in urban, peri-urban and rural areas, and the range of actors involved in biomass resource supply systems. Interdisciplinary departments and training courses at universities can support the detailed analytical capability needed to monitor and evaluate progress.
- Improving biomass resource management through tree plantations, agro-forestry, rehabilitation of degraded lands and more efficient charcoal production systems will be required in order to create a sustainable biomass supply for an expanding population.
- Implementing energy standards and management systems is important for both the technical and operational sides of bioenergy supply and demand. User acceptance of improved stoves will depend on reliable testing procedures, warranties and quality assurance. Fuel-switching will also require standardized procedures and accepted management systems that are verifiable and replicable.
- Ensuring availability of fuels to meet household demand is needed to facilitate market expansion. For example, in the case of bioethanol, some supply must be reserved for households, since transport demand constrains availability for households.

Deforestation and land degradation are serious problems in Ethiopia. Above, Sentbege, in the Amhara region.

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