Climate and Health Impacts of Biomass and Petroleum Energy Futures in Africa

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Biomass fuels are vital to economic activity and welfare in developing nations, especially in sub-Saharan Africa (SSA). Biomass meets more than 90% of the household energy needs in many African nations, used largely in the form of wood, dung, and agricultural residues in rural areas and at end of a charcoal production and supply chain in urban centers. Even in countries with large endowments of fossil fuels like Gabon, Angola, and Nigeria, biomass is a significant source of energy. Pyrolytic conversion and combustion of biofuels results in emissions of greenhouse gases (GHG) and a mixture of pollutants that is a cause of respiratory diseases and mortality with an estimated 1.6 million annual deaths globally (400,000 in SSA). Population growth and urbanization are expected to significantly increase biomass use in SSA, and increase pressure on biomass resources which are already managed unsustainably in most regions. We estimated future greenhouse gas emissions and mortality from household energy use, including the role of technological change and land management.

We developed a database of current biomass use in Africa, and a range of scenarios for household energy futures up to 2050. Current national-level energy production and consumption estimates (Figure 1) were from the United Nations Food and Agriculture Organization's (FAO) biomass energy database and the International Energy Agency's (IEA) statistical database of non-OECD countries. FAO provides biomass production and trade data from 41 countries in the region, including separate estimates for charcoal. IEA provides information on biomass and fossil fuels used in the residential sector from 21 countries in the region individually, as well as a single estimate for remaining countries. Data were checked for (i) consistency of estimates for each fuel type from FAO and IEA; and (ii) consistency of estimates for across fuel types from IEA.

Fraction of households using each fuel was from nationally representative welfare surveys in the 1990s compiled by the World Bank in 21 countries. These countries covered 47% of the region's urban population and 63% of the rural population. For other countries, population-weighted average of the countries that are represented was applied, separately for rural and urban populations. South Africa was excluded from the weighted average, because it has very different patterns of household fuel consumption than other countries in the region. The estimates show that currently a large proportion of Africa's rural and urban households use biomass as their primary source of energy, mainly in the

form of fuelwood in rural areas and charcoal in urban centers. The remaining household rely on a combination of kerosene, liquefied petroleum gas, and electricity.

The scenarios for household energy futures are based on technological change and land management, and account for population growth and urbanization. Economic growth and infrastructure development, the main drivers of change in energy technology, have been lowest in Sub-Saharan Africa, limiting shift to non-biomass resources among households in a business-as-usual scenario (even in countries like China, with rapid economic growth and infrastructure expansion, solid fuel use among households has exhibited little change). In addition to business-as-usual, one class of scenarios focus on shift from wood to charcoal. In most sub-Saharan African countries, charcoal can be purchased in small quantities and requires no expensive equipment to use; it is relatively clean, safe, affordable and storable. Therefore charcoal is the preferred fuel for most urban households as well as an increasing number of rural families. Charcoal production and marketing also provide employment for a large number of people. The other class of scenarios envision large-scale adoption of fossil fuels (kerosene and liquefied petroleum gas, LPG), the common alternative to biomass fuels in high- and mid-income societies.

For each fuel, we estimated emissions of CO_2 and non-CO_2 GHGs at all stages of production and delivery including factors such as ecosystem carbon storage, permanence, leakage, and the storage of carbon in long-lived products. Firewood is not typically associated with "upstream" (production) emissions. Charcoal, which is a process of intentional incomplete combustion, and fossil fuel production both lead to substantial emissions. Both upstream and end-use emissions were converted into CO_2 equivalent units using 100-year Global Warming Potential (GWP) to account for the differential warming effect (radiative forcing) of each emitted GHG. We present emissions of GHGs targeted within the Kyoto Protocol: CO2, CH4, and N2O. This omits the potentially significant, but uncertain warming effects of other combustion emissions like carbon monoxide (CO), non-methane hydrocarbons (NMHCs), and aerosols or particulate matter (PM).

The estimated health effects of various fuel scenarios included mortality from lower respiratory infections (mainly pneumonia) among children under 5 years of age and chronic obstructive pulmonary disease (COPD) among adult women. The implications for energy, climate, and public health policies are discussed.