An Energy Model for a Low Income Rural African Village

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This paper establishes and compares options, first using the MARKAL and then TIMES modeling frameworks, to optimally provide safe, reliable and affordable energy services to a typical rural village in Africa. It does this in the context of improved descriptions of fuel use patterns in the modeling frameworks. The modeling then allows the investigation of options which improve health effects associated with the village energy system, reduce the workload and/or cost, and shed some light on energy transition trends.

Energy use is closely linked to quality of life in rural Africa. Thousands lose their homes in fires caused by paraffin stoves or candles. Exposure to biomass smoke is a significant cause of health problems such as acute respiratory infections (ARI) in children, chronic obstructive lung diseases, lung cancer and pregnancy-related outcomes. Global estimates show that about 2.5 million deaths each year result from indoor exposure to particulate matter in rural and urban areas in developing countries (Bruce et al. 2002). Furthermore, children are poisoned by drinking paraffin, and the gathering of fuelwood is a strenuous and time consuming task mainly performed by women.

By applying the use of energy models, this paper analyses the energy consumption patterns of a surveyed non–electrified rural village. The behavior of rural households in energy matters is not well understood or documented, as can be seen by the failure of past attempts to model rural energy systems. Predictions on the effects of electrification have, in particular, been off target.

In a previous study (Howells et al. 2002) deficiencies in earlier studies were highlighted and suggestions for improvements were made. It was also shown that the inclusion of externality costs changed the least cost energy supply towards cleaner fuels. In this study unsatisfactory simplifications (using the MARKAL framework) have been improved by introducing a higher time-slice resolution and improving other features of the model (made possible in TIMES). This allows for the description of appliances used to meet more than one energy service concurrently, as is often the case in low income rural village settings, and further, to look at these in the context of low cost electrification and accompanying demand side management. Recent and planned surveys have been compiled to address energy planning issues and to increase the accuracy of results in the context of this modeling.

The paper reports load curves for energy demand activities such as cooking, heating and lighting and identifies least cost supply options. The work describes and captures the unique behavior and needs of low-income rural households in the MARKAL/TIMES modeling frameworks, and contrasts these. Selected links between energy development, health and poverty issues are investigated and discussed. The need to further develop the approach taken, and potential alternatives to the modeling framework chosen are also discussed.

References:

Bruce, N., et al, 2002, 'The health effects of indoor air pollution exposure in developing countries', World Health Organisation,

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