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# Calabashes for kilowatt-hours: Rural energy and market failure

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ABSTRACT

This paper describes how management and information failures can retard transitions from the traditional use of biomass fuel by low income rural consumers and micro-producers.

In general, societies move away from traditional biomass use as economic development takes place. If one accepts the doctrine of revealed preference (built on the initial work of Samuelson, 1938), then these trends imply that such transitions provide net gains in utility. This paper shows how various "failures" entrench existing fuel use patterns—hindering the transition to new fuel use patterns.

In order to qualitatively discuss how these transitions may take place, an indicative neo-classical description of consumer and producer behavior is used. Three types fuel-transition "driver" are identified. The effect of information and management failures on these drivers, and thus the energy transition, is discussed.

Reference is made to a specific case study in which a partial transition from biomass occurred in response to an intervention to address an environmental management failure (the deforesting of a carbon sink.)

It is concluded that interventions to encourage transitions to cleaner sustainable fuel use may need to recognize and address management and information failures in a systematic manner.



## 1. Fuel transitions

Services derived from fuel and appliances are often termed as 'useful-energy-services' (see Loulou et al. (2004)) and include for example lighting, cooking, crop-drying, etc. Fuel provides a service when it is used in an appliance (such as a kettle or fireplace) or productive technology (such as a lathe or fridge use to preserve foods for sale). There may be apparent anomalies in fuel and appliance selections. While utility flows from the service, some status goods also provide utility in themselves (the designer samovar or pot-belly stove). Moreover, a wealthy household may use an "inferior" woodburning fireplace or barbeque for heating and cooking. Such options provide "recreational" utility, rather than meeting basic needs.

A fuel transition has been described (Elias and Victor, 2005) as a change from one fuel source to another. In this paper the description is augmented to include changes in fuel use *and*, *or* appliance use, i.e. it is not limited just to fuel switching. Examples of this expanded definition of a fuel transition would include the following:

- No change in the *type* of fuel used for a particular service, but a change in the *way* it is used. (e.g. replacing a traditional fuel-wood stove with a more (thermodynamically) efficient wood-stove. Though the stove is changed, wood is still consumed. However, the transition may result in the consumer using less wood to achieve a similar quantity of cooking service, or the consumer using similar quantities of wood, but achieving more of the cooking service.)
- The consumption of a new energy service. An example includes the purchase and use of a battery powered radio for the first time. A new fuel is used, a new appliance owned and a new energy service consumed.
- The substitution of one fuel and appliance for another, e.g. heating water in an electric kettle, rather than in a pot on the stove. The same outcome is attained, but different appliance and fuel used.

Often only fuel switching is considered in the literature, but to do so clearly excludes other important aspects of fuel use.

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Fuel transitions are an integral part of socio-economic development as well as development's impact on the environment. In poor rural areas, households can spend several hours collecting fuel-wood daily—often the unenviable chore of women and children. Over a million people die annually due to indoor smoke (WEC/FAO, 1999) associated with poorly ventilated biomass use. To this one can add the greenhouse gas implications of destroying forests, which act as carbon sinks. Amongst other causes, deforestation takes place from over-harvesting fuel-wood (WRI, 2000; SADID/DWAF, 2002; Scholes and van der Merwe, 2000). Without energy, industrial or commercial activity cannot take place and income generation limited. Without access to, and the transition to, affordable forms of clean appropriate energy, many of the world's poor are 'locked into' livelihoods, which are often unnecessarily environmentally damaging, unhealthy and uneconomic. Producers may be unable to increase their competitiveness, and economic development may be obstructed.

Conversely, after economic development, households and economies generally move away from freely harvested biomass to cleaner[1] and more productive energy sources (Victor and Victor, 2002). We will assume that consumers and producers wish to use more convenient, cleaner, and less costly and more productive forms of energy. Certainly this is the trend of history (Nakicenovic et al., 1998). This is not to say, for example, that households will not in the future derive utility from fuelwood, or that multiple fuel use will not continue, given a choice. However, it is assumed that for the *bulk* of basic needs the household desires to move from one end of the so-called energy ladder[2] (Eberhard and van Horen, 1995) towards the other. (If one accepts the doctrine of revealed preference (built on the initial work of Samuelson, 1938), then these trends imply that such transitions provide net gains in utility.)

It should also be noted that many earlier transitions were "driven" by circumstances of technological development. (For example, the development of, and access to, steam engines drove up the consumption of coal for motive power during the industrial revolution in several now developed countries. Before the steam engine, that transition was not possible.) However, this discussion generally focuses on factors other than technology development. It rather considers transitions in a setting where technologies and their associated fuels exist, but their uptake – for other reasons (such as limited access, etc.) – is hampered.

Moving to a taxonomy to discuss the dynamics of fuel transitions, it is convenient to use the terms "primary", "circumstantial" and "informational" to classify the drivers of fuel transition.

## 2. The primary driver of energy transitions

Neo-classical economics typically describes consumers/households and producers/firms as "maximizers", either of utility or of profits. Over time changes in energy sources and energy using technologies provide utility in differing degrees and at different costs to the consumer. Maximizing utility therefore creates a "desire" for transitions, albeit subject to a household budget constraint. Utility maximization is taken as the 'primary driver'.

The neo-classical system uses perfect competition as a benchmark. This is a system in which there is full and symmetrical information, a single homogeneous product, no market power and frictionless exchange, while both production and consumption are free of externalities. Since these properties are hardly characteristic of the real world, markets do not always work 'as they should'. Collectively, evidences of such instances are called 'market failures' or market "distortions". This paper refers to information and governance failure as such a cause of observed market failure. It does not argue that a market simply "fails".

### 2.1. Energy and utility in production

In the neo-classical description, the *producer* in a cash or barter market will favor fuel-technology options that minimize costs and/or provide new services from which profit can be derived. For example if boiling water is required to make tea in an eating house, the choice between a cooking pot on an open fire or an electric kettle depends only on which of the two can be operated most cheaply (in terms of both money and time). If the eating house owner wants to serve cold beverages, biomass burning technologies are no longer relevant. In this case the purchase of a fridge is not related to cost minimization as much as it is to do with the profitability that could be derived from the new service. Then the choice rests between paraffin, gas or electric refrigerators. All are commercial products so if the services are equivalent the decision is made on the basis of simple monetary cost efficiency alone.

### 2.2. Energy and utility in consumption

Many of the considerations that inform producer choices also inform household fuel choices[3] consumption. Cost again is an important consideration, with relative cost determining the choice between two fuel–appliance combinations otherwise perceived[4] to be identical by consumer. Unlike firms, where only profit maximization is assumed to matter in adopting a new technology, a consumer can derive satisfaction from mere ownership; one may value the status of an electrical fridge even if other cheaper options exist (a fuller analysis of such issues was developed by Liebenstein (1950)). Such "utility" is difficult to measure. It is assumed here, however, that cleaner more convenient energy and appliances that provide new services (associated often with the richer or developed country user) are probably desired.

## 3. Circumstantial 'drivers'

Consumers (and producers) attempt to maximize their utility (or profitability) subject to constraints. As these constraints change, so may their purchases of energy consuming appliances, and their energy usage patterns. Constraints or changes in constraints due to interventions that affect the fuel transition are termed '*circumstantial drivers*'. As these are often constraints

[1] While few fuels are more hazardous to health than "traditional" biomass (see Eberhard and van Horen, 1995), it should be noted that during much industrialization, energy-use was not 'clean'. (Consider for example deadly smog events in London during the early 20th century—fueled in part by "commercial" coal.)

[2] The term energy ladder is often used to describe the generally observed trend of households moving from the use of biomass and candles, to kerosene, to electricity and gas, when meeting basic heating and lighting needs.

[3] In this discussion, entire households are considered as 'consumers'. This note does not attempt to dissect the role of agents within households, though aware that therein lies critical and oft overlooked issues relating to the role of gender. Given that much biomass collection in poor rural areas is undertaken by women, transitions to cleaner, less labor-intensive energy use could play an important part in enhancing their welfare (UNDP, 2001).

[4] Note that perception is important. An otherwise identical good can be perceived to be of higher quality if its price is higher (Shiffman and Kanuk, 1997), or to impart higher status if others cannot afford it. Hence, cost competition between rival services or goods is most important when the goods are perceived as otherwise close to equal.