Influence and Counter Measures for Combating Monetary Inflation on A4 Paper Waste Recycling Industry in Sri Lanka

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Abstract

Waste recycling is an important activity for the Local Authorities (LAs) to protect the health of the population and environment while prolonging the life of landfills. Recycling industries are constantly subjected to variations in transportation costs. The commodity prices too are affected with the escalation of fuel prices. The monetary value of the commodity can be considered to be the value of refined diesel in terms of energy, conceptually termed Commodity Price Energy Equivalent (CPEE). CPEE was applied as a test on A4 size paper, separating each of the energy flows in terms of percentages indexed to paper production E_p, residual energy E_r and services and transport E_s. It resulted in 0.20, 0.27 and 0.53, respectively for the current year. In recycling, these values became 0.14, 0.27 and 0.59. It provided a higher profit, as long as transport costs were low. In addition, residual values were profits for the producer and seller, thus made the paper worthless. In 2000, the values were 0.12, 0.17 and 0.71, respectively. Inevitably, the indexes of production and wastes have increased, while profits dwindled. Such reductions were due to exponential increase in diesel prices expressed as $24.93e^{0.123t}$ and paper responded to inflation of $152.7\ e^{0.101t}$. In 2023, the price gap will be Rs 360/L for diesel and over Rs 1,200 A4 paper packet. Instead of Life Cycle Cost (LCC) calculations, CPEE indexing can provide host of information, like converting paper wastes to electricity or bio-char in combating inflation, thus Hotelling rule can be applied with modifications.

Key words: Energy Equivalent, Hotelling Rule, Inflation Paper Recycling, Waste to Energy

Introduction

The local authorities (LA) in Sri Lanka are now making an effort to manage the solid wastes generated. It is an important part of urban infrastructure development to ensure protection of the human health and environment. The total collections of the generated wastes may amount to 60% or less. Some of these wastes are recycled through the informal sector before and during the collection process by the LA's. As far as environmental friendliness is concerned, recycling activities make significant positive influences by preventing green house gas emissions and water pollution, saving energy by avoiding virgin production process chains as well as diverting the waste from landfills and incinerators (Menikpura *et al.*, 2012).

This study was conducted to examine the gravity of the problem of escalating costs of fossil fuel prices on the future status of paper recycling. The monetary value of the commodity can be considered to be the value of refined fuel in terms of energy. It is an example for future research and a directive to promote recycling options of recycle paper and products or waste to energy, bio-char from wastes etc. to offset inflation. One or many options can become realistic in a life cycle perspective.

Materials and Methods

A brief literature review on global environmental impacts of the pulp and paper industry provided the basis of calculating the unit cost of one A4 sheet from virgin or recycled paper pulp. It was then converted to energy based on the price of refined diesel, instead of a petroleum barrel. The assumption is that the cost of refining, thus the energy used in processing the crude petroleum to diesel is also taken into account in this analysis. The other assumptions are given in the indices below. Thus, the proposed CPEE model is based on energy flows from 'cradle to grave' of one sheet of paper.

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Therefore,

$$C_d = \frac{\text{Cost of single paper}}{\text{Cost of a litre of diesel}}$$

$$M_d = C_d \times p$$

$$CV_d = M_d \times HHV$$

$$E_p = \frac{E_c}{CV_d}$$

$$E_r = \frac{CV_w}{CV_d}$$

$$E_s = 1 - E_p - E_r$$

Where;

C_d= Paper cost equivalent in diesel,

M_d= Mass of diesel equivalent,

ρ = Density of diesel,

CV_d and CV_w= Calorific value of diesel equivalent and waste paper, respectively,

HHV = High heating value of diesel and

E_c= Actual energy consumption for paper production.

CPEE can provide indices for;

E_p, E_s and E_r= Indices for energy contents (used) in paper production, waste discarded and in providing services(human energy), including transport.

A realistic approach was needed, thus mathematical expressions were developed for past prices of diesel (Central Bank, Sri Lanka, 2012) and A4 paper from available records. In order to relate these equations, mathematical relationships were obtained for inflation with respect to inflation coefficient, thus allowing predictions for future years. A simple comparison was made between Hotelling Rule (Krautkraemer, 1998) and the findings. Also Life Cycle Cost (LCC) is discussed. The limitation to material recovery is highlighted. In its place, Waste To Energy (WTE) and bio-char options were analyzed.

Results and Discussion

The demand for paper will increase from 40% to 50 % of industrial tree loggings in the world. The North Americans are reducing paper use, but still consuming 200 kg/capita in comparison to the reset 50 kg/capita. It takes 17 Wh to produce one A4 sheet of paper weighing 5g. The energy content gets reduced to 12 Wh/sheet when recycling paper is used to make, now good quality paper(US EPA, 2005). In plugging these values in to the equations in materials and methods with all the other variables such as present diesel price of Rs. 125/L with an energy content (HHV) of 44,800 kJ/kg at a density of 0.832 kg/L and HHV of paper of 17,000 kJ/kg (Menikpura and Basnayake, 2009), gave E_p = 0.20, E_r= 0.27 and E_s= 0.53. In recycling, these values became 0.14,0.27 and 0.59, respectively. In effect, the profits could then be the difference between value added and actual human energy in providing the labor, knowledge base, creativity and services. The additional profits could very well be environmental costs E_r of 0.2, which is at present Rs. 142.40 out of Rs. 520 per packet of A4 paper, making the wastes worthless. When cost of transport increases, profits derived from recycling will end up as greenhouse gas emissions.

In year 2000, E_r was 0.1 when price of diesel was Rs. 26.50/Land then gradually increased to 0.2 in 2007. The price of diesel was Rs.75/L. Thereafter, it reduced to 0.19 in 2011, when the diesel prices reduced to Rs. 73/L. There was a sharp rise in 2013 to Rs. 125/L. As a result of changes in diesel prices, there were noticeable fluctuations in price of paper. The profits in proportion must have reduced from E_p of 0.71 to 0.53. The large scale recycling in many parts of the world must have had an effect on lowering the prices in comparison to fuel. The general trend in increasing prices can be attributed to inflation. If inflation remains static year after year, it is an exponential function from year one to n^{th} year (Craude, 2012). It can be expressed as a e^{kt}. It is then a straight line between inflation, say 10% to 14% and the inflation coefficient (k), resulting an expression for inflation I =111k-0.525. The functional

relationships between year 2000 and 2013 for diesel and A4 prices, gave $24.93e^{0.123t}$ (R^2 0.946) and $152.7\ e^{0.101t}$ (R^2 0.951), respectively for t years and corresponds to 13.13% and 10.69% inflation. The gap between the two will increase tremendously in the next ten years to Rs. 379/L of diesel and over Rs. 1200/paper packet, thus making recycling unprofitable due to high cost of transport, lowering E_s to 0.40, while increasing E_r to 0.35or there could be very high inflation. The measures that can counteract to reduce inflation are improved technology through investing maximum profits from developed human resources and efficient production systems.

In the Sri Lankan context, this gap can be narrowed by converting the wastes to energy, rather than recycling all of the wastes back to paper and paper products. As an example, the paper and cardboard wastes of 8.3MT/day now dumped in Gohagoda dumpsite of Kandy Municipal Wastes that can be converted to electricity, will provide a revenue of Rs. 74 million/annum, considering a plant factor of 0.8 and conversion efficiency of 25%. The value of this revenue in comparison toA4 paper packet, works out to be 11.8%. It is then one of the best practices to negate inflation. Alternatively, the bio-char productions yielded a value of 05%, at a sale price of Rs. 35,000/MT of bio-char. CPEE on other commodities can be done to determine alternate means of combating inflation.

The findings are somewhat in line with the Hotelling Rule, which is based on profit and discount rate of none renewable resources like petroleum, controlled by the exploiter. Thus, it states that the net price of the natural none renewable resource must grow at the rate of interest (Krautkraemer, 1998). It could be mathematically interpreted to be proportional to the rate of interest with a rate constant equating interest rate to inflation. Notably, the interest rate too on average over number of years will yield an exponential function.

The present analytical tool of LCC entails capital cost + operation and maintenance costs + environmental costs (Menikpura *et al.*, 2012). The latter is dependent on complex issues of willingness to pay. Therefore, new approaches are needed to support recycling companies with Government supported loan sand stakeholder investments.

Application of the CPEE model is a useful tool to select the best technological option for overcoming some of the environmental impacts arising from land filling solid wastes. Diverting wastes from landfills and converting them to energy and power is a means to surmount present levels of inflation arising from fossil fuel use.

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