Renewable Energy 63 (2014) 432–444

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Energy consumption projection of Nepal: An econometric approach

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ARTICLE INFO

Article history:
Received 6 February 2013
Accepted 27 September 2013
Available online 19 October 2013

Keywords:
GDP
Total primary energy consumption
Fossil fuels
Renewable energy
Nepal

ABSTRACT

In energy dependent economies, energy consumption is often linked with the growth in Gross Domestic Product (GDP). Energy intensity, defined herewith, as the ratio of the total primary energy consumption (TPE) to the GDP, is a useful concept for understanding the relation between energy demand and economic development. The scope of this article is to assess the future primary energy consumption of Nepal, and the projection is carried out along with the formulation of simple linear logarithmic energy consumption models. This initiates with a hypothesis that energy consumption is dependent with the national macro-economic parameters. To test the hypothesis, nexus between energy consumption and possible determinant variables are examined. Status of energy consumption between the period of 1996 and 2009, and for the same period, growth of economic parameters are assessed. Three scenarios are developed differing from each other on the basis of growth rates of economic indicators: total GDP, GDP-agriculture, GDP-trade, GDP-industry, and other variables including growth in private consumptions, population, transport vehicles numbers, prices of fossil fuels etc. Scenarios are: Business as Usual (BAU), Medium Growth Scenario (MGS) and High Growth Scenario (HGS). Energy consumption in all the sectors and for all fuel types are not statistically correlated with every economic parameters tested in the assessment. Hence, the statistically correlated models are included in the prognosis of energy consumption. For example, the TPE consumption and electricity consumption, both are significantly dependent with the total GDP and population growth. Likewise, fuel wood consumption is significantly dependent with the growth in rural population and private consumptions. In BAU the estimated electricity consumption in 2030 would be 7.97 TWh, which is 3.47 times higher than that of 2009. In MGS, the total electricity consumption in 2030 is estimated to increase by a factor of 5.71 compared to 2009. Likewise, in HGS, electricity consumption would increase by 10-fold until 2030 compared to 2009, demanding installed capacity of power plant at 6600 MW, which is only from hydro power and other centralised system.

1. Introduction

There have been significant debates on the causal relationship between energy consumption and economic growth [1–6]. The understanding of the correlation between energy consumption and economy is highly relevant to policy makers. Realising this fact, this article assesses short-run econometric models of primary energy consumption of Nepal. Historical trends of the TPE consumption have a determinant role in analysing the energy situation of any economy, whereas on the other hand, when the economic structure changes it can also have a bearing on the energy supply and demand [7,8]. Thus the historical energy consumption pattern generally facilitates to delineate the future energy system. Assessment of the future energy consumption in relation to possible growth in economy is also important in the process of formulating conducive development plans and policies. Likewise, it is also relevant to identify the measures of energy diversification in such events.

Nepal is hugely dependent on the imported fossil fuel, despite the country has massive hydro power potential [9]. During fiscal year 2000/2001, import of the petroleum products was equivalent to 27% of the merchandise exports. With an annual average growth rate of 10%, spurred by rising power outage, in 2008/2009 the country spent NRs[1] 41.4 billion or 61.5% of its export earnings (NRs

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[1] 1$ = NRs 89.17 NRs, at June 18, 2012 price.

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http://dx.doi.org/10.1016/j.renene.2013.09.048

67.2 billion) just on petroleum products [10]. This actually exceeded the total export earnings of NRs 40.9 billion from India. Furthermore, estimates show that if oil prices hit US$150 per barrel (up from around US$120 now), then export earnings should be increased by 2-fold just to meet the demand of the petroleum products [10]. This situation reveals that the country has no choice rather than increasing the production capacity of electricity, utilising the available hydro power and renewable sources.

In this article, we discuss about the possible future primary energy consumption of Nepal. Forecasting of energy consumption is based on the formulated simple logarithmic equations, which we discuss in Section 5. Significance and importance of econometric models and as such formulated in this study are rationalised in Section 2. For instance, we discuss about the energy forecasting approaches, including as those of using sophisticated tools and simple linear logarithmic models, and their applicability in different economies. Energy models portrayed in Section 5 are based on the economic indicators that we have discussed in Section 3, and methods are elaborated in Section 4. In Section 6, prognosis of future primary energy consumption is discussed. It should be noted that the prognosis is carried out keeping in mind that the energy consumption would follow the similar pattern as experienced in the last decade, and changes in the energy intensity that would most likely take place in future is determined by their correlation with the economic indicators considered in the models. Prognosis for future energy consumption is carried out for the period of 2010–2030, and 2009 is the base year.

2. Review on energy models and forecastings

There are some debates on the energy and economy relationships. The results on the relationship between energy consumption and economic parameters based on some studies can be summarised into mainly three main categories; no causality, unidirectional causality and bi-directional causality, which are primarily defined on the basis of relation between energy consumption and income [11,12]. Unidirectional causality results can be further divided into two categories: (i) energy consumption causes income, and (ii) income causes energy consumption [11–13]. Furthermore, some distinct schools of thoughts found in understanding the correlation between energy and economy are the "growth hypothesis", "Conservation hypothesis" and "neutral hypothesis" [2,14–17]. The growth hypothesis often convey that energy consumption is a crucial component in economic growth, directly or indirectly as a supporting element to capital and labour as input factors of production. Analogously, a decrease in energy consumption causes a decrease in GDP in an energy dependent economy [11,16–19]. In contrast, the conservation hypothesis states that policies directed towards lower energy consumption may have little or no adverse impact on GDP [16,17,20]. Additionally, economic growth should be decoupled from energy consumption to avoid a negative impact on economic development resulting from a reduction of energy use. The neutrality hypothesis holds that energy and economy are uncorrelated thus reducing energy consumption does not affect economic growth or vice versa [12,21–23]. Hence, energy conservation policies would not have any impact on GDP [21–23]. The relation of energy consumption to GDP depends on the practice of energy generation, transformation and use in an economy [2,22–24]. When considering country-specific studies, the relation of energy consumption to the economic growth is not well attributed, as even in the increased GDP, more or less energy consumption is constant, which concludes that electricity could be a limiting factor to economic growth, and hence, shocks to energy supply will have a negative impact on economic growth [2,24]. However, more conflicting results come from high income and middle income countries, where energy consumption, and economic growth are closely correlated [18,24,25]. Furthermore, unidirectional causality running from economic growth to electricity consumption are argued in the context of developing countries in many studies [1,3,5,6], whereas some studies also support that there can be changes in the direction of electricity consumption and economic growth depending upon their long-run and short-run relationships [26]. One may observe energy intensity in relation to the GDP growth of Denmark that took place in the past three decades, for instance in 1980 and 2009 the energy intensity was 0.998 and 0.595 TJ per DKK mil. GDP at 2000 price respectively, which also indicates that the annual average decrease of energy intensity was 2% [27,28], despite there was growth in economy.

Due to the constant increase in electricity consumption in the last two decades, globally many energy planning and management efforts have been made to avoid electricity shortage and guarantee adequate infrastructures, where much effort have been made on the forecasting of electricity demand using different techniques [29–32]. Yee Yan [32] presented residential consumption models using climatic variables for Hong Kong. Egelioglu et al. [33] investigated the influence of economic variables on the annual electricity consumption in Northern Cyprus and they found that a model using number of customers, number of tourists and electricity prices have strong predictive ability. Mohamed and Bodger [31] studied a model for electricity forecasting in New Zealand, which is based on multiple linear regression analysis, taking into account economic and demographic variables. Similarly, Al-Ghandoor et al. [34] presented a model developed to forecast electricity consumption of the Jordanian industrial sector based on multivariate linear regression of time series in order to identify the main drivers behind electricity consumption. Electricity demand projections for Sri Lanka were carried out based on a time series analysis to show how different time series estimation methods perform; in terms of modelling past electricity demand, estimating the key income and price elasticities, and hence forecasting future electricity consumption [30].

There are some debates, if simple models can produce accurate results similar to those obtained from sophisticated models [35–38], but have been practiced in many developing countries including Nepal, Sri Lanka, as discussed earlier. In Nepal, linear regression models were developed to show the short-run energy consumption forecast for the period of 1988–2002 [7], and the models were formulated using different variables such as population, income, price, growth factors and available energy conversion technologies. Realising these approaches of determining the energy consumption models, and most importantly considering such initiative practiced in Nepal, this article also works with linear logarithmic model to estimate the future primary energy consumption of the country.

3. Energy and economics in Nepal

Energy sources of Nepal are generally classified into mainly three groups, traditional, commercial and renewable sources [7,9,39,40]. Traditional energy sources cover the energy supplied from indigenous sources like fuel wood, animal waste and agriculture residues [9,40–42]. Commercial energy sources are the imported fossil fuels and grid connected electricity. In this article, the grid connected system is defined as electricity generated from big hydro power (>5 MW) and thermal (diesel) plants [40]. Renewable energy is primarily "rural energy" solutions in the context of Nepal, as till date they have been playing an important role in increasing the energy access of the country. Solar photovoltaic technology and Micro/Mini hydro power plants are referred