Proceedings of IOE Graduate Conference, 2016
pp. 41–47

The Effects of Economy of Scale of Production on Energy Mix and GHGs Emissions for the Biscuit Industries of Nepal: A Case Study of Nebico Foods and Confectioneries Pvt. Ltd.

Subash Bhandari [1], Tri Ratna Bajracharya [2]

[1, 2] *Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University*
Corresponding Email: [1] subashsays@gmail.com, [2] triratna@ioe.edu.np

Abstract

This paper examines the effects of increase in production on the energy mix and GHGs emission for biscuit industries of Nepal. Bottom-up LEAP model was used to investigate future energy mix and GHGs emission from the base year 2016 to end year 2030. The energy consumption for the future is based on the capacity utilization factor. Specific consideration for future expansion was made to reflect the growing demand for the product. Empirical findings of the study suggest that the energy demand is expected to grow at 10.05% when the growth of production was assumed 10.00% implying that the total energy demand increases almost at a similar rate of production growth. Furthermore, total energy demand is expected to increase by 23.60% in the year 2023 while the demand for diesel is expected to grow by 33.45% in the same year suggesting that the energy demand increases abruptly with increasing share of diesel in the energy mix when the production capacity is expanded. Furthermore, the proportional increase in GHGs emission during period 2023-2029 is 76% as compared to 74% increase during period 2016-2023 due to extensive use of diesel to power additional load. Such scenario is in direct contrast with the objectives of Industrial Policy (2011) which envisions sustainable and reliable growth of manufacturing sector. The use of more efficient end-use device can reduce the cumulative GHGs emission by 16.15% suggesting significant possibility for GHGs emission reduction by investment in energy efficiency.

Keywords

Economy of scale–Energy mix–GHGs emission–Carbon Intentisy

Introduction

Nepal is one of 25 nations first classified as Least Development Countries (LDCs) by UN in 1971. Of the three indexes used to measure the well-being of a nation, Nepal has made remarkable progress in Human Asset Index (a measure of the level of human capital) between the periods 2012 -2015, exceeding the graduation threshold for the very first time. Nepal has continually exceeded the graduation threshold for Economic Vulnerability Index (a measure of the structural vulnerability of countries to exogenous economic and environmental shocks) in the recent past. Nepal met both the indices, while still being a low-income country. Nepal thus, fulfilled the criteria for graduation for the first time and will be considered for graduation at the next triennial review in 2018 and if verified; Nepal will graduate from LDCs to Developing Nations in 2021. Although, Nepal's performance in the aforementioned indexes has been improving, the same cannot be said about average per capita income. The value of Gross National Index for the year 2015 was mere 659 US$, almost half of the average for the LDCs. Thus, economic growth has to be accelerated as Nepal envisions of being a prosperous nation[1].

1. Problem Statement

Nepal has not followed the footprints that almost all the economies worldwide followed in their development history. Shrinking industrial activities is one of the disturbing features of Nepal's economy. Although manufacturing GDP at current price[1] has increased by

[1] GDP at factor cost is considered to eliminate the effects of taxes.

3.15 folds from NRs 37.70 billion at 2001/02 to NRs 118.98 billion at 2014/15, manufacturing GDP at constant price has only increased by 1.32 folds, i.e. the rise in price has been a major cause for growth than production volume. Figure 1 illustrates annual growth rate of manufacturing GDP and total GDP. The Average Annual Growth Rate (AAGR) of total GDP was 3.66 while that of manufacturing was 1.75 for the period 2001/02-2014/15 suggesting that manufacturing has not been able to keep pace with the overall economic growth[2].

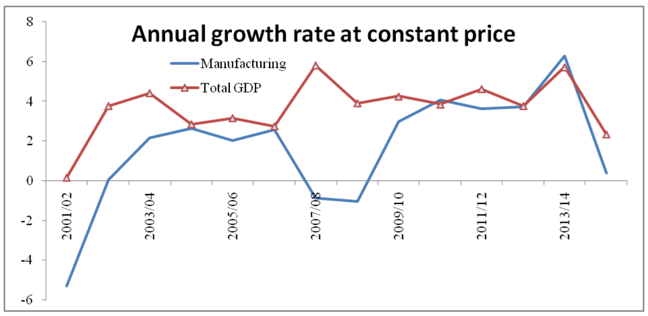

Figure 1: Overview of annual growth of manufacturing and total GDP. Source (Economic Survey: 2015/16, 2014/15, 2006/07)

Figure 2 illustrates major challenges to the industries in Nepal. All the manufacturing industries suffer from low supply of electricity. Lack of skilled manpower and unfriendly labour relations are also the major impingement to industrial development in the country. Interestingly, legal provisions like labour act, industrial policy and environmental act are also regarded as major problems for industries in Nepal. Apart from that, Nepal suffers from access to market and credit.

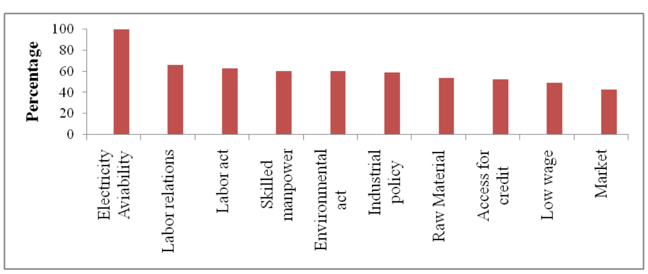

Figure 2: Major problems faced by industries in Nepal. Source (CBS, 2014)

Figure 3 illustrates the ratio of Manufacturing Value Addition (MVA) to output both at constant price, a measure of efficiency of industry. The ratio declined gradually from 0.40 in 1999/97 to 0.28 in 2011/12 with annual decline of 2.30% suggesting that the manufacturing sector also retreated towards more basic industries with low value addition.Thus, for the contribution of manufacturing industries in GDP to grow, the output has to increase. Economy of scale may offer such industries better competitive position, especially when the demand for the product is increasing.

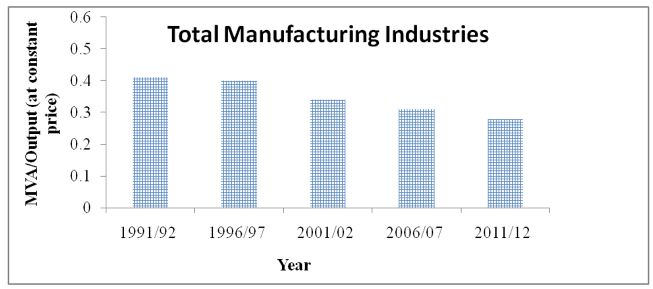

Figure 3: Manufaturing Value addition per output (at constant price). Source (CBS, 2014)

Industrial policy (2011) was formulated to accelerate the pace of industrialization in Nepal. It envisions sustainable and broad-based industrial development to support poverty alleviation. Establishment of sustainable and reliable industrial sector through the use of latest technology and environmentally friendly production process is one of the main objectives of the policy[3]. Since all the industries suffer from the shortage of electricity, it is interesting to investigate the future energy mix and GHGs emission when production is increasing. Such study can be helpful in understanding the fuel types that are expected to be complementing the production growth. Upon the identification of major fuels, appropriate policy intervention can be made to reduce the carbon intensity of the sector.

Biscuit industry being one of the few industries with robust growth in output in recent past is a plausible subject to investigate the effects of output growth on energy mix and GHGs emissions. GIZ (2012) has studied the energy consumption of biscuit industries of Nepal. The average specific energy consumption was found to be 285.58 kWh of electricity and 3,139.18 MJ of thermal energy per MT. CO_2 generation was found to be 380.19 kg per MT of Biscuit production[4]. The study however, does not investigate future energy mix and GHGs emissions.

2. Literature Review

Dhungel (2008) studied the causal relationship between commercial energy consumption and economic growth in Nepal based on Co-integrating and vector error correction model[5]. Empirical findings of the study reveal unidirectional causality from per capita real GDP to per capita electricity consumption. Asghar (2008) has also studied the energy-GDP relationship for five countries of South-Asia, namely India, Pakistan, Sri Lanka, Bangladesh and Nepal[6]. The study is based on Error Correction Model and Toda and Yamamoto (1995) approach. The empirical findings of the study identify no co-integrated relation between GDP and various energy consumption variables. While such study provides valuable insights, Granger causality and Co-integration test is sensitive to variable definitions, choice of additional variables in the model, sample period and size, and the introduction of structural breaks[7].The empirical findings of such studies are mixed and have not reached a general consensus, the findings may vary not only across countries but also on the methodology[8].

As the direction of causality is still inconclusive, researchers have utilized the economic growth to predict the future energy demand. Several studies have been carried out in the past for forecasting future energy demand of Nepal using econometric analysis. Shrestha and Rajbhandari (2010) projected the energy demand of industries in Kathmandu valley with population and GDP as independent variable using log-linear model[9]. The industries were divided into brick industry and other industry due to the high pollution potential of brick industry. Parajuli et al. (2014) also used Double-log multivariate econometric models to forecast energy demand of Nepal according to fuel type and also according to major sectors that consume energy for different growth scenario[10]. The empirical finding of the study fails to identify statistically significant relation between industrial energy consumption and independent variable like total GDP, private consumption, population and GDP-trade, industrial GDP. The author argues that since most industry always face electricity shortage; most firms have their own generators. Due to the unavailability of consistent data on energy used by such devices, it is difficult to identify the relationship between the variables. Gaire and Shakya (2015) have studied energy and environmental implication of graduating Nepal from LDCs to developing nation by 2022 using Long-Range Energy Alternatives Planning (LEAP) framework[11]. The study projects the energy demand for the country by segregating the energy demand for different sectors and region under different anticipated growth rate. The demand in the industrial sector is based on the industrial value addition (IVA). Bhattarai and Bajracharya (2015) projected the future energy demand of manufacturing industries with end use model based on Long-Range Energy Alternative Planning (LEAP) framework[12]. Industrial Value Addition (IVA) was taken as independent variable to predict the energy consumption of industrial sector.

Bajracharya et al. (2014) analysed energy system planning of Nepal[13]. The conclusion of the analysis suggests that sustainable economic growth is not possible without the incorporation of indigenous resources in an efficient way. Shakya et al. (2012) investigated the implication of time variant carbon tax in terms of energy mix, environmental implications, energy security, energy efficiency, energy system cost, and employment benefits[14]. Empirical findings of the study reveal that import of fossil fuels will be reduced due to the introduction of carbon taxes. Furthermore, the carbon taxes are also expected to increase use of renewable resource for electricity generation. Shrestha and shakya (2012) investigated the benefits of low carbon development in Nepal[15]. Empirical findings of the study suggest that the 40% reduction of CO_2 emission target would increase the generation of hydro-power by 16.5% and reduce cumulative fossil fuel import by 42%.

3. Methodology

To study the effects of output growth on energy mix and GHGs emission for the biscuit industries of Nepal, Nebico is selected as an appropriate case study primarily, due to its high share in the domestic market. According to economic survey 2012/13, the total annual production of biscuit product in Nepal was 45,537 metric tons. The production capacity of Nebico was 1,500 tons monthly and operated at 50% of its capacity in 2014[16].

Data Collection

The data of end-use energy devices and their energy consumption of Nebico were collected through questionnaire survey and field visit at Nebico Foods and Confectioneries Pvt. Ltd., Balaju on 6th October, 2016. The secondary data on calorific value of diesel, electricity and petrol was compiled using energy conversion calculator provided on-line by Energy Information administration (EIA). The secondary data on calorific value of wood was compiled online from Oak Ridge National Library (ORNL). The secondary data on energy efficiency were taken from the results of much comprehensive survey of manufacturing industries done by Gwanwali on 2012, published on his master's thesis for the Department of Mechanical Engineering, Pulchowk Campus[17].

Validation of the end-use database

Table 1: Comparison of Energy Demand through end-use database and purchase database

	Purchase Data	End-Use Data	Deviation
Wood(Kg)	96000	90000	6.25%
Electricity (kW-hr)	1258165	1211471	3.70%
Diesel (Lit)	318000	317160	0.40%
Petrol (Lit)		4260	

The high deviation in the firewood estimation may be due to the leakage problems which were not considered during the estimation of the energy demand. Furthermore, as the calorific value of wood varies greatly with wood type, moisture content and oxygen supply; the actual amount of wood used for a particular load is set to vary. Thus, the deviation is accepted as reasonable for firewood. The comparison could not be made for petrol due to the unavailability of data on petrol purchase. The findings of the study however, is expected to remain valid due to its nominal share in the energy mix. The deviation for other fuels is less than 5%. The database is thus accepted as valid for further computations.

Model development Bottom-up end-use LEAP Model was developed to investigate energy mix and GHGs emissions. Both Gwanwali (2012) and Bhattarai and Bajracharya (2015) have taken industrial value addition to project the future energy demand for the manufacturing sector. The method used however, could not be applied to this study due to the lack of reliable yearly data on energy consumption and due to the confidential nature of the data on value addition. Thus, for projecting the energy demand, capacity utilization factor and output growth has been considered.

The following assumptions have been made for projecting the future energy demand:

1. The energy demand depends only on the output of the industry apart from the efficiency of end-use device i.e. final useful energy depends only upon the output.
2. The load on end-use device is proportional to capacity utilization factor.
3. Industry is assumed to grow at a uniform rate of 10% for the study period.

Figure 4 shows the LEAP model developed to assess the energy mix and GHGs emissions.

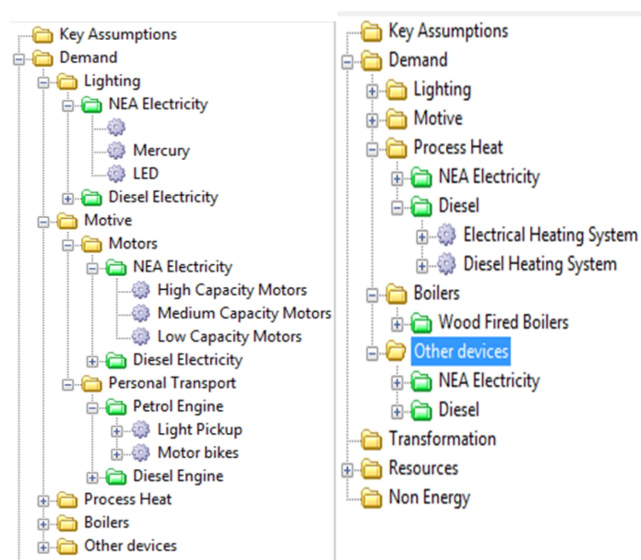

Figure 4: Overview of LEAP Model

The energy demand is based on five end-uses. Categories with energy intensity were created to depict special purpose each end-use was used for. Finally, fuel types were specified and environmental loading based on IPCC tier 1 emission factor was added to all the fuel types[2].

[2]Since IPCC tier 1 for industries does not differentiate the emission from gasoline and diesel, the environmental loading for personal transport is added from transport section.

End-use assumptions: The following assumptions were made during the consideration of the model:

1. The demand for lighting is assumed to be a step function. Lighting demand is assumed to increase only when the production hours increases.
2. The final-useful energy demand for Motors, process heat and boilers, which are integral part of the production process are assumed to grow at a same rate of production growth.
3. The final-useful energy demand for personal transport and other devices, which are not integral part of the production process are assumed to grow at half the rate of production growth.

Scenario Development: Energy efficient scenario (EES) is developed to assess the possibility of curtailing the GHGs emission by the use of more efficient end-use devices against Buisness as usual (BAU). Motors, heating system and boilers are considered for the energy efficiency as they are the integral part of the production process. Table 2 below illustrates the efficiency of different end-use devices used. The efficiency for EES has been compiled from the suppliers claim in www.alibaba.com.

Table 2: Efficiency of End-use devices.

	Efficiency	
Equipments	**BAU**	**EES**
Motor	87.5	92.5
Electrical Heating System	75	90
Diesel Heating System	35	45
Wood-fired Boiler	35	45

4. Result and Analysis

Energy mix by fuel types

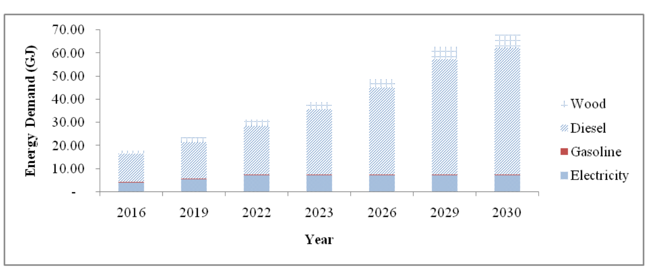

Figure 5: Energy mix by fuel types

Figure 5 illustrates the energy demand for the industry up to the year 2030. The energy demand is expected to increase over three folds from 18 GJ in the year 2016 to 67 GJ in the year 2030 with AAGR of 10.07%. According to the empirical findings of Bhattarai and Bajracharya (2015), the AAGR of the total energy demand for the manufacturing industries of Nepal was 3.60% when the AAGR for industrial value addition was assumed 2.90% for Business as Usual (BAU) case[12]. Considering the declining MVA/Outout ratio, the findings are rather similar. It can thus be argued that the total energy demand is almost proportional to output growth.

Energy mix for the industry shows a fundamental shift in its composition on the year 2023 when production hours is expected to be increased to meet the raising demand of the product, with significant increase in the demand for diesel due to the unavailability of electricity. The annual growth rate for total energy demand for the year 2023 is 23.60% while the demand for diesel is expected to increase by 33.45%. Diesel is expected to remain the primary fuel for the industry throughout the study period, followed by electricity and wood respectively. The share of petrol is expected to remain nominal throughout the study period as it is only used for personal locomotion.

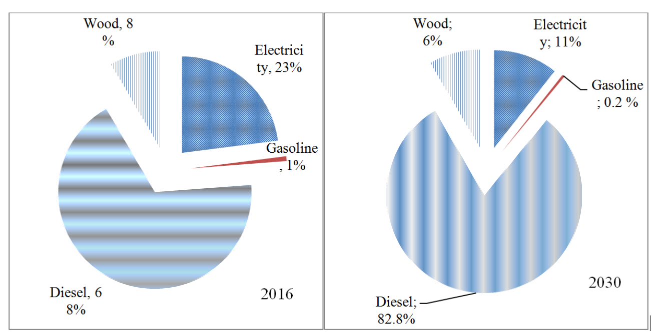

Figure 6: Fuel Composition in the base year and the end year

Figure 6 illustrates the energy mix for the base year and end year. The share of diesel is expected to increase in the future with AAGR of 11.52% from 67.80% in 2016 to 82.80% due to its extensive use in Diesel Generators. The share of electricity in the total energy mix is expected to decrease in future from 23.00% in 2016 to 10.60% in 2030 due to its unavailability. The energy mix reported in this study is quite different from the empirical findings of Bhattarai and Bajracharya (2015), which predict the increasing share of coal and electricity in the energy mix at the expense of diesel. Since Bhattarai and Bajracharya (2015), used the data upto 2009 to project future energy demand, their findings fail to consider the sudden change in energy composition during 2008/09 to 2011/12. The findings of this study is however, in accord with the national scenario. The share of diesel on the energy mix of the manufacturing sector has increased significantly in recent years at the expense of coal and electricity[18],[19]. While the share of diesel in the energy mix for manufacturing industries has increased from 1.80% on 2008/09 to 15.00% in 2011/12, the share of electricity has decreased from 23.2% in 2008/09 to 13.6% in 2011/12. The share of coal has decreased from 57.70% in 2008/09 to 46.20% in 2011/12. Furthermore, nearly 30% of the total coal is used in brick and cement industry[4],[19]. It can thus be argued that, in the context of unavailability of electricity, diesel is expected to be the most preferred fuel for biscuit industries.

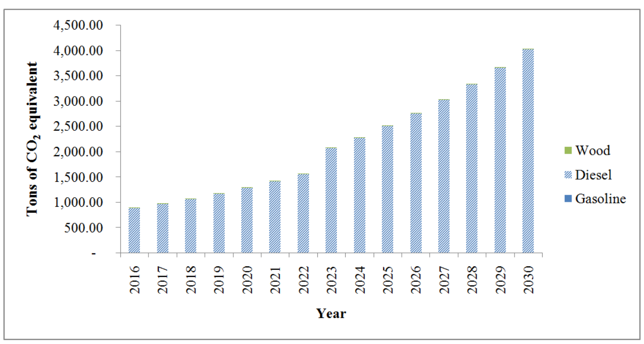

Figure 7: 100-Years GWP by fuel types

Figure 7 reflects the expected emissions by different fuel types up to the year 2030. The emission for the industry is expected to increase over four folds from 898 metric tons of CO_2 equivalent in the year 2016 to 4029 metric tons of CO_2 equivalents in the year 2030. The total annual emission is expected to increases by 33% in the year 2023 alone as diesel will be extensively used to power the night shift. Diesel is expected to be the major cause of emission throughout the study period followed by gasoline and wood respectively. Although the emission is expected to increase in absolute terms, the share of wood and petrol in the emission mix is expected to remain nominal throughout the study period. The emission share from wood is very small compared to its energy share due to the consideration of sequestering in estimating net emission.

Table 3: 100-Year GWP emission during different phases of production (in tonnes of CO_2 equivalent)

	2016	2022	% increase	2023	2029	% increase
Motive	128.54	218.90	70	405.29	708.33	75
Process	761.55	1333.01	75	1655.35	2932.55	77
Overall	898.01	1562.42	74	2080.32	3665.45	76

Table 3 illustrates change in GHGs emissions for proportional increase in production during different phases of its capacity utilization. 100-Year GWP is expected to increase by 74% between the period 2016 to 2022 and 76% between the period 2023 to 2029. The higher value of percentage increase in later years suggests that industry is expected to be more carbon-intensive in the future. Furthermore, the effect is more pronounced for the end-use motive power as electricity is the most preferred fuel for motive power and thus, diesel generators has to be used to power all the additional load.

Figure 8 illustrates the cumulative GHGs emission for BAU and EES. The use of energy efficient end-use energy demand can reduce the cumulative GHGs emissions by 16.15% from 32.10 thousand metric tons of CO_2 equivalents for BAU to 26.92 thousand metric tons of CO_2 equivalents for EES.

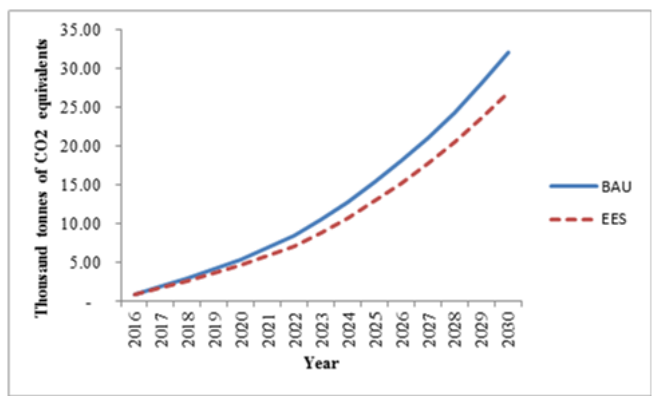

Figure 8: Cumulative GHGs emission (tonnes of CO_2 equivalents) for BAU and EES

5. Conclusion and Recommendations

The analysis of the results above suggests that total energy demand is found to vary almost at a similar rate to output growth. The sudden increase in annual total energy demand by 23.6% in the year 2023 compared to the AAGR of 10.07% for the whole study period suggests that there is abrupt increase in energy demand when new production line is added. Furthermore, the increase in annual energy demand for diesel by 33.45% in the year 2023 suggests the increasing share of diesel in future energy mix. Due to the extensive use of diesel, the emissions in the future are expected to be more. As all the industries in Nepal face severe electricity shortage, the increase in output will be accompanied by rise of diesel share in the energy mix. Due to the extensive use of diesel, the increase in emission of GHGs will be higher than the increase in production i.e. the industries of Nepal will be more carbon intensive. Such scenario violates the fundamental objectives of the Industrial Policy (2011). The use of energy efficient end-use devices can reduce the GHGs emission by 16.15 % suggesting that there is significant possibility of energy saving in the biscuit industries.

Acknowledgments

Authors would like to thank Nebico Pvt. Ltd. for their co-operation during data collection. Authors are grateful to Er. Y. P. Gaire for his assistance during the development of the model. Authors would also like to thank Er. Nabin Thapa, for sharing his expertise on industries during framing of this research. Authors are am grateful to Er. Bikal Adhikari for his assistance during the preparation of the LaTeX format of this research paper. Furthermore, authors are grateful to everyone who has directly or indirectly helped during the shaping of this study.

References

[1] Department of Economic and Social Affairs. The least developed country snapshots 2015. Technical report, United Nations, 2015.

[2] Ministry of Finance. Economic survey. Technical report, Government of Nepal, 2015/16: 2014/15: 2006/07:.

[3] Industrial policy, 2011.

[4] GIZ. Baseline study of selected sector industries to access the potentials for more efficient use of energy. Technical report, GIZ, 2012.

[5] Kamal Raj Dhungel. A causal relationship between energy consumption and economic growth in nepal. *Asia-Pacific journal of rural development*, 14(2):137, 2007.

[6] Zahid Asghar. Energy-gdp relationship: a causal analysis for the five countries of south asia. *Applied Econometrics and International Development*, 8(1), 2008.

[7] David I Stern and Kerstin Enflo. Causality between energy and output in the long-run. *Energy economics*, 39:135–146, 2013.

[8] Ugur Soytas and Ramazan Sari. Energy consumption and gdp: causality relationship in g-7 countries and emerging markets. *Energy economics*, 25(1):33–37, 2003.

[9] Ram M Shrestha and Salony Rajbhandari. Energy and environmental implications of carbon emission reduction targets: Case of kathmandu valley, nepal. *Energy Policy*, 38(9):4818–4827, 2010.

[10] Ranjan Parajuli, Poul Alberg Østergaard, Tommy Dalgaard, and Govind Raj Pokharel. Energy consumption projection of nepal: An econometric approach. *Renewable Energy*, 63:432–444, 2014.

[11] YP Gaire and Shree Raj Shakya. Energy and environmental implications of graduating nepal from least developed to developing country. In *Proceedings of IOE Graduate Conference*, pages 112–123, 2015.

[12] Nawraj Bhattarai and Iswor Bajracharya. Industrial sector's energy demand projections and analysis of nepal for sustainable national energy planning process of the country. *Journal of the Institute of Engineering*, 11(1):50–66, 2016.

[13] TR Bajracharya, SR Shakya, BB Ale, R Shrestha, C Bauer, E Doujak, and S Gossinger. Energy systems planning and analysis in terms of nepal. Conference Proceedings.

[14] Shree Raj Shakya, S Kumar, and Ram M Shrestha. Co-benefits of a carbon tax in nepal. *Mitigation and Adaptation Strategies for Global Change*, 17(1):77–101, 2012.

[15] Ram M Shrestha and Shree Raj Shakya. Benefits of low carbon development in a developing country: case of nepal. *Energy Economics*, 34:S503–S512, 2012.

[16] S. Basyal. Local biscuit makers hold their own against imports, July 2014.

[17] Khem Gyanwali. Demand side management of energy consumption in industrial sector of nepal. Master's thesis, Institute of Engineering, 2012.

[18] Water and Energy Commission Secretariat. Energy sector synopsis report. Technical report, Government of Nepal, 2010.

[19] Water and Energy Commission Secretariat. National survey of energy consumption and supply situation of nepal. Technical report, Government of Nepal, 2013.