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Electricity Demand, Forecast and Scenario Analysis of Shopping Malls, Kathmandu Valley

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Abstract

Commercial sector is one of the important sectors in terms of Revenue collection and fuel consumption in Nepal. Shopping malls are one of the main area among commercial sectors that are arising over Kathmandu and outside Kathmandu also. They are also responsible for high fuel consumption in Nepal. Yearly, a large amount of energy is consumed by the Shopping malls especially the ones with movie theater for providing their services. Considerable amount of non-renewable energy is used by them. The use of inefficient technologies also constitute for high fuel consumption. This leads to the Green House gas emissions and pollution. Energy demand management and selection of efficient fuel for end use technology not only reduces fuel consumption, but also increases the use of renewable energy. The report intends to analyze the energy demand Shopping Mall with movie theatre in Kathmandu valley. As of 2015, there are five Shopping Malls with movie theatre in Kathmandu. A questionnaire is developed and survey is carried out in shopping mall. This primary data will be used to develop a computer model using LEAP software. The base year for the model is taken 2015 whereas the end year is assumed 2022. Different scenarios are developed to predict the future energy consumptions of the shopping mall in different technological situations.They can be categorized according to the services are offered. The categorization includes Clothing, Electronics, Accessories, Coffee Shop, Corporate Office, Grocery, Beauty Parlor and salons, Cosmetics, Movie Theater, Gaming zone, Jewelry, food court and area under management. Among these categorization, movie theatre accounts for high energy consumption, consuming 397750 Kilowatt-hours electricity monthly for all theatre mall. All other consume in similar pattern for individual shops but as a whole due to domination of clothing shops in its number all shop consume 62533 Kilowatt-hours of electricity monthly.

Keywords

Energy Modeling – Shopping Mall – LEAP model

1. Introduction

A shopping mall is a large shopping centre within a roofed structure controlled by a limited number of entrances [1]. Stores and other services are only accessible via interior corridors. These days shopping malls have been an integrated part of urban living for shopping and entertainment purpose and in the commercial sector.The urban population of Nepal accounts for 17% of total population and the rate of urbanization is 3.62% [2]. Kathmandu valley is the largest and most populous urban agglomerate of Nepal [3]. Urbanization and modernization is taking place at a very rapid rate inside the Kathmandu valley. The urbanization has brought along with it a steep rise in energy demand.

Currently, there are five shopping center with theatre in Kathmandu Valley. (Civil Mall, Civil Trade Center Mall, Rising Mall, KL Mall, City Center Mall) which are supposedly consuming high energy than other shopping malls with no theatre. This is logical because the flow of visitors are higher due to these theatre. In addition, theatre mall are using high capacity air conditioner system. Shopping Mall Construction and operation of shopping malls are spreading very rapidly inside Kathmandu Valley and in other cities like Pokhara and Narayangarh.

Kathmandu Valley accounts for 9% of total population of Nepal with the population growth rate of 4.35% and is one of the fastest growing urban agglomerations in South Asia [4, 5]. The number of shopping centers has been increasing every year. People find it easy to shop their requirements in these large shopping centers because they get everything they need under a single roof. These large shopping complexes use a lot of electric machines to run which demands consumption of large amount of electricity. And if we can analyze the electricity consumption in them and find the loopholes, electricity consumption can be controlled in large amount. Thus, this creates a need for analysis of electricity trends in them.

Quite a large quantity of energy is consumed by the Shopping Center sector for its operation. Electricity consumption characteristics in shopping malls in subtropical climates, survey of four fully air conditioned shopping centers built during the 1990s was conducted to establish some energy use characteristics pertinent to shopping centers in subtropical climates [6]. The finding of the paper says air conditioning and electric lighting were the major electricity end uses, accounting for about 85% of the total building energy use. the method use was simple regression analysis.According to energy audits and surveys which have been made for commercial air-conditioned buildings [7], air-condition account for 40-60% of the total electricity consumption with lighting in the second place accounting for the 20-30%.

In order to be able to see and compare the different options for fulfilling and decreasing the energy demand in Shopping Mall, it is important to understand and become familiar with the actual needs of this type of building first [8]. Despite the fact that Shopping Mall is penetrating the building market in a very fast pace, only few studies have been done as regards to the electricity characteristics in shopping malls.Therefore, a thorough study of the energy demand of the shopping mall of the Kathmandu valley for efficient energy planning and management is inevitable. The characteristics of different malls are almost similar as the services provided by these malls and the people visiting are similar. Thus, it can be said that the energy demand analysis of few sample of these mall can resemble shopping mall sector. The main objective is to model the future electicity demand of the Shopping Mall in the Kathmandu valley and analyze the predictions in different scenarios. The energy consumption pattern can be known and then different future scenario is forecasted. Other specific objective is to determine the electricity savings within the shopping Mall.

Escalator and elevator are high electricity consuming device after air conditioner. They are using CFL and LED bulbs in most cases but fluorescent lamp and incandescent bulb are also found in considerable amount.

2. Methodology

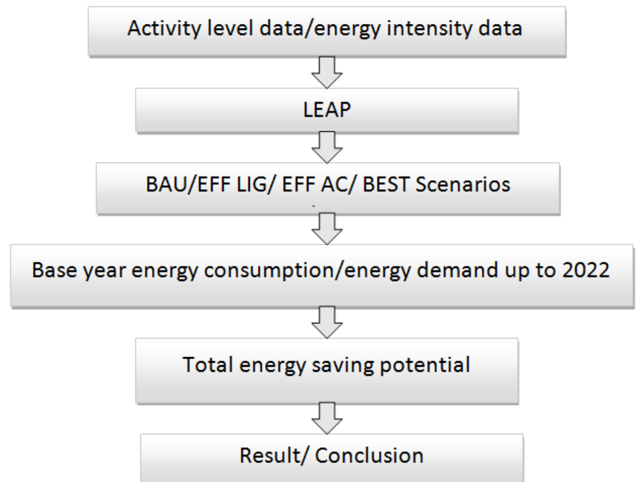

Figure 1: Methodology Flowchart

The activity level data and energy intensity data were interpreted into LEAP. In LEAP modeling, total shopping mall shops is categorized into 14 categorization. New unit shopdays is established. Shop days is total shop of these mall multiplied by days. For instance,shops days for shopping mall is 800 shops multiplied by 365 for annual shop day for all shopping mall. One shop is equivalent to 300 sq. feet of area.

3. Scenario Description

Efficient Lighting Scenario In the base year 2015, 15% of the total energy consumed in the lighting was though incandescent lamps, 15% through fluorescent lamps, 55% through CFL, 15% through LED .The replacement of the inefficient bulbs by the efficient ones also depends upon other factors like the availability of the different wattage bulbs in the market and price. The conversion factor taken in this research was 0.25 for incandescent bulbs and 0.67 for fluorescent and CFL bulbs [9] In this scenario it was assumed that by 2017, 80% of the incandescent bulbs and 25% of the fluorescent and CFL bulbs will be replaced by LED bulbs. Similarly, by 2019, 90% of the incandescent bulbs and 100% of the fluorescent and CFL bulbs will be replaced by LED bulbs.

Improved Air Conditioner (AC) Scenario: Of the surveyed malls, the COPs of the central air conditioners were found from below 2.5 to 3.15. On average the COP of the central ac was found to be 3.5. Nowadays we have AC systems with COP above 4 [10]. Thus in this scenario, it was assumed that the COP of air conditioning systems will improve to 4 by 2017 and to 4.5 by 2022. Here the year gap was kept wider as it is difficult to improve the efficiency of the air conditioning systems beyond certain limit.

Best Case scenario: In this scenario efficient lighting scenario and efficient AC scenarios were added.

4. Results and Discussion

4.1 Business As Usual(BAU) Scenario

The energy demand of the Shopping mall for every categorization has been forecasted using Business As Usual scenario (BAU). In this Scenario, current scenario is being considered. The growth of the shopping mall in the future is also considered. The growth is assumed on the basis of new shopping mall project that is going to be established in near future. All other end use demand values were assumed same. The shops days is assumed to increase by 365000 in 2015 and 100000 in 2022.The growth is assumed on the basis of new project that is going to be developed within 2022.

4.1.1 Total Electricity Demand

Total energy demand of the shopping mall according to BAU is shown in Figure 2 which shows electricity demand of these Shopping malls in the base year 2015 is 4773.9 thousand of Kilowatt-hours, in the year 2016 will be 5960.3 thousand of Kilowatt-hours, in the year 2020 will be 10706.2 thousand of Kilowatt-hours and that in the end year 2022 it will be 13079.1 thousand of Kilowatt-Hours. That is from base year 2015 to end year 2022 the energy demand is increased by 173.97%.

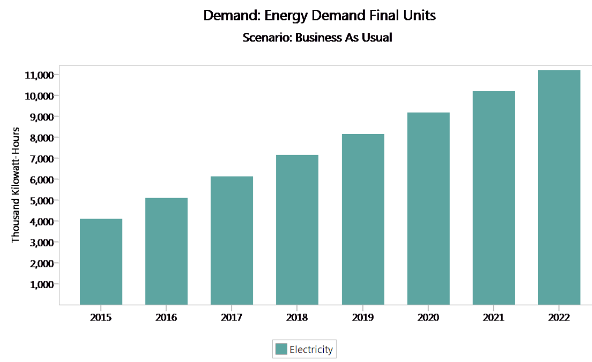

Figure 2: Electricity Demand of Shopping Malls

4.1.2 Electricity Demand Shop Wise

Table 1: Electricity Demand Shopwise(in thousand kilowatt-hours)

Categories	2015	2016	2022	Total
Clothing	750.4	936.9	2056.0	6736.3
Electronics	153.3	191.5	420.1	1376.5
Accessories	292.0	364.6	800	2621.1
Coffee Shop	111.7	139.5	306.1	1003.1
Others	91.8	114.6	251.5	823.9
Offices	101.8	127.1	278.9	914
Grocery	44.7	55.9	122.6	401.7
Salloon	25.8	32.2	70.7	231.6
Coesmetics	121.6	151.8	333.2	1091.7
Theater	2550.3	3184.2	6987.2	22893
Gaming Zone	41.8	52.2	114.6	375.4
Jewellery	124.1	154.9	339.9	1113.7
Foodcourtout	67.9	84.7	186	609.3
Foodcourtin	296.5	370.1	812.2	2661.2
Total	4773.9	5960.3	13079	42852

Table 1 shows the electricity demand in all the shops of each category with the base year 2015, continuing for 2016, 2018, 2020 and the end year 2022. The maximum electricity demand is for the theater at 22893.1 Kilowatt-hour in total, followed by clothing and food court inside at values 6736.3 kilowatt- hour and 2661.2 kilowatt-hour respectively.

4.2 Efficient lighting Scenario

In this scenario all other assumption are same as BAU, except replacement of energy efficient lighting devices. The total electricity demand in the base year 2015 is same as that of the previous scenario. The total electricity demand by shop decreases in the future as compared to Business As Usual scenario because low energy consuming and power saving bulbs and light sources are used here.

4.2.1 Total Energy Demand

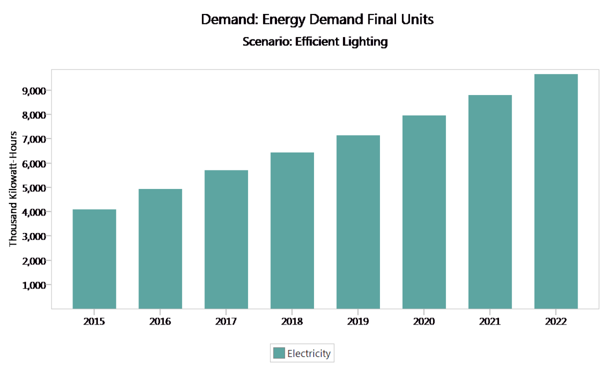

Figure 3: Total Electricity Demand(Efficient Lighting)

Figure 3 plots the electricity demand in thousand kilowatt-Hours against the year for efficient lighting scenario. This shows electricity demand of this Shopping mall in the base year 2015 is 4773.9 thousand of Kilowatt-hours, in the year 2016 it will be 5781.8 thousand of Kilowatt-hours. Similarly, in the year 2020 it will be 9506 thousand of Kilowatt-hours and that in the end year 2022 it is calculated to 11543.9 thousand of Kilowatt-hours. That implies that from the base year 2015 to the end year 2022, the energy demand will increased by 141.81%. There is the increase in electricity demand every year but the rate of increment is relatively lower in comparison to BAU.

4.2.2 Energy Demand Shop Wise

Table 2 depicts the electricity demand in all the shops of each category with the base year 2015, continuing for 2016, 2018, 2020 and the end year 2022. The maximum electricity demand is for the theater at 21669 Kilowatt-hour in total, followed by clothing and food court inside have high values, 5793.4 Kilowatt- hour and 2630.7 Kilowatt- hour respectively compared to other category. But comparing the table with BAU, the total energy demand has decreased by 11.73% in the year 2022 in the later scenario.

Table 2: Electricity Demand Shopwise(in thousand kilowatt-hours)

Categories	2015	2016	2022	Total
Clothing	750.4	887.7	1670.0	5793.4
Electronics	153.3	179.3	325.1	1144.3
Accessories	292.0	343.8	637.6	2224.2
Coffee Shop	111.7	138.8	300.9	990.3
Others	91.8	111.8	229.4	769.9
Offices	101.8	124.0	254.3	853.8
Grocery	44.7	53.9	107.3	364.2
Salloon	25.8	30.9	60.6	206.8
Coesmetics	121.6	143.2	265.4	926.2
Theater	2550.3	3120.3	6486.2	21669
Gaming Zone	41.8	50.7	85.3	321.4
Jewellery	124.1	144.3	136	740.6
Foodcourtout	67.9	84.7	186.0	609.3
Foodcourtin	296.5	368.5	799.8	2630.7
Total	4773.9	5781.8	11543	39244

4.3 Improved Air conditioning (AC) Scenario

In the efficient air conditioning scenario, there is a gradual rise in energy demand every year for each category of shops except that for food court outside since there is no air conditioning outside.

4.3.1 Total Energy Demand

Figure 4 plots the electricity demand in thousand kilowatt-Hours against the year for efficient lighting scenario.

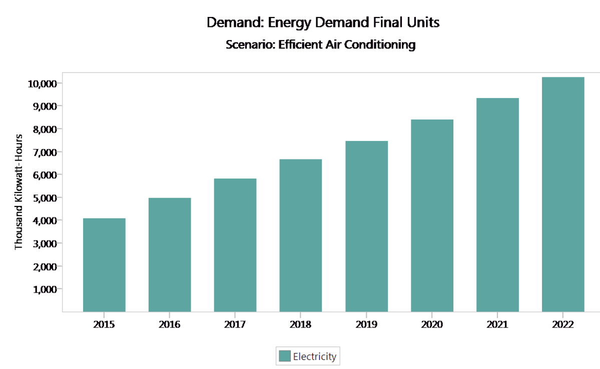

Figure 4: Total Energy Demand (Improved AC)

This shows electricity demand of the Shopping malls in the base year 2015 is 4773.9 thousand of Kilowatt-hours, in the year 2016, it will be 5833.3 thousand of Kilowatt-Hours, 9933.9 thousand of Kilowatt-hours in 2020 and that in the end year 2022 it is estimated to

12135.6 thousand of Kilowatt-hours. This implies from base year 2015 to end year 2022 the energy demand is increased by 154.20%. There is increase in electricity demand every year but the rate of increase is relatively lower in to BAU but higher than that of efficient lighting scenario.

4.3.2 Energy Demand Shop Wise

Table 3 depicts the electricity demand in all the shops of each category with the base year 2015, continuing for 2016, 2018, 2020 and the end year 2022. The maximum electricity demand is for the theater with total demand 21586.1 Kilowatt- hour, follow after theatre with total demand, clothing and food court inside have high values, 6319.5 Kilowatt- hour and 2643.9 Kilowatt- hour respectively comparing to other category. Comparing the table with Table 1 (Business as Usual), the total energy demand has decreased by 7.21% in the year 2022.

Table 3: Electricity Demand Shopwise (in thousand kilowatt-hours)

Categories	2015	2016	2022	Total
Clothing	750.4	914.6	1886.0	6319.5
Electronics	153.3	184.9	371.3	1256.3
Accessories	292.0	355.1	731.2	2451.4
Coffee Shop	111.7	139.1	303.1	995.6
Others	91.8	112.5	235.8	785.3
Offices	101.8	124.7	261.5	871.0
Grocery	44.7	54.4	111.8	374.9
Salloon	25.8	31.7	66.6	221.6
Coesmetics	121.6	147.9	304.4	1020.9
Theater	2550.3	3112.5	6456.1	21586
Gaming Zone	41.8	51.1	106.1	354.6
Jewellery	124.1	150.9	310.5	1041.4
Foodcourtout	67.9	84.7	186.0	609.3
Foodcourtin	296.5	369.2	805.2	2643.9
Total	4773.9	5833.3	12135	40531

The electricity consumption in the end uses will be less than Business as Usual scenario due to various efficient technologies. There will be the potential of energy savings, from the year 2015 and by 2022, the electricity saving will be around 10619.6 thousand Kilowatt-hours in year 2022. The savings in the year 2016 will be 305.5 thousand Kilowatt-hours and the savings will increase gradually with time.

4.4 Total Energy saving potential

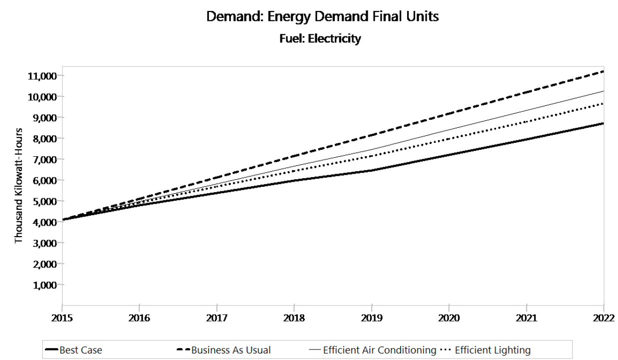

Figure 5: Electricity Saving potential in Best case Scenario

5. Conclusion

The total electricity demand can be decreased. For example,the Efficient Lighting Scenario, 1535.2 Thousand kilowatt-hours of electricity will be saved in the year 2022 to the normal trend. Improved Air Conditioner Scenario will save 943.5 thousand Kilowatt-hours of electricity in the year 2022 to the normal trend.

The low efficient incandescent, fluorescent and CFL bulbs of the sectors can be totally replaced by LED by the year 2022. The COP of air conditioner system will increase to 4 in 2017 and 4.5 in 2020 The total electricity saving potential thus at best case is reduced to 10619.6 thousand Kilowatt-hours resulting in saving large amount of electricity.

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