Electrical Energy Conservation through Human Behavior Change: Perspective in Bangladesh

I. Khan*, P. K. Halder**‡

*Department of Electrical and Electronic Engineering, Jessore University of Science and Technology, Jessore-7408, Bangladesh

**Deptartment of Industrial and Production Engineering, Jessore University of Science and Technology, Jessore-7408, Bangladesh

‡Corresponding Author: P. K. Halder, Tel: +880-1913-597592, pobitra.halder@gmail.com

Received: 11.11.2015 Accepted: 29.12.2015

Abstract- All the existing energy sources have environmental, social and economic impacts. The greenhouse effect results global warming, air pollution and energy security have led to increasing interest and more development in energy conservation. Electrical energy conservation is one of them. In this paper, critical electrical energy situation in one of the developing countries in the world, Bangladesh was considered in general. It is possible to serve maximum number of electrical energy consumers by maintaining proper use of the electrical energy. During hot summer the electrical power shortage is about 1000 MW to 1500 MW each year. If energy conservation is achieved through human behavior change, around 390 GWh of electrical energy per month and 4,683 GWh per year can be saved in Bangladesh. A related case study is conducted for this study and a bottom up method is used to conduct this study. The case study and many other literature shows that it is possible to save the electrical energy through behavior change from 3% to 20%.

Keywords- Energy efficiency; Human behavior change; Conservation of electrical energy

.

1. Introduction

Adequate amount of energy, especially electricity consumption boosts up any country's development activities. Not only in the developed countries in the world but also in developing countries such as-Bangladesh, the application of electric power both in household appliances and industrial equipment are growing rapidly. The per capita electricity consumption Bangladesh is increased to 348 kWh [1]. However, almost 70% of total rural population in the country has no electricity access yet because of the high consumption rates in urban regions. Therefore, Bangladesh is suffering from acute shortage of electricity supply especially during the summer season. Annually, 143.83kWh electrical energy is consumed per household of which 56.14% is consumed in lighting purpose only as shown in Fig. 1[2].

Domestic energy consumption is closely interrelated to the consumer's energy saving awareness which also related to the selection of new energy efficiency appliances. Efficient consumption of electricity contributes in security of sufficient supply, saving of energy and reduction in consumption cost as well as greenhouse gas emission.

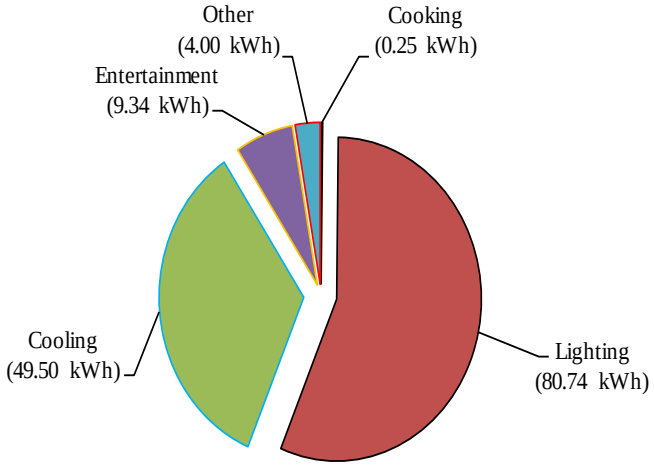


Fig.1. Sector wise electricity consumption per household [2]

In recent years, the researchers have given emphasis on efficient energy consumption and energy conservation. Some studies in different countries have evaluated the energy conservation measures of building energy consumption in

hot and humid climate for saving energy and improving the building performance [3-7]. Another study on commercial hotel building in Qatar has found an energy saving ranges between 10% and 24.12% of its energy through the development of envelope design and customer behavior change [8].

In addition, research continues on energy efficiency and conservation in various industries in different countries. Several researchers have studied the various energy saving methods and techniques and have recommended some policy suggestions on energy efficiency and conservation [9-13]. It has been found that cogeneration coupling with thermal energy storage can conserve about 21% of energy consumption [14]. Besides, other study has focused on energy efficiency and conservation through demand-side management (DSM) programs in United States of America [15]. Moreover, extensive studies have been carried out on energy conservation technologies and barriers and policy of energy efficiency in households [16-18]. Researchers have also developed some mathematical model, design method and multi-criteria approach for energy conservation [19-21].

A huge amount of electricity is misused everyday all over the world by unconscious behavior of consumer. Numerous studies have shown the effect of human behavior change on energy conservation and environmental sustainability [22-27]. Although there are various obstacles for upgrading the energy efficiency [28], some studies have shown different strategies to boost energy saving behaviors [23, 29, 30]. Energy saving or energy conservation through the change of human behavior only, without any capital cost can be a great option to meet demand instead of increasing generation. However, because of unpredictable nature of human behavior change long term individuals and organizational involvement is essential for energy efficiency achievement.

There are no sufficient literature on energy efficiency and conservation in Bangladesh context. Only one study has shown the theoretical framework of essential of energy efficiency and conservation [31]. However, it is good news that the government has realized the importance of energy efficiency and conservation and has taken some steps to solve this problem. A huge amount of electricity loss is incurred everyday due to the lack of awareness. This causes load shedding as well as inadequate supply in rural areas. Therefore, the use of energy efficient appliances and energy conservation is the other alternative way to mitigate this severe energy crisis in Bangladesh. This paper represents a novel attempt to save household electric power consumption through human behavior change that would open a pathway towards an energy-efficient future in Bangladesh as well as in any developing countries in the world. In the next section, the power scenario in Bangladesh will be explained to get the idea about the power situation in a developing country in the world. Then, the human behavior and energy conservation through human behavior change will be explored. Furthermore, the case study was conducted using bottom-up approach and presented in the section 6. Initially, ten households were agreed to be the volunteer for this study in three districts- Jessore, Sirajganj and Khulna in Bangladesh. Four households were in Jessore, four in Sirajganj and two in Khulna district. Unfortunately, not all but two households in Jessore completed the total volunteering task that were instructed them to do. So, the analysis was conducted only for the two households in Jessore. Finally energy saving prospect in Bangladesh using this human behavior change and some possible strategies that can be considered for Bangladesh are discussed.

2. Power scenario in Bangladesh

Bangladesh is one of the power deficient countries in the world where almost 41.1 million people live the poverty line and have no capability to access modern energy. Therefore, power sector is a major challenge for the past few years in the country. Total primary energy consumption in Bangladesh in 2013 has reached 26.7 million ton oil equivalent (Mtoe) corresponding to an increase of 2.69% in relation to the 0.21% increase of world's total consumption [32]. Electric power generation is greatly dependent on fossil fuel and only natural gas accounts almost 62.39% (6681MW) of the total installed generation capacity of 10709 MW at the end of the year 2014 in Bangladesh [33]. The petroleum reserve in the country is only 8% of the total demand on the other hand only 6% of total population has natural gas connection and expected to complete depletion within next 10–12 years [34]. Fig. 2 demonstrates the scenario of installed electricity generation capacity from various fuels [33]. In Bangladesh, Rural Electrification Board (REB), Dhaka Power Distribution Company Limited (DPDC), Dhaka Electric Supply Company Limited (DESCO), Power Development Board (PDB), West Zone Power Distribution Company Limited (WZPDCL) and Independent Power Producer (IPP) are contributing in electricity generation sector. Among them Bangladesh power development board is the leading contributor and shares about 4126 MW (35.83%) of total recent installed capacity.

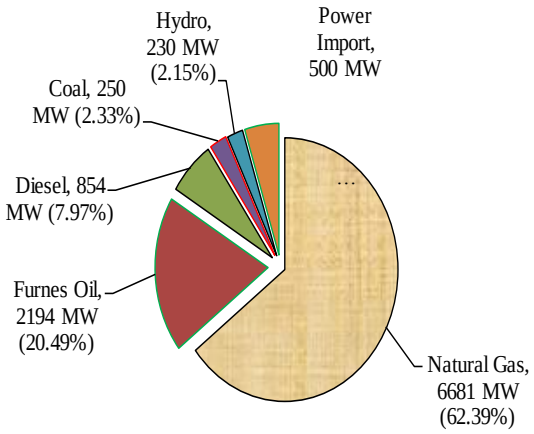


Fig.2. Installed electricity generation capacity as on December, 2014 by fuel type [33]

Country's demand for electricity is increasing sharply due to the latest proliferation of new electrical and electronic home appliances. In the year 2011, electricity consumption in household and industrial sector in Bangladesh has increased to 6154 GWh and 3205 GWh from 4654 GWh and 2661 GWh respectively in 2009 [35]. Sector wise electricity consumption in 2012 illustrated in Fig. 3 indicates that residential sector is the main consumer and consumes about 53% of total electricity generation [36]. In addition, it is expected that the total electricity demand in 2035 will increase to about 192.70 TWh comprising 101.50 TWh for industry, 64.46 TWh for residential areas, agriculture 10.67 TWh, commerce 12.96 TWh and other 3.09 TWh [35].

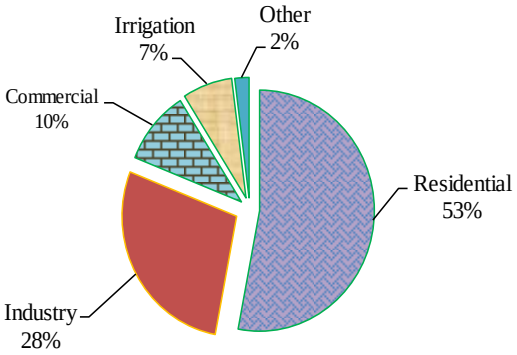


Fig.3. Electricity consumption by consumer type in 2012 [36]

The installed generation capacity has increased by 25.62% in year 2014 over the year 2013 and maximum electricity generation has increased to 7418 MW. However, it is still unable to meet country's electricity demand especially in rural and isolated areas. Recently, rural people are enjoying electricity facility from renewable sources like solar home system, biogas plant etc. that accounts only 1.0% of country's total electricity generation. To overcome this shortage government of Bangladesh has given emphasis to quick rental power plant and has taken plan to establish two coal fired power plants of capacity 1320 MW each [37].

3. Human Behavior Change

In general, behavior is an observable activity in a human. It can be defined as the range of actions made by individuals in conjunction with themselves or their environment. It is necessary to follow the step by step procedure to change the human behavior. It cannot be done instantly. Behavior change is commonly defined as a research oriented and consultative process for addressing any specific knowledge, attitudes, behavior and practices that are intrinsically linked to any certain program goals [38].

Triandis model in psychology identifies some key factors that influence the behavior of an individual. The factors are intention, habits and facilitating conditions. The 'intention' is related to the decision making process and this process is concerned with attitude, social factors and emotion. Frequently repeated behaviors that are automatic and often ingrained are known as the habit. Actual ability to act and relate to barriers that could be social, infrastructural or economic and people are perceived to facilitating conditions. Thus, the Triandis model presents behavior as a consequence of intention, habits and facilitating conditions [39].

Behavior change does not come easily; there are a number of ways or steps that need to be followed to achieve the behavior change. One of these ways is the Knowledge, Attitude, Behavior and Practices (KABP) model (Fig. 4).

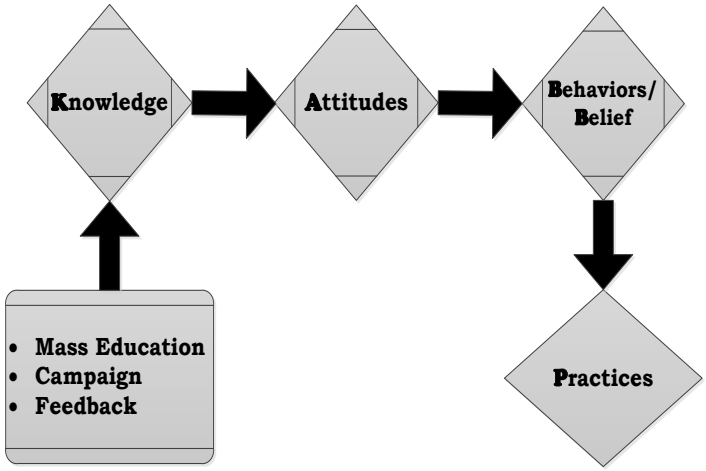


Fig.4. KABP Model

To change human behavior, it is necessary to follow the model mentioned above. The first step is the related education to the concerned matter. Then a lot of different types of campaigns are required regarding that matter. Next, it is necessary to receive the feedback from the participants. Through this step knowledge will be acquired by the participants and they will settle a way of thinking or feeling about that concerned matter. As a result, their belief or behavior will change accordingly. So, the outcome of these step by step processes is that they will be practicing these behaviors.

4. Energy Demand and Energy Conservation

To ensure sustainable national economic growth of Bangladesh it is important to meet the essential energy needs. Demand for electrical power is increasing day by day. To achieve the electrical energy sustainability, it is required to develop different ways of energy supply. At the same time, it is necessary to find out the way of proper utilization of this energy. So, the pre-conditions for sustainable energy are energy efficiency or conservation and renewable energy solutions. Energy efficiency is concerned with the improvement of energy security and efficient environmental management.

Nowadays Bangladesh is generating electricity using different sources as mentioned earlier. But due to the inefficient use of this generated electricity, load-shedding or electricity cutout during summer as well as all around the year is frequently experienced.

It is observed from Fig. 5 that there is always high demand of electricity but the generation is not sufficient to meet the demand. Whereas the installed capacity is enough to meet the demand but in actual case it is not possible due to some factors such as transmission loss, poor condition of the power plants, lack of maintenance and sufficient raw materials to generate the electricity. As an example, consider the case of fiscal year 2014, the installed generation capacity was 10709 MW and the demand was 9268 but it was possible to generate only 7356 MW. So there was lack of 1912 MW electrical power in that year which subsequently resulted in load shedding

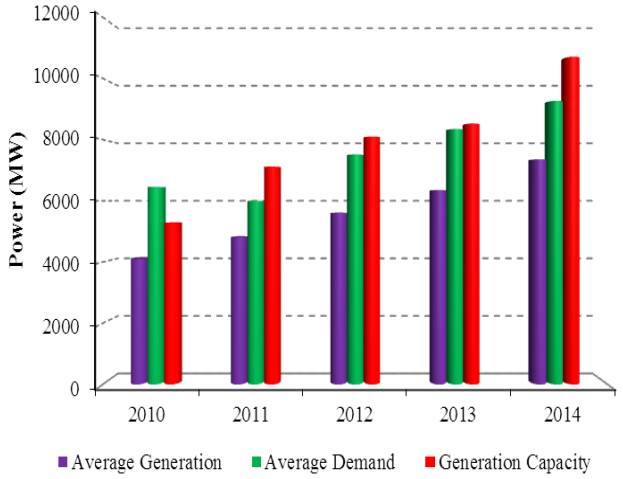


Fig.5. Average demand, average generation and generation capacity of electricity during summer from fiscal year 2010 to 2014 [2, 33, 37, 40, 41]

Considering the demand and distribution scenario of electrical power in the fiscal year of 2013, it is obvious that Bangladesh faced load shedding during summer. In Bangladesh there are 5 companies (public & private), who are involved in distributing the electrical power directly to the consumers.

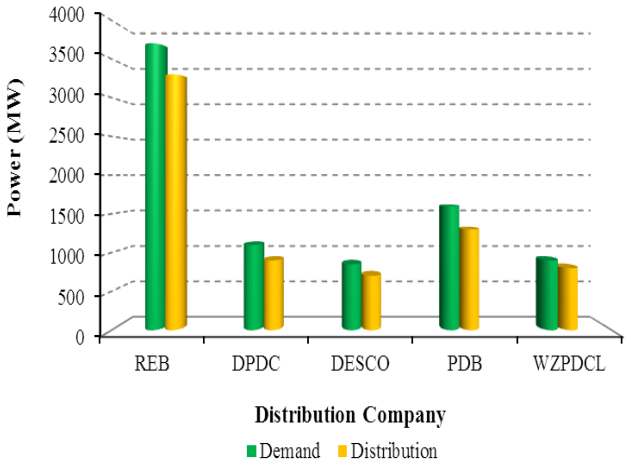


Fig.6. Load-shedding scenario during summer in 2013 [40]

They are- Rural Electrification Board (REB), Dhaka Power Distribution Company Limited (DPDC), Dhaka Electric Supply Company Limited (DESCO), Power Development Board (PDB) and West Zone Power Distribution Company Limited (WZPDCL). The demand and distribution scenario is depicted in the Fig. 6. It is observed that in 2013 the load shedding or lack of power was 1150 MW. But this situation can be improved without any investment. To improve the situation, efficient use of existing power in an appropriate way must be secured. It is possible to make the system more efficient by changing the human behavior regarding their use of electricity.

5. Energy Conservation and Change of Behavior

Efficiency can be defined as the proper way of using something by which the cost and time will be saved and the utilization will be optimum. Electrical energy must be efficiently utilized with minimum losses, expenses and efforts. The consumption of electrical energy is increasing day by day and it is clear from the energy consumption scenario of last decade in Bangladesh (Fig.7). Consider Fig.7, the electrical energy consumption was 14979 GWh in fiscal year 2001 and it increased to 39533 GWh in 2011 [42]. It is increasing steadily with time.

This huge amount of energy consumption all over the world forces the environment towards a critical situation. An instant initiative is therefore necessary in order for more people to be able to enjoy the benefits and comforts electrical energy can offer. One of these solutions of efficient energy use is the human behavior change towards residential electrical energy consumption.

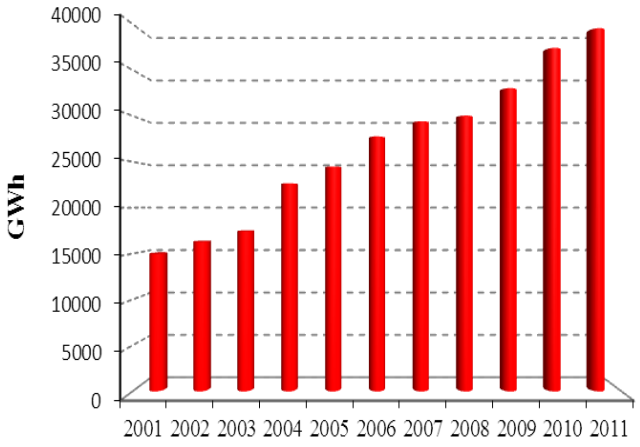


Fig.7. Electrical energy consumption in Bangladesh for a decade from fiscal year 2001 to 2011[40]

When concentration goes on the energy efficiencies the amount of energy consumed by equipment is only a part of the energy efficiency equation. The behavior of consumer plays a big part as they have direct control to their home appliances and the consumer may not know how to operate or control those appliances efficiently. To implement the human behavior change there are some barriers to overcome [39].

As the energy is invisible and saving energy is not getting priority, efficiency measures can be relatively expensive, lack of energy efficient technology, lack of knowledge and understanding of energy saving behavior and

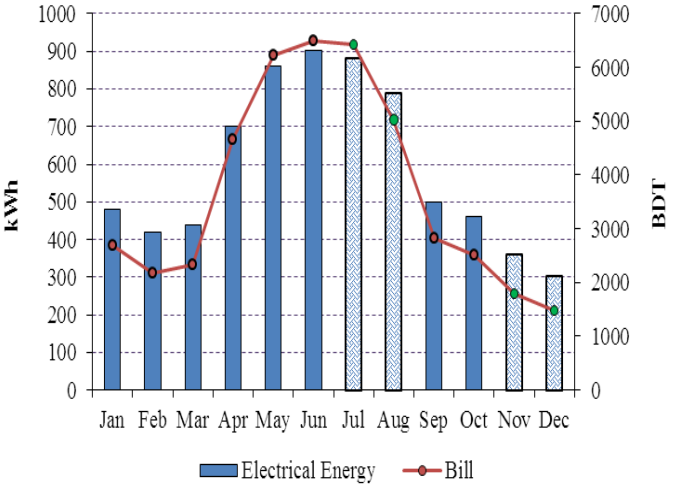
efficiency measures available, hassle factor of installing efficiency measures, aesthetics, social norms influence people's behavior and can prevent them from adopting a new efficiency measure, energy efficient new policy acceptability.

Considering the above barriers there are many ways to overcome these problems. Among them there are three major broad categories of programs that can be implemented for residential consumers' behavior change- real time feedback generating in home devices and displays, customized-regular feedback delivered to consumers and dynamic pricing and rate design programs [43]. Real time feedback is found from the smart meter that needs to be installed in home, which shows the live energy consumption of each appliance in home. On the other hand customized regular feedback can be found from a monthly customized electricity bill. Dynamic pricing can be done using time of use method. It is a scheme that defines the peak and off-peak hour energy price and consumers have the choice which appliances they want to use at that time to save energy or save money.

6. Case Study and analysis

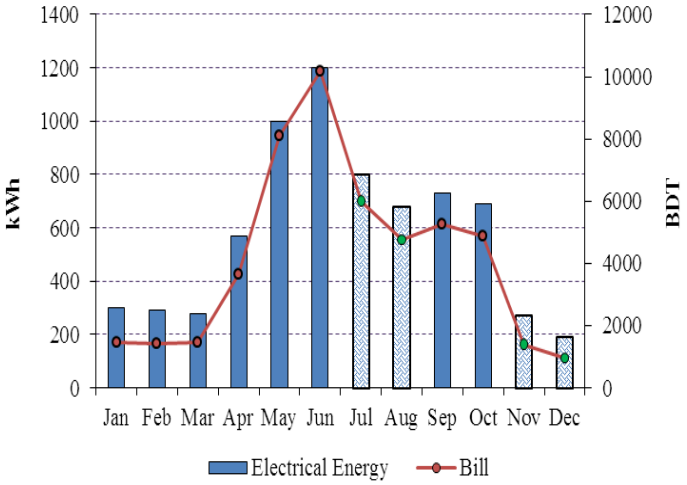
To achieve the electrical energy conservation for residential consumers, two case studies were conducted. The studies were conducted in two buildings. One of them was a student hostel and the other was a family house. The student hostel has the meter, No-155074 and the family has the meter, No-095782. There are six rooms in the student hostel and each room can host up to three students. So in total there were 18 students in the hostel when the study was conducted. On the other hand, there are five rooms in the building where the family was living, with total family members of 7 persons. The monthly energy meter reading was considered with and without energy conservation measures. The loads utilized in the students' hostel are typical lighting, computers, fans, electric kettle and immersion heaters. The loads utilized by the family are lights, fans, refrigerators, air conditioning systems, televisions, microwave oven, electric kettle, immersion heaters, and electric water pump. The study was conducted at the end of summer (July-August) and in the beginning of winter (November-December). The study was not conducted during summer due to the load shedding instances which might affect the results. Here the electrical energy conservation was achieved by motivating the students and the family members not to waste electrical energy by changing their common behavior towards the electricity use. They were advised not to leave the lights and fans on in empty rooms and not to let appliances such as televisions and computer monitors in standby mode and to avoid the use of air conditions unless it's too hot. In order to perform effective statistical analysis, the previous year meter readings were also collected and compared with the current result.

For the family it is clear from Fig. 8 that in 2013 the consumption was 880 kWh and 790 kWh for the month of July and August respectively. Consecutively, during November and December the consumption were 360 kWh and 303 kWh respectively. But after the application of consumer behavior change towards electrical energy conservation for the same months in the following year the energy savings were 30 kWh (120 kWh-90kWh) and 23 kWh (80kWh-57kWh) for July-August and November-December period (Fig. 9) comparing with the consumption for the year of 2013 respectively.



BDT- Bangladeshi Taka (Bangladeshi Currency)

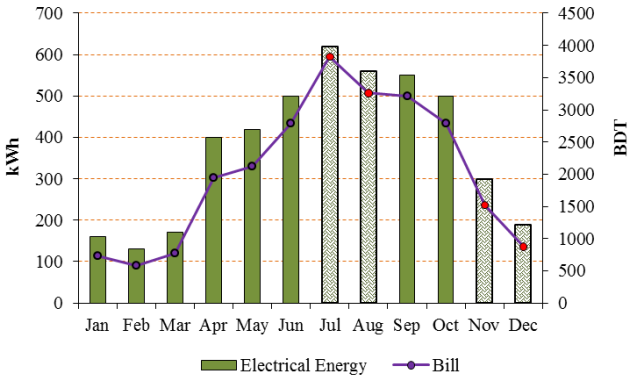
Fig.8. Energy consumption of the family in the year 2013 (before the behavior change)



BDT- Bangladeshi Taka (Bangladeshi Currency)

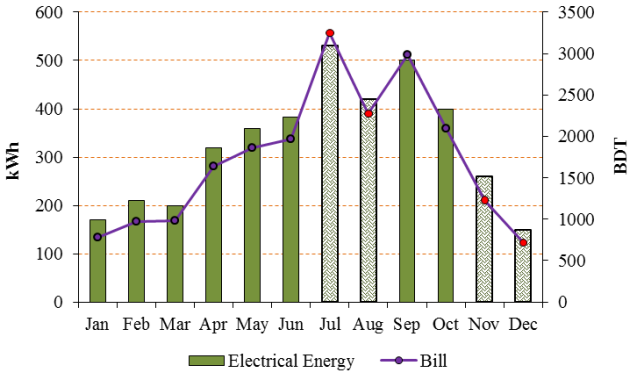
Fig.9. Energy consumption of the family in the year 2014 (after the behavior change for the duration Jul-Aug & Nov-Dec only)

Similarly in case of the student hostel the amount of saved energy was 49 kWh and 80 kWh for the duration of July-August and November-December respectively, comparing with the previous year as depicted in Fig.10 and Fig. 11. It is to be noted that in the year 2014, the number of household appliances and consumers in the case studies were almost the same that of in year 2013. On the other hand, the average temperature of the study periods in year 2013 and 2014 in Jessore was nearly the same. Copies of electric bills for the month of July and August, 2014 are shown in Fig. 12.



BDT- Bangladeshi Taka (Bangladeshi Currency)

Fig.10. Energy consumption of the student hostel in the year 2013 (before the behavior



BDT- Bangladeshi Taka (Bangladeshi Currency)

Fig.11. Energy consumption of the student hostel in the year of 2014 (after the behavior change for the duration Jul-Aug & Nov-Dec only)

NB. For privacy issue the name and address of the house owners are hidden

Fig.12. Snap shot of the electric bills for the month of July & August, 2014: meter number & consumed unit are indicated in black circle

7. Perspective in Bangladesh

According to the population and housing census 2011 of Bangladesh, the total number of households of all divisions (there are seven divisions in Bangladesh) is 23760645 [44]. There are 18807220 households in rural area and 4953425 households in urban area. Details are shown in Fig.13. Overall 56.60% households only have electricity access. Division wise electricity access is shown in Table 1.

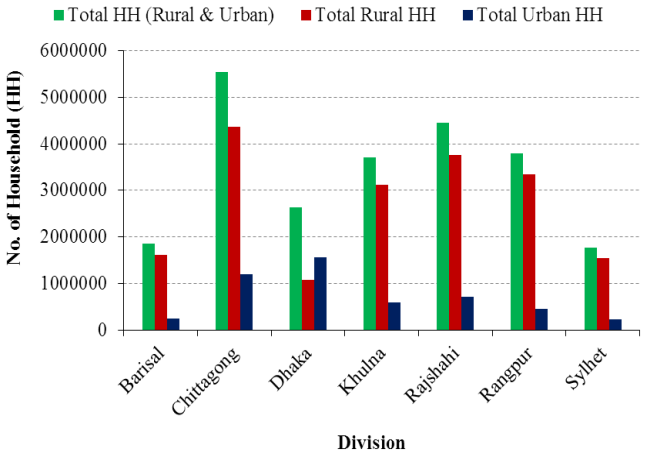


Fig.13: Division wise number of households in Bangladesh [44]

Table 1: Electricity access in Bangladesh [44]

Division	Rural (%)	Urban (%)
Barisal	28.4	80.7
Chittagong	58.0	90.4
Dhaka	56.3	94.7
Khulna	51.2	85.1
Rajshahi	49.3	79.9
Rangpur	29.4	69.8
Sylhet	43.2	88.8

According to international energy agency (IEA) the electrification rate is around 41% in Bangladesh [45]. Total electrification scenario of Bangladesh is shown in Fig.14. Only 46.2% rural households are electrified. Contrarily, 87.23% urban households of Bangladesh are electrified.

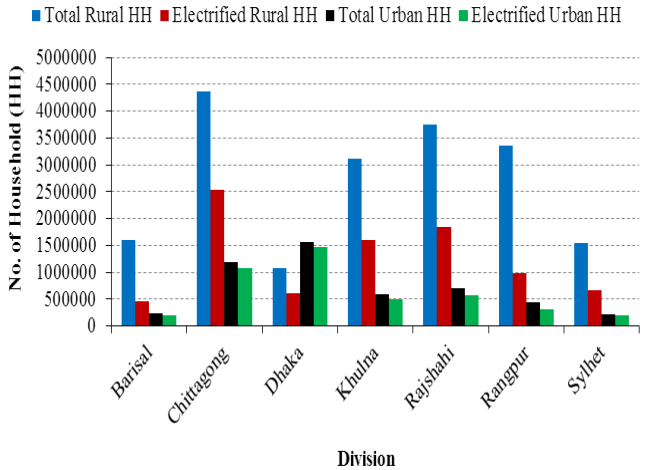
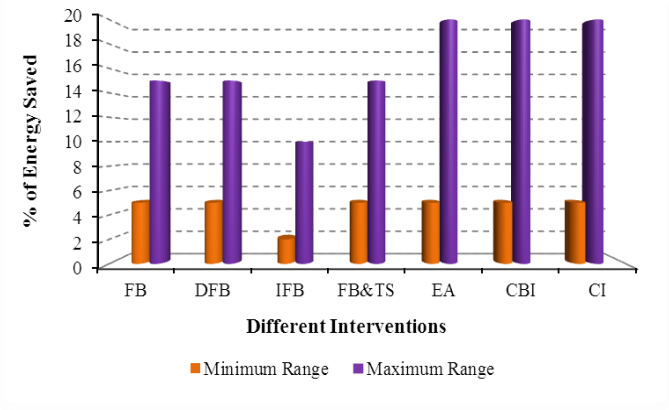


Fig.14. Division wise household (HH) electrification scenario of Bangladesh [45]

It is clearly exposed from the case study, that if the energy conservation through behavior change has been taken into account, it is possible to save 49 kWh per month (for student hostel; duration: Jul-Aug, Fig.10 and Fig.11). If we consider the average energy saving from a general household is around 30 kWh per month rather than 49 kWh, the amount of electrical energy that can be saved in Bangladesh is figured out in Table 2. Here, on an average 30 kWh energy saving per month was considered by taking into account the temperature of the six different seasons in Bangladesh and the obvious unavoidable summer load shedding effect.

From Table 2 it is clearly visualized that total electrical energy that can be saved is around 390 GWh per month and 4683 GWh per year only for the households in Bangladesh (excluding industrial, institutional & hospital buildings). According to IEA [46] in 2012 total consumption of electricity in Bangladesh was around 43239 GWh. Different types of energy efficiency measures are performed in different research.



FB: Feedback, DFB: Direct Feedback, IFB: Indirect Feedback, FB&TS: Feedback and Target Setting, EA: Energy Audits, CBI: Community based Initiatives, CI: Combination Intervention

Fig.15. Different interventions used to save energy [47]

Table 2: Total household electrical energy that can be saved in Bangladesh

Division	Electrified rural HH*	Energy saved in rural area (kWh/Month)	Electrified urban HH*	Energy saved in urban area (kWh/Month)
Barisal	457251	13717530	193127	5793810
Chittagong	2531635	75949050	1073392	32201760
Dhaka	604180	18125400	1477668	44330040
Khulna	1594591	47837730	504311	15129330
Rajshahi	1850586	55517580	565189	16955670
Rangpur	984982	29549460	310140	9304200
Sylhet	665584	19967520	197182	5915460
Total	8688809	260664270	4321009	129630270

*HH: Household

Research shows that it is possible to save the energy through behavior change from 3% to 20% by using different feedback method and interventions. Such as the direct feedback method through smart metering, indirect feedback method through monthly bill, feedback method with monthly energy reduction target setting, frequent energy audit by energy auditor and so on as described in [47]. It is also could be a good initiative to provide incentives to the consumers who will achieve the energy saving goal and it will be working as an inspiration for others. Again this 30 kWh energy per month is clearly savings of electrical energy of around 9% which is in the range of 3% to 20% energy saving due to the consumer behavior change as depicted in Fig.15. It is clearly. It has been also estimated that human behavior change can conserve energy between a range 2.74% and 15.80% [8]. So, if it is possible to implement the human behavior change towards energy conservation then it is obvious that there will be no lack of power during summer in Bangladesh. It will be feasible to serve the electrical energy consumers of Bangladesh with the existing power generation facilities. If the approach towards correct use of electrical energy is passed on to people there can be possible huge improvements and savings.

8. Strategy Deployment

Energy use behavior is directly affected by the attitudes and cultural tendencies of human beings. Energy conservation through behavior change is an effective energy policy specifically for the domestic sector because of rising energy demand and energy price. It is really shocking that people are yet to realize the benefits of energy efficiency and energy conservation and not aware about energy use behavior as the simple measures suggested in the case study above. Recently government of Bangladesh has taken the following remarkable initiatives for the improvement of energy efficiency and conservation [37].

- ✓ Preparation of energy efficiency and energy saving master plan
- ✓ Replacement of inefficient cooking stoves by clean cooking stove
- ✓ Introduction of energy audit system in the large industries
- ✓ Replacement of inefficient brick kilns and rice per-boiling to efficient brick kilns and improved rice per-boiling respectively

- ✓ Installation of PV system in government, semi government and autonomous organization's rooftop
- ✓ Inspiration for using CFL/LED bulb and solar lights instead of using conventional bulb
- ✓ Discouragement to use neon sign in the markets and shopping malls at night
- ✓ Shut down markets and shopping malls within 8 p.m.

However, most of the initiatives are not successful due to improper management and implementation. The success of energy efficiency is dependent on energy behavior practice. Therefore, awareness rising and motivation are the key parameters for energy efficiency rather than the formal written initiatives. Energy conservation and efficiency can be achieved by implementing KABP model through some motivation and awareness activities as indicated in Fig.16.

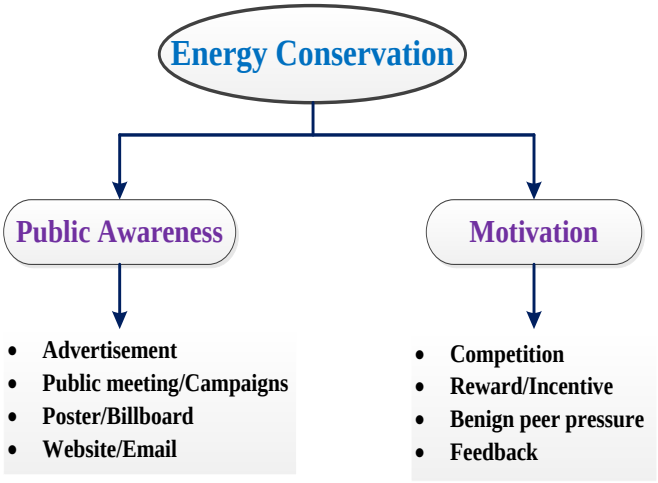


Fig.16. Effective factors for energy conservation

Government of Bangladesh should include this strategy in energy policy to force government and nongovernment organizations to come forward for increasing public awareness through various initiatives like advertisement, billboard, seminar, fairs, campaigns for the benefit of the consumers and the country. The messages that need to be conveyed to the energy consumers' are- a little effort through awareness can save the energy and your money. Moreover, motivation through award at national level, discount on green products like energy saving bulb, are incentives that will generate a better result.

9. Conclusion

One of the best ways to be electrical energy efficient is being aware of how energy is used. As a consequence, making conscious decisions, energy efficiency will come through energy conservation. Energy efficiency can save money, can reduce energy use and can help the environment by changing our way of thinking and a few of our habits. It is up to all of us to use energy efficiently to make sure people have plenty of energy in the future. The case studies clearly reflects that it is possible to save around 9% of electrical energy per month for a common household just by changing the consumer behavior change towards electricity use in Bangladesh as well as in the south Asia region. So, consumer behavior change is one of the vital keys of success towards energy conservation. This clearly matches with the other related research findings. As people do not have any other choices to use fossil fuels and nuclear energy until new as well as environment friendly technologies can replace them. It is our duty to conserve energy and use it efficiently. There may be no significant improvement on our energy bill right away after making energy changes. The point of changing consumer behavior or habits towards energy use now is to improve our energy efficiency over time. An easily achievable initialization will definitely add up to savings in future towards energy and environment. There are some limitations in this studies which require further research. One of the limitations was the sample size (number of households) for the case studies. It is necessary to conduct the similar case studies in different district/regions of Bangladesh with large number of households. Here the behavior change was considered for a month only. So, further exploration is required by applying the behavior change for longer period of time. The average energy saving per household was considered as 30 kWh per month, which needs to be investigated further by using more survey data analysis.

References

[1] Halder PK, Paul N, Joardder MUH, Sarkar M (2015). Energy Scarcity and Potential of Renewable Energy in Bangladesh. Renewable and Sustainable Energy Reviews, 51:1636-1649.

[2] Energypedia.https://energypedia.info/wiki/Bangladesh_Energy_Situation#Overview. (Accessed on January 2015).

[3] Rahman MM, Rasul MG, Khan MMK (2010). Energy conservation measures in an institutional building in sub-tropical climate in Australia. Applied Energy, 87(10):2994-3004

[4] Loganthurai P, Parthasarathy S, Selvakumaran S, Rajasekaran V (2012). Energy Conservation Measures in a Technical Institutional Building in Tamilnadu in India. *Energy Procedia*, *14*:1181-1186.

[5] Iqbal I, Al-Homoud MS (2007). Parametric analysis of alternative energy conservation measures in an office building in hot and humid climate.*Building and environment*, *42*(5): 2166-2177.

[6] Wen-Kuei C, Hung-Wen L, Ming-Shan J, Tianzhen H. (2013). A Case Study of Weather Impact on Energy Conservation Measures in Building.

[7] Desideri U, Leonardi D, Arcioni L, Sdringola P (2012). European project Educa-RUE: An example of energy efficiency paths in educational buildings. *Applied Energy*, *97*: 384-395.

[8] Ayoub N, Musharavati F, Pokharel S, Gabbar HA (2014). Energy consumption and conservation practices

in Qatar—A case study of a hotel building. Energy and Buildings, 84:55-69.

[9] Pareshkumar AV, Purnanad VB (2014). Experimental Investigation on Energy Efficiency of Electrical Utilities in Process Industries through Standard Energy Conservation Practices. Energy Procedia, 54:199-210.

[10] Lin B, Zhao H (2014). Energy efficiency and conservation in China's chemical fiber industry. Journal of Cleaner Production.

[11] Kaile Z, Shanlin Y, Chao S, Shuai D, Chaoping Sun (2015). Energy conservation and emission reduction of China' s electric power industry. Renewable and Sustainable Energy Reviews 45:10–19.

[12] Waleed A, Muhammad S, Farwa A, Nauman AZ (2015). Smart meters for industrial energy conservation and efficiency optimization in Pakistan: Scope, technology and applications. Renewable and Sustainable Energy Reviews, 44: 933–943.

[13] Jean-Christian B, Markus B (2014). Energy conservation measures for the German cement industry and their ability to compensate for rising energy-related production costs. Journal of Cleaner Production, 82:94-111.

[14] Khan KH., Rasul MG, Khan MMK (2004). Energy conservation in buildings: cogeneration and cogeneration coupled with thermal energy storage. Applied Energy, 77(1): 15-34.

[15] Taylor NW, Jones PH, Kipp MJ (2014). Targeting utility customers to improve energy savings from conservation and efficiency programs. Applied Energy, 115: 25-36.

[16] Sutherland R (1991). Market barriers to energy efficiency investments. The Energy Journal, 12: 15– 34.

[17] Jaffe A, Stavins R (1994). The energy efficiency gap: what does it mean? Energy Policy 22:804– 810.

[18] Gillingham K, Newell R, Palmer K (2009). Energy efficiency economics and policy. Annual Review of Resource Economics, 1: 597– 619.

[19] Xia X, Zhang J (2013). Mathematical description for the measurement and verification of energy efficiency improvement. Applied Energy, 111:247-256.

[20] Oh SY, Binns M, Yeo YK, Kim JK (2014). Improving energy efficiency for local energy systems. Applied Energy, 131: 26-39.

[21] Karmellos M, Kiprakis A, Mavrotas G (2015). A multi-objective approach for optimal prioritization of energy efficiency measures in buildings: Model, software and case studies. Applied Energy, 139: 131-150.

[22] Van Houwelingen JH, Van Raiij WF (1989). The effect of goal-setting and daily electronic feedback on in-home energy use. J. Consumer Research, 16(1): 98-105.

[23] Linda S (2008). Promoting household energy conservation. Energy policy, 36(12): 4449-4453.

[24] Revell K (2014). Estimating the environmental impact of home energy visits and extent of behavior change. Energy Policy, 73:461–470.

[25] Owens S, Driffill L (2008). How to change attitudes and behaviors in the context of energy. Energy Policy, 36(12): 4412-4418.

[26] Wood G, Newborough M (2003). Dynamic energy-consumption indicators for domestic appliances: environment, behavior and design. Energy and Buildings, 35(8): 821-841.

[27] Wood G, Newborough M (2007). Energy-use information transfer for intelligent homes: Enabling energy conservation with central and local displays. Energy and Buildings, 39(4): 495-503.

[28] Reddy Amulya K.N., Barriers to improvements in energy efficiency. Energy Policy 1991, 19(10): 953-961.

[29] Chatterton T. 'An Introduction to Thinking about 'Energy Behaviour': A Multi-model Approach. Department of Energy and Climate Change, London. 2011. https://www.gov.uk/government/ uploads/system/ uploads/attachment_data/file/48256/3887-intro-thinking-energy-behaviours.pdf.

[30] Wilson C, Dowlatabadi H (2007). Models of decision making and residential energy use. Annu Rev Environ Resour, 32:169–203.

[31] Mozumder SZ (1983). Energy efficiency and conservation in Bangladesh. Energy, 8 (4): 69-72.

[32] British Petroleum (BP). BP Statistical Review of World Energy, British: BP Plc, 2014. http://www.bp.com/content/dam/bp/pdf/Energyeconomics/statistical-review-2014/BP-statistical-review-ofworld-energy-2014-full-report.pdf. (Accessed on January, 2015)

[33] Bangladesh Power Development Board (BPDB), 2015. http://www.bpdb.gov.bd/bpdb/. (Accessed on January 2015)

[34] Halder PK, Joardder MUH, Beg MRA, Paul N, Ullah I (2012). Utilization of bio-oil for cooking and lighting. Advances in Mechanical Engineering 2012, http://dx.doi.org/10.1155/2012/190518.

[35] Mondal MAH, Boie W, Denich M. (2010). Future demand scenarios of Bangladesh power sector. Energy Policy, 38:7416-7426.

[36] Energy efficiency and GHG mitigation in Bangladesh (2014). http://www.ir3s.u-tokyo.ac.jp/3e-nexus/pdf/ 022414/ session06-02.pdf. (Accessed on January 2015)

[37] Power Division-Government of the People's Republic of Bangladesh. http://www.powerdivision.gov.bd/user/ index (Accessed on January 2015)

[38] The Housing Executive. www.nihe.gov.uk. (Accessed on January 2015)

[39] Energy Use Behavior Change. www.parliament.uk/post. (Accessed on January 2015).

[40] An overview of power sector of Bangladesh. http://www.usea.org/sites/default/files/event-file/493 /overviewofbpdb.pdf. (Accessed on January 2015).

[41] Rasel AR. Load shedding compounds summer heat. http://www.dhakatribune.com/bangladesh/2014/apr/22/ load-shedding-compounds-summer-heat. (Accessed on January 2015).

[42] The World Bank. http://www.worldbank.org/. (Accessed on January 2015).

[43] Carroll Ed, Hatton Eric, Brown Mark. Residential Energy Use Behavior Change Pilot. CMFS project code B21383, 2009. http://www.climateaccess.org/sites/ default/files/Carroll_Residential%20Energy%20Use%20 Behavior%20Change%20Pilot.pdf. (Accessed on January 2015).

[44] Population and housing census 2011. Socio-economic and demographic report. National series, vol. 4, Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, www.bbs.gov.bd. (Accessed on February 2015).

[45] International Energy Agency, http://www.iea.org/ publications/worldenergyoutlook/resources/energydevel opment/accesstoelectriciy/. (Accessed on February, 2015)

[46] International Energy Agency, http://www.iea.org/ statistics/statisticssearch/report/ (Accessed on January 2015).

[47] Achieving energy efficiency through behavior change: what does it take? EEA Technical report, ISSN 1725-2237, No. 5/2013. http://www.eea.europa.eu/ publications/achieving-energy-efficiency-through-behaviour. (Accessed on January 2015).