Executive summary of Energy Audits carried out at public buildings in Bangladesh under the EEPB Project

Submitted to

Sustainable and Renewable Energy Development Authority (SREDA)

On behalf of

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

By

Deloitte Touché Tohmatsu India LLP

July 2021

Disclaimer

The report is based on data from initial walk through audits, detail ANSI/ASHRAE 211-2018 Level 2 audits at subsequent phase and data as available with building management. Quality assurance of the data has been a challenge and COVID related restrictions made it more challenging. Therefore, this report should serve as an indicative baseline. Investment grade energy audits in future may provide more quality data to further substantiate the findings.

Acknowledgement

We wish to place on records our thanks to GIZ, especially Mr. Al Mudabbir Bin Anam and his team Mr. Ashraful Ambia, Ms. Chandramallika Ghosh for giving us the opportunity to be part of this landmark initiative and their constant support, technical and management guidance, expert review, and facilitation towards this study.

We also want to thank SREDA, especially Mr. Mohammad Alauddin, Chairman, Ms. Farzana Mamtaz, Member (Joint Secretary), Energy Efficiency and Conservation and Md. Abdullah Al Mamun, Assistant Director, Energy Audit for their unstinted cooperation, ownership, guidance, and deep involvement throughout the course of the study.

We also thank relevant Experts from GIZ Sector Project Proklima (Philipp Munzinger), Asian Infrastructure Investment Bank (David Morgado) and BUET (Dr. Md. Zahurul Haq and Dr. Md. Ziaur Rahman Khan), Mr. Mustafizur Rahman (GIZ Consultant) for their valued suggestion and guidance on the methodology, data collection, evaluation, and reporting.

Our thanks are due to Mr. Ashraful Haque, Additional Chief Engineer, E/M - P&D, and his team, from the PWD Office, with whose cooperation the study could be completed in time.

We take this opportunity to thank all other individuals and institutions- too many to mention - who showed collective ownership and had involved themselves directly and indirectly in the smooth and successful completion of the assignment.

Executive Summary

Commercial buildings including public (institutional) buildings accounted for about 2 per cent of electricity consumption in Bangladesh in 2015[1]. To assess the energy efficiency potential for optimising energy consumption in the public sector, a sample of 12 public buildings were selected across Bangladesh and energy audits were conducted according to ANSI/ASHRAE 211-2018 – Level 2 Energy Audit standard.

The energy audit findings unveiled total electricity savings potential of 1.06 million kWh or approx. 17 per cent of the electricity consumption, with an investment of about 8.5 Crores BDT (equivalent 1 million USD), having payback period range between 5 to 12 years for the 12 buildings.

The potential for installation of rooftop solar PV was also assessed with 10 of 12 buildings having suitable space for rooftop solar installation. The total estimated generation potential is 0.97 million kWh per year for 10 of the 12 buildings in the project scope. The rooftop solar PV would attract an investment varying from 11 lakh BDT to 1 Crore BDT (USD 13,000 to USD 118,000) for the buildings with an average payback period of approximately 6.5 years. An average of 33 per cent of the load can be catered through rooftop solar PV in the buildings audited excluding WAPDA and NESCO.

The audit findings were used to extrapolate the energy efficiency and conservation potential for selected 274 buildings across the country managed by Public Works Department (PWD). The analysis estimates an approximate electricity savings potential of 11 to 15 million kWh per year (11 to 15 Crore BDT or USD 1.3 to 1.8 million) with potential investment worth 80 - 120 Crores BDT (equivalent to USD 9.5 -14 million). The average payback period is expected to be about 7.6 years. The implementation of energy efficiency and conservation interventions will bring in a CO_2 reduction of approximately 7,500-9,000 tonnes of CO2 per annum.

The energy efficiency measures are also likely to help improve public staff's comfort and wellbeing, creation of local jobs and enhance public asset value. The energy audit recommendations have been categorised as short-, medium-, and long-term options. The Table below provides details on the energy efficiency & conservation interventions for implementation:

[1] Source – Terms of Reference GIZ

Sl.no	Title of the intervention	Energy savings in kWh	Investment in BDT (USD)	Payback Period (Years)
1.	Switching the power settings of desktops to power saving mode	92,000	0 (0)	Immediate
2.	Replacement of Fluorescent tube lights and CFLs with energy efficient LED lights	3,83,000	42,00,000 (USD 50,000)	Varies from 6 months to 1.5 years (Short Term Measure)
3.	Replacement of ceiling fans with energy efficient brush-less DC (BLDC) motor fans	1,65,000	1,37,00,000 (USD 164,200)	Varies from 5 years to 16 years (Medium/ Long Term measure)
4.	Replacement of older ACs with energy efficient AC	2,69,000	5,92,00,000 (USD 710,400)	15 years and above. This measure is applicable to building with payback period below 20 years. The measure shall be implemented in a phase wise manner.
5.	Replacement of plain windows with energy efficient glazed windows	1,47,000	80,00,000 (USD 96,000)	
	Total	**10,56,000**	**8,51,00,000 (USD 1,021,200)**	

The selected public buildings where energy audits have been conducted, are as follows:

Buildings in Dhaka city

1. Passport Bhaban (Department of Immigration and Passport), Agargaon
2. RAJUK Bhaban (Capital Development Authority), Motijheel
3. Registrar Office Building, Dhaka University (DU Registrar)
4. Rajswa Bhaban (NBR- National Board of Revenue Building), Segunbagicha
5. Purta Bhaban (PWD- Public Works Department), Segunbagicha
6. Ministry of Housing and Public Works (MoHPW) Bangladesh Secretariat
7. Petro Bangla Building, Kawranbazar C/A
8. WAPDA Bhaban (Power Development Board Office), Motijheel C/A
9. Planning Division Office, Agargaon (MoP)

Buildings in 3 Divisional Cities:

10. CDA (Chattogram Development Authority), Chattogram
11. DC (Deputy Commissioner) Office, Kushtia
12. NESCO (Northern Electricity Supply Company Limited) Head Office, Rajshahi

Highlights of the Scope and Methodology

The energy audits were conducted in public buildings in Dhaka, Chattogram, Rajshahi and Kushtia. As a first step, the walkthrough energy audits of the 12 public buildings were conducted for seven days, qualifying as level 1 energy audits. During the Level 1 energy audit, the analysis of utility structure, high level energy consumption, peak demand, the energy use intensity, potential low hanging interventions provided a base for conducting Level 2 energy audit in these buildings. The information collected through stakeholder consultations with building management is as follows:

1. Building Information - building type and use, date of construction, gross floor area, owner responsibilities, schedule of building, energy sources, etc.
2. Building Envelope – roof, opaque walls, fenestration

Following the completion of level 1 energy audit of the project, the level 2 energy audits were scheduled for a period of approximately 40 days during the winter months. These audits were conducted in two phases. ASHRAE level 2 audit required end use breakdown of the building energy consumption. The power measurements on field, detailed inventory of appliances and analytical calculations were used to estimate the load and energy consumption distribution by end use.

Key observations

Level 2	**Renewable Energy Potential**	• Roof Top Solar has been utilised by NESCO building to meet its electricity demand. • Roof structure and space for 11 audited buildings were found apt excluding WAPDA (as per stakeholder consultation).
Level 2	**End Use Applications**	• 80 per cent of the building energy loads consist of wall type or split air conditioner, CFL tubelight and ceiling fans. • Energy efficiency measures have only been implemented at CDA Chittagong, leading to their lower energy consumptions.
Level 2	**Contract Demand**	• 5 of the audited buildings pay extra utility charges as the contract demand reported on utility bills were lower than the sanctioned load.
Level 1	**Power factor Correction**	• Average power factor for 3 of the audited buildings were not reported on the utility. • 5 of the audited buildings were charged penalties for maintaining and average power factor below 0.95.
Level 1	**Building Information**	• The age of all 12 buildings range from 5 to 60 years and the building space is shared by multiple organizations. • 5 buildings in the audit scope shared their electrical meters(utility based) with neighboring building adding to the energy use intensity.
Level 1	**Energy Sources**	• Grid Electricity is the primary source of energy for most purposes in all 12 buildings. • Diesel generators is used as backup power source in Six of the buildings.

Grid electricity is the primary source of energy supply in all 12 buildings. The annual energy consumption of the audited buildings reported on their utility bills are captured in the exhibit below:

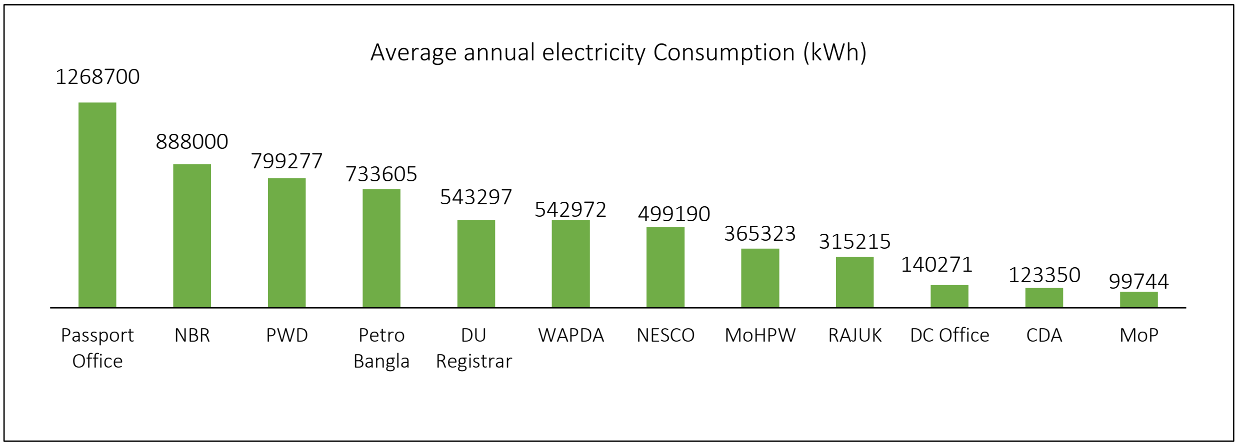

Exhibit 1 Annual Electricity consumption for 12 Buildings - Utility Bills

Six of the buildings have diesel generators as backup during interruption of electricity supply. Buildings including Secretariat, PWD, Passport Office, RAJUK building and WAPDA are located in heart of Dhaka. They are connected to the VIP feeder line resulting in rare power cuts and hence diesel generators are rarely used. However, the Chattogram Development Authority (CDA) experiences frequent power cuts leading to the usage of the diesel generator sets at least two-three times a week. NESCO building on the other hand uses renewable sources in form of the solar roof top panel and does not have any diesel generators. Buildings like the Registrar building of the Dhaka university, Planning Ministry, and DC Office, Kushtia do not use diesel generators as they are connected to the main feeders of the area, experiencing almost no power outages.

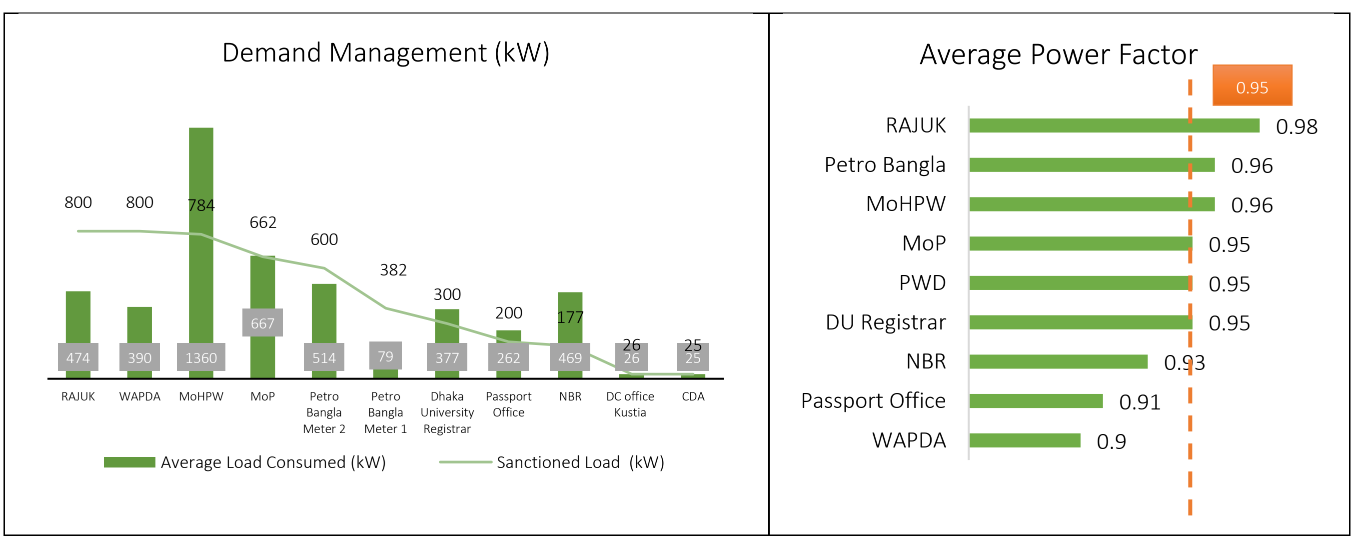

Exhibit 2 Key observations during walk through audits for 12 Buildings

Energy Audit Results

The Energy Audits were completed on the twelve buildings mostly during winter (December to February). Locating the distribution boards for overall power measurements was a challenge as the buildings were old and their electrical line diagrams were unavailable on site. As the audit was conducted in winter season, there was no air conditioning or fans load in the buildings. Revisit was arranged in summer to four major buildings to measure load on ACs along with air flow measurement, outdoor temperature, and power factor. Along with ACs, measurements for lighting and fans load were also conducted.

The buildings selected for the level 2 Energy Audits do not have central HVAC systems and dedicated hot water supply. It was observed that the approximately 75 per cent area of each of the buildings were underlit at many places, while the required lux for rooms is 300 and that of corridors is 100. The lower luminosity is due to the ageing lamps and dust settled over the lighting fixtures.

The key operating parameters of the building that consist of Energy Consumption load centres which make up more than 80 per cent of the energy use of the buildings were determined with help of the operating set points of appliances, operating schedules, and equipment efficiencies.

The overall power consumption measured on the distribution boards were utilised to calculate the annual base line energy consumption of the building by identifying and separating the day's peak and off peak loads.[2] TMY 3 weather data was used to develop annual hourly cooling load shape to estimate the annual weather dependent air conditioning energy consumption in buildings.

The following exhibits are a snapshot of the energy consumption of buildings reported on utility bills and baseline energy consumption calculated by the end use.

[2] The data recorded by power analyzer gives 15-minute interval load for entire day. We separate the loads in peak and off peak and calculate the mean in the 75th percentile. Using the peak and off-peak loads, we calculate the average weekly load consumption. As this load is exclusive of summer loads of fans and air conditioning, we assume that this is the baseline operational load of the building with lighting, appliance, and other loads. This load is annualized, with additional consideration of holidays and other factors.

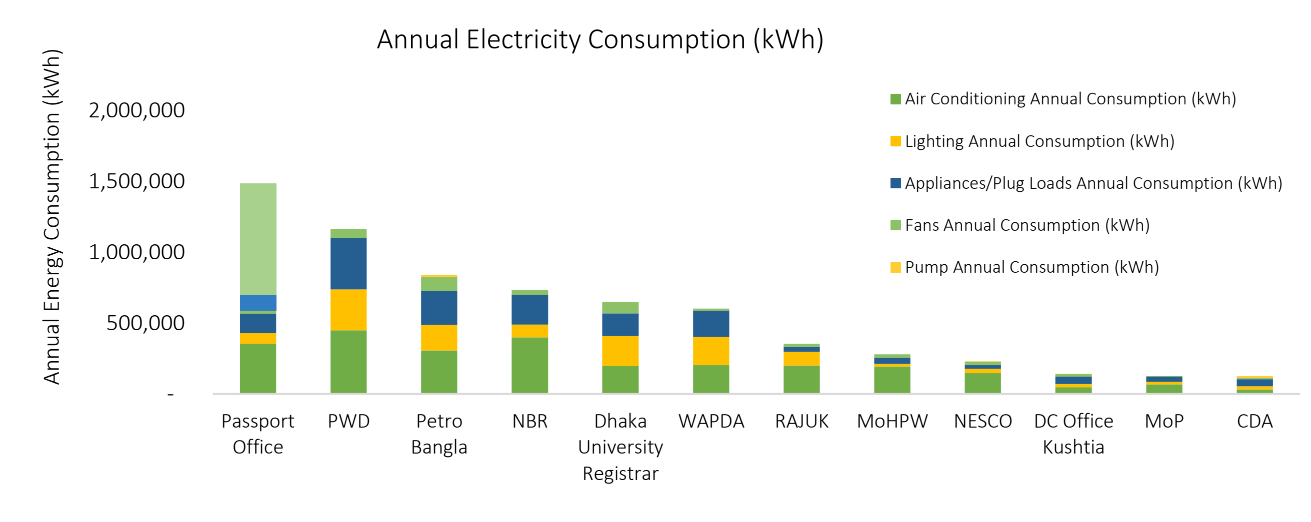

Exhibit 3 End Use based Annual Energy Consumption in 12 buildings

By connecting the power analyser to the main distribution boards, the measurements of data for each building was taken. The Passport office building had additional loads such as data centres where the entry was restricted due to national security reasons. For this building, power measurements were conducted for three days including weekend to deduce baseline consumption from data centres which are in operation for 24 hours a day including weekends.

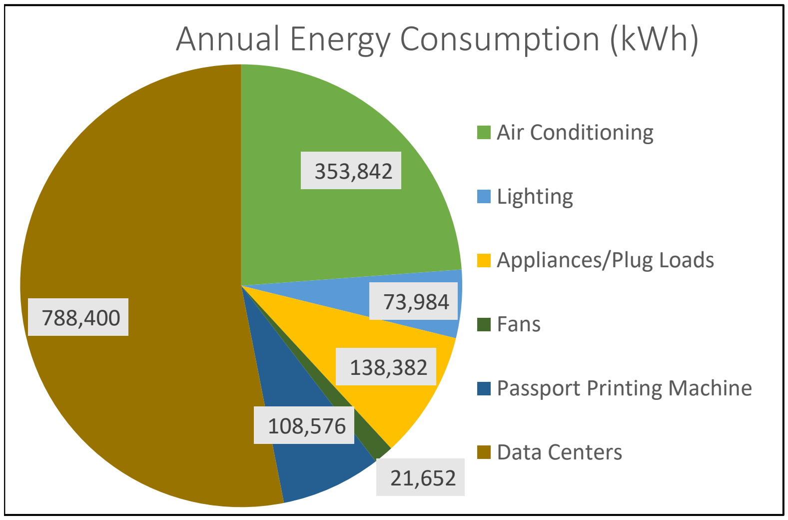

Exhibit 4 End Use Annual Energy Consumption for Passport office

Benchmarking of the Energy Use Intensity (EUI) of the 12 audited buildings were done using the Bureau of Energy Efficiency (BEE), Government of India, star rating for buildings as no such benchmarking data was available in Bangladesh during the study period. As per BEE, for a warm and humid climatic zone[3], one star rating of an office building will have an energy use intensity (EUI) of 85 - 75 kWh/m^2/year and it goes down to as low as 45 kWh/m^2/year for a five-star rated building. As per the benchmark, there is significant potential for optimising energy consumption and concomitant energy costs. The analysis showed that the building with the highest EUI with 258 kWh/m^2/year is the Passport Office. The EUI in passport buildings is higher than the others as a result of additional energy intensive loads of data

[3] BEE Star rating for buildings

centres and passport printing machines. The EUI for CDA is the lowest at 22 kWh/m^2/year. The EUI for Chittagong Development Authority (CDA) is an indication that upgrading to energy efficient technologies like LED lights would help optimise energy consumption.

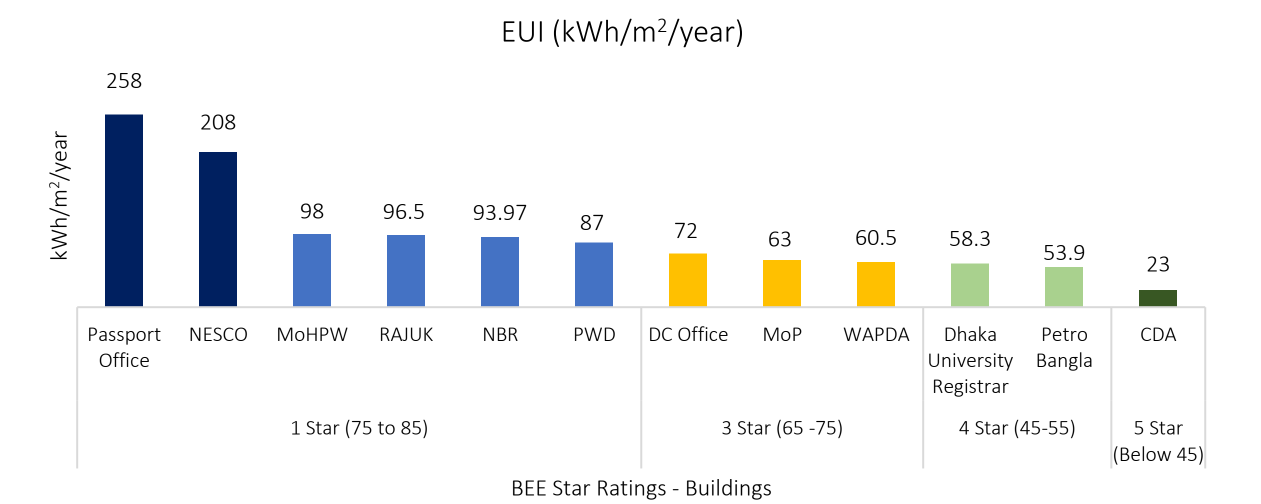

Exhibit 5 Energy Use Intensity in 12 buildings as per Indian Bureau of Energy Efficiency (BEE) Benchmark

Energy Efficiency and Conservation Measures

Energy Savings opportunities suggested for the buildings in this project, captures the low/no cost measures and capital-intensive measures. It is suggested that these measures should be implemented considering the building's life cycle cost, maintenance procedures and schedules, and the building insultation. This can be further studied at the time of investment grade audits.

A snapshot of energy saving opportunities and its financial evaluation encompassing its simple payback period for implementation is given in the exhibits below. The financial evaluation shown in exhibit 6 is an indication of annual financial savings and one-time investment cost incurred to implement all energy efficiency measures.

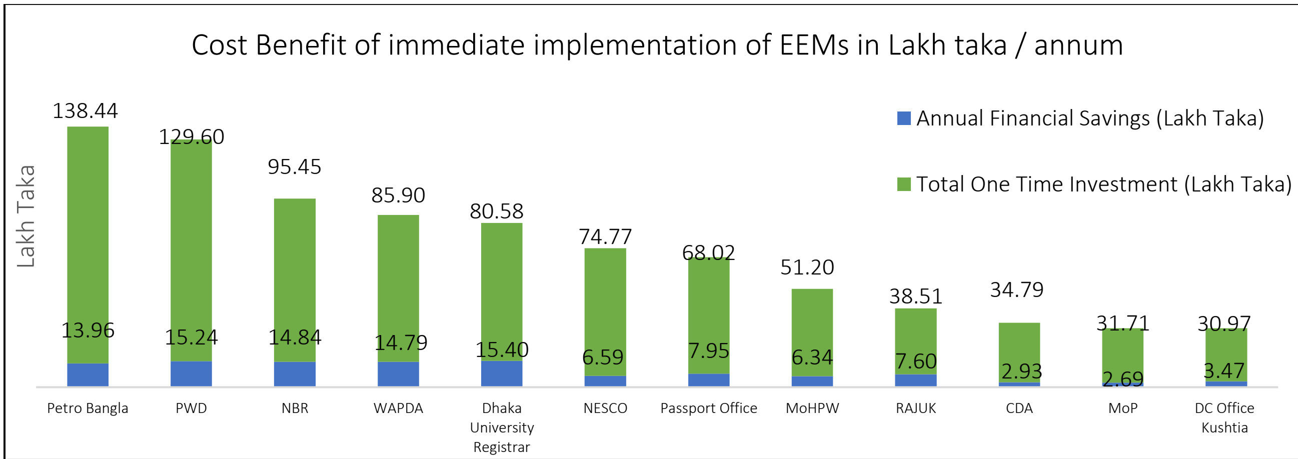

Exhibit 6 Financial Evaluation of Energy Efficient Measures

Measures	Particulars	Passport Office	Dhaka University Registrar	MoHPW	PWD	NBR	RAJUK	CDA	DC Office Kushtia	Petro Bangla	NESCO	MoP	WAPDA
Switching the power settings of desktops to power saving mode	Annual Savings kWh	6113	8874	7037	13875	10973	3781	4548	2023.3	9571	3718	1362	20266
	Estimated Investments (BDT)	0	0	0	0	0	0	0	0	0	0	0	0
	Simple Payback Period (Years)	Immediate											
	Efficiency improvements (%)	0.48%	1%	2%	1%	1%	1%	4%	2%	1%	1%	1%	4%
Replacement of Fluorescent tube lights and CFLs with energy efficient LED lights	Annual Savings kWh	10404	74311	8070	35977	40595	31525	13154	14955	77867	9464	9484	57989
	Estimated Investments (BDT)	75340	580165	129375	264020	334065	299575	271975	121325	1449180	213505	83950	378010
	Simple Payback Period (Years)	1	0.7	1.53	0.65	0.72	0.85	2	0.79	1.7	2.19	0.78	0.63
	Efficiency improvements (%)	1%	7%	2%	3%	5%	5%	11%	14%	11%	2%	8%	11%
Replacement of ceiling fans with energy efficient brush-less DC (BLDC) motor fans	Annual Savings kWh	6769	38317	7965	26343	10080	12251	7147	7513	30273	11360	2533	4067
	Estimated Investments (BDT)	553700	3180100	543900	1896300	857500	847700	965300	534100	3165400	597800	196000	343000
	Simple Payback Period (Years)	9	9	7	8	9	7	16	7	12	5	8	8
	Efficiency improvements (%)	1%	3%	2%	2%	1%	2%	6%	7%	4%	2%	2%	1%
Replacement of older ACs with energy efficient ACs	Annual Savings kWh	13162	31186	7965	45456	57800	16276	4934	6123	20934	25963	13677	25,230
	Estimated Investments (BDT)	4540800	4297920	3909840	8931120	8352960	2703360	2241360	1487620	9229440	4284720	2890800	6320160
	Simple Payback Period (Years)	38	16	15	22	20	18	53	24	49	16	23	24
	Efficiency improvements (%)	1%	3%	8%	3%	7%	3%	4%	6%	3%	5%	11%	5%
Replacement of plain windows with energy efficient glazed windows	Annual Savings kWh	11066	9885	4749	38317	12410	8664	1946	3431	33435	13522	1091	8,039
	Estimated Investments (BDT)	1632238	3233910	537082	1868300	2261425	1803904	780583	1408049	6724704	2380693	802181	1549156
	Simple Payback Period (Years)	16.5	37	13	5	20	23	47	40	22	17	80	19
	Efficiency improvements (%)	1%	1%	1%	3%	1%	1%	2%	3%	5%	3%	1%	21%

	Immediate Goal - Payback less than or equal to one year
	Short term goal - Payback more than one year and less than three years
	Long term goal - Payback more than five years and less than ten years
	Long term goal - Payback more than ten years
	Payback extremely high – Measure not directly feasible

Notes:

The total CO_2 reduction anticipated through implementation of these measures is approximately 721 tonnes of CO_2 per Annum.

Exhibit 7 Snapshot of Evaluation of Energy Efficient Measures in 12 buildings

Incremental cost analysis

As observed in exhibits 6 and 7, the replacement of fans and ACs seems financially unviable as the payback period is high. It is pertinent to note that the aforesaid payback period has been calculated considering immediate replacement. The general practice being followed by PWD is that the appliances are replaced either at its end of life or burn out. In such cases, PWD followed the government approved tender procedures and seek procurement of appliances from empaneled vendors considering its Schedule of Rates (SoR). The SoR defines the technical specification of appliances[4] and its concomitant ceiling price of each appliance. Whenever there is burn out or procurement, post the end of life of an appliance, instead of considering total capital cost, the incremental cost should be considered for financial evaluation i.e. cost of energy efficient appliance less cost of conventional new appliance. For example, a 1.5-ton AC is nearing its end of life and PWD decide to procure new AC from the market. It has two options:

a) PWD may procure energy efficient AC which costs approx. 92,000 BDT with an EER of 4.09 (as per the BAT report prepared by GIZ) or
b) Procure conventional new AC which costs 71,000 BDT with an EER of 2.5 (as per SoR).

The energy efficient AC is 63 per cent more efficient than a new conventional AC with an additional cost of 21,000 BDT. Therefore, in this case, during the assessment of procurement, incremental cost is to be considered instead of the total capital cost since the procurement will anyway occur as the AC reaches end of its life.

An incremental cost analysis has been prepared and tabulated below for BLDC ceiling fan, 1.5 Ton and 2 Ton AC as exhibit 8.

Sr No	Appliance	Savings (kWh)	Baseline Cost (Tk)	BAT Cost (Tk)	Incremental Cost (Tk)	Annual Savings (Tk)	Payback Period (Years)	IRR
1	BLDC Fan	50	2000	4900	2900	521	5.57	12%
2	1.5 Ton AC	1048	65740	95040	29301	9474	3.09	30%
3	2 Ton AC	831	77814	92400	14586	7510	1.94	51%

Exhibit 8: Financial Feasibility for replacement on burnout

It is observed that the payback period for the additional expenditure is lucrative for procurement. It may also be noted that in the nearby regions, super-efficient Air Conditioners having EER ranging from 4.45 to 4.75 are available with marginal increment in the costs. ***Thus, an upgradation of PWD SoR technical specifications and prudent policy measures in procurement of appliances will benefit the nation in the long run.***

[4] Copy of the SoR is enclosed in the appendices.

The below given parameters were derived to reflect the potential for optimizing the energy efficiency in selected 274 public buildings under PWD in Dhaka region.

Parameter	Values	Units
Total electricity consumption per annum	75	million kWh
Total electricity savings potential per annum	12.5	million kWh
Total Monetary savings per annum	13	Crores BDT
Total Monetary savings per annum	1.5	Mn USD
Reduction in CO2 emissions per annum	8,350	tonnes of CO_2
Total Investment Potential	100	Crores BDT
Total Investment Potential	11.7	Mn USD
Approximate payback period	7.6	Years

Renewable Energy Potential

The rooftop solar PV potential using SREDA Solar Calculator was simulated for the buildings' roofs. The roofs of 10 of 12 buildings had an open space excluding WAPDA due to its roof re-construction as confirmed by the building administration. It was highlighted that the roof of WAPDA might not be able to withstand the weight of the solar array installations. NESCO on the other hand was utilizing solar generated energy as per its requirements.

As a result, the connected load and a potential of annual solar energy generation was obtained as shown in the exhibits below. ***An average of 33 per cent of the load can be catered through rooftop solar PV in the buildings audited*** excluding WAPDA and NESCO. The resulting payback period for rooftop solar installations was 6.5 years for all audited buildings, with investments ranging from 11 Lakh taka to 100 Lakh Taka.

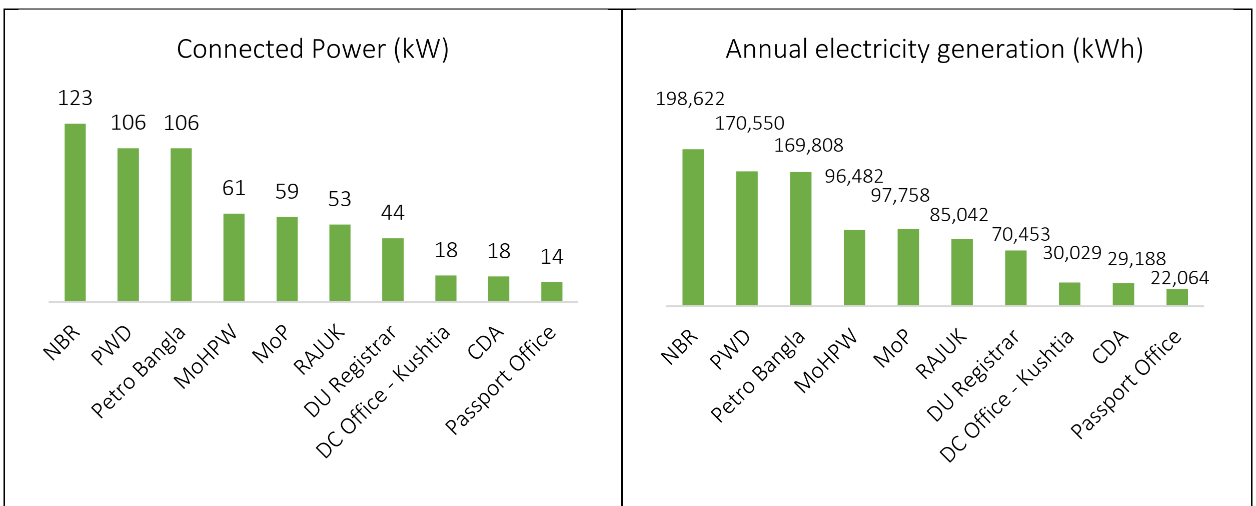

Exhibit 9 Solar PV Potential - Connected load (kW) and Annual Generation Capacity (kWh)

	Passport Office	DU Registrar	MoHPW	PWD	NBR	RAJUK	CDA	DC Office	Petro Bangla	MoP
Payback period (Years)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	5.58	6.5	6.23
Total Investment (Lakh Taka)	11	35	48	86	100	43	14	15	85	47

Recommendations

The key recommendation for energy management activities which can help optimize electricity consumption of the selected public buildings :

1. Decentralization of metering system where in each building in a campus shall possess at least one separate meter recording its energy consumption.
2. Re-evaluation of contract electricity demands to optimize utility bills.
3. Maintaining records of alternative fuel sources used to generate electricity as backup for the commercial buildings. For example: Maintaining daily logs for Diesel generator sets while quantifying operating hours and usage of diesel for power consumption. Exclusion could be the buildings which are designated 'Key Point Installations'. For example, WAPDA Building, Passport Office.
4. Capacity Building for building maintenance crew encompassing, the awareness on the electrical layout of the building, initiating, and maintaining a log of appliance inventory and single line electrical diagram for future energy management activities.
5. Setting annual targets for energy consumption reduction for the buildings based on the generated utility bills.
6. It is also recommended that public buildings shall conduct audits for electrical safety.
7. Shifting to renewable sources as alternative electricity generation fuels is recommended to meet the electricity demand of the commercial building as much as possible. A detailed solar potential analysis should be on the selected buildings based on their lineage and structure of the roof.
8. While Level 2 audit is not an investment grade energy audit, it does indicate a range of 10-20 per cent of potential energy savings in the audited 12 public buildings. Therefore, using the results of Level 2 as a base, further investigation in form of level 3 audits is recommended before any large investment decisions.

Challenges and limitations of data collection

The major challenge faced during the level 2 energy audits was the identification of main electrical connections and physical load distribution in the buildings due to the following:

1. Old electrical wiring of the 12 public buildings.
2. Lack of building electrical line diagrams with the building maintenance crew
3. Electrical safety – A safety concern which made measurements difficult on sites.

The other challenges and limitations faced during the audits were:

1. Lack of maintenance logbooks for the buildings. For example: Lack of records of alternative fuel sources for electricity generation, such as usage of Diesel Generator sets in few buildings.
2. Entry restrictions in multiple buildings for reasons such as national security, data privacy and shared spaces with other organizations.

3. Lack of utility bills on site. For Example: The DC Kushtia office building is a shared space with multiple organizations and hence the consolidated utility bills were unavailable with the building administrations.
4. Some of the buildings in the EEPB project shared utility meters with neighboring buildings which were not a part of the project scope. Therefore, energy consumption of those buildings as recorded by the shared meters were included during the analysis of utility bills at the preliminary stage.

Way forward

Thanks to the initiative of SREDA, this is known to be the first ever comprehensive assessment on energy consumption pattern and energy efficiency and conservation potential in public buildings of Bangladesh. The output of this study could be used by range of relevant national and international actors to further derive the energy efficiency and conservation implementation roadmap for the sector.

Referring to the above given values from this study and concurrent stakeholder interactions during the energy audits, the roadmap presented below shall assist in growth of the energy-efficient appliance market in Bangladesh and garner interest from key stakeholders in implementing energy efficiency projects in public buildings is shown in the exhibit below.

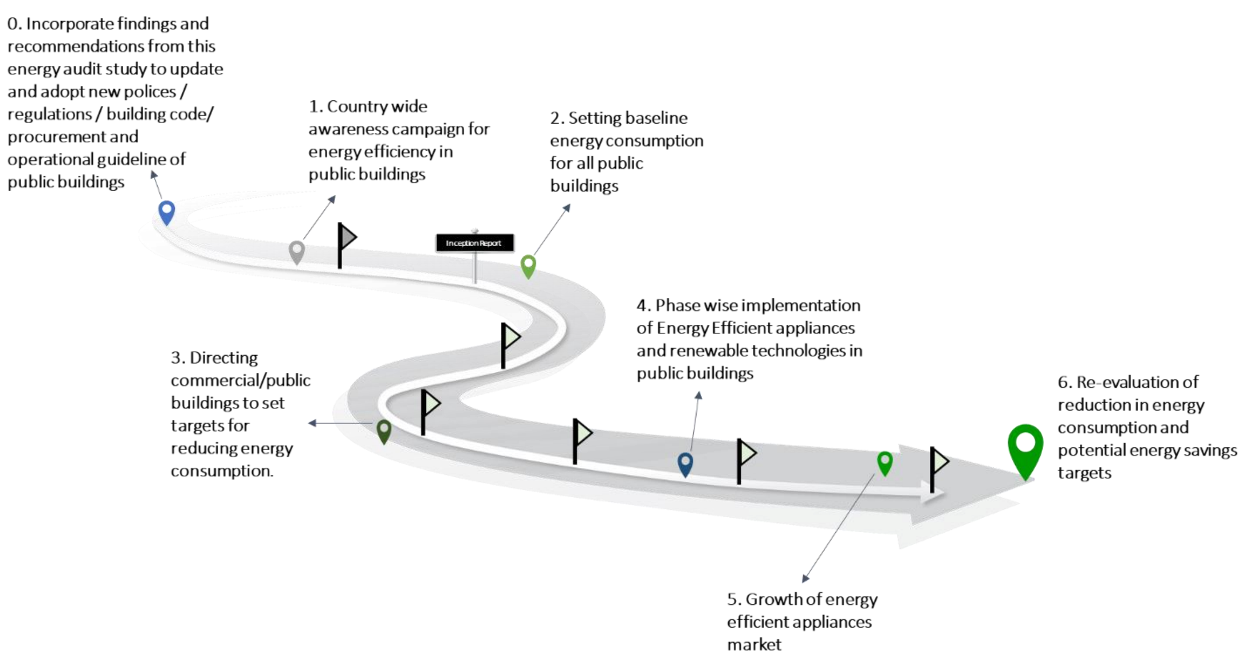

Exhibit 10 Roadmap for implementation of energy efficiency projects in public buildings