November 2022

NEXT GENERATION OF BRIGHTER 'ECO-EFFICIENT' LIGHTING DELIVERS BIG SAVINGS, PILOT DEMONSTRATION PROJECTS SUCCESSFULLY COMPLETED IN PAKISTAN

INTRODUCTION

In line with Pakistan´s Nationally Determined Contribution (NDC) commitments to reduce its emissions by 20%, and the approval of the National Energy Efficiency and Conservation (EE&C) Bill by the National Assembly in February 2016 to strengthen Pakistan's institutions and accelerate the procedures and mechanisms for the effective conservation and efficient use of energy in the country, the Global Environment Facility supported national market transformation programme, *Delivering the Transition to Energy Efficient Lighting in Residential, Commercial, Industrial, and Outdoor Sectors*, was formally launched in February 2019.

The project, jointly implemented by the National Energy Efficiency and Conservation Authority (NEECA) as the federal focal authority and the United Nations Environment Programme's United for Efficiency (U4E) initiative, aims to secure significant global climate change mitigation and environmental benefits by instituting energy-efficient lighting in Pakistan by transforming the lighting market to highly energy-efficient and quality lighting products.

Transitioning the market towards highly energy efficient alternatives, includes the introduction of new lighting technologies such as LED lighting and controls. LED lighting provides an energy saving alternative to traditional light sources (e.g., incandescent or fluorescent lamps) of up to typically 90% and 50% respectively. Occupancy controls, which are used to detect the presence of a person to automatically turn the lighting on and off, can lead to more than a 50% additional energy saving in some spaces such as corridors, restrooms, meeting rooms, storage areas and garages. The direct energy and related carbon savings make an enormous contribution towards climate change mitigation, but also provide a safer option than other very commonly used light sources such as mercury-based fluorescent lighting and high intensity discharge lighting.

To showcase these energy, environmental and financial savings and increase awareness of the benefits by direct user experience, Pakistan´s energy efficiency lighting project included the design, installation, monitoring and evaluation of lighting pilot demonstration projects in high profile government buildings as part of its scope of work.

These pilot projects were initial small-scale deployments used to prove the viability and benefits of replacing inefficient lighting with LED lighting and controls in line with the international performance recommendations in U4E´s *Green Public Procurement Guidelines and Technical Specifications for Energy-efficient Lighting*[1] and were undertaken at:

National Energy Efficiency and Conservation Authority (NEECA) office building

Quaid-i-Azam University´s Library

Capital Hospital

The programme of work for each pilot project followed the same methodology, including:

- An initial lighting audit to determine the existing inventory of lighting fixtures and any potential mechanical issues that could delay or prevent the lamp's replacement for LED technology and also the calculation of a baseline for the quantification of the upcoming energy savings.
- Procurement of the required replacement products. Wherever possible this was carried out in line with U4E's *Green Public Procurement Technical Guidelines and Specifications for Energy-efficient Lighting*.
- Installation and monitoring of performance.
- Calculation of project impact.

NATIONAL ENERGY EFFICIENCY AND CONSERVATION AUTHORITY (NEECA) OFFICE BUILDING

Picture 1. NEECA Office Building, Islamabad

BACKGROUND

The NEECA building in Islamabad was constructed in 1990 and has five floors, with a mezzanine and a basement and a total floor area of about 30,000 square feet. Prior to the pilot demonstration project, most of lighting technologies used in the building were fluorescent tubes and compact fluorescent lamps (CFLs), although some areas already used LED lights, including the main conference room and the basement.

LIGHTING AUDIT

The lighting audit revealed that there were 13 types of lighting fixtures and 483 luminaires installed in the NEECA building, mainly fluorescent tubes and screw-base light lamps (CFLs and LED lamps). As shown in Picture 2, some fluorescent tube fixtures and CFL luminaires contained two lamps, giving a total of 581 lamps installed in the building. The average efficiency of the old lamps was between 80 and 90 lumens/watt for the fluorescent tubes and 60 lumens/watt for the CFLs.

Picture 2. Surface mounted fluorescent tube luminaire and downlight luminaires at NEECA building

PROCUREMENT

A total of 262 units of 4-foot LED tubes, 114 units of 13 W LED lamps, and seven units of LED battens were procured for installation on the ground and first floor. In addition, nine occupancy sensors were procured and installed in toilets and stairs on the ground, first, second and fourth floors.

Procurement of the LED technologies was carried out by NEECA. Local suppliers were required to submit quotations for LED lights, compliant not only with the minimum energy performance standard (MEPS) regulations recently approved by PSQCA[2], but also the more ambitious level defined in U4E's green public procurement guidelines. The lighting fixtures procured had efficiencies ranging between 113 lumens/watt for LED lamps to 150 lumens/watt for LED tubes and included:

- Philips Master LED tube STD 1200mm 14W 865
- Philips Wall Light, Slimline/31170, My Living, Cool Daylight
- Philips Mycare Eyecomfort GLS LED bulb 12 W 1,360 lumen, E27 6500 K

INSTALLATION

Installation and commissioning of the energy efficient lighting and energy monitoring systems was carried out in two phases over five months (from May to September 2021). In the first phase, the new LED technologies were installed to replace the existing lighting technologies. In the second phase, the control and monitoring systems (based on an IoT[3]-based energy monitoring system) were installed and commissioning of the control and monitoring systems was carried out.

Installation of all LED lighting products was relatively straight forward, as all the LED lamps could be directly installed to replace the existing lamps with minimal, or no, rewiring requirements. Most of the LED tubes were directly installed to replace the existing fluorescent tubes with just the replacement of the original starter with a magnetic ballast circuit. For those fluorescent tubes with high frequency electronic ballasts, simple rewiring was also required. The LED battens were directly connected with the AC supply and LED lamps were installed directly in the existing E27 holders.

To maximise the savings achieved, occupancy sensors (230V 5.8GHz 360 Degree Microwave Sensor Light Switch) were installed in the staircase and toilets.

An energy management system and energy meters –tools to visualize, monitor, control, and report on building operations in real-time and assess the energy consumption– were installed on each floor. To mitigate disruptions to electricity supply, an uninterrupted power supply (UPS) system (Kstar 1KVA UPS) was installed.

PROJECT IMPACT

To assess the impact of the project in terms of energy savings, associated energy costs and greenhouse gas (GHG) emission reductions due to the energy efficient lighting measures implemented, monthly reports on electricity consumption were compiled in the last quarter of 2021. Key parameters measured included power draw and operating hours. It was found that weekday operating hours of lighting systems in the building ranged from around 5 hours on the ground floor to about 7.5 hours on the first to fifth floor. The estimated power drawn by original fluorescent and LED lighting technologies was based primarily on the nominal lamp power specified in technical specifications and product information labels.

A total of 363 LED lights were installed as part of the pilot demonstration project to replace 162 fluorescent tubes and 59 CFLs. Some existing LED lights which did not meet the requirements of the new MEPS were also replaced. For the fluorescent tube and CFL retrofits, it was estimated that each new LED tube reduced power consumption by 31 watts, while each LED lamp reduced power consumption by 6 watts.

Based on the operating hours, inventory of fluorescent tubes and CFLs, and reduced lamp wattages, the annual energy savings from the LED lighting retrofits in the NEECA building are 12.4 MWh, which is equivalent to annual cost savings of 248,780 Pakistani Rupees (1,111 USD)[6].

These savings represent a reduction of 6.15 tCO_2 in the GHG emissions released into the atmosphere. The investment of the lighting fixtures was 214,260 Pakistani Rupees (957 USD) and with savings due to the technology leapfrog of 248,780 Pakistani Rupees (1,111 USD), the payback period is estimated in less than one year (0.86 years). These estimates are conservative, as the calculation does not include energy savings from the occupancy sensors (due to the limited number of light points connected) and the marginal savings from replacement of old LED lamps with new LED lamps. Investment cost in the energy monitoring system to showcase the impacts of LED lighting retrofits was not included in the calculation.

These project impacts are summarised in Table 1.

Table 1. Estimated impacts from LED lighting retrofits

Description	#
Pre-installation - fluorescent tubes and CFLs	
Total power demand (kW)	8.4
Annual energy consumption (kWh)	23,937 kWh per year
Post-installation - LED tubes and LED bulbs	
Total power demand (kW)	3.0
Annual energy consumption (kWh)	11,498 kWh per year
Post-installation - LED tubes and LED bulbs	
Annual energy savings (kWh)[4]	12,439 KWh per year
Annual cost savings (Rs.)[5]	248,780
Estimated GHG emission reduction ($kgCO_2$)[7]	7,930
Investment cost (Rs.)[8]	214,260
Simple payback period	**0.86 years / 10 months**

Emissions reduction of **7.9 tCO_2**

Annual energy savings of **12.4 MWh**

Cost savings of **248,780 Rs** per year

Payback of **0.86 years**

QUAID-I-AZAM UNIVERSITY LIBRARY

BACKGROUND

Quaid-i-Azam University (QAU) in Islamabad was founded in July 1967 and has an enrolment of over 5,500 students, including research programmes, PhDs and Masters degrees. The Central Library of QAU –named after the University Vice Chancellor Dr. Raziuddin Siddiqi– has three floors, plus a basement, and a total floor area of approximately 102,500 square feet.

Picture 3. Quaid-i-Azam University Central Library, Dr. Raziuddin Siddiqi. Islamabad

LIGHTING AUDIT

The lighting audit was conducted in the library building in late 2019 and revealed that the main lighting fixtures installed consisted of:

- Recessed 26 inch x 28 inch fluorescent tube luminaires, with six 18 W 2-foot fluorescent tubes with magnetic ballasts.
- Slightly smaller 2 foot x 2 foot recessed luminaires with four 18 W 2-foot fluorescent tubes with magnetic ballasts.
- 4-foot fluorescent tubes and CFLs.

Overall, there were a total of 893 lamps: 539 fluorescent tube luminaires, 257 4-foot fluorescent tubes, 88 CFLs and nine LED spotlights.

The lighting audit further found that many failed fluorescent lamps had not been replaced and some of the existing fluorescent luminaires were not routinely used. Based on the discrepancy between the kW demand computed for the full operation and the kW demand measured by the energy monitoring system, the operating and outage factor of the lighting system on the lower entrance floor before installation of LED planar was estimated at only around 36%.

PROCUREMENT AND INSTALLATION

Based on the lighting audit, the project team recommended replacing 103 existing 26 inch x 28 inch fluorescent tube luminaires with 36-watt LED 24 inch x 24 inch planars in accordance with the standard procurement guidelines. Additional frames were required to fit these into the existing 26 inch x 28 inch space in the false ceiling. The original installations and the new LED planars are shown in Picture 4.

Picture 4. Original 26 inch x 28 inch recessed fluorescent tube luminaire (left), 24 inch x 24 inch LED planar (centre) and its frame (right).

The installation of both the original luminaires and new planars in the lower entrance floor can be seen in the Picture 5, which clearly shows the improvement in illumination levels from the new fixtures. Before the installation of LED planars, spot measurements of lux levels showed values between 90 to 150 lux. After the replacement, the lux levels increase to 200 to 400 lux – an improvement of between 120% and 170%.

Picture 5. The lower entrance floor of QUA Library Building before (left) and after (right) the installation of replacement LED luminaires

In parallel with the procurement and installation of LED lights, a wireless energy monitoring system was installed to monitor and control demand of energy consumption.

PROJECT IMPACT

The average operating hours of the lighting system at the QUA Library on the lower entrance floor are 3,300 hours per year. The replacement of the original recessed fluorescent luminaires with new LED planars represented a leapfrog from an efficiency of 50 lumens/watt to an impressive 120 lumens/watt and is equivalent to a lamp power reduction of 107 watts.

The annual energy savings from the LED planar retrofits in the QUA library building were estimated at 37 MWh which is equivalent to a GHG emissions reduction of about 23 tCO_2 . The annual cost savings were estimated at 730,320 Pakistani Rupees (3,260 USD)[6]. With a total investment cost of 424,360 Pakistani Rupees (1,894 USD), if all-existing fluorescent luminaires and LED planars are in operation, the payback is only about 0.6 years.

However, because of the discrepancy between the actual operation of the original fluorescent lamp luminaires identified in the lighting audit and the full operation of the LED planars, the energy and cost savings are lower than expected, and the simple payback period is estimated to be about 3.2 years. Nevertheless, these are still attractive compared with the long useful lifetime of LED planars. A summary of the project impacts is shown in Table 2.

Table 2. Estimated annual impacts from LED lighting retrofits at full and actual operating factors

Description	Full Operation	Actual Operation
Pre-installation - recessed fluorescent lamp luminaires		
Operating and outage factor (%)	100%	36%
Total power demand (kW)	14.9	5.4
Annual energy consumption (kWh)	49,177	17,754
Post-installation - LED planars		
Operating and outage factor (%)	100%	89%
Total power demand (kW)	3.8	3.4
Annual energy consumption (kWh)	12,661	11,220
Project impacts		
Annual energy savings (kWh)[4]	36,516	6,534
Annual cost savings (Rs.)[5]	730,320	130,680
Estimated GHG emissions reduction ($kgCO_2$)[7]	23,280	4,166
Investment cost (Rs.)	424,360	424,360
Simple payback period	**0.58 years / 7 months**	**3.25 years / 39 months**

Emissions reduction of 4.1 tCO_2

Annual energy savings of **6.5 MWh**

Cost savings of **130,680 Rs** per year

Payback of **3.25 years**

CAPITAL HOSPITAL

BACKGROUND

The Capital Hospital in Islamabad was established in 1981 and is owned and managed by the Capital Development Authority. It is an acute tertiary care hospital, with 400 beds, committed to providing state of the art healthcare. With its wide-ranging departments and diagnostic facilities, it provides sustainable, high quality health services to CDA´s employees in particular and residents of Islamabad in general. It also provides training and post-graduate training in various disciplines of medicine and surgery.

Picture 6. Capital Development Hospital in Islamabad

LIGHTING AUDIT

A walk-through lighting audit was conducted in the areas of the hospital designated for the project, including the reception area, gynaecology unit and its adjoining nursery wards, in late 2021. This revealed that there was a total of 140 fluorescent tube fixtures installed in the three sections: reception having 60, the gynaecology unit 56 and the adjoining nursery area 24. As shown in Picture 7, these luminaires contained four tubes, giving a total of 560 fluorescent tubes installed in the 140 luminaires.

Picture 7. Surface mounted fluorescent tube luminaire

PROCUREMENT

Based on the lighting audit, the project team recommended that the existing fixtures of 4 x 36 W fluorescent tubes were replaced with 36 W 2 foot x 2 foot LED panels. It was possible to achieve the same lighting levels by installing 100 fixtures instead of the 140.

The LED lights procured were Phillips SmartBright Direct RC048B LED32S/840 PSU W6AL6A NOC GM with a Power Factor of 0.9, in accordance with U4E´s green public procurement guidelines.

INSTALLATION

Installation and commissioning of the energy efficient lighting systems was carried out in two phases over a span of about three months (from February to May 2022) – the first for the gynaecology unit and nursery wards and the second phase for the reception area. In both phases, installation of the new panels was achieved with little modification needed to the false ceiling and the wiring circuits.

PROJECT IMPACT

The new LED lighting fixtures have an efficacy of 88 lumens/watt, compared to the replaced fluorescent tubes of 50 lumens/watt. The installation of new LED lighting has not only improved the efficiency of the luminaires and decreased of number of lighting fixtures needed, but has promoted the aesthetic look of the designated areas and created a better uniformity in light, as can be seen in Picture 8 and 9.

The replacement of the lighting fixtures described above, represents annual energy savings for 68,328 KW, equivalent to 43,561 kg per annum of GHG emission reductions. With a total investment of 495,000 Pakistani Rupees (2,210 USD)[6] and cost savings due to the technology leapfrog of 1,366,560 Pakistani Rupees (6,101 USD) per year, the payback period is estimated in 0.3 years. These project impacts are summarised in Table 3.

Picture 8: Replacement LED panels in the gynaecology ward

Picture 9. Replacement LED panels in the reception area

Table 3. Estimated impacts from LED lighting retrofits

Description	#
Pre-installation - fluorescent lamps and CFLs	**560**
Total power demand (kW)	**14 kW**
Annual energy consumption (kWh)	**91,980 kWh per year**
Post-installation - LED tubes and LED bulbs	
Total power demand (kW)	**3.6 kW**
Annual energy consumption (kWh)	**23,652 kWh per year**
Project impacts	
Annual energy savings (kWh)[4]	**68,328 kWh per year**
Annual cost savings (Rs.)[5]	**1,366,560**
Estimated GHG emission reduction ($kgCO_2$)[7]	**43,561**
Investment cost (Rs.)[9]	**495,000**
Simple payback period	**0.36 years / 4 months**

Emissions reduction of 43.5 tCO_2

Annual energy savings of 68.3 MWh

Cost savings of 1,366,560 Rs per year

Payback of 0.36 years

Endnotes

1 - Available at https://united4efficiency.org/sustainable-public-procurement/

2 - Available at https://united4efficiency.org/resources/pakistans-minimum-energy-performance-standards-and-labelling-regulations-for-lighting-products/

3 - Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves

4 - Annual energy savings calculated based on 22 working days per month and 260 working days per year

5 - Based on an average electricity tariff of 20 Pakistani Rupee (Rs.) per kWh

6 - Based on an exchange rate of 1 US dollar (USD) to 224 Pakistani Rupee (Rs). November 2022 values

7 - Calculated based on the emission factor of 0.63753 $kgCO_2$/kWh published by the Institute for Global Environmental Strategies (IGES), available for download at: https://www.iges.or.jp/en/publication_documents/pub/data/en/1215/IGES_GRID_EF_v10.10_20210223.xlsx

8 - Based on the total investment cost of LED lighting provided by NEECA

9 - Based on the total investment cost of LED lighting and energy monitoring system provided by NEECA

ABOUT THE NATIONAL ENERGY EFFICIENCY AND CONSERVATION AUTHORITY

The National Energy Efficiency and Conservation Authority (NEECA) was established under the Ministry of Energy (Power Division) to initiate, catalyze, and coordinate all Energy Efficiency and Conservation (EE&C) activities in different end-use sectors in Pakistan. NEECA through its Strategic Plan (2020-2023) aims at achieving energy saving targets by introducing and implementing EE&C programs in all major sectors of the economy.

To learn more about NEECA´s work, please visit: www.neeca.gov.pk

For more information, please contact: neeca.enlighten@gmail.com

ABOUT UNITED FOR EFFICIENCY

United for Efficiency (U4E) is a global initiative led by the United Nations Environment Programme (UNEP), funded by the Global Environment Facility (GEF), and supported by an array of leading companies, expert organizations, and public entities with a shared interest in transforming global markets for lighting, appliances and equipment to more energy efficiency alternatives saving all electricity consumers, including government, $ billions at the same time.

To learn more about United for Efficiency's work and tools, please visit: united4efficiency.org

For more information, please contact: unep-u4e@un.org