LUX DEV
Luxembourg Development Cooperation Agency

THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of the Environment, Climate
and Sustainable Development

UBND TỈNH
THỪA THIÊN HUẾ

DỰ ÁN THÍ ĐIỂM NAMA - HỆ THỐNG CHIẾU SÁNG SỬ DỤNG NĂNG LƯỢNG HIỆU QUẢ Ở THÀNH PHỐ HUẾ
ENERGY EFFICIENT LIGHTING NAMA PILOT IN HUE CITY • VIE/401

TECHNICAL MANUAL FOR MEASUREMENT, REPORTING AND VERIFICATION (MRV) IMPLEMENTATION

HUE, DECEMBER 2019

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LIST OF ABBREVIATIONS

CC	Climate Change
CCA	Climate Change Adaptation
CCM	Climate Change Mitigation
CDM	Clean Development Mechanism
CO2	Carbon Dioxide
CO2e	Carbon dioxide equivalent
CTA	Chief Technical Adviser
DCC	Department of Climate Change
DOET	Department of Education and Training
DOIT	Department of Industry and Trade
DONRE	Department of Natural Resources and Environment
EE	Energy Efficiency
EF	Emission Factor
EOP	End of Project
GHG	Greenhouse Gas
GOV	Government of Vietnam
HEPCO	Hue Urban Environment and Public Works Joint Stock Company
ICF	International Climate Fund
IPDCC	Industry Promotion and Development Consultancy Centre
KWh	Kilowatt-hour
LED	Lighting Emitting Diode
LuxDev	The Luxembourg Development Cooperation Agency
Luxembourg PMB	Luxembourg Projects Management Board
M&E	Monitoring and Evaluation
MONRE	Ministry of Natural Resources and Environment
MRV	Measurement, Reporting, Verification
MWh	Megawatt-hour = 1,000 KWh
NAMA	Nationally Appropriate Mitigation Action
INDC	Intended Nationally Determined Contribution
NDC	Nationally Determined Contribution
PPC	Provincial People's Committee
PTF	Project Task Force
SMB	School Management Board
SPSS	Statistical Package for the Social Sciences
TA MRV	Technical Adviser Climate Change Measurement, Reporting, Verification
TA PIPP	Technical Adviser on Physical Infrastructure Planning and Procurement
TAO	Technical Assistance Office
tCO2	Ton of Carbon Dioxide
TT Hue	Thua Thien Hue
UNFCCC	United Nations Framework Convention on Climate Change
VND	Vietnamese Dong

I. INTRODUCTION

1. Overview

Under the Paris Agreement, the Vietnam NDCs targets 8% GHG emission reduction (62.8 million tCO_{2e}) with domestic resources, and this target could be increased up to 25% of GHG emission reductions (135.4 million tCO_{2e}) with international support (including bilateral & multilateral cooperation and new mechanisms under the Global Climate Agreement) by 2030, compared to the BAU scenario in 2010. The national GHG inventory in 2010 showed an amount of 246.8 million tCO_{2e} emitted from energy, agriculture, waste and LULUCF sectors, which was projected to increase up to 787.4 million tCO_{2e} by 2030.

With funding from the Climate and Energy Fund (CEF) coordinated by Luxembourg's Ministry of the Environment, Climate and Sustainable Development (MECSD), LuxDev has currently implemented two projects on climate change (CC) adaptation and mitigation in Thua Thien Hue province, VIE/433 and VIE/401, which are considered as International Climate Finance (ICF). VIE/433 project focuses on numerous interventions on CC adaptation and resilience, particularly a component that supports the development of provincial CC adaptation monitoring & evaluation system and provincial MRV system for mitigation actions. VIE/401 is a pilot of nationally appropriate mitigation action (NAMA) that aims to achieve electric energy savings and CO2 emission reduction through the substitution of conventional lamps (fluorescent and sodium lamps) with more energy-efficient Light Emitting Diode (LED) lamps in public areas, particularly street lightings and public schools in Hue City. It is expected that this pilot intervention will demonstrate the effectiveness of LED lightings for the above purposes, and lead to the formulation of an upscaling mitigation intervention in due course.

VIE/401 targets the lighting systems of 54 schools (29 primary schools, 22 secondary schools and 3 high schools) and 18 streets in Hue city. It aims to achieve an average emission reduction of approximately 1,392 tCO2/year through the average energy saving of 1,610MWh/year, estimated by the use of the currently applied national electricity grid emission factor of 0.8649 tCO2/MWh (The Correspondence No.330/BĐKH-GNPT dated 29/3/2019, DCC, MONRE). The annual CO2 emission reduction achieved will be calculated on the updated emission factor for national electricity grid annually issued by MONRE.

Given the minimum life time of 36,000 hours required for LED luminaires installed at target school and street lightings, the VIE/401 project supported LED lightings at target schools and streets are expected to save at least 19.32GWh in a period of 12 years. Using the emission factor (EF) of 0.8649 tCO2/MWh, VIE/401 is expected to achieve a total emission reduction of approximately 16,710 tCO2 by its LED light pilot interventions.

The project purpose is to contribute to the effort of achieving the GHG emission reduction targets that the Government of Vietnam has committed to the international community under the Paris Agreement. For that purpose, the project results of CO2 emission reduction have to be reported and registered with the Ministry of Natural Resources and Environment (MONRE) for recognition and inclusion in Vietnam NDC reports, periodically submitted to the Intergovernmental Panel on Climate Change (IPCC) of the United Nations Framework Convention on Climate Change (UNFCCC).

On that account, the Project is required to develop a Measurement, Reporting and Verification (MRV) system that is aligned with the international and national MRV framework and guidelines. The MRV system is particularly key to any climate change mitigation action because it will help to measure the impacts of GHG emission reduction interventions; and for the Government of Vietnam (GOV), it is an important base on which the GHG emission reduction achieved against the national targets, committed to the international community under the Paris Agreement, can be reported. As part of the roadmap for implementing the Paris Agreement and in compliance with the Katowice Climate Package: the Implementation Guidelines for the Paris Agreement on climate change (UNFCCC, COP24), MONRE recently proposed the draft Decree formulating a specific plan on the mitigation of GHG emission in Vietnam. This draft Decree, when approved and promulgated by the GOV, will provide a significant legal basis for relevant policies, programmes and plans on GHG emission reduction and development of technical guidelines and procedures for MRV of GHG emission reductions. In this GHG draft Decree, MONRE proposes three levels of MRV system on GHG emission reduction including 1) Project/Institutional level MRV; 2) Sectorial/Provincial MRV and 3) National MRV. VIE/401 MRV system is the Project/Institutional level MRV which is supposed to comply with guidelines and procedures of the Sectorial/Provincial MRV framework. Following the GOV promulgation of this GHG Degree, MONRE will issue a Circular that provides more detailed technical guidelines and procedures for national and sub-national measurement, reporting and verification (MRV) of GHG emission reduction. At the present, the GOV has not yet approved and promulgated this GHG Emission Reduction Decree and therefore there are no official regulations and technical guidelines for the project to comply with when developing its MRV system.

On account of the current absence of official top-down guidelines and procedures required from a national or sub-national framework, which always brings about multiple benefits of developing a MRV system, the Project will adopt international MRV guidelines and procedures to develop this project MRV manual and follow relevant technical procedures for measurement and calculations as guided in the two measurement methodologies: 1) AMS-II.L for energy efficient (outdoor) street lightings, and 2) AMS-II.N for energy efficient (indoor) lighting in buildings for selected schools (UNFCCC CDM Methodology Booklet). The process of developing this MRV manual has involved the provincial governance structures as well as referred to the information and guidelines from the DCC, MONRE, to establish an effective and relevant measurement, reporting and verification mechanisms.

2. Concept of Measurement, Reporting and Verification (MRV)

The term “Measurement, Reporting and Verification” originally came from the Bali Action Plan of the UNFCCC in Bali, Indonesia at the end of 2007. MRV emerges as one of the key elements of the mitigation framework developed under the UNFCCC for mitigation actions by developing countries, agreed at COP16 and further defined at COP17. The key objective of MRV is to increase the “transparency of mitigation efforts made by the developing countries’ as well as build mutual confidence among all countries (UNFCCC, 2011). MRV is not a new concept, and it has been widely used in many contexts at the national and international levels to ensure transparency and help in effective implementation (UNEP Risoe, 2012).

Measurement refers to collecting information on the progress of implementation and impacts of a NAMA. Reporting is a relevant mechanism designed to submit the measured information in a defined and transparent manner to the appropriate authorities. Verification is the assessment of the information that is reported for completeness, consistency and reliability (Sudhir Sharma, 2014). A robust system of measuring, reporting and verifying is essential for effective monitoring of NAMA implementation, as well as in assessing its impact in terms of GHG emission reductions, cost effectiveness and sustainable development benefits.

The new draft GOV Decree on the roadmap for GHG emission reductions (2019) define MRV as “a follow-up, quantitative monitoring of the progress and results achieved by GHG mitigation actions through a complete and consistent system”.

MRV is central to effectively implementing the Nationally Determined Contributions (NDCs) which describe party countries’ mitigation goals, policies and projects submitted under the Paris Agreement. The MRV framework for developing countries has the following two key elements (UNFCCC Handbook on MRV):

- MRV of national efforts: GHG inventory and information on the efforts made to mitigate GHG emission by the country; and
- MRV of NAMAs: specific mitigation actions in the context of sustainable development identified and implemented by countries.

The stringency level of MRV may differ depending on whether a mitigation action applies to a carbon trading scheme or not. Stringent GHG emission reduction calculation and monitoring methods are required for MRV under carbon crediting system such as Clean Development Mechanism (CDM)-an international mechanism under Kyoto Protocol that allows emission-reduction projects in developing countries to earn carbon credits. However, if a mitigation action is not intended to generate carbon credits, less stringent GHG emission reduction calculation and monitoring methods can be applied, for the objective of such MRV is not to ensure the credibility of generated carbon credits but rather to evaluate the effect of project implementation.

3. Goal and Objectives

The goal of this manual is to provide technical guidelines for the development and operation of the project MRV system through specific technical procedures and MRV activities during the project period and after the project end. The document aims to achieve the following specific objectives:

1) Describe the key operational activities of the project MRV system that will be undertaken during the project period;

2) Present and give explanations for methodologies and equations used to calculate the electric energy savings and the CO2 emission reductions achieved on the basis of collected data for measurement parameters;

3) Describe key activities and work plan for the reporting and verifying of project results undertaken by relevant agencies/units;

4) Propose the roadmap for handing over and implementing MRV activities after the project end.

4. Manual Structure

The manual is composed of the following seven major sections:

I. Introduction: This section presents the overview of the project context, concepts of MRV, goal and objectives, structure and scope of this technical manual for MRV implementation;

II. Project Summary: Key information that briefly introduce the VIE/401 project with regard to project outline, goal and objectives, expected results and tasks, target locations and beneficiaries, and stakeholders;

III. Project MRV Framework: This section briefly describes the context of and key elements of the project MRV system, Scope of the project MRV system; Institutional Arrangements for MRV; Measurement Mechanism including measurement methodologies, baseline methodology, monitoring methodology and calculations; Reporting Mechanism; and Verification Mechanism;

IV. MRV implementation: Presented in this section includes key information on MRV work that aims to put the project MRV system into operation through the process and technical procedures of implementing MRV activities within the project scope of interventions during the project period and after the project phase-out. The detailed contents presented in this section will help project stakeholders or any concerned audiences better understand 1) Measurement which consists of collection of data for baselines; monitoring plan and calculations of electricity savings and CO2 emission reductions; 2) Reporting plan 3) Verification plan;

V. Registration of project results of CO2 emission reductions: The section briefly describes the purpose and what to be registered and procedures for registering project results of CO2 emission reduction with relevant national authorities and UNFCCC for recognition;

VI. Hand-over of the project MRV system at the end of project cycle: Procedures and plan for the handover of VIE/401 MRV performance and organizational structure of the post project MRV system and proposed in this section.

VII. Appendices: This section includes the table of MRV implementation plan, lists of schools and streets selected for project support LED light replacement, and UNFCCC measurement methodologies AMS-II.L & AMS-II.N, and the bibliography.

This document can be used as a technical reference for project managers, experts, technicians and project officers who are concerned and interested in the development and operation of the MRV system of a GHG mitigation intervention. Mr Hoang Thanh Hung, Climate Change MRV Technical Advisor has prepared this manual based on technical references and in consultation with the relevant experts and technical advisers of LuxDev, relevant stakeholders of project MRV activities as well as the experts and technicians of concerned government agencies such as DONRE, DOIT, DOET and DPI.

II. PROJECT SUMMARY

1. Project profile

Project name & code	Energy Efficient Lighting NAMA Pilot in Hue City-VIE/401
Total budget	2,200,000 EUR
Local contribution	*200,000 EUR*
Luxembourg Government funding	*2,000,000 EUR*
Project starting time	July 2018
Duration (years)	3 years (36 months)
Local counterpart	Thua Thien Hue Provincial P.C and DPI
Primary beneficiaries (target groups)	Pupils, teachers and staff of high schools, secondary schools, primary schools and local people in Hue city

VIE/401 and its sister project VIE/433 are the first two Luxembourg Cooperation projects implemented with funding from the Climate and Energy Fund (CEF) coordinated by Luxembourg's Ministry of the Environment, Climate and Sustainable Development-MECSD (formerly the Ministry of Sustainable Development and Infrastructure). LuxDev signed the VIE/401 Execution Mandate on 19/4/2018.

This new intervention, from Luxembourg perspective not considered as Official Development Assistance (ODA) but International Climate Finance (ICF), is the first Energy Efficiency project implemented by LuxDev. The pilot project aims to achieve energy savings and Greenhouse Gas (GHG) emission reduction through the substitution of conventional lamps with more energy-efficient LED lamps in public areas in Hue City. The intention is that the pilot interventions will demonstrate the effectiveness of LED lighting for the above purposes, and will lead to the formulation of an upscaling mitigation intervention in due course.

2. Goal and specific objective

The goal of VIE/401 is formulated to "contribute to the national and provincial Green Growth, Climate Change, and Energy Efficiency Target Programmes in Hue City, TT Hue Province". The specific objective is to "pilot an energy efficient (EE) lighting NAMA that achieves energy savings and GHG emission reductions through the substitution of conventional lamps of public lightings with LED lights", with the focus on three dynamics: (i) capacity strengthening and enabling activities for the project pilot; (ii) the installation of LED light systems and MRV of outcomes and impact; and (iii) exploration for upscaling and proposal development beyond the pilot intervention in Hue City. The strategy serving the project objective is realised through interacting elements: capacity strenghening and awareness raising for mitigation inteventions (pilot software component), infrastructure in the form of installation of LEDs (pilot hardware component), data management and reporting tools for the MRV system, and institutional strengthening enabling the development of a higher level mitigation intervention beyond the pilot project. The project includes a set of activities under five most effective tasks to achieve the key elements of three expected results.

Result 1: Capacity strengthening and enabling activities for the NAMA pilot
Task 1: Preparation and enabling activities for the pilot;
Task 2: Awareness raising and capacity development;

Result 2: LED demonstration procurement and installation
Task 3: LED installation and impact measurement;

Result 3: Exploration for upscaling and proposal development beyond the NAMA pilot in Hue City
Task 4: Documentation and communication on the pilot intervention's outcomes, for further use and support to an upscaling proposal;
Task 5: Preparation of, and full proposal for a higher level mitigation intervention.

3. Target locations and beneficiaries

3.1 Target locations for project pilot interventions

The target locations for project pilot interventions include the lighting systems of 18 streets (with a total length of 25,962 m and located in the North and South of the city) and 54 schools (29 primary schools, 22 secondary schools and 03 high schools) in Hue city.

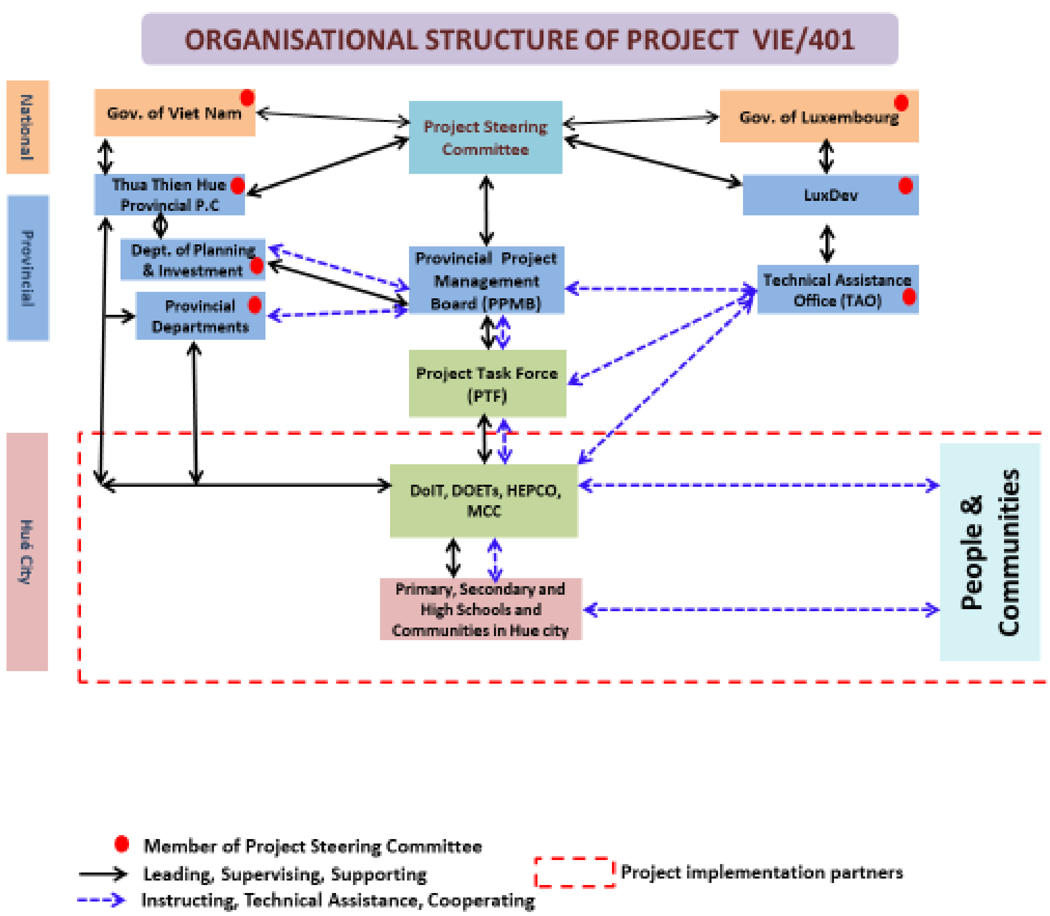
3.2 Target beneficiaries

The main target groups include students, teachers and staff of primary, secondary and high schools for the awareness raising activities on energy efficiency and climate change mitigation impacted by the retrofit of LED lights, as well as government and technical staff for the institutional capacity strengthening for the development and operationalization of a robust MRV system and enabling activities for the upscaling component.

4. Institutional set-up

The organizational setup of VIE/401 is shown in the Figure 1 below:

Figure 1: Organizational Structure of Project VIE/401



Project Stakeholders

Project Steering Committee (PSC)

The Project Steering Committee (PCS) brings together the governing and owning entities, and is responsible for major strategic decisions and final reviews of progress. The PSC members from the Vietnamese Government includes Chairman of Thua Thien Hue Pronvical People's Committee, representatives of Ministry of Planning and Investment, Ministry of Finance, and leaders, provincial Department of Planning and Investment (DPI) and provincial Department of Natural Resources and Environment (DONRE). The Luxembourg Government donor includes the representative of the Ministry of the Environment, Climate and Sustainable Development (MECSD), the Luxembourg MFEA and LuxDev based in Vientiane, Lao. The deputy director of TTH DPI as Director of the Provincial Project Management Board, and the Chief Technical Advisor (CTA) as head of the LuxDev Technical Assistance Office are also the members of the Steering Committee.

TTH Provincial People's Committee (PPC)

As defined in the Government Decree No. 16/2016/ND-CP dated 16 March 2016, the governing agency for Vietnam will be the TTH PPC. The DPI will be delegated as the project owner.

Luxembourg Projects Management Board (Luxembourg PMB)

The Luxembourg Projects Management Board (Lux PMB) established in January 2018 to support implementation of Luxembourg's two climate change projects, is headed by the same DPI Deputy Director as previously under project VIE/033. He and Lux PMB staff (five technical and one admin-finance) are existing DPI staff and will support the two Luxembourg projects for 50% of their time.

Technical Assistance Office (TAO)

The TAO, established by LuxDev, has responsibility for technically supporting the project implementation in close cooperation with Lux PMB. The TA team for VIE/401 consists of 03 technical staff including 01 international Chief Technical Adviser and 02 national Technical Advisers, who work 50% of their time for the project implementation. Two national technical advisers include a CC MRV Technical Adviser and a Physical Infrastructure Planning and Procurement (PIPP) Technical Adviser.

Project Task Force (PTF)

In addition to the technical advisers and technical staff of the TAO and Lux PMB, the PTF includes the representatives from three provincial departments such DONRE, DOIT and DOET and Hue Municipal P.C. In addition, HEPCO, a project implementing partner, also has a technician involved in the PTF. The key function of the PTF is to assist the Project Management in reviewing, provide technical advice and comments as well as endorsing the technical issues of relevant project activities.

Project Implementing Partners

Hue Municipal P.C is the key partner for project LED pilot interventions at primary, secondary & high schools. For street lightings, HEPCO is the implementing partner for the LED pilot interventions. The provincial DOET and Hue Municipal DOET as well as Management Boards of target schools are also key project partners for capacity building and IEC activities at schools. Management Boards of target schools will be involved in supporting the measurement, collection and reporting of monitoring data.

5. Scope of project pilot interventions

5.1 Pilot LED light intervention in target schools

Through the procedures of assessing and selecting LED light retrofit proposals and based on the set of technical selection criteria agreed between the Luxembourg Projects Management Board (Lux PMB) and Technical Assistance Office (TAO), LuxDev, the Project has approved the support for installation of LED lights at 54 schools, including 29 primary schools, 22 secondary schools and 03 high schools in Hue city. As planned, the project will support the procurement and installation of around 18,482 LED tubes of 1.2m length with rated power of 14-24W to replace 13,916 conventional lamps including T8 and T10 fluorescent tubes and T8 LED tubes of poor-quality, and add more LED luminaires in line with the lighting design to achieve the required illuminance standards. The installation is scheduled to tentatively begin in August 2020. Please see the list of selected schools in Annex 1. The implementing partner agency signing the Delegation Agreement with the Luxembourg Development Cooperation Agency to carry out the pilot LED light installation interventions is Hue City People's Committee.

5.2 Pilot LED light interventions at target street lightings

For street lightings in Hue City, the Project has approved to financially support the installation of LED luminaires for the lighting systems of 18 streets with a total length of about 25,962 m located in the North and South of the city. As planned, the Project will finance the procurement and installation of about 1,071 LED luminaires with rated power of 120-150-180W to replace the existing number of operating conventional luminaires (SODIUM). The installation is scheduled to tentatively begin in August 2020. Please see the list of target streets in Annex 2. The implementing partner agency signing the Delegation Agreement with the Luxembourg Development Cooperation Agency to carry out the pilot LED light installation intervention, is Hue Urban Environment and Public Works Joint Stock Company (HEPCO).

III. PROJECT MRV FRAMEWORK

1. Context

The VIE/401 is a NAMA pilot project but its results of CO_2 emission reduction are aimed to contribute to the achievement of Vietnam INDC targets of GHG emission reduction committed under the Paris Agreement. On this account, the Project is required to build a MRV system which tracks progress toward achieving its objective and expected results of CO_2 emission reduction and report periodical accomplishments to relevant authorities for approval and recognition. The project MRV framework is therefore supposed to adopt the technical guidelines, procedures and regulations as provided in the project/institutional, sectorial and provincial MRV framework. Up to the present, the GOV has not yet promulgated any specific technical guidelines and procedures that measures, reports and verifies the impact on GHG emission reduction achieved by a mitigation action, particularly in the area of energy efficiency. As a result, the Project referred to the guidelines on MRV framework in several technical documents of national and international organizations/agencies listed in the bibliography to develop its MRV framework. The process of developing the project MRV system has been done in close collaboration and consultations with the experts and technical staff of TAO, LPMB, implementing partners and provincial departments such as DONRE and DOIT, as well as the experts and technical staff from other concerned agencies. For the measurement mechanism, the Project will follow the principles, process and technical procedures as guided in the two measurement methodologies (AMS-II.L & AMS-II.N, UNFCCC). For reporting and verification mechanisms, the Project will formulate administrative procedures and institutional arrangements based on the existing management and institutional set-up of the project and aligned with the existing structure of relevant governing bodies and technical units in TT Hue province.

2. Key elements of the project MRV Framework

Effective mitigation of climate change requires a regular monitoring of mitigation strategies and their impacts. The project MRV system is part of the project Monitoring & Evaluation (M&E) system focusing on measuring and monitoring the project impact on CO_2 emission reduction achieved from project LED pilot interventions at target schools and streets. The operation of a project MRV system includes three independent, but inter-related processes of measurement or monitoring (M), reporting (R) and verification (V), which fundamentally constitutes the project MRV system. The project MRV framework is a structure and institutional arrangement under which MRV activities are implemented within the scope of project interventions, capacity and available resources. The project MRV framework is a package of institutional arrangements, process, procedures and guidelines for operationalizing the system. Key elements of the project MRV framework include:

- Scope of the MRV, which includes the aim and objectives of the MRV performance, define the boundaries, objectives and requirements of the MRV. It lays the foundation for assigning the roles of various actors and their interactions, as well as what is MRVed;
- Institutional arrangements for the operation of project MRV system which define roles, responsibilities of institutions involved in the MRV implementation. Involved institutions are mainly concerned project stakeholders including governing body and technical units which support in establishing guidelines and systems for data collection and storage and verification entities;
- Measurement methodology, reporting and verification mechanisms that comprise clear process and procedures as well as guidelines for different steps in the process of establishment and operation of the MRV system;
- Regulatory framework to support the institutional arrangements and the responsibilities of various actors involved in the MRV.

3. Scope of the project MRV system

3.1. Purpose and objective of the project MRV system

The purpose of the project MRV system is to ensure that the CO_2 emission reductions achieved by the project LED pilot interventions in 18 streets and 54 schools (29 primary, 22 secondary and 03 high schools in Hue city, are measurable, and additional to what would have happened in the absence of project support.

Overall, the aim of the project MRV system is to ensure accurate estimates of electricity savings and CO2 emission reductions achieved by the project implementation.

The objective of the project MRV system is to MRV the energy savings and CO2 emission reduction resulted from project pilot interventions on energy efficiency LED lighting. Thus, what are MRVed include the baseline CO2 emissions and project CO2 emissions, so that "real" emission reductions are estimated and confirmed through periodical monitoring of the relevant data for estimating CO2 emissions. More importantly, verification of the data, data collection systems and records is required to be undertaken during and after the MRV process.

The project MRV system will measure, monitor and evaluate the achievement of two expected results on electricity savings and CO2 emission reduction at target schools and streets based on the three outcome & impact indicators (#1a and #1b in the ME matrix) as described in Table 1.

3.2 What to be MRVed

The MRV system will focus on measuring, reporting and verifying the accomplishments of two impact indicators as follows:

Table 1: Project Impact Indicators to be MRVed

No	Impact Indicators	Unit. of Measurement	Annual target	Emission factor (EF) for National electricity Grid
1a	Reduction in GHG emissions (tCO2/year) by pilot interventions;	tCO2/year	1,392	EF=0.8649 tCO2/MWh *(Issued under the Correspondence No.330/BĐKH-GNPT dated 29/3/2019, DCC, MONRE)*
1b	Energy savings (MWh/year) from the pilot interventions;	MWh/year	1,610	

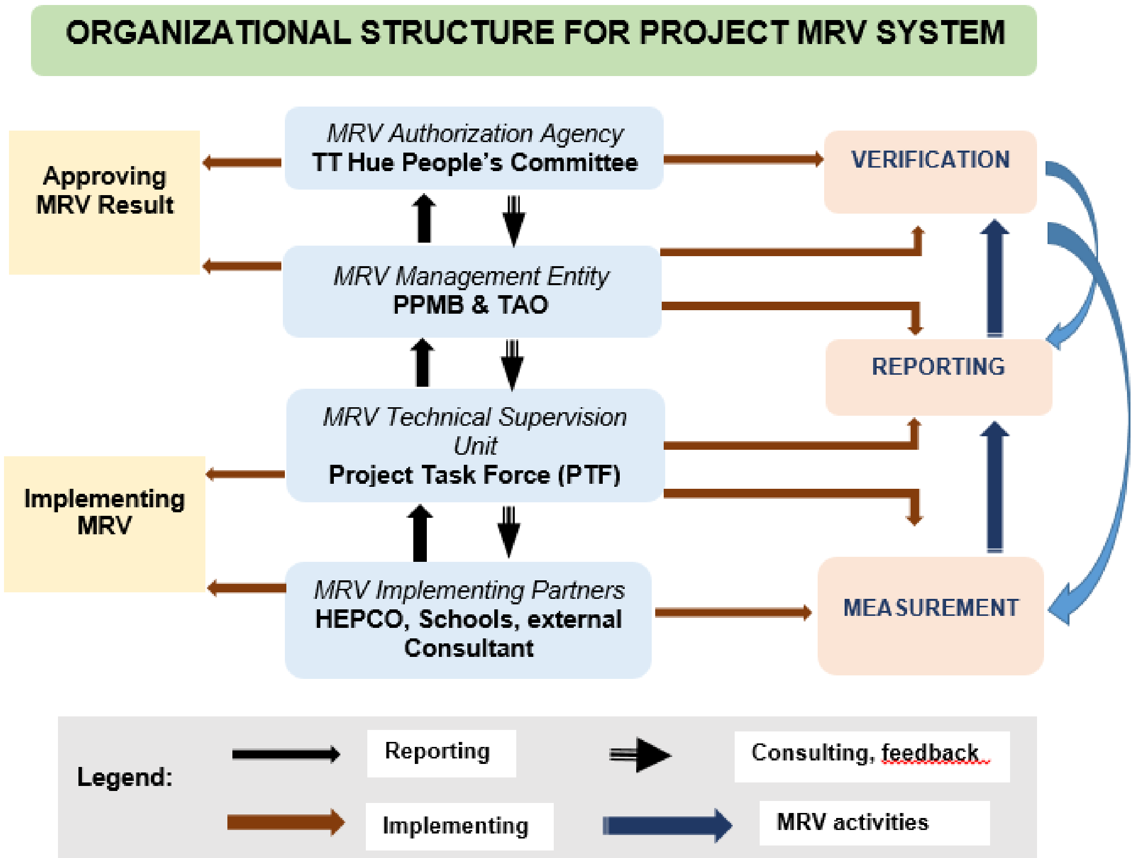
4. Institutional Arrangements for MRV

Institutional arrangements to operate the project MRV system is an important element in developing a required framework of project MRV. Effective operational implementation of the project MRV system as well as the sustainability and capacity building for the MRV implementation will result from clearly defined institutional arrangements for the project MRV system, in which a single entity responsible for its overall coordination and implementation is very crucial. The institutional arrangements designate institutions/entities involved in MRV performance and highlight their associated roles and responsibilities in different stages and activities of the MRV process. The organizational setup of the project MRV system includes four major actors/MRV Stakeholders as listed in Table 2 below:

Table 2: Stakeholders of the project MRV system

No	MRV Stakeholders	Project Stakeholders
1	MRV Authorization Entity	TT-Hue Provincial P.C
2	MRV Management Unit	TAO and Lux PMB
3	MRV Technical Supervision Unit	Project Task Force (PTF)
4	MRV Implementing Partners	HEPCO for street lightings, Management Boards of target schools for school lightings

Figure 2: Organizational Structure for Project MRV System



Roles and Responsibilities of MRV stakeholders

1) MRV Implementing Partners

MRV implementing partners include those institutions/entities which directly benefit from project support as well as the independent technical consultants hired from outside. The main role of MRV implementing partners are to collect baseline and monitoring data which are used to calculate the results of project interventions and to verify the project results reported. Table 3 summarizes key responsibilities of MRV implementing partners.

Table 3: Responsibilities of the MRV Implementing Partners

MRV Implementing Partners	**Responsibilities**
HEPCO, target schools (primary, secondary and high schools) and external consultants (for baseline survey and measurements and verification)	• Participate in the capacity building activities or IEC activities organized by the project; • Facilitate, assist in or implement the collection of baseline data and measurements under the technical guidelines of the MRV Technical Supervision Unit; • Organize the collection of monitoring data on periodical basis; • Report the collected monitoring data on a regular basis to the MRV Technical Supervision Unit for review and approve; • Facilitate and assist in the field verification activities if required.

2) MRV Technical Supervision Unit

This unit is a technical body which involves technical advisors, experts and technical officers from Lux PMB, TAO, DONRE, DOIT, provincial DOET, Municipal DOET and HEPCO. Its main roles are 1) to provide technical assistance, guidelines for development and operation of the project MRV system; 2) to review, verify and endorse the results of all the MRV activities; 3) to provide technical advice on project MRV for the Lux PMB and TAO (MRV Management Unit). Table 4 below entails the responsibilities of the MRV Technical Supervision Unit.

Table 4: Responsibilities of the MRV Technical Supervision Unit	
MRV Technical Supervision Unit	**Responsibilities**
Project Task Force (PTF)	• Develop the MRV framework and plan for MRV implementation, tools for collection of baseline and monitoring data for measurement and calculations; • Build capacity for MRV implementing partners and supervise measurement activities such as collection, storage and analysis of baseline and monitoring data; • Review and verify the baseline and monitoring data for measurement parameters reported by the MRV Implementing Partners • Responsible for doing calculations for energy savings and CO2 emission reductions; • Establish and supervise the operation of the project MRV system; • Prepare and submit periodical MRV reports to the MRV Management Unit (which include Lux PMB and TAO); • Provide technical advice on the procedures of registration for project results of CO2 emission reduction with MONRE and UNFCCC registry.

3) MRV Management Unit

This unit plays a key role in managing and supervising the development and operation of the project MRV system. Its specific roles include providing necessary technical support, review, verify and endorse the MRV plan and MRV reports on measurement and results of CO2 emission reduction. The specific responsibilities are described in Table 5 below.

Table 5: Responsibilities of the MRV Management Unit	
MRV Management Unit	**Responsibilities**
Luxembourg Projects Management Board (Lux PMB and Technical Assistance Office (TAO)	• Review and endorse the MRV framework and MRV plan and implementation plan of MRV activities; • Oversee the implementation of MRV activities; • Review, verify and approve the MRV reports in consultation with the Project Task Force; • Provide necessary technical expertise and oversight of the development and operation of the project MRV system; • Update database on energy consumption, energy savings and CO2 emission reduction; • Submit project reports on the achieved CO2 emission reduction to the MRV Authorization Entity (TT-Hue P.C); • Complete the procedures to register the project accomplishment of CO2 emission reduction as a contribution to the NDC target of GHG emission reduction with MONRE and UNFCCC.

4) MRV Authorization Entity

The main role of this entity is to check and approve the project results on GHG emission reduction measured, verified and reported by the MRV Management Unit. More specifically, the MRV Authorization Entity is proposed to undertake the tasks shown in Table 6 below.

Table 6: Responsibilities of MRV Authorization Entity

MRV Authorization Entity	Responsibilities
TT-Hue Provincial People's Committee	• Review and approve the MRV report on project results of GHG emission reduction submitted by the MRV Management Unit; • Endorse the amount of CO2 emission reduction (tCO2/year) resulted from the project pilot interventions; • Report the project results of CO2 emission reduction to MONRE; • Support and facilitate the procedures to register the amount of CO2 emission reduction achieved by the project as a contribution to the NDC target of GHG emission reduction with MONRE and UNFCCC.

5. Measurement

5.1 Measurement Methodologies

Up to the present time, the Government of Vietnam still has not promulgated any standard methods for measurement and calculations of electric energy savings and CO2 emission reduction resulted from the use of energy-efficient lighting systems with LED lights. Therefore, the Project will adopt the guidelines on baseline & monitoring methodology, measurement & calculations of electricity savings and CO2 emission reductions as instructed in the following two measurement methodologies of the UNFCCC:

1) Street Lightings: AMS-II.L: Small-scale methodology: Demand side activities for efficient outdoor and street lighting technologies.

This measurement methodology was introduced as Approach A in the Project Document. Data will be collected for parameters as required in the Equations that calculate the gross/net electricity savings and reduction of CO2 (using the emission factor for the national electricity grid). For more detailed information on this measurement methodology, please refer to the Appendix 3.

***2) School Lightings: AMS-II.N: Small-scale methodology: Demand side energy efficiency activities for installation of energy efficient lighting and/or controls in buildings*.**

Data will be collected for parameters as required in the Equations that calculate electricity savings and reduction of CO2 (using the emission factor for the national electricity grid). For more detailed information on this measurement methodology, please refer to the Appendix 4.

5.2 Baseline methodology

The project MRV system is designed to measure and report against either a baseline or a standard for compliance. A baseline is generally defined as a base case scenario for related GHG emissions without mitigation actions or projects within a geographical location. Baselines are used to describe a business as usual GHG emission scenario from which a mitigation deviation is desired, so a baseline is required to be established in order to provide the best estimate of real GHG emission reductions achieved from project interventions. On that account, the establishment of baselines on electric energy consumption is essential for measuring the impacts of VIE/401 on electricity savings and CO2 emission reductions.

The baseline methodology is an important method implemented to collect data for establishing the baseline GHG emission that that would occur in the absence of project pilot interventions on LED light retrofits at target schools and streets. To determine the baseline CO2 emission, the project MRV system is required to collect data to establish baseline values for measurement parameters such as power consumption, operating hours and quantity of operating conventional lamps at target schools and streets, which are used to calculate the baseline electric energy consumption of existing lightings with conventional lamps. The baseline electric energy consumption is then used to calculate what would be the baseline CO_2 emissions of conventional lamp lightings (without interventions). Baseline methodologies significantly vary for different project types and scopes, but comply with a standardized structure and procedure. The project baseline methodology should indicate what and how to collect the data/information required to calculate electricity savings and CO_2 emission reductions. In addition, the baseline methods are required to determine who will be responsible for collection of baseline data and how to store and analyse data for calculations. Basically, the Project will follow technical procedures and process to collect data to establish baselines as instructed in the baseline methodology of the two UNFCCC measurement methods adopted (AMS.II.L and AMS.II.N).

5.3 Monitoring methodology

Monitoring is key to the measurement of project accomplishments on expected outcomes/impacts on electricity savings and CO_2 emission reductions. The monitoring methodology is supposed to formulate how the VIE/401 project should develop and implement a monitoring plan during the project implementation period and after the project phase-out. The monitoring plan is required to monitor all parameters used to calculate the project emissions as well as other relevant parameters required by the monitoring methodology adopted by the project. The monitoring plan should outline what parameters to be measured and how to collect data, how to store and ensure the quality of collected data as well as institutional arrangements for implementation of monitoring plan and reporting of monitoring results.

Basically, the Project will follow technical procedures and process to collect monitoring data as guided in the monitoring methodology of the two UNFCCC measurement methods adopted (AMS.II.L and AMS.II.N).

5.4 Collection of baseline and monitoring data

The project MRV system is required to collect data to establish baseline values for ex ante measurement of relevant variables before the project LED pilot interventions. The monitoring data used for ex post assessment and measurement of project achievements are supposed to be collected during and after the installation of project LED luminaires. Monitoring data will be continuously collected and analysed for ex post assessment throughout the project implementation period and after the project phase-out. The amount of electricity savings per pilot site will be estimated based on the ex-ante (baseline) and ex-post (monitoring) data.

Quantitative metrics are applied to collect baseline and monitoring data for relevant variables and major measurement parameters. The project MRV system will mainly collect baseline and monitoring data for both quantitative process metrics and technical metrics. Output data are for variables of quantitative process metrics while outcome data are for variables of quantitative technical metrics.

The plan for collection of baseline and monitoring data should outline in detail the following information:

- What information and data to collect for measurement?
- How to collect measurement information and data, and with what instruments?
- Who is responsible for collecting baseline and monitoring information and data?
- How to store and analyse baseline and monitoring information and data?
- Quality assurance and quality control of baseline and monitoring data.

5.5 Calculations of electricity savings and CO2 emission reductions at target streets and schools

5.5.1 Calculations of electricity savings

a) Street lightings:

-Calculating the electricity savings as a result of the replacement of project supported LED luminaires at 18 streets in Hue city will use the below Equations guided in the AMS-II.L measurement methodology, CDM, UNFCCC.

-Once the project LED lights are installed, the electricity saved by the project activity in year *y* is calculated as follows:

$$NES_y = \sum_{i=1}^{n} ES_{i,y} \times \frac{1}{(1 - TD_y)} \quad \text{Equation (1)}$$

Where:

$$ES_{i,y} = \left(Q_{i,BL} \times P_{i,BL} \times O_{i,BL} \times (1 - SOF_{i,BL})\right) - \left(Q_{i,P} \times P_{i,P,y} \times O_{i,y} \times (1 - SOF_{i,y})\right) \quad \text{Equation (2)}$$

$$SOF_{i,BL} = AFR_{i,BL} \times OF_{i,BL} \quad \text{Equation (3)}$$

$$SOF_{i,y} = AFR_{i,y} \times OF_{i,y} \quad \text{Equation (4)}$$

Where:

NES_y	=	Net electricity saved in year *y* (kWh)
$ES_{i,y}$	=	Estimated annual electricity savings for equipment of type *i*, for the relevant type of project equipment in year *y* (kWh)
y	=	Crediting year counter
i	=	Counter for luminaire type
n	=	Number of luminaires
TD_y	=	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the luminaires are installed, expressed as a fraction.
Q_i ($Q_{i,BL}$ and $Q_{i,Py}$)	=	Quantity of baseline (*BL*) or project (*P*) luminaires of type *i* distributed and installed under the project activity (units). Note that $Q_{i\ BL}$ and $Q_{i\ P}$ may represent a different number of luminaries (e.g. a larger number of LEDs with less output), but they must represent the same illuminated area
$P_{i,BL}$	=	Rated power of the baseline luminaires of the group of *i* lighting devices (kW)
$P_{i,P,y}$	=	Rated power of the project luminaires of the group of *i* lighting devices (kW),
O_i ($O_{i,BL}$ and $O_{i,y}$)	=	Annual operating hours for the baseline and project luminaires in year *y*. May differ from *BL* to *P*.
SOF_i ($SOF_{i,BL}$ and $SOF_{i,y}$)	=	System Outage Factor (*SOF*) for equipment type *i* in year *y*. *SOF* is calculated as the product of the equipment Outage Factor and the equipment Annual Failure Rate. The value for *BL* is assumed to be the same as monitored for *P* and may vary from year to year

OF_i ($OF_{i,BL}$ and $OF_{i,y}$)	=	Outage Factor is the average time, in hours, elapsed between failure of luminaires type *i* and their replacement, divided by $O_{i,y}$, annual operating hours.
AFR_i ($AFR_{i,BL}$ and $AFR_{i,y}$)	=	Annual Failure Rate of luminaires calculated as a fraction of *Q*. The value for failure rate during the baseline (*BL*) is assumed to be the same as determined for each year of the crediting period *y* and may vary from year to year.

b) Lightings in school buildings:

-Calculating the electricity savings as a result of the replacement of project supported LED luminaires at target schools will use the below Equations guided in the AMS-II.N measurement methodology, CDM, UNFCCC.

- Equation (1) below is used when baseline and project fixture counts and wattages are surveyed and operating hours are monitored.

$$ES_y = \sum_{u,i} \left(\frac{1}{1{,}000{,}000}\right) \times [(W/fixture_{b,u,i} \times N_{b,u,i} \times Hours_{b,u,i}) - (W/fixture_{p,u,i} \times N_{p,u,i,y} \times Hours_{p,u,i,y})]$$

Equation (1)

Where:

ES_y	=	Lighting energy savings associated with project in year *y* (MWh)
$W/fixture_{b,u,i}$	=	Baseline lighting demand per fixture of type *i* in usage group *u*, Watts
$W/fixture_{p,u,i}$	=	Project lighting demand per fixture of type *i* in usage group *u*, Watts (for projects that involve only lighting controls, this value may be same for project and baseline)
$N_{b,u,i}$	=	Quantity of baseline affected fixtures, adjusted for inoperative lighting fixtures, of type *i* in usage group *u*
$N_{p,u,i,y}$	=	Quantity of project affected fixtures of type *i* in usage group *u* (for controls and efficiency projects, this value may be same for project and baseline) in operation in year *y*
$Hours_{b,u,i}$	=	Baseline annual operating hours for operative lighting fixtures, of type *i* in usage group *u*, hours and adjusted to represent an annual value. For efficiency only projects (no controls), this value equals $Hours_{p,u,i,y}$
$Hours_{p,u,i,y}$	=	Project annual operating hours for operative lighting fixtures, of type *i* in usage group *u*, hours in year *y* adjusted to represent an annual value
u	=	Building usage groups with similar operating hour characteristics, for example private offices, conference rooms, hallways, and storage areas.
i	=	Unique fixture/lamp/ballast combinations

5.5.2 Calculations of CO2 emission reduction

-The electricity savings from the project LED luminaires installed by the project activity shall be considered from the date of completion of installation of all the project luminaires.

-The emission coefficient currently applied is the emission factor (EF) for Vietnam National Electricity Grid 2018 which is 0.8649 tCO2/MWh (Official Correspondent No. 330/BĐKH-GNPT dated 29/3/2019 issued by DCC, MONRE). The calculation of CO2 emission reduction in year y is required to apply the most updated emission factor for Vietnam National Electricity Grid annually issued by DCC, MONRE.

a) Street lightings

-The estimate of CO2 emission reduction is based on the net electricity saved by the installation of LED luminaires at selected street lightings and the currently applied emission factor (EF) for Vietnam Electricity Grid.

-Emissions reduction is the net electricity savings (*NES*) times an emission factor (*EF*).

$$ER_y = NES_y \times EF_{CO2,ELEC,y} \qquad \text{Equation (1)}$$

Where:

$EF_{CO2,ELEC,y}$	=	Emission factor in year *y* (tCO_2/MWh)
ER_y	=	Emission reductions in year *y* (tCO_2e)
ES_y	=	Amount of electricity saved in year *y* (kWh)
NES_y	=	Net electricity saved in year *y* (kWh)

b) School lightings

Calculating the CO2 emission reduction achieved by the project LED light interventions at target school lightings will use the Equation as below:

-Emissions reduction is the electricity savings (*ES*) times an emission factor (*EF)*.

$$ER_y = ES_y \times EF_{CO2,ELEC,y} \qquad \text{Equation (2)}$$

Where:

$EF_{CO2,ELEC,y}$	=	Emission factor in year *y* (tCO_2/MWh)
ES_y	=	Amount of electricity saved in year *y* (kWh)
ER_y	=	Emission reductions in year *y* (tCO_2e)

6. Reporting Mechanism

While the national and provincial MRV framework, with reporting requirements to be followed, have not been promulgated up to present, the Project formulates a reporting mechanism based on guiding references and based on its management and organizational structure.

6.1 Reporting principles

The project reporting must consider the following principles (Sudhir Sharma, 2014:

- *Consistency:* reporting of information should be consistent between different periods of time for the same project. The information or estimates, especially of CO2 emission reductions should be reported in a consistent format. In case standardized report formats have not been issued, the project will design template/forms for reporting of project results;
- *Transparency:* all the data and methodologies used should be clearly explained and appropriately documented in the report, so that anyone can verify their accuracy. Reporting should include all relevant information to enable readers to come to the same conclusions as the report and to replicate the impact results arrived at in the report.

6.2 Institutional arrangements for reporting and registering the GHG emission reduction

The draft GOV Decree on Roadmap for GHG emission reduction plans foresees the MRV systems of mitigation actions at three levels: national MRV, sectorial/provincial MRV, and project-level MRV. As VIE/401 MRV is considered as a project-level MRV, the provincial P.C is the MRV Authorization Agency which is designated to approve the achieved GHG emission reductions to be reported at the end of project. Therefore, the project (specifically TAO and Lux PMB, with the technical advice of the PTF) will report the GHG impacts and SD co-benefits (if any), achieved by its pilot interventions over project period, to the TT Hue provincial P.C. After the TT Hue provincial P.C has approved the total project results achieved at the end of project, TAO and Lux PMB will prepare a dossier to report and register the project CO2 emission reductions with the DCC, MONRE for recognition and inclusion in the national NDC reports.

At the end of its cycle, the project will hand over the MRV work to a designated entity with technical qualifications, which is responsible for the continuous MRV operations and will reporting the post-project accomplishments of CO2 emission reductions resulted from project pilot interventions of LED light retrofits to the provincial P.C and DCC, MONRE.

6.3 Information to be reported

The information to be reported is divided into two types: measured information and project results of CO2 emission reductions achieved in a reporting period. Measured information includes data and information collected during the baseline surveys and monitoring activities. The contents of the report on project results in the first year should be in compliance with those required in a report format/template. The reporting of project results starting from the second reporting year consists of shortened contents with the focus on project profile, implementation of measurement and reporting, verification of measured and reported results, achieved results of electricity savings, CO2 emission reduction and reduction of electricity cost in the reporting year.

6.4 How to report measured information and project results

The reporting of measured information including baseline and monitoring data and results of data analysis and calculations will use the templates/forms prepared by TAO. Those designates involved in collecting and reporting baseline and monitoring data should be instructed on how to use the templates provided by TAO.

For the reporting of project results of electricity savings and CO2 emission reduction, the Project will follow the standard template/form for reporting of results of a mitigation project issued by the provincial P.C or the DCC, MONRE if it is in place for use at the reporting time. Otherwise, the project will prepare a tailor made template for reporting of its accomplishments.

6.5 The frequency of reporting

For monitoring information and data, the reporting is done on monthly, quarterly and annual basis for monitoring and calculating purposes. The reporting of project achievements of CO_2 emission reduction is required to be made on an annual basis and may comply with the reporting guidelines of the provincial P.C and MONRE if any.

7. Verification mechanism

7.1 Concept of Verification

Verification helps to ensure accuracy and conformance with any established procedures and principles, and can provide meaningful feedback for future improvement. Verification of the reported information is the key element in increasing transparency and trust (UNEP, 2014). The International Standards Organization (ISO) defines verification as a process that uses objective evidence to confirm that specified requirements have been met. Verification is the assessment of the data collection and estimating of impacts being undertaken and reported against a defined procedure or standards that establishes the requirements of relevance, completeness, consistency, transparency and accuracy.

For the project MRV system, verification is a process of assessing and checking the accuracy and reliability of reported information on collected data, measurement and calculations of electric energy savings and CO_2 emission reduction resulted from project interventions.

7.2 Verification plan

The verification of the measured information and the project GHG impact is based on documentary evidence and physical evidence (Sudhir Sharma, 2014). Physical evidence is information gathered by direct observation through a visit by the verifier to pilot sites where data are collected, measured and stored while documentary evidence is the reports that the Project submit to relevant authorities such as the TT Hue provincial P.C or DCC, MONRE.

The project MRV will apply two forms of verification: internal verification and external verification. The internal verification will be undertaken by the project MRV stakeholders including MRV Technical Supervision Unit (PTF) and MRV Management Unit (Lux PMB and TAO). This is a self-certification process that validates and endorses data collection methods, measurement/calculation methodologies and the achieved GHG emission reduction as well as sustainable development co-benefits that the MRV Management Unit will report to TT-Hue provincial P.C. The internal verification mechanism will be further developed in consultation with the members of PTF, TAO and Lux PMB. The MRV Management Unit may organize an internal verification of the MRV system and project results carried out by an independent/external technical consultant.

External verification is usually be undertaken by the government authoritative agency that sets the standards against which the assessment is done. The MRV Authorization Agency (TT Hue provincial P.C) may require a number of external verification procedures which assess the MRV system and project accomplishments reported. After the registration of project CO_2 emission reduction results is completed, the DCC, MONRE or its delegated agency/assigned accredited organization may carry out an external verification with necessary procedures to validate and verify the project MRV system and reported achievement of GHG emission reductions. Specific guidelines and requirements for the verification procedures will need to follow and comply with when the Project makes registration of its CO_2 emission reduction results with DCC, MONRE.

IV. IMPLEMENTATION OF MEASUREMENT, REPORTING AND VERIFICATION

A. MEASUREMENT

1. Collection of data for baselines

1.1 Baseline survey and measurements

Overview

To collect data to establish baselines for measurement parameters, the TAO Lux Dev has hired the Industry Promotion and Development Consultancy Centre (IPDCC) to implement the baseline survey & measurements. IPDCC belongs to the TT Hue provincial DOIT and is an external, independent and qualified consultant agency which has relevant capacity in the fields of optics, and electrics, preferably electrical engineering or power engineering and extensive experience in energy auditing, lighting survey and measurement of lighting levels and power consumption. In addition, it has also met all the requirements such as having 1) relevant calibrated measurement meters; 2) staff/officers with certified energy auditing and 3) the legally designated functions in consultancy services in energy efficiency and energy auditing. The IPDCC tasks were to collect statistical data and do baseline measurements, aggregate and report the collected data and results of data analysis. The CC MRV Technical Adviser (MRV TA) assisted the IPDCC in determining sampling method, estimate of sample size, determination of measurement parameters, field work plan for data collection and measurements. In brief, the MRV TA has responsibility for overall coordination, support and supervision of baseline data collection and on-site measurements. The PIPP TA will assist in providing technical guidelines for on-site measurement of power consumption and illuminance levels of lighting fixtures to ensure the quality of the consultant performance. The MRV TA and PIPP TA will closely work together in the whole processes from planning, implementation and evaluation of the survey and measurement results.

Purpose and objectives

Prior to the installation of LED lights at target schools and streets, the Project has implemented a baseline survey and measurements to collect necessary data to determine baseline values of measurement parameters, as per calculation equation instructed in the UNFCCC standard measurement methodologies (AMS-II.L & AMS-II.N) and the illuminance levels of target streets as required. The baseline survey and measurements aim to obtain the following specific objectives:

1) Verify and survey the data of baseline lighting fixtures at 1,285 rooms in 54 selected schools with regard to the quantity of affected fixtures (both operative and inoperative), types of lamps and/or ballasts (or combinations) with capacity in Watts/hour per usage group (room type: classrooms, computer-foreign language rooms, practical-experimental rooms, private/common offices and functional-service rooms);
2) Measure the actual power consumption of baseline lighting fixtures at the Last Point of Control (a single switch that controls the power use of a lighting system) in 116 sampled usage groups in all the selected schools, to estimate the actual average electricity consumption of conventional lighting fixtures of different types (fluorescent lamps and/or LED lamps) per room and average rate of actual power use of light bulbs of different types as compared to the rate power defined by the manufacturer;
3) Measure and calculate the average illuminance level of baseline lightings in 116 sampled usage groups (rooms) in all the schools;
4) Measure and calculate the average illuminance level of baseline lightings at all the streets selected for project support.

Target Locations

For school lightings, the baseline survey and measurements will be carried out in 54 selected schools, including 29 primary schools, 22 secondary schools and 03 high schools. For street lightings, the measurement of baseline average illuminance level is made at 18 streets selected for project support.

1.2. Description of Baseline Survey and Measurements

The following sections present the activities of baseline survey and measurements that the project has implemented to collect baseline data for measurement parameters at selected schools and streets.

A. School Lightings

<u>Activity 1:</u> **Verify and survey the baseline data of conventional lamp lightings at target schools**

+Sampling Method and Sample Size

The sampling approach is not applicable for the verification and survey of baseline data for lighting fixtures at target schools because this performance is required to be undertaken for all target 1,285 rooms in 54 schools;

+Data to be verified & collected and parameters to be measured

Based on the equations for calculations of electricity savings guided in the AMS-II.N Measurement Methodology, the variables to be verified, documented, collected and parameters to be measured in the baseline survey are summarized in Table 7 below:

Table 7: Summary of variables to be verified & collected and parameters to be measured

No	Variables and Measurement Parameters	Notes
1	Spaces of appropriate usage area designation in each school	Area (m^2) of each usage group room will be measured and documented.
2	Number and type of baseline affected luminaires/fixtures per Usage Group per school	It is an inventory of conventional luminaires made for ex ante calculation per Usage Group. The target rooms in each school are categorized into 05 Usage Groups (classrooms, computer-foreign language, practical-experimental rooms, private & common offices and function-service rooms).
3	Operative luminaires/fixture	Count the number of luminaires which are operating at the survey time.
4	Inoperative luminaires/fixture	Count the number of luminaires which are out of order and/or not operating at the survey time.

The data of the above measurement parameters, including the quantity of baseline affected fixtures (both operative and inoperative), types of lamps and/or ballasts (or combinations) with capacity in Watts/hour per usage group, baseline lighting demand per luminaire/fixture type per Usage Group per school and lighting levels will be disaggregated by room type: classrooms, computer-foreign language rooms, practical-experimental rooms, private/common offices and functional-service rooms.

<u>Activity 2:</u> **Measurement of actual power consumption and average illuminance levels of baseline school lightings**

+Sampling approach

The purpose of sampling is to obtain unbiased and reliable estimates of the mean value of parameters used in the calculations of energy savings and CO2 emission reductions such as baseline lighting demand and average illuminance. Thus, the sampling approach is employed to select the room samples by usage groups <u>to measure the actual power use of conventional lighting fixtures and average illuminance per usage group in all the selected schools</u>. The results of the recent pilot field measurement carried out by an external consultants showed the high degree of variance in actual average power use of lighting fixtures and average illuminance among the sampled rooms of different types in 05 sampled schools, representing three different levels of schools (primary, secondary and high school). The pilot data analysis indicated that the sampled rooms divided into five groups in sampled schools are not homogeneous, with great differences of actual average power use per room and average illuminance among measured rooms. Therefore, to improve the precision of the estimate of the measurement parameters for the survey population based on the data collected from a statistical valid and representative samples of rooms in selected schools, the Project will employ the Stratified Random Sampling method to sample and calculate the total sample size for the baseline survey using the mean and standard deviation values resulted from the project pilot measurement.

There are 1,285 rooms at 54 schools proposed for project support, which are stratified into 05 strata, called Usage Groups. The Usage Groups are the school rooms with different functions and services, stratified into five appropriate room types such as 1) Classrooms, 2) Computer-Foreign Language rooms, 3) Practical-Experimental rooms, 4) Private & Common Offices and 5) Functional-Service rooms that are defined as follows:

1) Usage Group#1-Classrooms: are the rooms where a class of students is taught with lectures;
2) Usage Group#2-Computer & Foreign Language rooms: are the rooms mainly used to study and practice computer skills and foreign languages;
3) Usage Group#3- Practical-Experimental rooms: are the rooms used for practice and do experiments in the field of Physics, Chemistry, Biology, etc.
4) Usage Group#4-Private & Common Offices: Private offices are the offices of Principal/Deputy Principals and Common offices include teachers' offices/rooms, school offices, Finance-Accounting rooms, etc.;
5) Usage Group #5: Functional-Service rooms includes conference halls, Pioneers/ Youth Association rooms, library, medical rooms, arts, music, etc.

Using the Equation instructed in the UNFCCC Guidelines for sampling and survey (Version 02.0) and the mean and standard deviation values of the interest parameter, that is the actual power use of conventional lighting fixtures per room and average illuminance resulted from the recent project pilot measurement, the total sample size is determined across five stratified Usage Groups in all selected schools. Then, the probability proportional to the size of each Usage Group with the total usage groups (rooms) is used to calculate each Usage Group sample size and the sample size for each school level (primary, secondary and high school). Based on the sample size estimated for each Usage Group, the rooms of different types will be randomly selected for measurement of actual power use of existing conventional lighting fixtures and average illuminance based on the actual conditions and convenience in each target school.

+Determination of the Sample size for baseline measurement

Following the UNFCCC guidelines for sampling, the Stratified Random Sampling Equation is used to estimate a statistical sample size for the baseline survey and measurements, using the mean and standard deviation of power use of conventional lighting per room type and average illuminance determined through the project pilot measurement. The UNFCCC standard sampling and surveys for programme of activities require that the estimate of a survey sample size shall use at least 90% confidence level and ±10% precision as the criteria for required reliability of sampling efforts for small-scale project activities. Adopted from the UNFCCC Guidelines for Sampling and Surveys for CDM project activities and programme of activities, the Equation/formula is used to calculate the total sample size for the baseline survey based on mean values of interest parameter as below:

$$n = \frac{Z^2 \times NV}{(N-1) \times e^2 + Z^2V}$$

$$V = \left(\frac{SD}{mean}\right)^2$$

SD Is the overall standard deviation, and

Mean Is the overall mean.

$$SD = \sqrt{\frac{(g_a \times SD_a^2) + (g_b \times SD_b^2) + (g_c \times SD_c^2) + \ldots + (g_k \times SD_k^2)}{N}}$$

Where:

SD	Weighted overall standard deviation SD_i Standard deviation of the i[th] group where i=1,…,k, (note that these are all squared – so the group size is actually being multiplied by the group variance)
g_i	Size of the i[th] group where i=1,…,k
N	Population total

$$mean = \frac{(g_a \times m_a) + (g_b \times m_b) + (g_c \times m_c) + \ldots + (g_k \times m_k)}{N}$$

Where:

Mean	Weighted overall mean
m_i	Mean of the i[th] group where i=1,…,k

Of which:

-n is the total sample size for the baseline survey;

-N is the survey population size (1,285 rooms in 54 selected schools)

-Z is the z-score or standard score of 1.645 for 90% confidence level or 1.96 for 95% confidence level required;

-e is the desired level of precision (sometimes called sampling error, is the range in which true value of the population is estimated to be, a relative term usually expressed in percentage points (for example: ±5 % or ±10%).

-Mean is the expected average value

-m_i is mean of the usage group i, of which i=1,………,k

-SD is expected overall Standard Deviation

-g_i is the room number of usage group i, of which i i=1,………,k

+Sampling and Sample sizes

Sample size 1: for measurement of actual power consumption of baseline lighting fixtures at target schools

Table 8: The results of actual power consumption of conventional lighting fixtures per room type discovered in the pilot measurement

No	Usage Groups/Room Types	Mean (Watts)	Standard deviation (Watts)
1	Classrooms	260.8	90.3
2	Computer-foreign language rooms	192.5	46.0
3	Practical-experimental rooms (Physics, Chemistry, Biology,)	244	103.6
4	Private & Common offices	254.5	109.6
5	Functional-Service rooms	276	50.8

The determination of total sample size for baseline measurement has used the above data to calculate the values of overall mean and standard deviation (SD) in the Equation. With the 90% confidence level and ±5% desired precision, <u>the statistically valid and representative sample size calculated for the measurement of power consumption of baseline lighting fixtures and average illuminance is **116 rooms**</u>, which will be pro-rated to estimate the sub-sample size for each Usage group (room type) and for each target school, using the PPS method (the probability proportional to the size of each Usage Group or school level with the total usage groups). The estimated sample size per usage group is presented Table 9 below.

Table 9: Sample size by Usage group for the baseline survey and measurements

No	Usage Groups/Room types	Primary schools	Secondary schools	High schools	Sample size by Usage group
1	Classrooms	45	30	6	81
2	Computer-foreign language rooms	4	4	1	9
3	Practical-experimental rooms (Physics, Chemistry, Biology,)	0	4	2	6
4	Private & Common offices	3	5	1	9
5	Functional-Service rooms	4	5	2	11
	Total	**56**	**48**	**12**	**116**

The sample size of each Usage group continues to be estimated for each school, using the PPS method. Random sampling method was employed to select the samples for baseline measurement. Based on the total sample size and sample size assigned for each Usage group, the consultant has randomly selected the room samples to make baseline measurement of power consumption and average illuminance.

b) Measurement parameters

The parameters to be measured from the stratified sample size of rooms per usage group (each room) in all 54 schools include the actual power consumption of baseline lighting fixtures and average illuminance of all lighting equipment (see Table 10 below) which will be used with the baseline average operating hours (to be monitored after installation of project LED lamps) to estimate the baseline electric energy consumption of per room and per school before undertaking the project LED light pilot interventions.

Table 10: Parameters to be measured in the baseline survey

No	Measurement Parameters	Notes
1	Power consumption of baseline lighting fixtures per room type	Is the actual power consumption of each room sample to be measured in wattage (W) at each lighting switch or circuit by an external consultant and using a calibrated energy measurement meter is required
2	Baseline lighting demand per luminaire/fixture type per Usage Group per school	Is the actual power (W) of baseline luminaires/fixtures disaggregated by luminaire type, Usage Group and target school (a luminaire includes bulb and ballast). The electricity use of lighting fixtures in each room per Usage Group based on the randomly selected, representative rooms is measured at the lighting switches/circuits by an external consultant and using a calibrated energy measurement meter is required.
3	Lighting levels (average Illuminance)	Baseline average illuminance (lux) of each room/Usage Group in each target school will be measured by an independent/external consultants, using the national technical regulations and procedures as guided in the National Technical Regulations on measuring the average illuminance in school buildings. It is required that a calibrated meter is used to measure illuminance and these measurements be taken during non-daylight hours.

The operating hours of lighting fixtures will not be collected in this baseline survey but will be monitored after the LED luminaires have been installed at pilot locations. Since the project does not involve lighting controls, the operating hours of the fixtures/luminaires are assumed to be the same for the baseline and project scenarios and are based on values determined/monitored at each Last Point of Control (or lighting switch) after project LED light installation. Operating hours for lighting fixtures/luminaires are monitored at each Last Point of Control (switch) per Usage Group in a period of at least four weeks (30 days) for each year, during representative time periods of the year, after project LED light installation, and the determined operating hour values are converted into annual hours, taking into account of the seasonal variability to adjust to represent an annual value.

Sample size 2: for measurement of average illuminance of room lightings

Table 11: Actual average illuminance of each room type measured in the pilot measurement

No	Usage Groups/Room Types	Mean (Lux)	Standard Deviation (Lux)
1	Classrooms	116.1	51.0
2	Computer-foreign language rooms	61.5	19.1
3	Practical-experimental rooms (Physics, Chemistry, Biology, etc.)	132.3	58.0
4	Private & Common offices	145.5	3.5
5	Functional-Service rooms	135.0	60.6

The determination of total sample size for illuminance measurement has used the data in the above table to calculate the mean and standard deviation (SD) of the overall Equation. With the 90% confidence level and ±10% desired precision, the statistically valid and representative sample size calculated for the measurement of baseline average illuminance is at least 63 rooms. However, the project will use the sample size of 116 rooms (estimated for measurement of actual energy use of baseline lighting fixtures) to measure the average illuminance of usage groups, in order to increase the confidence level to 95% and around ±7% precision.

Measuring Techniques: Illuminance level required for each room type varies in different room types. The first step is to measure the room dimensions: length, width and height (from the light tube to the desk surface) of classrooms and functional rooms. For classrooms, the first calculation point should be located at the middle of a table in a row and within a distance of 1-1.5m from the wall, depending on the room size. The space between two calculations point must be at least 1 m applied in longitudinal and transverse directions. For functional rooms, depending on the room size, a reasonable distance is determined but the distance between two calculation points should be within 1-1.5m.

B. Street Lightings

Activity 1: Collection of statistical data and measurement of actual power consumption of street lightings

To collect statistical data on the number of luminaires, lamp types and rated power, actual power consumption of the conventional street lighting system, the Project will use the secondary data collected directly from HEPCO's lighting monitoring and control system - a networked control system with central scheduling, monitoring and/or reporting features - currently used to manage, control and operate the lighting systems of all the streets in Hue City. The time period for collecting statistical data and measurement data prior to the installation of project LED luminaires is at least 90 days (03 months). The data collected during this period will be used to calculate, estimate average values and extrapolate for the annual values of measurement parameters, and determine baseline values for measurement parameters. Sampling method is not applied because the statistical data and actual power consumption of all 18 street lightings will be collected.

+Statistical data and measurement parameters

With the support of HEPCO, TAO has collected statistical data and data for measurement parameters since June 2019, using five templates/forms. The baseline data and measurement parameters will be collected in a period of six months prior to the installation of project LED luminaires.

Table 12: Baseline data and measurement parameters to be collected

No	Variables and measurement parameters	Notes
1	Quantity and types of lamps/luminaires at lighting points in each street will be replaced with the project LED lamps	Inventory in details information/data of existing lighting luminaires to calculate baseline values for each project-support street for LED replacement. As for streets that the project does not donate to replace all but only some lighting lamps, it is necessary to inventory the number of lamps and their rated power
2	Operative luminaires/fixture in streets to be replaced with the project LED lights	Count the number of luminaires which are operating at the survey time
3	Inoperative luminaires/fixture in streets to be replaced with the project LED lights	Count the number of luminaires which are out of order and/or not operating at the survey time.
4	Rated power in Watts/hour of luminaires/fixture by type	Document the rated power of luminaires/fixtures to be replaced with LED lights
5	Power consumption per project street (KWh)	Calculate power consumption of each project street and non-project street (based on rated power and field measurements)
6	Average operating hours of each street	Collect data of daily and monthly average operating hours of each street in the baseline measurement.
7	Time of monthly power blackout (hours)	It is a monthly failure of electrical power supply (if any)
8	Outage factor (hours)	It is the average time, in hours, elapsed between failure of equipment and replacement of equipment, divided by annual operating hours
9	Number of power cabinets/meters that record electricity consumption at target street lightings	Collect statistical data of electric cabinets/meters that read power consumption of target street lightings

Activity 2: Measurement of average illuminance level of selected street lightings

Evaluating street lighting illuminance, which is a measure of the amount of luminous flux falling per unit area-lumens/m^2, or lux (lx), is a comparative basis for road way lighting systems based on the average maintained illuminance on a target street lighting from the baseline and project luminaires. Maintained illuminance takes into consideration the depreciation in luminous flux over time between two light sources when a LED luminaire has come to an end of its maintenance cycle. Therefore, it is important to measure the baseline average illuminance before and after the LED light installations, and continuously measure the maintained illuminance when the LED luminaires have ended its maintenance time.

+Sampling method

Because street uses, dimensions, and lighting systems layout vary from location to location and the number of selected street lightings is small, the measurement of average illuminance is supposed to be done in all 18 target street lightings. However, it is not practical to measure the illuminance of an entire street lighting system, so a space between conventional luminaires will be randomly selected to be measured with the assigned number of calculation points. There are 18 spaces randomly sampled, with one space sample per street lighting. Following the method for measuring and calculating average illuminance instructed in the AMS-II.L measurement methodology for street lightings, the number of calculation points are determined for each street lighting system based on the street length (m), number of baseline luminaires and space between luminaires and space between points in the longitudinal and transverse directions.

-Sample size of calculation points

Based on the guidelines in the International Commission on Illumination standards -CIE 140:2000 which is detailed in the Appendix 2 of the AMS-II.L measurement methodology, there require at least 247 calculation points to be measured at the randomly selected spaces between luminaires at 18 street lighting systems. One space between two luminaires is randomly selected for each street and there are ≥10 calculation points to be measured illuminance in the longitudinal direction. The number of calculation points in the transverse direction per street lighting system will be determined based on the width of the roadway or intersection and the number of luminaires of that street lighting system. More details on the number of calculation points in the transverse and longitudinal directions per street lighting system will be determined with more detailed information and data later. The above sample size of calculation points is the minimum number of points to be measured average illuminance. The field measurement will apply the Vietnam Construction Standards 259:2001 so the number of calculation points may be higher per street lighting. It is required that a calibrated meter is used to measure illuminance and these measurements be taken during non-daylight hours or at night.

-Applied method for illuminance measurement

According to the AMS-II.L measurement methodology, the determination of illuminance level can either be done through computer modelling of illuminance level or on-site measurement of actual illuminance level. In this baseline, the method of on-site measurement of actual illuminance level is employed to gauge the baseline average illuminance values prior to the installation of LED luminaires at all the target street lighting systems. The average illuminance of each street lighting system will be determined with the measurement methods/techniques which are in compliance with Vietnam Construction Standards 259: 2001: *Artificial lighting for urban road, street and square, design standards.*

Based on the space sampled per street and calculation points that have been determined, the measurement procedure requires to be undertaken in the following five steps:

-Step 1: Make necessary watch-out procedures/activities for traffic safety (a watchman in charge of showing traffic signs, reflective materials, flashing lights, signal flags);

-Step 2: Measure the distance between 2 lampposts, determine the width of the road surface, the number of lanes and verify the form;

-Step 3: Calculate the intervals equally divided between points in the horizontal and vertical axes, use the colour paint to locate calculation points on the road surface in line with the number of horizontal and vertical axes;

-Step 4: Put the illuminance meter on a specified calculation point and do the measurement and record the measured data. Observe the external influences on the calculation points such as trees, external bright spots to reflect on the measurement results;

-Step 5: Based on the measured data, calculate the average illuminance level per street lighting.

Notes: The illuminance meters are required to be tested and calibrated by a legal professional agency before being used, and the illuminance measurement must be taken at night.

1.3 Tools for data collection, aggregation and reporting

Table 13 below summarizes the templates/forms used to collect, report and aggregate baseline data and measurement results from existing lighting systems at target schools and streets.

Table 13: List of forms for collection, aggregation and reporting of baseline survey and measurement data

No	Lighting systems	Forms for collection, aggregation and reporting of baseline survey and measurement data
I	**School Lighting System**	
A	**Inventory of luminaires and measurement of power consumption**	
1	Form #1A	Inventory of conventional luminaires per target school
2	Form #1B	Aggregate data on conventional luminaires at all target schools
3	Form #1C	Aggregate measurement outcome of baseline power consumption at sampled rooms
B	**Measurement of Illuminance level**	
1	Form #1A	Technical guidelines and aggregate data on measured illuminance per room type
2	Form #2B	Aggregate measurement outcome of baseline power consumption and illuminance at all sampled rooms
II	**Street Lighting System**	
A	**Inventory of luminaires, measurement of power consumption and monitoring of operating time**	
1	Form # 1	Baseline data on daily usage hours of conventional luminaires per street lighting
2	Form # 2	Aggregate baseline data on monthly average usage hours of conventional luminaires per street lighting
3	Form # 3	Inventory of conventional luminaires at all street lightings
4	Form # 4	Monitoring data on changes of conventional luminaires and outage time at all street lightings
5	Form # 5	Aggregate baseline data on monthly gross electric energy consumption of target street lightings measured by power meters
6	Form # 6	Aggregate baseline data on monthly net electric energy consumption of target street lightings measured by power meters
B	**Measurement of Illuminance level**	
1	Form # 1	Technical guidelines and aggregate data on measured illuminance per street lighting
2	Form # 2	Aggregate outcome data on average illuminance measured at target street lightings

2. Monitoring Plan

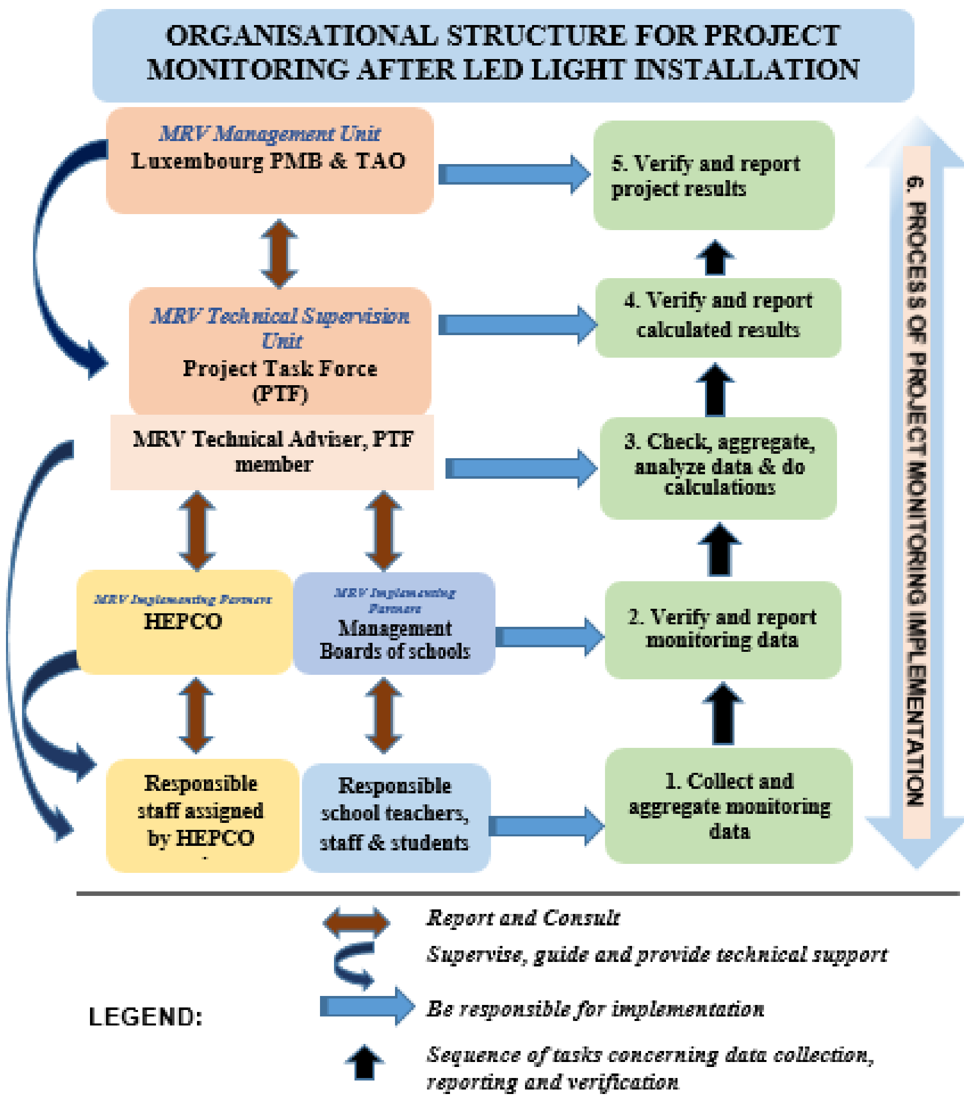
The monitoring methodology is very crucial to the measurement of project accomplishments on expected outcomes/impacts on electricity savings and CO_2 emission reductions. It outlines how the VIE/401 project implement the collection, storage, usage and reporting monitoring data during the project implementation period and the time after the project phase-out.

2.1 Institutional Arrangements

2.1.1 Organisational structure

The organisational structure illustrated in Figure 3 below outlines the institutional arrangements for implementation of project monitoring activities.

Figure 3: Organisational structure for project monitoring



Hue Urban Environment and Public Works Joint Stock Company (HEPCO) and 54 schools, including 29 primary schools, 22 secondary schools and 03 high schools, are both beneficiaries and actors of MRV performance, which have important roles and key responsibilities in collecting, aggregating and reporting project monitoring data after the project LED light installation. Target schools are required to assign teacher(s)/staff in charge and mobilise all students, teachers and staff to get involved in the collection of monitoring data.

The Project Task Force is a MRV Technical Supervision Unit, comprised of technical advisors, experts and technical staff from the PMB, TAO, DONRE, DOIT, Provincial/City DOETs and HEPCO. The MRV Management Unit composes LPMB, TAO, Lux Dev. For more detailed information on the roles and responsibilities of individuals and agencies involved in the project monitoring performance, see Table 14 and 15 in the below sections.

2.1.2 Roles and responsibilities of individuals & agencies/units involved in the project monitoring

The roles and responsibilities of involved individuals and agencies are summarised in Table 14 & 15:

Table 14: Roles and responsibilities of agencies involved in the project monitoring after the installation of project LED lights

No	MRV stakeholders	Monitoring agencies/units	Roles	Responsibilities
1	***MRV Implementing Partners***	**a) HEPCO) for street lightings**	Organise, coordinate and report monitoring results on a periodical basis	- Facilitate, assist in or implement the collection of baseline data and measurements under the technical instructions of the MRV Technical Supervision Unit; - Organize periodical collection of monitoring data; - Report periodically collected monitoring data to the MRV Technical Supervision Unit.
		b) School Management Boards for school lightings	Organise, coordinate and report monitoring results on periodical basis	- Facilitate, assist in or implement the collection of baseline data and measurements under the technical instructions of the MRV Technical Supervision Unit; - Organize periodical collection of monitoring data; - Report periodically collected monitoring data to the MRV Technical Supervision Unit.
2	***MRV Technical Supervision Unit***	**Project Task Force (PTF)**	Provide technical guidance, coordinate monitoring performance, aggregate monitoring results and use the results for calculations	- Develop the monitoring plan and provide technical instructions for monitoring implementation; - Design and guide how to use tools for data collection, aggregation, and reporting monitoring results; - Coordinate and give support in the collection of monitoring data; - Aggregate and verify the reported monitoring data; - Store and periodically update monitoring databases; and - Use monitoring data to do calculations of energy savings and CO2 emission reductions and electricity cost reductions.
3	**MRV Management Unit**	**Luxembourg Projects Management Board (Lux PMB and Technical Assistance Office (TAO)**	Verify and endorse monitoring results; Review and resolve issues, proposals, recommendations	- Review and endorse the monitoring plan; - Verify and approve monitoring results in consultation with the Project Task Force; - Review and resolve issues, proposals and recommendations related to the implementation of monitoring plan; - Store data and update monitoring database in order to calculate electric energy consumption, electricity savings, and CO2 emission reduction.

Table 15: Roles and responsibilities of those people in charge of monitoring after the project LED light installations				
No	**MRV stakeholders**	**Individuals in charge of monitoring**	**Roles**	**Responsibilities/Tasks**
1	***MRV Implementing Partners***	**HEPCO monitoring staff designate**	Collect, aggregate and report monitoring data	- Periodically collect monitoring data from the lighting monitoring and control system of HEPCO; - Aggregate and report periodical monitoring results in compliance with required templates/forms; - Store and update monitoring data on a periodical basis; - Aggregate and rapidly provide monitoring data on an ad hoc basis (if any); and - Justify and support the data verification when required (if any).
2	***MRV Implementing Partners***	**School monitoring staff designates**	Provide technical guidance, organize the collection of monitoring data, aggregate and report results on a periodical basis	-Provide guidance on how to use templates/forms for monitoring data collection, aggregation and reporting for other school teachers/staff involved in the monitoring; -Aggregate and report periodical monitoring results in compliance with required templates/forms; - Store and update monitoring data on a periodical basis; - Aggregate and rapidly provide monitoring data on an ad hoc basis (if any); and - Justify and support the data verification when required (if any).
		Students, teachers and staff	Supervise lighting systems in target rooms and collect monitoring data	- Monitor the operation of lighting systems in target rooms; -Periodically collect and report monitoring data in room as instructed; - Participate in other activities related to the monitoring and other technical instructions.
3	***MRV Technical Supervision Unit (Project Task Force)***	**Climate Change MRV Technical Adviser**	Advise, provide technical instructions coordinate, and supervise the plan implementation, aggregate and report the monitoring results	- Develop the monitoring plan and provide technical instructions for monitoring implementation; - Design and guide how to use tools for data collection, aggregation, and reporting monitoring results; - Coordinate and give support in the collection of monitoring data; - Aggregate and verify the reported monitoring data; - Store and periodically update monitoring databases; and - Use monitoring data to do calculations of energy savings and CO_2 emission reductions and electricity cost reductions.

2.2 Methods for monitoring data collection at target schools

2.2.1 Data collection during the project period

The following measurement parameters will be documented at the time of project LED light installation:

- The number, type and rated power of the project LED luminaires installed at schools, model numbers and date of supply/installation at each location, as well as of each Usage Group, in school buildings in the project area;

- The number and specifications of luminaires/lamps/ballasts retrofitted with LED lights;

- Data, diagrams clearly determining the position of the LEDs distributed for the lighting system of each room.

Table 16: Parameters to be monitored in surveyed usage group (or sampled rooms)			
Parameter to be determined	**Survey Subject**	**When Completed**	**Notes**
Operating hours	Last Point of Control for fixtures, see below for definition	(a) Baseline; (b) When project installation is completed; (c) Repeated per paragraph 1	Sampling approach is not applicable because the number of operating hours of the lighting system in all rooms will be monitored
Lighting levels	Spaces where lighting retrofits are to occur or have occurred	One time each for baseline and project	Sampling uses stratified random approach, with usage groups defined as the stratum. The sample size at least 95% confidence interval and 10% margin of error shall be achieved for sampling parameter
Number of operating fixtures	Lighting fixtures	(a) When project installation is completed; (b) Repeated per paragraph 1	Sampling will not apply because number of operative and non-operative lamps of the lighting system in all rooms will be monitored
Lighting energy use (MWh)	Lighting circuits	(a) Baseline; (b) When project installation is completed; (c) Repeated per paragraph 1	Sampling uses stratified random approach, with usage groups defined as the stratum. The sample size at least 95% confidence interval and 10% margin of error shall be achieved for sampling parameter

Be noted that all luminaires or operating devices controlled by a Last Point of Control (LPC) have the same operating hours per year. For the purpose of measuring power consumption, it can be assumed that the measurements made for a single luminaire or a single device at a Last Point of Control (LPC) would reflect the result of operating hours of all lighting equipment on the same circuit.

The Project will collaborate with target schools to monthly collect monitoring data and quarterly aggregate monitoring results with the engagement of students, school teachers and staff. In order to raise the knowledge and awareness of students and teachers aimed to change their behaviours on energy efficiency, the Project will not collect the monitoring data of lighting system at one sampled room/usage group, but in all target rooms per school for all target schools retrofitted with project LED lights.

The calculation of baseline and monitoring values for electricity consumption of the lighting system per usage group will use the same data on operating hours monitored after the project LED light installation at target schools is completed. The collection of monitoring data on operating hours of LED lighting systems at target schools is required to start prior to the commencement of any of IEC activities, which are planned to be implemented in target schools and last for at least four weeks. Data collected in this timeframe are respectively used for and enable the calculations of results on electric energy savings achieved by the application of LED technology into school lightings. After this period of time, the IEC activities can start in schools and the monitoring data are used for calculations to measure the impact of behaviour changes gained by teachers and students on electricity savings and hence, CO_2 emission reductions.

2.2.2 Data collection after the project phase-out

-The project MRV system will be handed over to a qualified designated entity at the end of project, which will take over the MRV operation after the project phase-out. This entity will continue to collect monitoring data of project LED lightings, on a monthly and annual basis, with the support of designated staff of target schools after the project phase-out;

-CO_2 emission reduction can only be calculated and reported annually for the project LED lighting that has been installed and operated during the reporting period;

-The Project applies the biennial monitoring inspection, following the first inspection during the year of project installation. The total period for reporting project results of CO_2 emission reduction is 12 years from 2020 to 2032 (estimated based on the minimum lifetime of LED luminaires). Therefore, the monitoring inspection has to be maintained and implemented at least 5 times, in the years 3, 5, 7, 9 and 11. The results of monitoring inspections in each of these years can be used to report for two crediting years. For example, if the project has LED luminaires installed in 2020, the following inspections are required to be implemented in the years 2023, 2025, 2027, 2029 and 2031. The results of such monitoring inspections can be applied to crediting years 2023-2024, 2025-2026, 2027-2028, 2029-2030 and 2031-2032;

-The biennial monitoring inspections shall be used to determine and update the values for quantity of project luminaires, operating hours or circuit energy consumption. Project fixture wattages do not need re-evaluated after their initial determination at time of project implementation;

-The monitoring inspection can use the same sample size determined for the baseline survey. If the sample size is required to be determined for monitoring inspection, at least a 95 per cent confidence interval and 10 per cent margin of error shall be achieved for the sampling parameter.

2.3 Methods for monitoring data collection at target street lightings

2.3.1 Data collection during the project period

After the installation of project LED luminaires at target street lightings is completed, the project will start to collect monitoring data on a monthly basis with the support of HEPCO designated staff.

Measurement Parameters

First ex post monitoring survey, carried out within the first year after installation of all project luminaires, shall provide a value for the following parameters:

+ Outage factor (OF_i);

+ Annual failure rate (AFR_i);

+ Average annual operating hours (O_i);

+ Average project equipment power (P_i);

+ Number of project luminaires placed in service and operating under the project activity ($Q_{P,i}$). While project luminaires replaced as part of a regular maintenance or warranty program can be counted as operating, project luminaires cannot be replaced as part of the maintenance process and counted as operating;

-Subsequent ex post monitoring surveys are carried out at least every other year after the first year of the crediting period to determine ex post OF_i, AFR_i, O_i, and $P_{i,\ P}$ for use in ex post emission reduction calculations until such time when they register with competent agency;

-For each monitoring survey after the project LED installation, the project monitoring plan shall include continuous monitoring of equipment run-time for at least 90 continuous days to determine average daily operating hours for extrapolation to annual operating hours (O_i);

-For monitoring survey, individual project luminaires or groups of project luminaires if applicable (i.e. a continuous string of project luminaires on a dedicated electric circuit that can be monitored) shall constitute the population constituents when determining sample size and distribution;

-For measurement of average annual operating hours (O_i), a simple recorder of on/off time or direct monitoring over time of power or even light intensity may be used. This is monitored through the public lighting monitoring and control system of HEPCO.

-Monitoring includes recording of luminaire distribution data and ex post monitoring surveys after the project LEDs installation. During the installation of project LED luminaires, the following data are to be recorded and monitored:

1) Number of project luminaries distributed and installed at each street lighting, identified by the type of luminaires, operating schedule and adaptive controls strategy, if any, and the date of installation;

2) The number, rated power, and operating schedules of both replacing and replaced luminaires;

3) Information on baseline and project lighting controls indicate: Networked controls with central scheduling, monitoring, and/or reporting features.

2.3.2 Data collection after the project phase-out

-The project MRV system will be handed over to a qualified designated entity at the end of project, which will take over the MRV operation after the project phase-out. This entity will continue to collect monitoring data of project LED lightings, on a monthly and annual basis, with the support of HEPCO designated staff after the project phase-out;

- CO_2 emission reduction can only be calculated and reported annually for the project LED lighting that has been installed and operated during the reporting period;

-The Project applies the biennial monitoring inspection, following the first inspection during the year of project installation. The total period for reporting project results of CO_2 emission reduction is 12 years from 2020 to 2032 (estimated based on the minimum lifetime of LED luminaires). Therefore, the monitoring inspection has to be maintained and implemented at least 5 times, in the years 3, 5, 7, 9 and 11. The results of monitoring inspections in each of these years can be used to report for two crediting years. For example, if the project has LED luminaires installed in 2020, the following inspections are required to be implemented in the years 2023, 2025, 2027, 2029 and 2031. The results of such monitoring inspections can be applied to crediting years 2023-2024, 2025-2026, 2027-2028, 2029-2030 and 2031-2032;

-The biennial monitoring inspections shall be used to determine and update the values for quantity of project luminaires, operating hours or circuit energy consumption. Project fixture wattages do not need re-evaluated after their initial determination at time of project implementation;

-If the sample size is required to be determined for monitoring inspection, at least a 95 per cent confidence interval and 10 per cent margin of error shall be achieved for the sampling parameter.

2.4 The Monitoring Process

2.4.1 School Lightings

Before the monitoring activities starts in schools, the Project has implemented the following preparatory activities:

1) Give orientation and introduction of MRV framework and implementation plan to School Management Board representatives and designated monitoring staff from 54 schools in Hue city;

2) Design templates/forms for data collection & aggregation and reporting of monitoring data; and

3) Develop work plan for periodical collection of monitoring data.

Activity 1: Capacity building and planning

As required for project monitoring performance, each benefiting school is asked to assign one staff/teacher who will assist in collecting monitoring data after the project LED light installation. Before undertaking the collection of monitoring data, the project TAO will organize half-day training courses for designated teachers/staff from 54 target schools. In this training, the MRV TA will introduce the MRV framework and monitoring plan which outlines periodical collection of monitoring data, roles and responsibilities of involved persons. Trainees will be guided on the monitoring procedures and how to use the tools to collect, aggregate and report monitoring data during the project cycle and after the project end. During the trainings, the work plan for collecting and reporting monitoring data and logistic arrangements on the ground will be shared and consulted with the training attendees for its finalization.

Activity 2: Collect and aggregate monitoring data

The main purpose of the monitoring data collection is to determine the values of measurement parameters for electric energy consumption that help to calculate the amount of electricity savings and electricity cost reduction through the LED light retrofits in target schools. The collection of monitoring data aims to achieve the following objectives:

- Ensure the quality of monitoring data (in terms of accuracy and objectivity) of the lighting systems collected in each school;
- Raise awareness and change EE behaviours of school students, teachers and staff during their participation in monitoring school lighting systems;
- Collect data to study and calculate the impacts of information, education and communication (IEC) activities on EE; and
- Enhance the sustainability of project impact results through integration with IEC activities on EE.

In order to achieve the above objectives, the collection of monitoring data will mobilize the active participation of teachers and students in 54 schools. The monitoring data collection at schools comprises the following key activities:

1) Devise a plan for collection of monitoring data at each school: The designated teachers/staff, after being trained, will assist the school Management Boards in preparing their school plan for data collection in compliance with the common instructions and rules;

2) Implement the collection of monitoring data: The designated teachers/staff hold a session to present and introduce the plan for collection, aggregation and reporting of monitoring data in compliance with the provided forms to form teachers/subject teachers/staff assigned to be in charge of monitoring room lighting systems. After that, these teachers/staff will continue to disseminate the implementation plan and guide their students to take part in monitoring the lighting system in their classrooms;

3) Aggregate and report school monitoring data: On a monthly basis, the form teachers/subject teachers/staff in charge will report the monitoring results of lighting system in the room for which he/she is responsible (using the provided forms). The designated teachers/staff will aggregate the monitoring data collected from all rooms and prepare the report of monitoring results for the School Management Boards to review and approve. Designate teachers/staff are responsible for filing the monitoring data of their schools.

Activity 3: Reporting monitoring results

Once the School Management Board (SMB) has approved the monitoring results, the designated teacher/staff will send the report of school monitoring data results to the MRV TA to make data aggregation for all 54 schools. To meet the requirements for verification, target schools will send monthly reports of monitoring results via email and in written documents (using the provided templates for filing) which are sealed and signed by one of the SMB representatives.

MRV TA has responsibility for checking the quality of the reported monitoring results, summarizing, filing data & reported documents in order to meet the requirements of an independent verification later on. The aggregated monitoring data will be used to calculate, determine the values of measurement parameters and calculate the monthly or quarterly electric energy consumption of the project LED lightings. The calculation results, on the values of measurement parameters and calculations of electric energy consumption and savings, will be periodically reported to the Project Task Force for review and endorsement.

2.4.2 Street Lightings

Similar to baseline data, the monitoring data of street lightings after the project LED light installation will be collected from the public lighting monitoring and control system of HEPCO - the networked control with central scheduling, monitoring and/or reporting features. The MRV TA will show the HEPCO designated staff how to use the forms/templates for collecting, aggregating and reporting of monitoring data for the street LED lightings. On a monthly basis, the designate staff of HEPCO will extract data from the company's lighting monitoring and control system, aggregate and report monitoring results to the TAO. The MRV TA will aggregate monitoring data on a periodical basis and estimate the values of measurement parameters, and then calculate the amount of electric energy consumption and electricity savings of street lighting systems retrofitted with project LED luminaires.

2.5 Data storage and analysis

The project will use Spreadsheets to develop a MRV database to store baseline and monitoring data for ex ante and ex post calculations. Templates/forms for data collection, aggregation, and reporting are respectively designed in Excel spreadsheets which facilitate the data aggregation, processing and analysis of quantitative metrics and the calculations that perform basic arithmetic and mathematic functions. Data analysis mainly involves the calculations and comparison of key measurement parameters required as per Equations.

2.6 Data Quality Assurance and Control

To assure the quality of baseline and monitoring data collected for ex ante and ex post calculations, the project is supposed to follow the following strategies and/or methods:

-Prior to the design of baseline survey and measurements, a pilot measurement at sampled schools is required to be done to test the survey and measurement methods adopted to collect baseline data. Data collected from this pilot measurement are used to estimate the values of standard deviations and mean of actually consumed power of conventional lamps of all types, actual power consumption of lighting system per usage group and average illuminance level per room category. The pilot results of these measurement parameters are used to determine the statistical sample size of usage groups (rooms) for the baseline survey and measurements;

-For the Baseline survey and measurements, the technically qualified and experienced consultant entity (IPDCC) is contracted to conduct the survey and make measurements of major parameters used for calculations under the technical supervision of TAO Technical Advisers. The measurement required the consultant to use calibrated meters/devices.

-Tools for collection of data used to calculate the baseline values of key measurement parameters are required to be designed and tested before being used;

-Tools for monitoring data collection, aggregation and reporting were designed and tested before being used for data collection;

-Those involved in monitoring and reporting, particularly school staff/teachers designated to be responsible for monitoring, have to be trained on how to use the data collection templates/forms and to have good understanding of the monitoring process and plan;

-Internal verifications that supervise and control the quality of baseline and monitoring data collected are carried out by TAO TAs and members of Project Task Force.

2.7 Tools for collection, aggregation and reporting monitoring data

Table 17 below presents the templates used to collect, report and aggregate data and monitoring results at schools and streets.

Table 17: List of forms for collection, aggregation and reporting of monitoring data		
I	**School Lighting System**	
1	Form # 1	Inventory of project LED luminaires installed per target school
2	Form # 2	Aggregate data on project LED luminaires installed at all target schools
3	Form # 3	Monitoring data on changes of project LED luminaires per target school
4	Form # 4	Monitoring data on daily usage hours of project LED luminaires at each room per target school
5	Form # 5	Aggregate monitoring data on monthly average usage hours of project LED luminaires per room per target school
6	Form # 6	Aggregate monitoring data on monthly gross electric energy consumption of project LED luminaires per room per target school
7	Form # 7	Aggregate monitoring data on monthly net electric energy consumption of project LED luminaires per target school
8	Form # 8	Aggregate monitoring data on annual net electric energy consumption of project LED luminaires at all target schools
II	**Street Lighting System**	
1	Form # 1	Inventory of project LED luminaires installed at all target street lightings
2	Form # 2	Monitoring data on monthly change of project LED luminaires at all target street lightings
3	Form # 3	Monitoring data on daily usage hours of project LED luminaires at each street lighting
4	Form # 4	Aggregate data on monthly usage hours of project LED luminaires at each street lighting
5	Form # 5	Aggregate data on monthly gross electric energy consumption of project LED luminaires at all target street lightings
6	Form # 6	Aggregate data on monthly net electric energy consumption of project LED luminaires at all target street lightings

2.8 Implementation plan for monitoring activities

Table 18: Implementation Plan for Project LED light monitoring			
No	**Activities**	**Time and frequency**	**Responsible person**
1	**Preparations before implementation**		
1.1	Design templates/forms for monitoring data collection, aggregation and reporting	During the time of developing the MRV implementation plan	CC MRV TA, Lux Dev TAO
1.2	Training on monitoring plan, tools for data collection, aggregation and reporting for designated staff/teachers of target schools	Before the installation of project LED lights, 01 training course organized	CC MRV TA, Lux Dev TAO
1.3	Guide the HEPCO designated staff on how to use templates/forms for data collection, aggregation and reporting	Before the installation of project LED lights	CC MRV TA, Lux Dev TAO
2	**During the project implementation**		
2.1	Inventory the number of project LED luminaires installed at target schools and streets	Before and during the installation of project LED lights	CC MRV TA and PIPP TA, Lux Dev
2.2	Follow up on the change/variation in the number of operating and non-operating project LED light data at target schools and streets	Right after the project LED light installation is completed and monthly reported	Designated staff of target schools and HEPCO
2.3	Monitor the operating time (hours) of project LED lighting systems	Daily and monthly	Designated staff of target schools and HEPCO
2.4	Report aggregated operating time of project LED lighting system of each school and street	Daily and quarterly	Designated staff of target schools and HEPCO
2.5	Periodically aggregate and report the monthly gross electricity consumption of project LED lighting systems at target schools and streets	Monthly and/or quarterly	Designated staff of target schools and HEPCO
2.6	Periodically aggregate and report the net electricity consumption and CO2 emission reduction of project LED lighting systems at target schools and streets	Quarterly and annually	CC MRV TA, Lux Dev TAO
3	**After the project phase-out**		
3.1	Continue to follow up on the change/variation in the number of operating and non-operating project LED light data at target schools and streets	Monthly, starting at the time of project end	Designated staff of target schools and HEPCO
3.2	Monitor the operating time (hours) of project LED lighting systems	Daily and monthly, starting at the time of project end	Designated staff of target schools and HEPCO
3.3	Report aggregated operating time of project LED lighting system of each school and street	Monthly and quarterly, starting at the time of project end	Designated staff of target schools and HEPCO
3.4	Periodically aggregate and report the monthly gross and net electricity consumptions of project LED lighting systems at target schools and streets	Monthly and/or quarterly, starting at the time of project end	Designated staff of target schools and HEPCO
3.5	Re-organize the periodical survey of LED luminaire data at target schools and streets	Every two years, starting from the year of project end (2021)	Designated staff/officials of the agency/entity which takes over the project MRV system

3. Calculations of electricity savings and CO2 emission reductions

3.1 Calculation methodologies

-According to the guidance of AMS-II.L and AMS-II.N measurement methodologies, theoretically, if the use of energy efficient equipment or technology for outdoor and indoor lighting systems will help to save/reduce an amount of electric energy consumption (MWh), significantly contributing to reducing an amount of CO2 emission (tCO2) calculated on the basis of the emission factor for the national electricity grid, which is 0.8649 tCO2/MWh (Official Correspondent No.330/BĐKH-GNPT dated 29/3/2019 issued by DCC, MONRE). The calculation of CO2 emission reductions in year y is required to apply the most updated emission factor for Vietnam electricity grid annually issued by DCC, MONRE.

-The electric energy consumption of a lighting system is calculated based on the actually measured power consumption (KWh) and the actual operating time (hours) of that system.

-Baseline operating hours and project operating hours of a lighting system or a lighting point are equal. Therefore, the project will use the average number of operating hours of the project LED lighting systems to be monitored, to calculate the baseline electric energy consumption of conventional lamp lightings at target school and streets.

-Due to the huge difference between consumed power actually measured (at 116 sampled rooms) and rated power defined for T8 and T10 fluorescent tubes in schools, the project MRV system will not use the rated power of each lamp type, but will use the average consumed power of fluorescent lamps of each type to calculate the baseline power consumption of each room lighting in target schools.

-For street lightings, the power of a replaced SODIUM luminaire (W) includes both power of SODIUM lamp and ballast, so the project MRV system will not use the rated power (W) of SODIUM luminaires to calculate the baseline power consumption (KW) of 18 street lighting systems. Alternatively, the project MRV system will use the baseline data of 18 street lightings (collected from HEPCO public lighting control and monitor system for at least 03 months prior to the LED light installation), to estimate the average actually consumed power (W) of each type of SODIUM luminaire. After that, the estimated average actually consumed power (W) of each SODIUM luminaire type is used to calculate the power consumption (KW) of the conventional lightings at target streets.

-LED lamps/luminaires do not have ballast, so the project MRV system will use the rated power of project LED lamps/luminaires to calculate the electric energy consumption for all rooms in target schools and street lightings after monitoring data have been collected.

- For the school lighting, the design of the LED lighting for each room category is required to meet the illuminance level in compliance with the national technical standards in order to improve the lighting quality. Illuminance (lux) is a measure of the amount of luminous flux falling per unit area-lumens/m^2. Therefore, increasing the illuminance level of a room to meet the required standard is required to increase the luminous flux (emitted from a lighting energy source of the system), leading the situation that 1) the number of LED lamps installed in line with the lighting design is more than the number of replaced conventional lamps and 2) may increase the power consumption of a lighting system because of using more LED lights. Therefore, for the calculation of electricity savings, it is impossible to use the baseline electric energy consumption calculated on the number of existing conventional lamps at room lighting system that has very low illuminance level as compared to the national standard. For example, the current average illuminance of a classroom actually measure is 155 lux, compared to the standard of the QCVN 22:2016/BYT, which is 300 lux. To solve this problem, the Project will use the standard illuminance levels required for the LED lighting design (for example, 300 lux is required for a classroom) to calculate the number of T8 and T10 fluorescent lamps required to be added to the classroom lighting system so that it can meet the standard illuminance level of 300 lux. The project will calculate the luminous flux, illuminance level and total number of conventional lamps assumed to be in place for the lighting of a room category so that it can reach the standard illuminance level required for the project LED lighting design. Calculating the baseline power consumption of each room in each school will utilize the number of fluorescent tubes T8 and T10 calculated on the standard illuminance applied to the project LED lighting design.

- For street lightings, since the number of SODIUM luminaires to be replaced is the same as the number of LED luminaires retrofitted at the same location of each lighting point, so the project will not use the standard illuminance levels to recalculate the luminous flux (lm) and used as a factor to re-estimate the number of conventional luminaires.

-The estimate of CO2 emission reductions is based on the achieved electricity savings and the emission factor (EF) for Vietnam electricity grid periodically updated by MONRE.

3.2 Procedures for calculating values of electric energy savings and CO2 emission reductions

In order to calculate the electricity savings and CO2 emission reductions achieved from the retrofitting with project LED lamps/luminaires in at street lightings and in schools, the project MRV system will adopt the Equations guided in the two measurement methodologies of CDM, UNFCCC.

A. Outdoor Street Lightings (AMS-II.L measurement methodology, CDM, UNFCCC)

-Once the project LED lights are installed, the electricity savings and CO2 emission reductions achieved by 18 street lightings in year *y* is calculated using the following 02 Equations:

-Calculation of the electricity savings:

$$\boldsymbol{NES_y = \sum_{i=1}^{n} ES_{i,y} \times \frac{1}{(1 - TD_y)}} \qquad \textbf{Equation 1}$$

Where:

$ES_{i,y} = \left(Q_{i,BL} \times P_{i,BL} \times O_{i,BL} \times (1 - SOF_{i,BL})\right) - \left(Q_{i,P} \times P_{i,P,y} \times O_{i,y} \times (1 - SOF_{i,y})\right)$
$SOF_{i,BL} = AFR_{i,BL} \times OF_{i,BL}$
$SOF_{i,y} = AFR_{i,y} \times OF_{i,y}$

-Calculation of CO2 emission reductions:

$$\boldsymbol{ER_y = NES_y \times EF_{CO2,ELEC,y}} \qquad \textbf{Equation 2}$$

-The calculating procedures will follow 04 steps as bellows:

Step 1: Calculate the baseline electric energy consumption (KWh) of a street lighting system with conventional luminaires;

Step 2: Calculate the electric energy consumption (KWh) of a street lighting system with project LED luminaires;

Step 3: Calculate the net electricity savings (KWh) achieved as a result of LED luminaire retrofits at target street lighting systems;

Step 4: Estimate CO2 emission reductions based on the electricity saved by project LED luminaire retrofits at target street lighting systems.

More detailed guidelines for methods of calculations and equations employed are presented in Table 19 below.

Table 19: Technical procedures for calculating the electricity savings and CO2 emission reductions achieved at 18 street lightings		
No	**Measurement Parameters**	**Methods of calculations**
Step 1: Calculate the baseline electric energy consumption (KWh) of a street lighting system with conventional luminaires		
Parameters to be determined/measured		
1	$Q_{i,BL}$ = Quantity and type of Sodium luminaires to be replaced	Number of operating Sodium luminaires counted from HEPCO public lighting monitoring and control system.
2	$P_{i,BL}$= Average consumed power (W) of Sodium luminaires of a given type actually measured	Calculate the average actually consumed power of Sodium luminaires based on the baseline data collected from HEPCO public lighting monitoring and control system for at least 03 months prior to the LED light installation
3	$O_{i,BL}$= Operating time of Sodium luminaires (hours)	Operating hours of Sodium luminaires at street lighting systems calculated, using the monitoring data collected from HEPCO public lighting control and monitoring system. The operating time of Sodium luminaires is assumed to be the same as monitored for project LED luminaires
4	$OF_{i,BL}$=Outage Factor of Sodium luminaires	The average time, in hours, elapsed between failure of Sodium luminaires and replacement of Sodium luminaires, divided by annual operating hours
5	$AFR_{i,BL}$ = Annual Failure Rate of Sodium luminaires	Calculated as a fraction of *Q* of conventional luminaires. It is a per cent of Sodium luminaires of a given type within a system that fail annually.
6	y = Crediting year counter	Reporting years
7	i = Counter for luminaire type	Types of Sodium luminaires
Parameters to be calculated		**Calculating Equations**
1	$SOF_{i,BL}$ = System Outage Factor for Sodium luminaires in year *y*	$$SOF_{i,BL} = AFR_{i,BL} \times OF_{i,BL}$$ $AFR_{i,BL}$ = Annual Failure Rate of Sodium luminaires $OF_{i,BL}$ = Outage Factor of Sodium luminaires
2	Ei,BL = Electric energy consumption (KWh) of a street lighting system with conventional luminaires	$$Ei,BL = \left(Q_{i,BL} \times P_{i,BL} \times O_{i,BL} \times (1 - SOF_{i,BL})\right)$$ Ei,BL= Electric energy consumption (KWh) of a street lighting system with Sodium luminaires $Q_{i,BL}$ = Quantity of Sodium luminaires to be replaced $P_{i,BL}$ = Average consumed power (W) of Sodium luminaires of a given type actually measured $O_{i,BL}$ = Operating time of Sodium luminaires (hours) $SOF_{i,BL}$ = System Outage Factor for Sodium luminaires in year *y*
Step 2: Calculate the electric energy consumption (KWh) of a street lighting system with project LED luminaires;		
Parameters to be determined/measured		
1	$Q_{i,Py}$ =Quantity and types of project LED luminaires installed at a street lighting	Verified and documented during the installation of project LED luminaires and in the installation completion reports.
2	$P_{i,P,y}$ =Rated power of LED luminaires of a given type that have been installed (W)	Use the rated power of project LED luminaires in the lighting design and procurement dossiers
3	$O_{i,y}$ = Operating time (hours) of LED luminaires	Annual operating hours of project LED luminaires at street lighting systems calculated, using the monitoring data collected from HEPCO lighting monitoring and control system. The operating time of Sodium luminaires is assumed to be the same as monitored for project LED luminaires. The monitoring time lasts at least 90 days.
4	$OF_{i,y}$=Outage Factor of LED luminaires	The average time, in hours, elapsed between failure of LED luminaires and replacement of LED luminaires, divided by annual operating hours.

5	$AFR_{i,y}$ = Annual Failure Rate of LED luminaires	Calculated as a fraction of *Q* of LED luminaires in the crediting period *y*. It is a per cent of LED luminaires of a given type within a system that fail annually
6	y = Crediting year counter	Reporting years
7	i = Counter for luminaire type	LED luminaires by type
Parameters to be calculated		**Calculating Equations**
1	$SOF_{i,y}$ = System Outage Factor for LED luminaires in year *y*	$$SOF_{i,y} = AFR_{i,y} \times OF_{i,y}$$ $AFR_{i,y}$ = Annual Failure Rate of LED luminaires $OF_{i,y}$ = Outage Factor of LED luminaires
2	$E_{i,P,y}$ = Electric energy consumption (KWh) of a street lighting system with project LED luminaires in year y	$$E_{i,P} = (Q_{i,\boldsymbol{P},y} \times P_{i,\boldsymbol{P},y} \times O_{i,y} \times (1 - SOF_{i,y}))$$ $E_{i,P}$ = Electric energy consumption (KWh) of a street lighting system with LED luminaires $Q_{i,\boldsymbol{P},y}$ = Quantity of LED luminaires installed $P_{i,\boldsymbol{P},y}$ = Rated power (W) of LED luminaires of a given type $O_{i,y}$ = Operating time of LED luminaires (hours) $SOF_{i,y}$ = System Outage Factor for LED luminaires in year *y*
Step 3: Calculate the net electricity savings (NES) achieved as a result of LED luminaire retrofits at all target street lighting system;		
Parameters to be calculated		**Calculating Equations**
1	$ES_{i,y}$ = Gross electricity savings (KWh) achieved at a street lighting with project LED luminaires in year y	$\boldsymbol{ES_{i,y} = E_{i,BL} - E_{i,P,y}}$ Or $$\boldsymbol{ES_{i,y} = (Q_{i,BL} \times P_{i,BL} \times O_{i,BL} \times (1 - SOF_{i,BL})) - (Q_{i,P} \times P_{i,P,y} \times O_{i,y} \times (1 - SOF_{i,y}))}$$ $E_{i,BL}$ = Electric energy consumption (KWh) of a street lighting system with Sodium luminaires $E_{i,P,y}$ = Electric energy consumption (KWh) of a street lighting system with project LED luminaires
2	NES_y =Net electricity savings achieved as a result of LED light retrofits at all the street lightings in year y (KWh)	$\boldsymbol{NES_y = \sum_{i=1}^{n} ES_{i,y} \times \frac{1}{(1-TD_y)}}$ (Equation 1) $ES_{i,y}$ = Gross electric energy savings (KWh) achieved in year y; TD_y = Annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the luminaires are installed, expressed as a fraction. If there is no recent data or the available data are considered to be not accurate and reliable, use the value of 10% for the average annual technical grid losses; n = number of street lightings (18 streets)
Step 4: Estimate CO2 emission reductions based on the electricity saved by project LED luminaire retrofits at target street lighting systems		
1	$\boldsymbol{ER_y}$ = Emission reductions achieved by street lighting systems with project LED luminaires at target streets in year *y* (tCO_2)	$$\boldsymbol{ER_y = NES_y \times EF_{CO2,ELEC,y}}$$ $\boldsymbol{NES_y}$ =Net electricity savings achieved by project LED lighting systems at all the street lightings in year y (MWh). Convert the unit of measurement from KWh to MWh (1MWh=1,000KWh); $\boldsymbol{EF_{CO2,ELEC,y}}$ = Emission factor in year *y* (tCO_2/MWh). The emission factor for Vietnam electricity grid issued under the Official Correspondence No.330/BĐKH-GNPT dated 29/3/2019 is 0.8649 tCO2/MWh. At the calculation time, the project will employ the emission factor for the national electricity grid periodically updated by DCC, MONRE.

B. Lightings in School Buildings (AMS-II.N measurement methodology, CDM, UNFCCC)

-Once the project LED lights are installed, the electricity savings and CO2 emission reductions achieved by lighting systems in 54 schools in year *y* is calculated using the following 02 Equations:

-Calculation of the electricity savings: (Equation 1)

$$\boldsymbol{ES_y} = \sum_{\boldsymbol{u,i}} \left(\frac{\mathbf{1}}{\mathbf{1,000,000}}\right) \times [(\boldsymbol{W/fixture_{b,u,i}} \times \boldsymbol{N_{b,u,i}} \times \boldsymbol{Hours_{b,u,i}}) - (\boldsymbol{W/fixture_{p,u,i}} \times \boldsymbol{N_{p,u,i,y}} \times \boldsymbol{Hours_{p,u,i,y}})]$$

-Calculation of CO2 emission reductions: (Equation 2)

$$\boldsymbol{ER_y} = \boldsymbol{ES_y} \times \boldsymbol{EF_{CO2,ELEC,y}}$$

-The calculating procedures will follow 04 steps as bellows:

Step 1: Calculate the baseline electric energy consumption (KWh) of lighting systems with conventional luminaires in a school;

Step 2: Calculate the electric energy consumption (KWh) of lighting system with project LED luminaires in a school;

Step 3: Calculate the electricity savings (KWh) achieved as a result of LED luminaire retrofits at lighting systems in all target schools;

Step 4: Estimate CO2 emission reductions based on the electricity saved by project LED luminaire retrofits in all target schools.

More detailed guidelines for methods of calculations and equations employed are presented in Table 20 below:

Table 20: Technical procedures for calculating electric energy savings and CO2 emission reductions achieved at lighting systems in 54 target schools		
No	**Measurement Parameters**	**Methods of calculations**
Step 1: Calculate the baseline electric energy consumption (KWh) of lighting systems with conventional luminaires in a school;		
Parameters to be determined/measured		
1	$N_{u,i}$ =Quantity and type of lamps to be replaced	$N_{u,i} = \mathrm{N}fluorescent$. Data are collected in the baseline survey and measurements at target schools
2	Actual average illuminance (lux) of each room type	The baseline survey and measurements have used calibrated meters to measure the actual illuminance of 116 sampled rooms (divided into 5-6 room categories). Use the actual average illuminance to calculate the luminous flux (lumen) of the existing lighting and compare it with the standard illuminance level of each room category.
3	$W/fixture_{b,u,i}$ = Power of conventional lamp of a given type (W)	$W/fixture_{b,u,i}$ = $P_{\text{fluorescent}}$ is the actually consumed power of fluorescent lamps of a given type in existing lighting systems. Average consumed power (W) of fluorescent lamps T8 and T10 are actually measured by an external and independent consultant. Calculate the average consumed powers $P_{\text{fluorescent}}$ of a given type of fluorescent lamps based on the actual measurement data of 116 sampled rooms in the baseline survey and measurements at target schools
4	$N_{b,u,i} = \mathrm{N}required$ Total number of conventional luminaires estimated based on the standard illuminance level required for each room category in a school	Use the following 04 equations to calculate the quantity of conventional luminaires required for a room based on the standard illuminance level in the project LED lighting design for schools.
	Calculating Equations	**Where**
a	**Equation 1**: Calculate the luminous flux of a luminaire (lm) $\Phi = \frac{Emean \times S \times d}{Uf}$	-Φ is the total luminous flux of a luminare to be calculated (lm); -E_{mean} is the average illuminance level of the room (lux); -S is the area of the room (m2); -d is the lumen compensation factor for room reflectance (of walls, ceiling, floor, window) and d=1.2 for classroom -Uf is the Ultilization factor of a luminaire type, for the fluorescent luminaire, Uf=0.5 and for the LED luminaires, Uf=0.7
b	**Equation 2**: Calculate the power consumption of a room lighting (W) $P_{room} = N_{fluorescent} \times P_{\text{fluorescent}}$	-P_{room} is the power consumption of a room lighting to be calculated (W); -$N_{fluorescent}$ is the total number of existing conventional luminaires; and - $P_{\text{fluorescent}}$ is the average consumed power of a conventional luminaire (fluorescent) actually measured (W)
c	**Equation 3**: Calculate the average illuminance of each room type based on the quantity of conventional luminaires $E\mathrm{mean} = \frac{\Phi luminaire \times \mathrm{N}fluorescent \times \mathrm{Uf}}{S \times d}$	-E_{mean} is the average illuminance level of the roon (lux); - $\Phi luminaire$ is the luminous flux of conventional luminaires (lm); -$N_{fluorescent}$ is the total number of existing conventional luminaires; -Uf is the Ultilization factor of a luminaire type, for the fluorescent luminaire, Uf=0.5 and for the LED luminaires, Uf=0.7 -S is the area of the room (m2) -d is the lumen compensation factor for room reflectance (of walls, ceiling, floor, window) and d=1.2 for classroom
d	**Equation 4:** Calculate the number of conventional luminaires based on the required illuminance level $Nrequired = \frac{E\mathrm{required} \times \mathrm{S} \times \mathrm{d}}{\Phi luminaire \times Uf}$	-$N_{required}$ is the number of conventional luminaires calculated based on the required illuminance level -$E_{required}$ is the illuminance level of the room as required by national technical standards (lux) - $\Phi luminaire$ is the luminous flux of conventional luminaires (lm) -Uf is the Ultilization factor of a luminaire type, for the fluorescent luminaire, Uf=0.5 and for the LED luminaires, Uf=0.7 -S is the area of the room (m2) -d is the lumen compensation factor for room reflectance (of walls, ceiling, floor, window) and d=1.2 for classroom
5	$Hours_{b,u,i}$ =Operating time of conventional	Baseline annual operating hours for operative lighting fixtures. Operating time of conventional luminaires/lamps is assumed to be the same as monitored for project LED lights

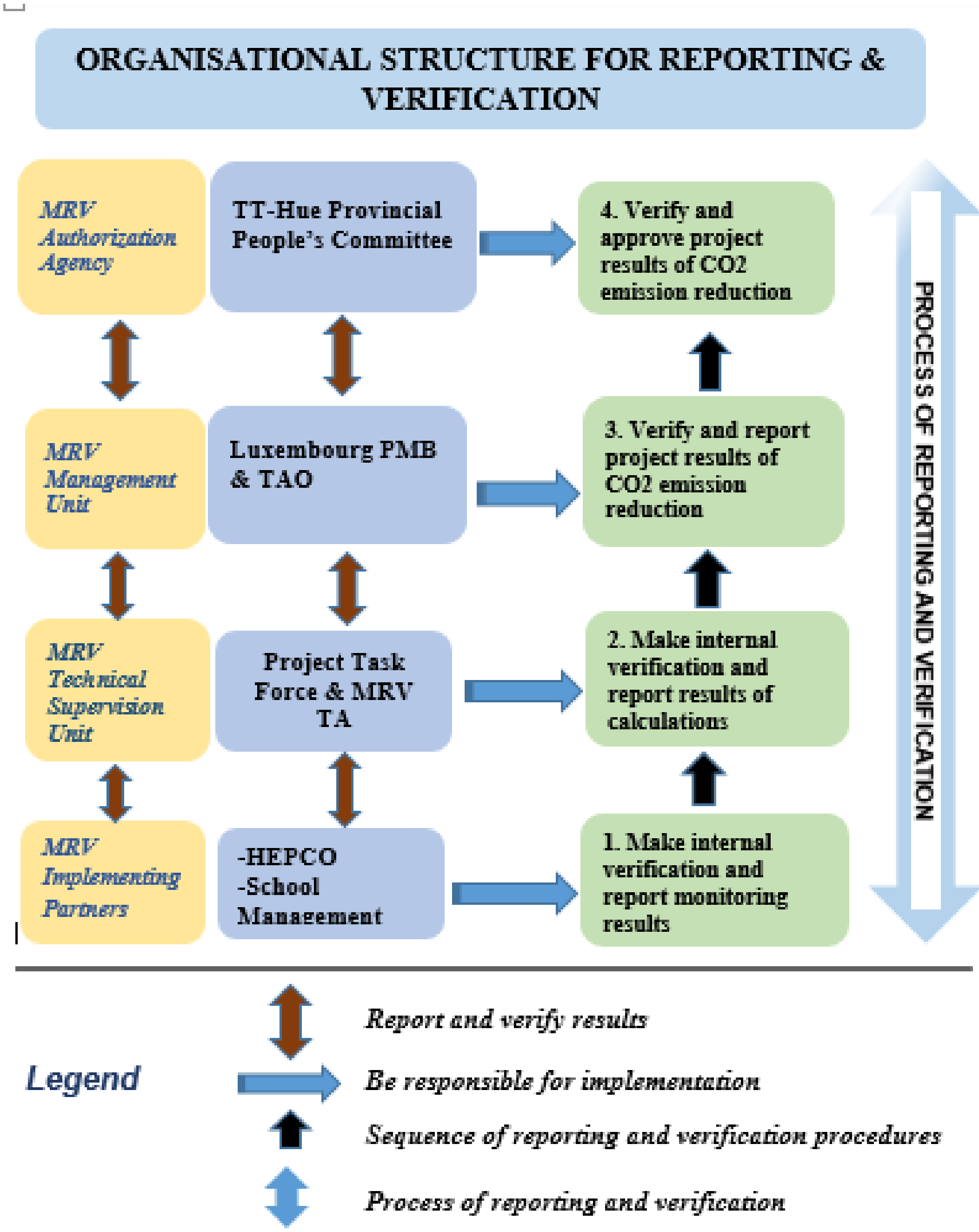
	luminaires/lamps (hours/year) in a school	Daily monitoring is carried out after the installation of project LED lights, using the monitoring templates. Class teachers and students in target schools will be engaged in the collection of data for this parameter for the lighting of their classroom.
Parameters to be calculated		**Calculating Equation**
1	$E_{b,u,i}$= Electric energy consumption (KWh) of lighting systems with conventional luminaires/lamps in a school	$E_{b,u,i}= (W/fixture_{b,u,i} \times N_{b,u,i} \times Hours_{b,u,i})$ $W/fixture_{b,u,i}$ = Average consumed power (W) of fluorescent lamps T8 and T10 actually measured; $N_{b,u,i}$ = Total number of conventional luminaires estimated based on the standard illuminance level required for each room category in a school; $Hours_{b,u,i}$ = Operating time of conventional luminaires/lamps (hours) in a school
Step 2: Calculate the electric energy consumption (KWh) of lighting system with project LED luminaires in a school;		
Parameters to be determined/measured		
1	$W/fixture_{p,u,i}$ =Rated power of project LED luminaires/lamps by type (W)	Use the rated power of project LED luminaires/lamps as required in the lighting design and procurement dossiers.
2	$N_{p,u,i,y}$= Quantity and type of project LED luminaires/lamps installed in a school	Verify and document during the installation of project LED luminaires/lamps and collect data from the installation completion reports.
3	$Hours_{p,u,i,y}$= Operating time (hours/year) of project LED luminaires in a school in year y	Project annual operating hours for operative LED luminaires/lamps. Operating time of conventional luminaires/lamps is assumed to be the same as monitored for project LED lights Daily monitoring is carried out after the installation of project LED lights, using the monitoring templates. Class teachers and students in target schools will be engaged in the collection of data for this parameter for the lighting of their classroom.
4	Average illuminance (lux)	Document the illuminance levels modelled in the LED lighting design to compare the lighting levels before and after project LED light installation
Parameters to be calculated		
	$E_{p,u,i}$= Electric energy consumption (KWh) of lighting systems with LED luminaires/ lamps in a school in year y	$E_{p,u,i}= (W/fixture_{p,u,i} \times N_{p,u,i,y} \times Hours_{p,u,i,y})$. $W/fixture_{p,u,i}$ =Rated power of project LED luminaires/lamps by type (W) $N_{p,u,i,y}$= Quantity and type of project LED luminaires/lamps installed in a school $Hours_{p,u,i,y}$= Operating time (hours) of project LED luminaires in a school in year y
Step 3: Calculate the electricity savings (KWh) achieved as a result of LED luminaire retrofits at lighting systems in all target schools;		
1	ES_y = Electricity savings (KWh) achieved as a result of LED luminaire retrofits in a school in year y	$\boldsymbol{ES_y = E_{b,u,I} - E_{p,u,I}}$ $\boldsymbol{E_{b,u,i}}$= Electric energy consumption (KWh) of lighting systems with conventional luminaires/lamps in a school $\boldsymbol{E_{p,u,i}}$= Electric energy consumption (KWh) of lighting systems with LED luminaires/ lamps in a school in year y

2	ES_y = Electricity savings (KWh) achieved as a result of LED luminaire retrofits in all target schools in year y	$$\boldsymbol{ES_y = \sum_{u,i}\left(\frac{1}{1,000,000}\right) \times [(W/fixture_{b,u,i} \times N_{b,u,i} \times Hours_{b,u,i}) - (W/fixture_{p,u,i} \times N_{p,u,i,y} \times Hours_{p,u,i,y})]}$$ $W/fixture_{b,u,i}$ = Average consumed power (W) of fluorescent lamps T8 and T10 actually measured; $N_{b,u,i}$ = Total number of conventional luminaires estimated based on the standard illuminance level required for each room category in a school; $Hours_{b,u,i}$ = Operating time of conventional luminaires/lamps (hours) in a school $W/fixture_{p,u,i}$ =Rated power of project LED luminaires/lamps by type (W) $N_{p,u,i,y}$= Quantity and type of project LED luminaires/lamps installed in a school $Hours_{p,u,i,y}$= Operating time (hours) of project LED luminaires in a school in year y *n*= Number of target schools (54) i= Types of luminaires/lamps u= Usage group/room category
Step 4: Estimate CO2 emission reductions based on the electricity saved by project LED luminaire retrofits in all target schools		
1	$\boldsymbol{ER_y}$ = Emission reductions achieved by project LED lighting systems in all the target schools in year y (tCO_2)	$$\boldsymbol{ER_y = ES_y \times EF_{CO2,ELEC,y}}$$ $\boldsymbol{ES_y}$ = Electricity savings (KWh) achieved by project LED lightings in all target schools in year y. Convert the unit of measurement from KWh to MWh (1MWh=1,000KWh) $\boldsymbol{EF_{CO2,ELEC,y}}$ = Emission factor in year *y* (tCO_2/MWh). The emission factor for Vietnam electricity grid issued under the Official Correspondence No.330/BĐKH-GNPT dated 29/3/2019 is 0.8649 tCO2/MWh. At the calculation time, the project will employ the emission factor for Vietnam electricity grid annually updated by DCC, MONRE.

B. REPORTING AND VERIFICATION

1. Organisational Structure for Reporting and Verification

Figure 4: Organisational structure for reporting and verification of results



2. Roles and responsibilities of involved agencies or units

Roles and responsibilities of agencies/units involved in Reporting and Verification are briefly presented in the below table:

Table 21: Roles and responsibilities of agencies/units involved in Reporting and Verification

No	MRV Stakeholders	Involved Agencies/Units	Roles	Responsibilities
1	***MRV Implementing Partners***	**a) HEPCO (street lighting systems)**	Verify and report results of periodical monitoring	-Conduct internal verification of monitoring results prior to reporting; -Report periodically collected monitoring data to the MRV Technical Supervision Unit; and -Provide favourable conditions and support for any external verification if required.
		b) Management Boards of target schools (indoor lighting systems)	Verify and report results of periodical monitoring	-Conduct internal verification of monitoring results prior to reporting; -Report periodically collected monitoring data to the MRV Technical Supervision Unit; and -Provide favourable conditions and support for any external verification if required.
2	***MRV Technical Supervision Unit***	**Project Task Force**	Verify, calculate and report project results	-Conduct internal verification of results reported from MRV activities such as collection of baseline data, monitoring, measurement and calculations -Calculate project results (electric energy consumption and CO2 emission reduction); and -Report project results to the MRV Management Unit PPMB and TAO)
3	***MRV Management Unit***	**Luxembourg PPMB and TAO**	Verify and report project results	-Organize external/independent verification of the MRV data and results of calculations before giving the endorsement; -Endorse and report project results (electric energy consumption and CO2 emission reduction) to the MRV Authorization Unit-TT-Hue provincial P.C.
4	***MRV Authorization Agency***	**TT-Hue Provincial P.C**	Approve and report project results	-Organize additional verification of the MRV system and project results (if necessary); -Approve project results (electric energy consumption and CO2 emission reduction); -Report and approve necessary procedures to register project results with the Department of Climate Change, MONRE; -Endorse/verify the procedures to register project results for recognition on the UNFCCC online Registration system.

3. Reporting Plan

3.1. Reporting contents

The contents of MRV results consist of measured information and project results of CO_2 emission reduction achieved in a reporting period:

+Measured information: measured information includes 1) baseline information and data collected prior to the installation of project LED lights; 2) monitoring data of project LED lightings after the project LED lightings have been put into use; and 3) results of baseline and monitoring data analysis and calculations.

+Project results of CO_2 emission reduction: The project result of CO_2 emission reduction is supposed to be prepared and reported in a reporting period and on an annual basis. The reporting of project impact on CO_2 emission reduction in the first reporting year is required to include but not limited to the following information: project summary, achieved results versus the targets set forth for outputs and outcome/impact indicators, scope of project pilot interventions; brief description of project MRV system, implementation of measurement and reporting, verification of measured and reported results, achieved results of electricity savings, CO_2 emission reduction and reduction of electricity cost in the reporting year, conclusion and recommendations (if any). The dossier prepared for registration of project results of CO_2 emission reduction with sub-national and national authorities should report the adequate information as the above, but may be subject to be in compliance with other additional information required in a standard format/template issued (if any).

The reporting of project results starting from the second reporting year consists of shortened contents with the focus on project profile, implementation of measurement and reporting, verification of measured and reported results, achieved results of electricity savings, CO_2 emission reduction and reduction of electricity cost in the reporting year.

Reporting the project results is required to include but not limited to the following information:

- Project summary
- Achievements of project expected results against the targets set forth for output and outcome indicators;
- Scope of the project interventions
- Implementation of Measurement, Reporting and Verification (MRV) includes:
    - Organisational mechanism for MRV implementation
    - Methodologies of measurements and calculations;
    - Measurement and calculation activities;
    - Verification of MRV results.
- The project results achieved by the pilot LED light interventions in the reporting year (including electricity savings, CO_2 emission reductions, electricity cost reduction and other co-benefits of sustainable development)
- Conclusions and recommendations (if any)

3.2 Procedures for Reporting

+ Reporting baseline and monitoring data

-Street lightings

HEPCO, as one of the MRV implementing partners, is responsible for collecting both baseline and monitoring data for measurements and calculations of project results. These data are daily recorded and updated in its public lighting control and monitoring system. HEPCO is required to monthly report monitoring data to the PTF via the CC MRV Technical Adviser, one of PTF members, who has responsibility to store, calculate and report measurement and calculation results, in form of periodical MRV reports, to the PTF for review and endorsement.

-Indoor school lightings

The collection of baseline data and measurements of actual power consumption and average illuminance of conventional lighting fixtures prior to the installation of project LED lights will be outsourced to an external consultant, who is qualified and required to meet the technical requirements for energy measurement and auditing. The prospective consultant will report data of baseline survey and measurements to the MRV Technical Supervision Unit, which is the PTF, via the CC MRV Technical Adviser after the completion of their consultancy service.

While monitoring data on the quantity, type and rated power of project LED luminaires as well as average illuminance will be collected from technical design documents and procurement documents, the daily operating hours of project LED luminaires will be collected with the engagement of school teachers and pupils. The Management Boards of target schools, one of the MRV Implementing Partners, will report monthly data on operating hours of project LED luminaires to the PTF via the CC MRV Technical Adviser, who has responsibility to store and aggregate data for measurement and calculations.

+Reporting results of measurement and calculations;

The CC MRV Technical Adviser, with the technical assistance of the PIPP Technical Adviser, will take charge of doing calculations to measure the electric energy consumption, electricity savings and CO2 emission reductions of baseline and project luminaires based on the provided data and in compliance with the procedures and guidelines of the two CDM measurement methodologies AMS-II.L and AMS-II.N.

The CC MRV Technical Adviser will prepare and submit a periodical MRV report on the results of ex ante and post ante measurement and calculations of electricity savings and CO2 emission reductions for the PTF review, verification and endorsement. After making plenary review and technical verification of MRV results, the PTF will report CO2 emission reductions periodically achieved against the performance target to the MRV Management Unit, which includes the Lux PMB and LuxDev TAO.

+Reporting CO2 emission reduction results periodically achieved by the project

After receiving the MRV reports, Lux PMB and LuxDev TAO (MRV Management Unit) will review and approve periodical MRV reports. In addition to internal verification activities implemented before and after each periodical MRV report, Lux PMB and LuxDev TAO will organize an external verification, undertaken by an independent consultant hired from outside, which is based on periodical MRV reports, databases and field visits. At the end of project cycle, Lux PMB and LuxDev TAO will endorse and report the project final result of total electricity savings and CO2 emission reduction to TT-Hue provincial P.C, which is the MRV Authorization Agency.

After reviewing, TT-Hue provincial P.C will approve the report on project results of CO2 emission reduction. With the approval and certification of the provincial P.C, Lux PMB and TAO will proceed with procedures that register project result of CO2 emission reductions with the DCC, MONRE, as a contribution to achieving the national target of GHG emission reduction committed to the international community under the Paris Agreement. For more information on the procedures for reporting implementation, please refer to Table 22.

4. Verification Plan

4.1 Forms of Verification

The project MRV will apply two forms of verification: internal verification and external verification. The internal verification will be undertaken by the Project Task Force members who are representatives from TAO, Lux PMB, DONRE, DOIT and DOET, HEPCO. This is a self-certification process that validates and endorses data collection methods, measurement/calculation methodologies and the achieved GHG emission reduction as well as sustainable development co-benefits that the MRV Management Unit (Lux PMB and TAO) will report to TT-Hue provincial P.C. The internal verification mechanism will be further developed in consultation with the Project Taskforce members. The MRV Management Unit may organize an internal verification of the MRV system and project results carried out by an independent/external technical consultant.

External verification is usually be undertaken by the government authoritative agency that sets the standards against which the assessment is done. The MRV Authorization Agency-TT Hue provincial P.C may require a number of external verification procedures which assess the MRV system and project accomplishments reported. After the registration of project CO2 emission reduction results is completed, the DCC, MONRE or its delegated agency/assigned accredited organization may carry out an external verification with necessary procedures to validate and verify the project MRV system and reported achievement of GHG emission reductions. Specific guidelines and requirements for the verification procedures will need to follow and comply with when the Project makes registration of its CO2 emission reduction results with DCC, MONRE.

4.2 Verification Approaches

The verification activities of the project reporting results is mainly based on the two following verification approaches: 1) verification based on documentary evidence and 2) verification based on physical evidence.

4.2.1 Verification based on documentary evidence

Documentary evidence refers to the reports that the project would submit to relevant authorities such as the funding agency, LuxDev, TT-Hue provincial P.C and MONRE. The reported information gives the details of the collected data, process of collection, frequency of data collection, systems for quality assurance/quality control of data, measurement/calculation methodologies. Internal and external verifiers may review such reports to evaluate the accuracy of the information reported. Therefore, the quality of collected data is an important part of the measurement plan because it can help to better verification.

4.2.2 Verification based on physical evidence

Another approach to verification is based on physical evidence, which is the information gathered by direct observations through field visits by the verifiers to pilot sites where data are collected and the TAO where data are measured/calculated and stored. Examples of physical evidence include the inspection to see whether the meters used for power or illuminance measurement are present, operational and correctly calibrated. The verifiers may also observe how the measurement technician uses this equipment to collect relevant data to determine whether the measurement is be done properly.

The objective of verification based on physical evidence is to ensure through on-site observation and records that due process has been followed in recording and storing information and the accuracy of meters is assured. The physical evidence verification is also to confirm 1) that project activity is implemented in accordance with the project implementation plan; 2) that the measurement system is in compliance with the approved methodology; 3) the completeness and accuracy of data provided in the reports and 4) to evaluate the CO2 emission reduction data recorded and stored in accordance with the baseline and monitoring methodology.

4.3 Verification of reports

The project internal verification will be carried out by MRV implementing stakeholders (HEPCO and the Management Boards of target schools) and MRV Technical Supervision Unit (PTF and MRV TA) through integration during the monitoring, technical assistance, receiving and reporting results of each MRV activity on the basis of their assigned specific roles and responsibilities. Lux PMB and TAO will outsource external consultant to conduct independent verification of the MRV system and the project results before getting them endorsed and reporting the project result to PPC. If necessary, PPC will appoint a functional agency to organize the verification before approval and reporting the CO2 emission reduction results to MONRE.

5. Implementation plan for reporting and verification

Table 22: Implementation plan for reporting and verification of project results

No	MRV implementation components	Time and frequency of Reporting	Reporting Entities	Verifying Entities	Endorsing/Approving Entities
1	Collect baseline and monitoring data before and after the installation of project LED luminaires	Monthly and quarterly. The commencement time follows the implementation plan of specific MRV activities	HEPCO & Management Boards of target schools	CC MRV TA, TAO	Project Task Force
2	Verify and report the results of measurement and calculations	Quarterly and annually, after the installation of project LED luminaires is completed	CC MRV TA, TAO	Project Task Force	Project Task Force
3	Verify and endorse project MRV results	Quarterly and annually, during the project period	Project Task Force	External/independent Consultant Verifier	Luxembourg PPMB and TAO
4	Verify and approve the reported project results of CO2 emission reduction periodically achieved	Annually, during the project period	Luxembourg PPMB and TAO	Agency/unit designated by TT-Hue provincial P.C (if any)	TT-Hue provincial P.C
5	Register total project CO2 emission reductions and report periodical results during the project period	Start in the first year after the installation of project LED luminaires is completed and report annually during the project period	TT-Hue provincial P.C	Department of Climate Change, MONRE	MONRE
6	Report periodical results of CO2 emission reduction achieved during the time after the project end	Annually after the project end and continue until the end of the registered reporting period	TT-Hue provincial P.C, Luxembourg PPMB and TAO	Department of Climate Change, MONRE	MONRE

V. REGISTERING PROJECT RESULTS OF CO2 EMISSION REDUCTION

1. Purpose of registering project results

The overall objective of VIE/401 is to contribute to efforts of achieving the national GHG emission reduction target for the period 2020-2030 that the Government of Vietnam has committed to the international community under the Paris Agreement. Therefore, the purpose of registering the project results with MONRE is to get project accomplishment of CO2 emission reduction recognized and included in the update reports of Vietnam Nationally Determined Contribution. After MONRE has approved and recognized project results of CO2 emission reduction in the first reporting year, the Project will continuously complete the registration procedures required for the project CO2 emission reduction to be recognized in the UNFCCC Registry.

2. Project results of CO2 emissions reduction to be registered

The timeframe registered for official recognition of project results of CO2 emission reductions is 12 years. It is expected that the use of project LED lightings will result in saving at least 19.32GWh in this period of time, leading to a total emission reduction of approximately 16,710 tCO2 achieved (use the current national electricity grid emission factor of 0.8649 tCO2/MWh for the estimate). The project CO2 emission reductions will be calculated per annum, so the total CO2 emission reduction achieved by the project interventions may change, if the emission factor for the national electricity grid changes with the update figure.

3. Procedures for registering project results of CO2 emission reduction

The process of registering project results of CO2 emission reduction composes the following procedures:

-Report project results of CO2 emission reduction. Luxembourg PMB submits a report on project results of CO2 emission reduction in the reporting year to TT-Hue provincial P.C for written approval. In the following years after the project end, the MRV Management Unit (designated afterward) will have responsibility for annually reporting project results of CO2 emission reduction.

-Approve project results of CO2 emission reduction. After review and appraisal, the provincial P.C will approve project results of CO2 emission reduction achieved in the reporting year in writing.

-Register project results of CO2 emission reduction. After the provincial P.C has approved project results of CO2 emission reduction, Luxembourg PMB, with the technical assistance of TAO, will prepare procedures for reporting and registering project results with the MONRE in compliance with regulations and guidelines of the Department of Climate Change. Procedures for registering the total project CO2 emission reduction result with MONRE will be done once during the project period. In the following years after the project end, the MRV Management Unit designate will be responsible for annual reporting and completing update registration procedures if required by MONRE.

-Approve and recognise the project result of CO2 emission reduction. After receiving the project result registration dossier, MONRE will review and issue a written document that approves and recognises the project results of the CO2 emission reduction achieved in the reporting year and send to the Luxembourg PMB.

-Register with the United Nations Framework Convention on Climate Change. After receiving the confirmation document from the DCC, MONRE, TAO, in cooperation with Luxembourg PMU will proceed with required procedures for registering the project results for recognition on the UNFCCC Registry with the support of LuxDev.

-Report annual project results of CO2 emission reduction. During the project period, Luxembourg PMB, with the technical assistance of the TAO, will prepare procedures to report on project results of annual CO2 emission reduction in compliance with the forms instructed by the DCC, MONRE (if any). In the following years after the project end in 2021, the MRV Management designate will be responsible for continuously reporting project results of annual CO2 emission reduction until the end of the reporting period of 12 years, which is the registered timeframe for reporting project results of CO2 emission reduction.

VI. HANDOVER OF PROJECT MRV SYSTEM AT THE END OF PROJECT

1. Purpose

After the project has come to an end by 2021, the project MRV system is supposed to continuously operate and the MRV results are still to be reported for the provincial P.C approval and reported to MONRE for recognition until the end of proposed reporting timeframe. Therefore, the Project needs to hand over the roles and responsibilities for running the MRV system and reporting CO2 emission reduction results to an appropriate and qualified technical management entity at the end of project. The handover process is considered as an important part in the project MRV implementation plan.

The purpose of the handover procedure is to ensure that the project MRV system is still running to measure and report project results achieved after the project phase-out and until the end of the reporting period registered with the DCC, MONRE.

2. Plan for MRV system handover

2.1 Time of handover procedure

The project will start the handover of MRV system at least three months before the project end, tentatively from March 2021.

2.2 Activities of MRV system handover

The Project will implement the following activities to hand over the MRV system at the end of project:

a) Develop an implementation plan for MRV after the project phase-out

The Project, with technical assistance of TAO, will develop and finalize an implementation plan for post project period MRV in consultation with the relevant agencies/units through technical consultation meetings and workshops with Lux PPMB, PTF and concerned professional agencies.

b) Strengthen/enhance MRV knowledge and capacity for concerned agencies

In addition, the Project will organize relevant trainings to strengthen/improve knowledge and capacity on how to develop a MRV system, MRV of project results for specialized officials/staff of provincial concerned agencies, particularly the entity designate that will take over the project MRV system.

c) Complete required handover procedures with the entity designate that takes over the project MRV system

After having identified the entity designate that will manage and operate the project MRV system, PPMB and TAO will discuss and agree on the handover plan and proceed with a written agreement on the handover of the project MRV system.

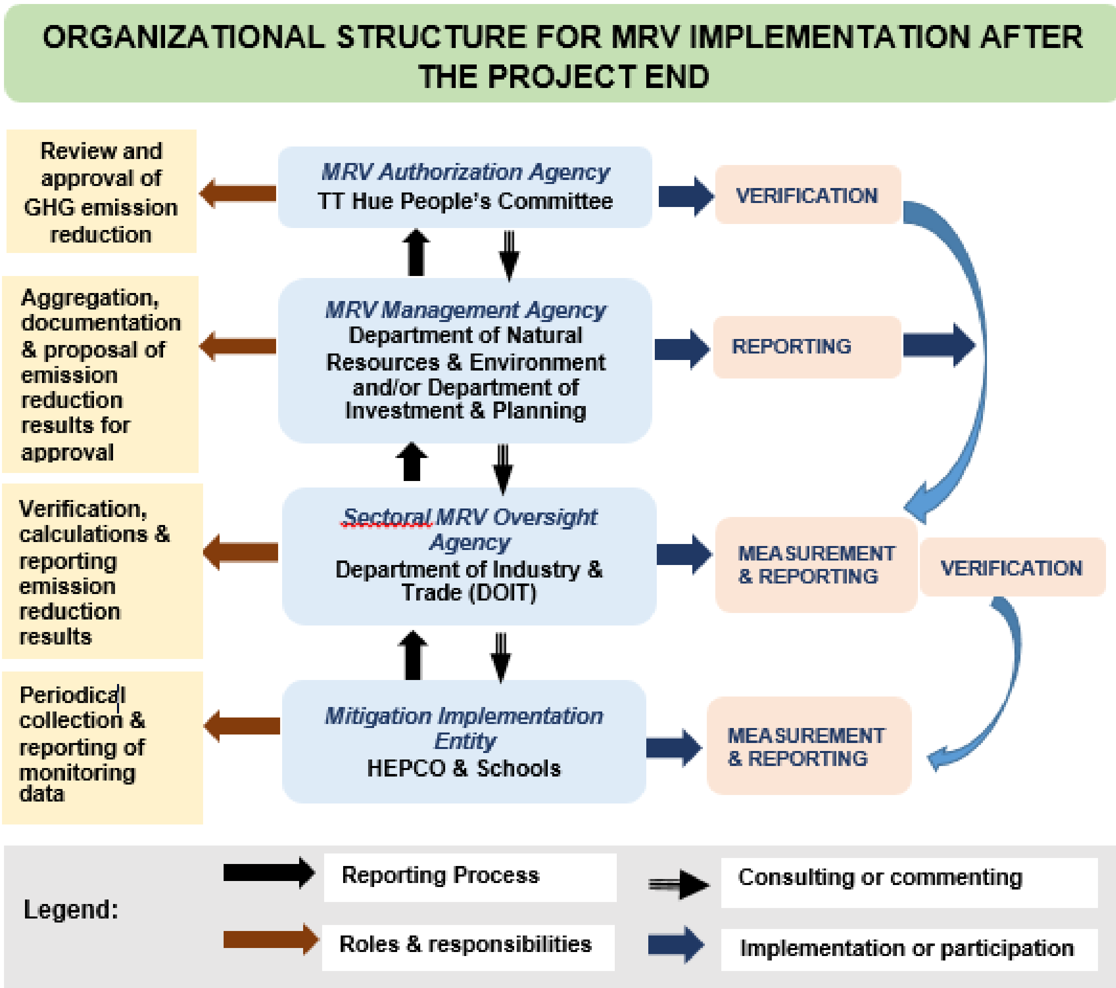
d) Support the implementation of project MRV system handover plan

In order for the entity designate to continuously implement MRV activities well after the project end, the Project will finance a number of activities that support the implementation of MRV system handover plan prior to the time of project end. Specific supporting activities will be discussed and agreed upon between the project and the agency/unit designated to take over the project MRV system.

3. Organisational Structure for MRV Implementation after the Project end

The MRV activities of Project VIE/401 are within the framework of a project-level MRV system, so the proposed organizational structure for the MRV implementation is mainly based on the organizational structure for project implementation, including the agencies and units involved in the management and implementation of project activities. However, after the project phase-out, this implementation structure is no longer legally valid and appropriate for the reality, so it needs a feasible and suitable organizational structure for MRV implementation, and integrated into a provincial MRV Framework that will be developed afterward. As a result, the Project proposes an organizational structure for MRV implementation after the project phase-out as shown in the following diagram.

Figure 5: Proposed Organisational Structure for MRV Implementation after the project phase-out



VI. APPENDICES

Appendix 1: List of schools selected for project supported LED light replacement

No	School name	Quantity of rooms (or usage groups)							Total teachers & pupils
		Classroom	Computer-foreign language rooms	Practical-experimental rooms	Private & common offices	Library	Others	Total	
PRIMARY SCHOOLS		**500**	**30**	**0**	**38**	**16**	**25**	**609**	**22.411**
1	No 1 An Đông	12	1	0	2	1	0	16	984
2	An Cựu	18	0	0	3	0	0	21	794
3	An Hòa	12	0	0	0	0	0	12	437
4	Hương Sơ	20	2	0	8	1	5	36	801
5	Huyền Trân	11	2	0	0	1	0	14	430
6	Kim Long 1	15	3	0	6	1	5	30	482
7	Kim Long 2	12	1	0	1	1	3	18	531
8	Lý Thường Kiệt	29	1	0	3	1	0	34	1.456
9	Ngô Kha	7	2	0	0	1	0	10	188
10	Ngự Bình	15	1	0	0	1	0	17	06
11	Phường Đúc	18	0	0	0	0	0	18	50
12	Phước Vĩnh	13	0	0	1	0	0	14	1.057
13	Phú Bình	16	0	0	1	1	1	19	438
14	Phú Cát	17	1	0	0	0	0	18	975
15	Phú Hậu	20	1	0	4	1	4	30	642
16	Phú Hòa	17	1	0	0	1	1	20	622
17	Phú Lưu	10	2	0	2	1	1	16	282
18	Quang Trung	26	2	0	0	0	0	28	1.289
19	Tây Lộc	7	0	0	0	0	0	7	136
20	Thủy Biều	6	0	0	0	0	0	6	218
21	Thủy Xuân	8	1	0	1	0	2	12	391
22	Thuận Hòa	24	1	0	0	1	0	26	1.074
23	Thuận Lộc	21	2	0	0	0	0	23	796
24	Thuận Thành	22	1	0	2	1	2	28	991
25	Trần Quốc Toản	30	1	0	0	1	0	32	1.131
26	Trường An	17	1	0	0	0	0	18	1.419
27	Vỹ Dạ	27	1	0	0	0	0	28	1.228
28	Vĩnh Ninh	28	1	0	2	0	0	31	1.158
29	Xuân Phú	22	1	0	2	1	1	27	1.105
SECONDARY SCHOOLS		**332**	**51**	**48**	**58**	**20**	**39**	**548**	**18.904**
1	Chu Văn An	30	2	4	0	0	0	36	2.076
2	Duy Tân	12	3	2	2	2	5	26	699
3	Hàm Nghi	18	3	1	2	1	2	27	644
4	Hùng Vương	9	3	4	0	1	1	18	1.170
5	Huỳnh Thúc Kháng	9	3	2	3	0	4	21	576
6	Lê Hồng Phong	22	1	2	6	1	1	33	956
7	Lý Tự Trọng	12	2	2	3	1	0	20	273
8	Nguyễn Bỉnh Khiêm	11	1	2	0	1	1	16	656
9	Nguyễn Cư Trinh	15	1	2	0	1	2	21	651
10	Nguyễn Chí Diễu	22	2	3	3	1	0	31	2.049

11	Nguyễn Du	6	1	2	0	0	0	9	571
12	Nguyễn Hòang	7	2	3	4	1	3	20	641
13	Nguyễn Thị Minh Khai	11	2	2	5	1	4	25	660
14	Nguyễn Văn Linh	16	4	3	4	1	4	32	534
15	Nguyễn Văn Trỗi	15	0	0	0	0	0	15	469
16	Phạm Văn Đồng	28	7	3	3	2	2	45	1.093
17	Phan Sào Nam	20	2	1	4	1	3	31	816
18	Tôn Thất Tùng	16	2	2	5	1	1	27	593
19	Tố Hữu	11	1	2	3	1	1	19	639
20	Thống Nhất	13	3	2	6	1	1	26	1.045
21	Trần Cao Vân	17	4	2	0	1	0	24	1.470
22	Trần Phú	12	2	2	5	1	4	26	623
HIGH SCHOOLS		**82**	**12**	**11**	**14**	**3**	**6**	**128**	**4,209**
1	Cao Thắng	19	4	2	13	1	4	43	1.180
2	Gia Hội	21	4	3	0	1	2	31	1.666
3	Quốc Học	42	4	6	1	1	0	54	1.363
TOTAL 54 SCHOOLS		**914**	**93**	**59**	**110**	**39**	**70**	**1.285**	**45.524**

Appendix 2: List of streets selected for project supported LED light replacement

No	Street name	Length (m)	Road type
1	Lê Duẩn near Sông Hương	1.600	Urban-level street: main pillar street, inter-area street, without median strip
2	Lê Duẩn QL1A GPC	2.100	Urban-level street: main pillar street, with median strip
3	Trần Hưng Đạo A (GPC)	314	Urban-level street: main pillar street, with median strip
4	Trần Hưng Đạo B (EVN lampspost)	462	Urban-level street: main pillar street, with median strip
5	Bạch Đằng	1.758	Area-level street: main street of the area, without median strip
6	Huỳnh Thúc Kháng	1.211	Area-level street: main street of the area, without median strip
7	Đào Duy Anh (steel lamppost)	710	Area-level street: main street of the area, without median strip
8	Đào Duy Anh (EVN lamppost)	610	Area-level street: main street of the area, without median strip
9	Tăng Bạt Hổ	2.732	Area-level street: main street of the area, without median strip
10	Đinh Tiên Hoàng	1.692	Area-level street: main street of the area, without median strip
11	Nguyễn Trãi	2.464	Area-level street: main street of the area, without median strip
12	Nguyễn Văn Linh	2.284	Urban-level street: main pillar street, with median strip
13	Mai Thúc Loan	850	Area-level street: main street of the area, without median strip
14	Yết Kiêu	630	Area-level street: main street of the area, without median strip
15	Thái Phiên	1.500	Area-level street: main street of the area, without median strip
16	Nguyễn Chí Thanh	1.305	Area-level street: main street of the area, without median strip
17	Hùng Vương + An Dương Vương	2.200	Urban-level street: main pillar street, with median strip
18	Trần Phú	1.540	Area-level street: main street of the area, without median strip
	Total	**25.962**	

Appendix 3: UNFCCC CDM Measurement Methodology-AMS-II.L: *Small-scale methodology: Demand side activities for efficient outdoor and street lighting technol*ogies

1) Methodology key elements

Typical project (s)	Adoption of energy efficient lamps and/or fixture combinations to replace less efficient lamps and/or fixture combinations in public- or utility-owned street lighting systems
Type of GHG emissions mitigation action	Energy efficiency: Displacement of less-efficient lighting by more-efficient technology

a) Scope and applicability

-This category comprises activities that lead to efficient use of electricity through the adoption of energy efficient lamps and/or fixture combinations to replace less efficient lamps and/or fixture combinations in public- or utility-owned street lighting systems. Project and baseline lamps and/or fixture combinations are referred to here as luminaires, which encompasses all of the components in an individual assembly of street lighting equipment, including lamp, lens and reflector, fixture housing, wiring, and driver or ballast and individual and centralized controls components/system(s). This methodology covers projects involving multiple luminaires used to illuminate roadways.

-This methodology is applicable for one-for-one replacements of baseline luminaires with project luminaires or for replacing multiple baseline luminaires with multiple project luminaires.[1] This methodology is also applicable to projects that involve the implementation of lighting controls that reduce total operating hours or average wattage of the lighting system as well as for new construction installations;

-This methodology is only applicable if failed project equipment will continuously be replaced based on local maintenance practices, during the crediting period, with equipment of equivalent or better lighting and energy performance specification.

-The luminaires selected to replace existing equipment must be new equipment and not transferred from another project activity.

-Controls covered by this methodology may include simple photocells and/or astronomical time clocks that provide basic streetlight scheduling control. Controls may also include advanced systems that allow for more sophisticated strategies, such as dynamically altering street lighting power (dimming or multiple levels of operation such as bi-level lighting) based on vehicle and/or pedestrian traffic sensors or schedules, time of night, ambient conditions, etc.; a practice known as adaptive lighting.[2]

-This methodology applies to street lighting projects that provide lighting performance quality either: (a) equivalent to or better than the baseline lighting performance; or (b) equivalent to or better than the applicable street lighting standard. If adaptive controls will be used to vary light output for project luminaires, lighting performance must be proven to meet or exceed baseline performance or the applicable standard for all light output settings. The preferred standard would be the local standard if there is one, in the absence of a local standard the national standard if there is one, or the CIE standards, if there is no local or national standard.

b) Definitions

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[1] For example, a project involving replacing a collection of street lighting luminaires with new street lighting luminaires when the number of project luminaries may be more or less numerous than the baseline luminaires, but the project luminaires in total consume less energy than the replaced luminaries.

[2] The International Commission on Illumination (CIE) Roadway Lighting Standard 115:2010, addresses adaptive street lighting and gives guidance on its application for temporal change in parameters such as traffic volume and composition (CIE 115:2010, section 6.2.2) that effectively alter a location's lighting class. Lighting classes are a system of differentiation amongst areas where streetlights are used based on traffic and pedestrian volume and other considerations. The lighting class for a roadway is normally determined by the most onerous conditions, while the use of adaptive lighting recognizes that roadway conditions are not static. Care must be taken however to ensure that appropriate light levels are always present.

The definitions contained in the Glossary of CDM terms shall apply. For the purpose of this methodology, the following definitions apply:

(a) **Annual failure rate** - fraction or per cent of equipment of a given type within a system that fail annually;

(b) **Lighting classes (roadway and intersection)** - system of differentiation between areas where streetlights are used, based on traffic and pedestrian volume and other considerations. In the methodology's use of representative locations, lighting classes are the primary means of differentiation between locations. Applying CIE 115:2010 standards also requires the use of lighting class to determine the applicable lighting criteria;

(c) **Outage factor** - the average time, in hours, elapsed between failure of equipment and replacement of equipment, divided by annual operating hours. This shall be determined by documented maintenance practice and records of maintenance turn-around time from failure to replacement;

(d) **Representative location** - representative locations are defined here as sample locations selected during project design for each roadway and intersection lighting class found within the project boundaries, and including multiple locations within a lighting class if any significant variation in streetlight pole spacing and mounting height, and street dimensions occur. Fields of calculation for average illuminance shall be laid out for each representative location according to the current national standards provided. Representative locations are used only for comparing baseline and measure lighting performance and are not intended to constitute the sampling plan for ex post power and operating hours monitoring;

(e) **System outage factor** - the product of the equipment outage factor and the equipment annual failure rate, as defined here; used to de-rate total annual electricity for baseline and project street lighting systems due to equipment outages within the systems;

(f) **Luminance** - luminance a measure of the intensity of reflected light per unit area of an illuminated surface, in candela (cd)/m^2, is common metric for evaluating street lighting performance. Luminance can be measured in the field or calculated as well and is acceptable metric for compliance with applicable street lighting standards or comparison of baseline and measure technology performance;

(g) **Total useful illuminance** - the average maintained illuminance on the target task plane (i.e. roadway surface), from the baseline and project street lighting equipment. Maintained illuminance takes into account the depreciation in luminous flux over time, and is defined as illuminance delivered when a product has reached the end of its maintenance cycle. Appropriate depreciation factors should be applied to modelled or measured illuminance values, based on the lighting technology used.

2) Calculations of electricity savings

Calculating the electricity savings as a result of the replacement of project supported LED luminaires is key to the estimate of CO2 emission reduction achieved by the project pilot interventions at 18 street lightings (with a total length of 25,962 m) in Hue city.

-Once the project is installed, the electricity saved by the project activity in year *y* is calculated as follows:

$$NES_y = \sum_{i=1}^{n} ES_{i,y} \times \frac{1}{(1 - TD_y)}$$

Equation (5)

Where:

$$ES_{i,y} = \left(Q_{i,BL} \times P_{i,BL} \times O_{i,BL} \times (1 - SOF_{i,BL})\right) - \left(Q_{i,P} \times P_{i,P,y} \times O_{i,y} \times (1 - SOF_{i,y})\right) \quad \text{Equation (6)}$$

$$SOF_{i,BL} = AFR_{i,BL} \times OF_{i,BL} \quad \text{Equation (7)}$$

$$SOF_{i,y} = AFR_{i,y} \times OF_{i,y} \quad \text{Equation (8)}$$

Where:

NES_y	=	Net electricity saved in year *y* (kWh)
$ES_{i,y}$	=	Estimated annual electricity savings for equipment of type *i*, for the relevant type of project equipment in year *y* (kWh)
y	=	Crediting year counter
i	=	Counter for luminaire type
n	=	Number of luminaires
TD_y	=	Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the luminaires are installed, expressed as a fraction. This value shall not include non-technical losses such as commercial losses (e.g. theft/pilferage). The average annual technical grid losses shall be determined using recent, accurate and reliable data available for the host country. This value can be determined from recent data published either by a national utility or an official governmental body. Reliability of the data used (e.g. appropriateness, accuracy/uncertainty, especially exclusion of non-technical grid losses) shall be established and documented by the project participant. A default value of 10 per cent shall be used for average annual technical grid losses, if no recent data are available or the data cannot be regarded accurate and reliable
Q_i ($Q_{i,BL}$ and $Q_{i,Py}$)	=	Quantity of baseline (*BL*) or project (*P*) luminaires of type *i* distributed and installed under the project activity (units). Once all of the project luminaires are distributed or installed, $Q_{i,P}$ is normally a constant value independent from *y* unless size of operating luminaire inventory decreases during crediting period, in which case only operating project luminaires shall be credited. Note that $Q_{i\,BL}$ and $Q_{i\,P}$ may represent a different number of luminaries (e.g. a larger number of LEDs with less output), but they must represent the same illuminated area
$P_{i,BL}$	=	Rated power of the baseline luminaires of the group of *i* lighting devices (kW), or time-integrated average power if equipment operates at various power settings, constant value independent from *y*. For retrofit projects, project proponents shall maintain records to demonstrate what type of luminaire are replaced

$P_{i,P,y}$	=	Rated power of the project luminaires of the group of *i* lighting devices (kW), or time-integrated average power if equipment operates at various power settings, normally constant value independent from *y* unless operating schedule or parameters changes during crediting period. Time-integrated average power takes into account controls savings such as dimming or bi-level operation that reduce lighting power for periods of time. For example, if on average, project equipment operates at full power 50 per cent of annual operating hours, and half power 50 per cent of annual operating hours, $P_{i,\,P}$ will be de-rated from full value to 75 per cent of full value {(1 x 50%)+(0.5 x 50%)}
O_i ($O_{i,BL}$ and $O_{i,y}$)	=	Annual operating hours for the baseline and project luminaires in year *y*. May differ from *BL* to *P*. This value is based on continuous measurement of daily average usage hours of luminaires for a minimum of 90 days at monitoring survey sample locations (sampling determined by minimum 90 per cent confidence interval and 10 per cent maximum error margin) corrected for seasonal variation of lighting hours and multiplied by 365 days. The method used to extrapolate the 90 days of data to annual values must be documented. For projects involving the following control strategies, the monitoring for determination of annual operating hours shall be continuous for 365 days per year: (i) Luminaires controlled by motion sensors; (ii) Luminaires controlled by advanced controls that allow scheduling options other than light sensing or time clock. The measurements shall be repeated at the monitoring survey sample locations at the time of ex post monitoring. In no case can a value greater than the daily average annual number of hours between sunset and sunrise hours, per 24 hour period, be used under this methodology to calculate annual operating hours
SOF_i ($SOF_{i,BL}$ and $SOF_{i,y}$)	=	System Outage Factor (*SOF*) for equipment type *i* in year *y*. *SOF* is calculated as the product of the equipment Outage Factor and the equipment Annual Failure Rate. The value for *BL* is assumed to be the same as monitored for *P* and may vary from year to year
OF_i ($OF_{i,BL}$ and $OF_{i,y}$)	=	Outage Factor is the average time, in hours, elapsed between failure of luminaires type *i* and their replacement, divided by $O_{i,y}$, annual operating hours. This shall be determined by documented maintenance practice and records of maintenance turn-around time from failure to replacement. The outage factor value during the baseline (*BL*) is assumed to be the same as determined for each year of the crediting period (*y*) and may vary from year to year
AFR_i ($AFR_{i,BL}$ and $AFR_{i,y}$)	=	Annual Failure Rate of luminaires calculated as a fraction of *Q*. The value for failure rate during the baseline (*BL*) is assumed to be the same as determined for each year of the crediting period *y* and may vary from year to year. Failure rates during the crediting period should be determined ex post from maintenance records that indicate the actual fraction of system-wide equipment of type *i* that fail annually. For ex ante calculations, failure rate in year *y* could be assumed to equal to $O_{i,y}$ divided by the rated average life for project equipment type *i*

3) Calculations of CO2 emission reductions

-Emissions reduction is the net electricity savings (*NES*) times an emission factor (*EF*).

$$ER_y = NES_y \times EF_{CO2,ELEC,y} \qquad \text{Equation (9)}$$

Where:

$EF_{CO2,ELEC,y}$	=	Emission factor in year *y* (t CO_2/MWh)
ER_y	=	Emission reductions in year *y* (t CO_2e)

-The electricity savings from the project equipment installed by the project activity shall be considered from the date of completion of installation of all the project equipment.

4) Methodologies for Baseline and Monitoring Data Collection

a) Baseline Methodology

-Ex ante calculations are done to estimate the nameplate/rated power (Watts) of the baseline and project luminaires, or the time-integrated average power if adaptive street lighting controls will decrease lighting power at periods of lower demand; nightly, weekly, seasonally or otherwise. If patterns of variation in parameters such as traffic volume are well known, such as from records of traffic counts, such records shall be used to estimate time-integrated average power based on controls settings;

-Daily hours of operation of luminaires is assumed to be equal for baseline and project luminaires;

-Calculate the gross electricity savings by comparing the total average power of the project luminaires multiplied by project annual hours of operation, with the average power of the baseline luminaires multiplied by baseline annual hours of operation (daily hours times 365 or other number equal to the number of days per year that the lights are expected to be operated);

-Calculate the net electricity saving (NES) by correcting the gross electricity savings for any leakage and transmission & distribution losses.

b) Monitoring Methodology

(a) Ex post monitoring and adjustment of net electricity savings:

1) First ex post monitoring survey, carried out within the first year after installation of all project luminaires shall provide a value for:

2) Outage factor (OF_i);

3) Annual failure rate (AFR_i);

4) Average annual operating hours (O_i);

5) Average project equipment power (P_i);

6) Number of project luminaires placed in service and operating under the project activity ($Q_{P,i}$). While project luminaires replaced as part of a regular maintenance or warranty program can be counted as operating, project luminaires cannot be replaced as part of the CDM monitoring survey process and counted as operating;

(b) Subsequent ex post monitoring surveys are carried out at least every other year after the first year of the crediting period (for example years 3, 5, 7, 9 and onward for projects that have selected renewal of crediting period in years 11, 13, 15, 17, 19 and 21) to determine ex post OF_i, AFR_i, O_i, and $P_{i,P}$ for use in ex post emission reduction calculations until such time as CERs are no longer being requested;

(c) For each ex post monitoring survey, the project monitoring plan shall include continuous monitoring of equipment run-time for at least 90 continuous days to determine average daily operating hours for extrapolation to annual operating hours (O_i). For projects involving the following control strategies the monitoring must for determination of annual operating hours (O_i) and average project equipment power ($P_{i, P}$) shall be continuous for 365 days per year:

1) Luminaires controlled by motion sensors;

2) Luminaires controlled by advanced controls that allow scheduling options other than light sensing or time clock;

(d) For monitoring survey, individual project luminaires or groups of project luminaires if applicable (i.e. a continuous string of project luminaires on a dedicated electric circuit that can be monitored) shall constitute the population constituents when determining sample size and distribution;

e) If multiple systems of scheduling and/or controls are installed within the project boundaries, the luminaires under each system of schedules and/or controls shall represent unique population sets for sample sizing and sample location selection;

f) For measurement of average annual operating hours (O_i), a simple recorder of on/off time or direct monitoring over time of power or even light intensity may be used.

-Monitoring includes recording of luminaire distribution data and ex post monitoring surveys as defined in the above paragraphs. During project activity implementation, the following data are to be recorded:

1) Number of project luminaries distributed and installed under the project activity, identified by the type of luminaires, operating schedule and adaptive controls strategy, if any, and the date of installation;

2) The number, power, and operating schedules of the replaced devices;

Appendix 4: UNFCCC CDM Measurement Methodology AMS-II.N: *Small-scale methodology: Demand side energy efficiency activities for installation of energy efficient lighting and/or controls in buildings*

1) Methodology key elements

Typical project (s)	Retrofits of existing electric lighting fixtures, lamps, and/or ballasts with more energy-efficient fixtures, lamps, and/or ballasts; Installation of lighting controls
Type of GHG emissions mitigation action	Energy efficiency: Displacement of more GHG-intensive service

a) Scope and applicability

-This methodology comprises activities in buildings for:

(a) Retrofits of existing electric lighting fixtures, lamps, and/or ballasts with more energy-efficient fixtures, lamps, and/or ballasts;

(b) Permanent de-lamping of electric lighting fixtures with or without the use of reflectors;

(c) Installation of lighting controls, such as occupancy sensors or timers (with or without delamping or changes to fixtures, lamps, or ballasts) in order to reduce electric lighting lamp operating hours.

-Only retrofit projects involving direct installation (or delamping) of equipment are eligible. Projects only involving the sale or distribution of efficient lighting systems and/or controls are not included under this methodology.

-New construction (Greenfield) projects are not included under this methodology.

-Projects involving variable dimming of lighting equipment (i.e. reduction in fixture/lamp wattage), for example, in response to daylighting controls, bi-level fixtures or adaptive dimming controls, are included under this methodology.

-This methodology is applicable to non-residential and multi-family residential buildings supplied with grid electricity.

-Project equipment shall have the following warranties: 1) LED lamps – three years, $L_{70} \geq 25{,}000$ hours; 2) LED fixtures – five years, $L_{70} \geq 36{,}000$ hours.

2) Definitions

The definitions contained in the Glossary of CDM terms shall apply. For the purpose of this methodology, the following definitions apply:

(a) **Last Point of Control (LPC)** - the last point of control is defined as the portion of an electrical circuit that serves a set of equipment that is controlled on a single switch;

(b) **Usage Group** - a usage group is a subset of the whole population of affected equipment at the project site.

3) Calculations of electricity savings

-Equation (1) is used when baseline and project fixture counts and wattages are surveyed and operating hours are monitored.

$$ES_y = \sum_{u,i}\left(\frac{1}{1{,}000{,}000}\right) \times [(W/fixture_{b,u,i} \times N_{b,u,i} \times Hours_{b,u,i}) - (W/fixture_{p,u,i} \times N_{p,u,i,y} \times Hours_{p,u,i,y})] \quad \text{Equation (1)}$$

Equation (2) is used when baseline and project lighting circuits are monitored.

$$ES_y = \sum_j [(\frac{1}{1,000}) \times [(Average\ kWh_{b,j})_{baseline} - (Average\ kWh_{p,j,y})_{project}]$$ Equation (2)

Where:

ES_y	=	Lighting energy savings associated with project in year *y* (MWh)
$W/fixture_{b,u,i}$	=	Baseline lighting demand per fixture of type *i* in usage group *u*, Watts
$W/fixture_{p,u,i}$	=	Project lighting demand per fixture of type *i* in usage group *u*, Watts (for projects that involve only lighting controls, this value may be same for project and baseline)
$N_{b,u,i}$	=	Quantity of baseline affected fixtures, adjusted for inoperative lighting fixtures, of type *i* in usage group *u*
$N_{p,u,i,y}$	=	Quantity of project affected fixtures of type *i* in usage group *u* (for controls and efficiency projects, this value may be same for project and baseline) in operation in year *y*
$Hours_{b,u,i}$	=	Baseline annual operating hours for operative lighting fixtures, of type *i* in usage group *u*, hours and adjusted to represent an annual value. For efficiency only projects (no controls), this value equals $Hours_{p,u,i,y}$
$Hours_{p,u,i,y}$	=	Project annual operating hours for operative lighting fixtures, of type *i* in usage group *u*, hours in year *y* adjusted to represent an annual value
u	=	Building usage groups with similar operating hour characteristics, for example private offices, conference rooms, hallways, and storage areas. Building usage areas will be identified for areas with comparable average operating hours, as determined by the lights operating during the year or by each of the electric utility's costing periods. Usage areas must be defined in a way that groups together areas that have similar occupancies and lighting operating-hour schedules
i	=	Unique fixture/lamp/ballast combinations
$Average\ kWh_{b,j}$	=	Lighting baseline energy use based on lighting circuit time period measurements, adjusted to represent an annual value, for lighting circuit *j*
$Average\ kWh_{p,j,y}$	=	Lighting project energy use based on lighting circuit time period measurements, adjusted to represent an annual value in year *y,* for lighting circuit *j*
j	=	All or all representative lighting circuits in project building(s)

4) Calculations of CO2 emission reduction

-Emissions reduction is the electricity savings (*ES*) times an *EF*.

$$ER_y = ES_y \times EF_{CO2,ELEC,y}$$ Equation (3)

Where:

$EF_{CO2,ELEC,y}$ = Emission factor in year *y* (t CO_2/MWh)

ER_y = Emission reductions in year y (t CO_2e)

5) Methodologies for Baseline and Monitoring Data Collection

a) Baseline Methodology

-Emission reductions are calculated as the net energy savings associated with:

1) Reduction in the amount of electricity required for lighting, multiplied by an emission factor for the electricity displaced;

2) Reduction, or increase, in the amount of fossil fuel and/or electricity required for building heating and/or cooling caused by interactive effects, multiplied by appropriate emission factors.

-With respect to determining reduction in the amount of electricity required for lighting:

3) Baseline surveys are required to document the spaces (e.g. rooms) in each project building where project activities will occur; the appropriate usage area designation (e.g. private offices, common offices, and hallways) for each of these spaces in the project building; the identification of and number of baseline fixture, lamp, ballast types and ballast factors in each space including counts of operating and non-operating fixtures; lighting control type in each space; and whether the spaces are air-conditioned and/or heated. Baseline surveys of energy usage may also be documented by sampling the energy consumption of randomly selected, representative lighting circuits;

4) Project surveys are required at the time of project installation and per the monitoring requirements of this methodology to document, in each project building, the identification of and number of project fixture, lamp, ballast types and ballast factors in each building space including counts of operating and non-operating fixtures; lighting control type in each space; and to confirm whether the spaces are air-conditioned and/or heated. Project surveys of energy usage may also be documented by sampling the energy consumption of randomly selected, representative lighting circuits;

5) Documentation including values for the parameters indicated in Table 8 shall be provided in an organized table format;

6) The surveys shall identify any non-operating fixtures. Non-operating fixtures are those that are typically operating, but that have broken lamps, ballasts, and/or switches that are intended for repair. A de-lamped fixture is not a non-operating fixture; thus, de-lamped fixtures should have their own unique designations in the baseline and project surveys;

7) Fixtures that have been disabled or de-lamped or that are broken and not intended for repair should not be included in the calculation of baseline energy consumption. They should, however, be noted in the lighting survey to avoid confusion;

8) For non-operating fixtures, the baseline electricity consumption may be adjusted by using values for equivalent operating fixtures. The adjustment for non-operating fixtures will be limited to no more than (10 per cent~~)~~ of the total number of lighting fixtures in a building. If more than 10 per cent of the total number of fixtures is non-operating, the number of fixtures beyond 10 per cent will be assumed to have baseline fixture wattage of zero;

9) All project fixtures, however, that are non-operating shall be considered to be operating for the purposes of calculating project energy use;

10) Lighting level measurements or specification sheets are required for all projects. Lighting levels are measured once for a statistically valid, representative sample of spaces with the baseline lighting systems and once for a statistically valid, representative sample of the same spaces with the project lighting systems. These measurements shall be taken during non-daylight hours;

11) Operating hours for lighting fixtures, for each Last Point of Control, are determined through measurements with run-time data loggers that indicate the number of hours that a light fixture is on (with a light sensor that records status of lights – on or off - in at least five minute increments). The number of hours the lighting fixtures are on will be recorded over a specific period of time and

converted into annual hours. The specific period of time for recording operating hours must be at least four weeks, for each year when recording is required, during representative time periods of the year.

12) Annual hours shall be determined from the recorded data with consideration of the following factors:
(a) Seasonal variation in operations;
(b) Seasonal variations if lighting controls are used near windows;
(c) Number of days the building is closed, such as on holidays or special events;
(d) Non-lighting loads;
(e) Anomalies that may have occurred due to broken equipment or unusual occurrences during monitoring period.

13) For projects not involving lighting controls, the operating hours of the fixtures are assumed to be the same for the baseline and project scenarios and are based on values determined after project installation. Operating hours are measured for a statistically valid, representative sample of project fixtures after project installation and throughout the crediting period either at regular intervals or continuously;

14) For projects involving lighting controls the operating hours of the fixtures are not assumed to be the same for the baseline and project scenarios. Baseline operating hours are measured for a statistically valid, representative sample of baseline fixtures during representative periods prior to the project installation. Project operating hours are also measured for a statistically valid, representative sample of project fixtures during representative periods after project installation and throughout the crediting period either at regular intervals or continuously;

15) In all cases the monitoring time period(s) must be representative of annual conditions and account for seasonal variations in occupancy (such as in schools which are not in session during summer months or vacation periods);

16) Baseline and project fixture wattages will be determined using one of the following methods:
(i) Measurements of fixture wattage for a representative sample of fixtures in each project building;
(ii) Measurement of all or a representative sample of lighting circuits (non-lighting loads should be excluded when lighting circuits are measured) in each project building (in which case energy use will be determined as a combined value for fixture wattages and fixture operating hours); or
(iii) Provision of manufacturer documentation on wattages for the exact baseline and project fixture/ballast and ballast factor/lamp combinations.

b) Monitoring Methodology

1) In any given year, emission reductions can only be claimed for project lighting equipment and/or control systems that are demonstrated to be in place and operational on an annual or biennial (every other year) basis during the crediting period. Compliance with this requirement shall be implemented via an annual or biennial inspection of a sample of the equipment and systems that were installed during the installation period. When biennial inspection is chosen, following the inspection during the year of project installation, the inspections can be done in years 3, 5, 7, 9 and onward for projects that have selected renewal of crediting period in years 11, 13, 15, 17, 19 and 21 and the results of such inspections can be applied to crediting years 3 and 4, 5 and 6, 7 and 8, and 9 and 10; and onward for projects that have selected renewal of crediting period 11 and 12, 13 and 14, 15 and 16 17 and 18, 19 and 20 and 21 years respectively (under this inspection scenario, the initial inspection results are valid for years 1 and 2). A statistically valid sample of the project fixtures and lamps (and as applicable, lighting control equipment and systems) in the building(s) where the project equipment and systems are installed can be used to determine the percentage of systems operating. Such percentage will be used to determine $N_{p,u,i,y}$ for each type of fixture in each usage group. That is $N_{p,u,i,y}$ equals the number of project fixtures, of each type and in each

usage group, documented to have been installed in the year of project implementation multiplied by the percentage of project fixtures found to be installed and operating in year *y*;

2) Sample selection shall take into consideration occupancy type and schedules and space usage type differences, as per the relevant requirement for sampling in the latest version of the standard for “Sampling and surveys for CDM project activities and programme of activities”;

3) When biennial inspection is chosen at least a 95 per cent confidence interval and 10 per cent margin of error shall be achieved for the sampling parameter. When annual inspections are used, at least a 90 per cent confidence interval and 10 per cent margin of error shall be achieved for the sampling parameter;

4) While project equipment or systems replaced as part of a regular maintenance or warranty program can be counted as operating, project equipment or systems cannot be replaced as part of the survey process and counted as operating;

5) In addition, the annual or biennial inspections shall:

    a. Confirm the operation and estimated efficiency of building heating and/or cooling systems;

    b. Be used to determine and update the values for project fixture operating hours ($Hours_{p,u,i,y}$) or circuit energy consumption ($AveragekWh_{p,j,y}$).

6) Project fixture wattages do not need to be re-evaluated after their initial determination at time of project implementation;

7) The following parameters shall be documented at time of project implementation:

    a. Number, type and wattage of project fixtures/lamps/ballasts/ballast factors and/or control systems installed under the project activity, identified by the manufacturer and model numbers and the date of supply for each space, and thus usage group, in the project building(s);

    b. The number and specifications of replaced fixtures/lamps/ballasts;

    c. Data to unambiguously identify the location of the equipment distributed under the project activity;

    d. Specification of which spaces in the project building(s) are heated and/or cooled with systems that consume electricity and/or fossil fuel and the characteristics, specifically the estimated annual efficiencies, of such systems taking into consideration related auxiliary equipment.

8) The following table indicates the surveys that are or may be required in accordance with this methodology for which a sample may be used versus a census;

9) As a result, all of the fixtures or pieces of equipment on that LPC are typically operated the same number of hours per year. For metering purposes, it is assumed that measurements taken of a single light fixture or piece of equipment on an LPC captures the operating hours for all of the equipment served on the same circuit;

10) In the equations for determining sample sizes, the total number of LPCs in the project or building is denoted as the population for determining operating hours of fixtures. An example of an LPC would be a set of lighting fixtures in a room that operates on a single switch. If there were two separate switches controlling different groups of fixtures in the room, each one would constitute an LPC for the metering purposes.

Parameters determined by sampling and survey

Parameter to be determined	Survey Subject	When Completed	Notes
Operating hours	Last Point of Control for fixtures, see below for definition	(a) Baseline; (b) When project installation is completed; (c) Repeated per paragraph 1	Sampling uses stratified random sampling, with usage groups defined as the stratum, see below for definition of usage groups
Lighting levels	Spaces where lighting retrofits are to occur or have occurred	One time each for baseline and project	Sampling uses stratified random sampling, with usage groups defined as the stratum
Number of operating fixtures	Lighting fixtures	(a) When project installation is completed; (b) Repeated per paragraph 1	Sampling uses stratified random sampling, with usage groups defined as the stratum
Lighting energy use (MWh)	Lighting circuits	(a) Baseline; (b) When project installation is completed; (c) Repeated per paragraph 1	Sampling is based on a statistically valid, representative set of lighting circuits in each building (for example 3 randomly selected floors in a 10 story office building), plus a lobby floor. Note: that either operating hours of fixtures or lighting circuit energy use will be measured, but not both

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Appendix 6: Project MRV implementation plan

Implementation Plan For Project Measurement, Reporting and Verification (MRV)

No	MRV Activities	MRV Implementation Timeline																										
	Year	2019									2020												2021					
	Month	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
I	**Preparations**																											
1	Develop & finalize the project MRV Framework																											
2	Pilot measurements of actual consumed powers and illuminance of lighting systems at 05 sampled schools																											
3	Design necessary tools and baseline methodology for the MRV system (guidelines, tools and databases)																											
4	Develop & finalize the technical manual for MRV implementation																											
II	**Baseline Survey and Measurements**																											
1	Recruit and contract an external qualified consultant for baseline survey and measurements																											
2	Collect baseline data for measurement parameters from HEPCO lighting monitoring and control system for target street lightings																											
3	Conduct the baseline survey & measurements at target schools																											
4	Make measurements of baseline average illuminance at target street lightings																											
5	Aggregate and analyze baseline survey data and measurement data for target schools and streets																											
6	Make calculations to estimate baseline values of measurement parameters for target school and street lightings																											
III	**Project Monitoring (after the installation of LED lights is completed)**																											
1	Make monitoring measurements of project LED lighting systems at target schools and streets																											
2	Organize trainings on monitoring data tools and work plan for designated teachers/staff of target schools																											

3	Collect monitoring data for measurement parameters at target schools
4	Collect monitoring data for measurement parameters from HEPCO lighting monitoring and control system for target street lightings
5	Aggregate and analyze monitoring data and measurements for target schools and streets
6	Make calculations to estimate monitoring values of measurement parameters for target school and street LED lightings
IV	**Reporting, Verification, Approval and Registration**
1	Make calculations to estimate the achieved amount of electricity savings, CO2 emission reductions and electricity cost savings
2	Make reports on project MRV results
3	Carry out internal verification and make endorsement of project MRV results by the MRV Technical Supervision Unit (PTF) and MRV Management Unit (PMB &TAO)
4	Organize an external verification of project MRV results by an independent consultant verifier
5	Review and approve project MRV results by MRV Authorization Agency (TT-Hue provincial P.C)
6	Complete required procedures to make registration of annual project MRV results with MONRE for inclusion in VN NDC reports
V	**Handover of the MRV system at the end of project**
1	Develop and finalize the implementation plan for MRV after the project phase-out
2	Organize a training course on establishment and operation of project-level MRV system for staff/officials of concerned provincial agencies
3	Complete the handover procedures and regulations with the agency/entity designated to take over the project MRV system
4	Support the implementation of the project MRV system handover plan