CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Activity 5 Report

"CTCN Technical Assistance: Energy Efficient Street Lighting Technologies and Financing Models in Thailand"

Roadmap and Recommendation

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Roadmap and Recommendations

The Provincial Electricity Authority (PEA) started the implementation of energy efficiency public and street lighting projects in 2004. PEA has since 2004 implemented projects under its investments for equipment purchases, however large scale implementation was not found feasible.

The Energy Service Company (ESCO) approach was therefore used to implement an EE street lighting project. Under this approach, PEA has entered into agreements with local ESCOs which provided initial investments and installation of the equipment including operation and maintenance (O&M) throughout the contract. ESCOs will then gradually recover the investment cost from the repayments made by PEA through the energy-saving gained as agreed in the contract.

PEA has successfully implemented many energy efficiency street lighting projects using the above mentioned ESCO approach since 2007. Several public and private ESCOs have been contracted by PEA, including Kasetsart University (KU), King Mongkut's University of Technology Thonburi (KMUTT), Burapa University, Philips Lighting, and L&E. Implementation of these EE street lighting projects involved replacing conventional street lights in the selected cities with dimmers, energy-efficient reflectors and LED street lights.

In the Technical assistance, a survey of 50 municipalities was conducted and detailed techno-economic studies of energy-efficient street lighting projects in 3 municipalities were carried out. This was done to evaluate the technical awareness of Thai municipalities about the energy-efficient street lighting; to gather information regarding any issues of the operation and maintenance (O&M) requirements of the efficient technologies; and to collect information on how measurement and verification (M&V) have been conducted in the energy-efficient street lighting projects.

In the detailed survey carried out in **Activity 1**, municipalities were asked whether specific budget and time for allocated for implementation of EE street lighting and rate several key barriers to implementing EE street lighting. 30% of respondents indicate that their municipalities have specifically allocated budget and manpower for implementing EE street lighting projects.

The **findings of the survey show that most municipalities are still facing several key obstacles and challenges in implementing EE street lighting projects** such as High-cost of EE street lighting technologies, Budget, Contractor's after-sales service, Confidence in EE street lighting technologies and Knowledge & insufficient skilled staff for M&V.

The municipalities were also asked to rate types of assistance that would be most useful to them in adopting EE technologies. Error! Reference source not found.

indicates that municipalities will benefit from the provision of training of O&M personnel and technical knowledge e.g. techno-economic assessment and procurement. Financial assistance was rated as the third most important factor.

The review of national regulations and guidelines, energy performance standards, standards of road design, illumination requirements of different categories of roads, standard and labeling requirements of lamps, lighting fixtures, accessory and control gears, installation standards and operations and maintenance (O&M) guidelines for the street lighting including relevant laws at the municipal level were carried out in the **Activity 2** of the technical assistance Although PEA has shouldered electricity expenses for street and outdoor lighting in Thailand, its involvements in developing and implementing relevant national energy efficiency standards for street and outdoor lighting have been very limited. In general, installation and maintenance of street and outdoor lighting in PEA's service areas lie with the three following organizations:

- Department of Local Administration (DLA);
- Department of Highways (DOH);
- Department of Rural Roads (DORR).

DLA is under the Ministry of Interior and governs all municipalities in the country, while DOH and DORR are under the Ministry of Transport. These government agencies do not harmonize relevant standards for street and outdoor lighting, and each agency has its own classifications of roads and specify slightly different lighting quality requirements (illumination and uniformity) for each road classification. High-Intensity Discharge (HID) technologies, such as High-Pressure Sodium (HPS) lamps, Mercury Vapor (MV) lamps, and linear fluorescent lamps (FL) are the common lighting technologies in PEA's service areas, and these conventional lighting technologies are included in the guidelines and regulations issued by DLA, DOH and DORR.

HID and FL lighting technologies commonly used in PEA's service areas need reflectors attached behind the lamps in the luminaires to direct light to where it is needed, and much of the light is lost – at least 20% to 30% for new luminaires[1], and the loss figures are higher for old luminaires. These types of luminaires also produce light pollution in the surrounding area, which leads to inconvenient glare for drivers and pedestrians and may cause roadway hazards. FL luminaires have similar characteristics as of the HID luminaires but fluorescent lamps have poorer efficacy than HPS lamps. It should be noted that over the past few years, Thai municipalities

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[1] Based on technical specifications of HPS luminaires supplied by lighting manufacturers, including but not limited to Philips Lighting Thailand, and Lighting and Equipment Public Company Limited (Thailand).

have become familiar with Light-Emitting Diode (LED) technologies, and small-scale installations of LED luminaires and LED tubes have been haphazardly carried out by Thai municipalities. However, the overall penetration of LED technologies in the street and outdoor lighting sector in Thailand is still limited.

Report of **Activity 3** of technical assistance summarizes findings from a techno-economic assessment of retrofitting conventional street and outdoor lighting technologies in PEA's service areas with applicable energy-efficient street lighting technology design options. The report also provides recommendations on suitable energy-efficient technologies for Thai municipalities to minimize operations and maintenance costs of the street and outdoor lighting for Lampang, Nakornsawan, and Pathumthani municipality are detailed in the report.

Outcomes of techno-economic study of energy-efficient technologies

- The pilot demonstrations of **LED technologies for street and outdoor lighting by PEA since 2011 have proven their technical viability**.
- **Retrofitting or replacing existing HID/FL luminaires with LED luminaires in PEA's service areas is considered to be cost-effective in meeting the illumination requirements specified by DLA and DOH.** The average simple payback periods range from about 3 years to slightly over 6 years, depending on the tariff rate applied. It is envisioned that the payback periods for large-scale LED investment in PEA's service areas will be shorter due to lower unit costs from bulk purchasing.
- **Large-scale implementations (installations of more than 10,000 luminaires annually) have also been successfully undertaken internationally**. These implementation experiences have also confirmed that the cost of LED street lighting has been decreasing rapidly, and **applying a bulk procurement approach could further reduce the unit cost of LED luminaires with extended warranties (5-7 years).**
- **Thai municipalities that partially adopted LED lighting technologies have AECI lower than 3 kWh/m2.** However, replacing fluorescent tube lamps and MV lamps with LED tubes and **LED luminaires can further reduce AECI to be lower than 2 kWh/m2**. The investment per light point ranges between US$20 – 50 depending on the existing lighting technologies with an average payback period of less than 2.5 years depending on the combination of LED technologies and wattages. Based on findings from various pilot demonstration projects, the useful lifetime of LED technologies for street and outdoor lighting in Thailand can be up to 7 years.
- **The study finds that PEA has a very high metering rate for street and outdoor lighting**. Savings from LED street lighting can be monitored through the electricity bills and can be strength that PEA can build its financial mechanisms. The report also recommends the approved CDM methodology

AMS.II-L (Demand-side activities for efficient outdoor and street lighting technologies), as it provides guidelines for measuring and calculating energy consumptions for both metered and non-metered light points, emission reduction, and lighting quality.

Challenges for implementation of energy-efficient street lighting technologies

There are also multiple challenges in the implementation of Energy Efficiency Projects in Thailand. Major challenges faced in policy, institutional mechanisms, technical capacity, and financing of the energy-efficient street lighting projects are described below these have been detailed in activity 4 report

- **Policy Challenge:** Municipal street lighting EE projects face several challenges, such as inflexible procurement systems and the lack of policy support. In the absence of relevant policies and incentives for the implementation of energy conservation measures, municipalities are hesitant to face the technical and financial burdens of efficiency improvements. Government procurement procedures tend to favor lowest-cost technology replacements and investments that achieve rapid service improvements but often result in inefficient structures and equipment systems.

  The study of regulation, standards, and guidelines for public and street lighting design in Thailand found that the existing legal documents (such as acts and ministerial regulations) related to public and street lighting in Thailand stipulates only duties and responsibilities of the abovementioned organizations and authorities related to the provision of the roadway and public lighting as public services. There are neither rules/regulations nor national standards for public and street lighting design and O&M.

  Concerning energy efficiency requirements for public and street lighting, the Department of Alternative Energy Development and Efficiency (DEDE) has authority to regulate and set the policy measure on energy efficiency, however, no legal measures related to saving energy from the use of energy-efficient street lights have been developed or adopted by DEDE.

- **Institutional Challenges:** one of the greatest barriers to street lighting energy-saving initiatives in Thailand is the lack of adequate technical and managerial capacity within municipal bodies to upgrade the street lighting design and implement efficiency measures. Without proper policy support institutional capacity slowly becomes outdated resulting in missed opportunities of savings at a national scale.

  The key barriers hampering the future scaling-up of LED retrofits for street and outdoor lighting in PEA's service areas include: a lack of proper financial

mechanisms; and limited capacity at the local government level to handle large scale projects.

- **Technical Challenge:** While designing or making changes to street lighting, it is important to first understand the lighting requirements of the roads. The most common reasons for inefficient street lighting systems in municipalities include:

    a) Inadequate understanding and analysis of required service levels;
    b) Need for a more rigorous approach to selecting appropriate luminaires;
    c) Poor lighting system design and installation;
    d) Poor or inconsistent power quality; and
    e) Poor operation and maintenance.
    f) Variability if the useful life of LED luminaires in piolet projects.

    Many projects in the past have not been able to deliver the expected outputs and benefits and have resulted in disputes over the quantification of savings primarily due to issues related to baseline establishment. Some demonstration sites have successfully demonstrated LED luminaire useful lifetime of more than 30,000 hours (around 7 years), while some demonstration sites indicated a useful lamp life of only around 10,000 hours.

- **Financial Challenge:** Given the constraints on municipal budgets, financing for municipal projects must often come from other sources. These are often constrained by the conditions imposed by the grantors, lenders, or co-investors for contributing their resources to municipal projects, especially if they are based on performance contracts. Grantors need assurance that the money they provide to municipal projects will be used for its intended purpose. Lenders and co-investors need a guarantee of repayment and receiving their agreed-upon share of a project's payback. Local financial institutions and banks lack the technical knowledge to evaluate energy efficiency projects, based on their energy and cost-saving potential, especially where it is cash-flow based financing, rather than the traditional assets or collateral-based financing. Lack of access to financing for such projects is often perceived to be a key barrier to their implementation. Access to financing also depends on the creditworthiness of the borrower, the cash flow to be generated by a project, and available mechanisms for credit enhancement (such as collateral and loan guarantees). Recent successes of green municipal bonds in some countries offer renewed hope that innovative financing instruments can be used to generate better financial packages to implement energy-efficient street lighting projects. In the case of Thailand since we have two separate entities 1. The owner of the street lighting system i.e. urban local body and 2. PEA who shoulders the cost of electricity, the complexity of the financial model will vary from the market practice.

Financial model

Even though the upgrade of street lighting offers high energy savings, its upgrade rate is low in many municipalities in Thailand. High up-front investment costs are among the highest barriers for municipalities to upgrade street lighting along with Policy, institutional and technical challenges highlighted in the earlier section of the report hinder the scaling up of the implementation of energy-efficient street lighting. There are various financial models discussed in Activity 4 of the technical assistance with details of benefits challenges and implementation mechanisms that can enable the projects of infrastructure energy efficiency projects. Specific limitations of the lack of adequate technical knowledge for implementation poses as risks to PEA as well as the Municipalities. In such a scenario implementation of energy efficiency projects through the **Energy performance contracts (EPC**s) enable funding of energy efficiency upgrades from cost reductions. Under an EPC arrangement, an external organization, typically called an **Energy Service Company (ESCO)** implements an energy efficiency project and uses the stream of income from the cost savings to repay the project costs. The ESCO only receives full payment if the project delivers predicted energy savings; **this transfers project technical risks from the client to the service provider**. Such an approach has been followed in may pilot projects and it has proved to be successful.

The funding for such contracts can be sourced through many mechanisms like Public-Private Partnership, Green credit line, Green Bonds, revolving loan fund, crowdfunding, leasing, and municipal financing. There are many Energy service companies which also provide funding for implementation of energy-saving contract under **Deemed saving contracts**. Such **contracts also transfer the financial management risks from client to service provider**. Guaranteed-savings EPC models can be supported by standardized contracts, independent validation entities, additional insurances to cover the customer in case of non-compliance by the ESCO, credit guarantees to support the client to assume the investment repayment risk and by positive lists.

Way forward

The following ways forward for the implementation of energy-efficient street lighting are recommended for the consideration by PEA and municipalities:

- **PEA needs to collaborate with municipalities** to initiate discussion with the national government (e.g., Ministry of Energy and Ministry of Finance) in creating an enabling environment **for implementation of energy-efficient street and outdoor lighting** in Thai municipalities which will significantly reduce electricity subsidies currently shouldered by PEA.
- Retrofitting fluorescent tube lamps with LED tubes is recommended as the priority measure for energy-efficient street and outdoor lighting in Thai municipalities. **A phase-step multi-year implementation plan for energy-**

efficient street and outdoor lighting should be developed with a listing of priority municipalities for each phase.

- In the first phase, **PEA needs to collaborate with the priority municipalities to verify street and outdoor lighting inventories**, lengths, areas, and classifications of roadways covered by street and outdoor lighting, annual electricity consumption, and lighting quality.
- **Energy efficiency street lighting projects to be implemented through the Deemed Saving model of ESCOs. Energy Savings are delivered by the Energy Service Company generates the finances from the market and implements the energy efficiency street lighting project.** An energy performance contract for deemed savings is signed between the stakeholders.
- the **approved CDM methodology AMS.II-L** (Demand-side activities for efficient outdoor and street lighting technologies)for measuring and calculating energy consumptions for both metered and non-metered light points, energy savings , emission reduction, and lighting quality can be followed.
- Large national level projects can aggregate **the demand for a certain product on a national scale; bulk procurement has the potential to transform markets.** This will benefit PEA in negotiating the cost of ESCO. This will also benefit ESCO by getting an extended warranty on the energy efficient system component from manufacturers of the components.

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