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TA 7798 - REG:
Promoting Energy Efficiency in the Pacific (Phase 2)

Cook Islands

PNG POWER Ltd
Papua New Guinea

Tonga Energy Road Map 2010-20
www.tonga-energy.to
Tonga

Samoa

Vanuatu

FINAL REPORT

Prepared for

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ACRONYMS

ADB	–	Asian Development Bank
AusAID	–	Australia's Aid Programme
BCI	–	Bank of the Cook Islands
CCE	–	Cost of Conserved Energy
CCI-POM	–	Chamber of Commerce and Industry – Port Moresby
CDM	–	Clean Development Mechanism
CEO	–	Chief Executive Officer
CFL	–	Compact Fluorescent Lamp
CITC	–	Cook Islands Tourism Corporation
CSO	–	Commercial Service Obligation
DEC	–	Department of Environment and Conservation
DEMM	–	Department of Energy, Mines and Minerals
DPE	–	Department of Petroleum and Energy
DSM	–	Demand-Side Management
EC	–	Energy Commissioner
EE	–	Energy Efficiency
EE&C	–	Energy Efficiency and Conservation
EOI	–	Expressions of Interest
EPC	–	Electric Power Corporation
ESCO	–	Energy Service Company
EU	–	European Union
EUI	–	Energy Use Index
FFRP	–	Fridge/Freezer Replacement Program
FTL	–	Fluorescent Tube Lights
GEF	–	Global Environment Facility
GHG	–	Greenhouse Gas
GWH	–	Gigawatt Hour
HH	–	Household
HIES	–	Household Income and Expenditure Survey
HPS	–	High Pressure Sodium
HVAC	–	Heating, ventilation and air-conditioning
IA	–	Implementing Agency
IB	–	Incandescent Bulbs
ICCC	–	Independent Consumer and Competition Commission
IGA	–	Investment Grade Audit
IIEC	–	International Institute for Energy Conservation
IRR	–	Internal Rate of Return
JICA	–	Japan International Cooperation Agency

kVA	–	Kilovolt Ampere
kWh	–	Kilowatt Hour
LED	–	Light-Emitting Diode
M&V	–	Measurement & Verification
MEPS	–	Minimum Energy Performance Standards
MFEM	–	Ministry of Finance and Economic Management
MNRE	–	Ministry of Natural Resources and Environment
MOF	–	Ministry of Finance
MoU	–	Memorandum of Understanding
MWH	–	Megawatt Hour
MWTI	–	Ministry of Works, Transport & Infrastructure
NACCC	–	National Advisory Committee on Climate Change
NECC	–	National Energy Coordination Committee
NERM	–	National Energy Roadmap
NETF	–	National Energy Task Force
NISIT	–	National Institute of Standards and Industrial Technology
NPV	–	Net Present Value
NSC	–	National Steering Committee
NTP	–	Notice to Proceed
NZ	–	New Zealand
NZAID	–	New Zealand Aid Programme
OPM	–	Office of the Prime Minister
PALS	–	Pacific Appliance and Labelling Standards
PDMC	–	Pacific Developing Member Country
PEEP	–	Promoting Energy Efficiency in the Pacific
PFC	–	Power Factor Correction
PIC	–	Pacific Island Country
PICT	–	Pacific Island Countries and Territories
PMU	–	Project Management Unit
PNG	–	Papua New Guinea
PPA	–	Pacific Power Association
PPL	–	PNG Power Limited
PR	–	Public Relations
PRISM	–	Pacific Regional Information System
PV	–	Photovoltaic
RE	–	Renewable Energy
REDD	–	Renewable Energy Development Division
REEEP	–	Renewable Energy and Energy Efficiency Partnership
RETA	–	Regional Technical Assistance
SBS	–	Samoa Bureau of Statistics
SHS	–	Samoa Hotel Association
SIDS-DOCK	–	Small Island Developing States Dock
SN&PS-UPNG	–	School of Natural and Physical Science at the University of Papua New Guinea
SOPAC	–	South Pacific Applied Geoscience Commission

SPC	–	Secretariat of the Pacific Community
SPREP	–	South Pacific Regional Environment Program
STA	–	Samoa Tourism Authority
TA	–	Technical Assistance
TAU	–	Te Aponga Uira
TERM	–	Tonga Energy Road Map
TERM-IU	–	Tonga Energy Road Map Implementation Unit
TPL	–	Tonga Power Limited
UNDP	–	United Nations Development Program
UNELCO	–	Union Electrique du Vanuatu Limited
UPNG	–	University of Papua New Guinea
URA	–	Utilities Regulatory Authority
VERM	–	Vanuatu Energy Roadmap
VNSO	–	Vanuatu National Statistics Office
VUI	–	Vanuatu Utilities and Infrastructure, Ltd. (Santo)
WB	–	The World Bank

1 KNOWLEDGE SUMMARY

The Asian Development Bank (ADB) approved a regional Technical Assistance (RETA) for Promoting Energy Efficiency in the Pacific (PEEP) in September 2008 to be implemented in two phases. Phase 1, which concluded in May 2011, focused on conducting pilot programmes and identifying some energy efficiency projects for funding or co-financing by ADB, GEF and other sources. Phase 2 (PEEP2) focused on establishing the policy and implementation frameworks and energy efficiency targets and implementation of Energy Efficiency (EE) measures in the 5 participating PDMCs (PNG, Vanuatu, Tonga, Samoa and the Cook Islands) in order to contribute to achieving the overall goal reducing energy consumption in the residential, commercial and public sectors.

The key achievements of PEEP2 include the following:

- Development of an energy use database to provide access to information on electricity consumption and energy efficiency indicators at national and end-use sector levels. The database system was designed focusing primarily on the major end-use sectors (commercial and public sector buildings; residential sector, and street lighting); and is capable of accommodating expansion to include additional end-use sectors and countries in the future. The database was designed as a web-based system and is capable of operating in an "off-line" mode with all the core system components based on open source technologies.
- The information on end-use consumption and energy efficiency indicators was used to support design, implementation and monitoring of various project activities under PEEP2.
- Development of national EE targets for the five PDMCs based on a set of energy and economic parameters that influence projections of energy consumption and end-use energy savings. Projections were made for three policy scenarios – conservative, moderate and aggressive - for the years 2020, 2025 and 2030.
- To improve EE best practices, several complementary activities were undertaken including: Energy Efficiency Technology Assessment, International Best Practices for Energy Efficiency Building Codes, Green Hotels Rating Scheme for the Pacific, Green Commercial Buildings Rating Scheme for the Pacific; and Energy Efficiency Assessment Guidelines, Framework and Scorecard.
- Comprehensive energy audit training was conducted in all five PDMCs. The training program included four modules - Basic and Intermediate energy auditing (Modules 1 and 2) and Intermediate and Advanced energy auditing (Modules 3 and 4), practical on-site training and preparation of Investment Grade Audit Reports.
- A total of 35 EE projects were designed and 34 projects implemented following ADB procurement guidelines. The total investment (ADB component) was US$ 1,912,481 resulting in energy annual savings of 3,411 MWh, annual cost savings of $1,458,922 and CO_2 savings of 3,204 tons/year. The average cost of saved energy across these projects, for example in Samoa was 6 US cents/kWh. This compare very favorably with the electricity tariffs in the PDMCs that range between 29 and 61 US cents/kWh, thereby demonstrating the economic attractiveness of EE measures.
- A series of "Energy Saving" tips for printing on the back of electricity bills were prepared and provided to the utilities. Also, "Home Energy Guides" providing information on electricity costs for common electrical appliances (both efficient and inefficient) customized to each PDMC and energy saving tips for each electrical appliance were printed and distributed.

PEEP2 has established several guidelines, templates and implementation models that would be suitable for scaling up EE implementation throughout the Pacific region.

2 EXECUTIVE SUMMARY

2.1 Background

Based on a consultation process conducted in 2007 on behalf of the Global Environment Facility (GEF) Pacific Alliance for Sustainability, five Pacific Developing Member Countries (PDMCs) — the Cook Islands, Papua New Guinea (PNG), Samoa, Tonga, and Vanuatu expressed interest in and assigned high priority to the reduction of fossil fuels. In response, the Asian Development Bank (ADB) approved a regional Technical Assistance (RETA) for Promoting Energy Efficiency in the Pacific (PEEP) in September 2008. This program was to be implemented in 2 Phases and the first phase which concluded in May 2011 focused on conducting pilot programmes and identifying some energy efficiency projects for funding or co-financing by ADB, GEF and other sources.

The objective of Phase 2 (PEEP2) was to implement EE measures in the 5 PDMCs in order to contribute to achieving the overall goal reducing energy consumption in the residential, commercial and public sectors, and to establish the policy and implementation frameworks to move towards the goals of reducing fossil fuel imports, achieving total energy savings, and reducing greenhouse gas (GHG) emissions.

The International Institute for Energy Conservation (IIEC), Thailand, was selected as the TA Consultant for the implementation of the PEEP2 project. The Notice to Proceed (NTP) was issued by the ADB to IIEC on 4 November 2011. The project commenced on 6 November 2011 and was originally scheduled to be completed by 5 November 2014. It was extended by six months and the contract completion date was set for 30 April, 2015. This Final Report summarizes the activities and achievements during the project period and provides recommendations for scaling up and sustaining the benefits throughout the Pacific Island Countries (PICs).

2.2 Project Objectives

The objectives of PEEP2 were to:

- Establish an energy database in the five PDMCs with provision for expansion to other PDMCs;
- Recommend national energy policies with practical and implementable EE targets;
- Establish government policies and procedures for use of EE appliances, incorporation of EE best practices in building codes, and capacity building of service providers;
- Implement EE projects in the residential, commercial and government sectors and in public lighting;
- Develop a comprehensive information dissemination program for all stakeholders; and
- Leveraging other regional energy programs to maximise benefits to all PDMCs.

2.3 Summary of Activities by Components

2.3.1 Output 1: Development of Energy Use Database

The main objectives of this output were to design, develop and implement an Energy End-Use Database, provide access to the stakeholders, and implement procedures for maintaining and updating it. The database provides relevant data and information for the implementation and monitoring of the activities under Outputs 2, 3 and 4. The main outcome is an accessible database of energy use by sector and major appliance category in each of the five participating PDMCs.

2.3.2 Output 2: Development of EE Policies and Procedures

Based on the initial assessment of EE policy measures in PEEP1 RETA, this task undertook the review these assessments and defined the institutional frameworks and the implementing regulations and procedures to establish targets and achieve the needed results to accomplish these targets. The key activities of this task included:

- Establishment of practical and implementable energy efficiency targets and incorporate these into national energy policies and plans;
- Assistance in suppressing the sale and use of high-energy-consumption appliances and equipment through appropriate import regulations brought about by the development and enforcement of effective minimum energy performance standards (MEPS) and/or energy labeling;
- Recommendations for improving energy efficiency best practices for newly built residential, commercial, and government buildings, including the identification and recommendation of simple, effective, and enforceable energy efficiency provisions in building codes for new buildings;
- Development and implementation of training programs for local experts in undertaking energy audits and in providing energy efficient products and services; and
- Supporting the development of motivated and organized service providers who will implement energy efficiency activities.

2.3.3 Output 3: Implementation of Energy Efficiency Programs

The objective of this task was to design and implement a range of Energy Efficiency and Conservation (EE&C) projects in the five PDMCs in meeting the overall project objectives of reducing fossil fuel consumption for electricity generation and the consequent reduction of greenhouse gas (GHG) emissions. The EE&C projects built on the results of some of the pilot programs in PEEP1. This task aimed at large scale implementation of sustainable EE&C programs to achieve tangible benefits to the respective electricity utility, consumers and society as a whole. The emphasis was on replicability and scale-up opportunities, not only in the five PDMCs, but also in the other Pacific Island Countries (PICs). Accurate determination of program impacts was considered paramount and formal Measurement & Verification (M&V) protocols were developed and adopted for each project.

The EE projects implemented were categorized as follows:

i. Energy Efficient Street Lighting Program
ii. Energy Efficient Lighting Program for Residential, Commercial and Public Sector
iii. Implementation of EE Measures in Hotels and Commercial Sector
iv. Implementation of EE Measures in the Public Sector

2.3.4 Output 4: Information Dissemination and Public Awareness

The objective of this task was to implement a comprehensive information dissemination program to all stakeholders in the five PDMCs and to expand to other PDMCs using regional events. Public awareness and education programs using a variety of promotional channels were also included in this activity. The basic approach was both country specific (five participating PDMCs) and regional (all PDMCs) to ensure the widest promotion of the benefits of energy saving technologies using actual case studies and implementation models that would be relevant for all PDMCs. This activity was undertaken in collaboration with the Pacific Power Association (PPA) and other regional agencies to ensure participation of all PDMCs and leverage funds from other programs.

2.4 Project Outputs

The specific outputs outlined in this section relates to the Design and Monitoring Framework detailed in the ADB Technical Assistance Report (Project Number: 44099, March 2011) for Promoting Energy Efficiency in the Pacific (Phase 2).

Output 1: Stakeholders have access to comprehensive information on energy use by sector and appliance.

An energy use database was developed to provide access to information on electricity consumption and energy efficiency indicators at national and end-use sector levels in the five participating PDMCs. The information on end-use consumption and energy efficiency indicators was used to support design, implementation and monitoring of various project activities under Outputs 2, 3 and 4 of PEEP2. In addition, the PEEP2 energy use database also provided substantial amount of data for the development the Pacific Regional Efficient Lighting Strategy (PELS), funded by the Australian Government and managed by the United Nations Environment Programme (UNEP), and the Secretariat of the Pacific Community (SPC).

The database system was designed focusing primarily on the major end-use sectors in the five PDMCs, i.e. commercial and public sector buildings; residential sector, and street lighting. However, the database system is capable of accommodating expansion to include additional end-use sectors and countries in the future, if needed. The energy end-use database system was designed using a web-based platform which is capable of operating in an "off-line" mode (or without Internet connection). The database system is accessible through the PEEP2 project website (www.ee-pacific.net/index.php/database). All the core system components are based on open source technologies which are cost-effective, in both development and maintenance, reliability proven and widely used around the world.

Output 2: Energy efficiency practices have been mainstreamed into government processes, procedures and policies in participating countries.

The project developed a generic tool that allows capturing data from the surveys and allows specific default values to be used in carrying out the analysis for determining EE targets for the five PDMCs. The spreadsheet tool developed helped to determine energy efficiency targets for the years 2020, 2025 and 2030. Based on data inputted for a set of energy and economic parameters, the end-use energy savings were projected for three policy scenarios – conservative, moderate and aggressive. A summary of the EE targets for the two extreme scenarios (Conservative and Aggressive) are shown in Figure 2.1 below.

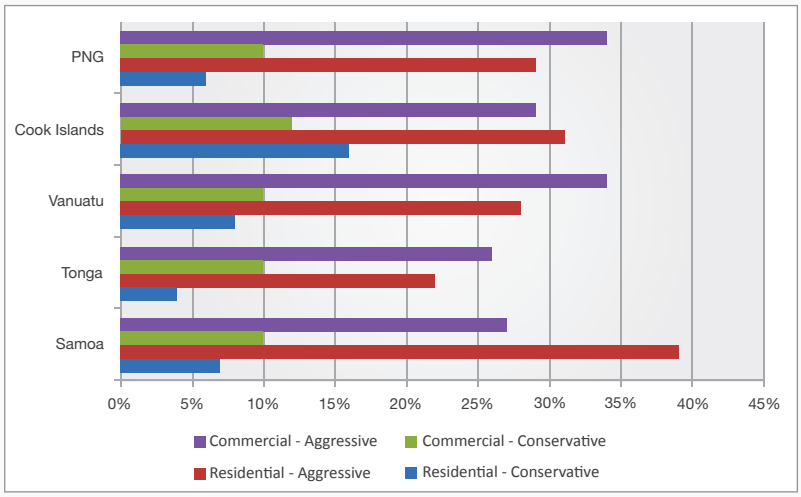

Figure 2.1: Projected EE Targets

In the area of efficient appliances, the Pacific Appliance Labeling and Standards (PALS) program being implemented by the Secretariat for the Pacific Community (SPC) focused on regulations for minimum energy performance standards (MEPS) in each of the PICs. A Fridge/Freezer Replacement Program (FFRP) implemented in the Cook Islands under PEEP2 demonstrated the significant benefits of higher efficiency appliances (refrigeration).

To improve energy efficiency best practices, several complementary activities were undertaken including the following:

- Energy Efficiency Technology Assessment
- International Best Practices for Energy Efficiency Building Codes
- Green Hotels Rating Scheme for the Pacific
- Green Commercial Buildings Rating Scheme for the Pacific
- Energy Efficiency Assessment Guidelines, Framework and Scorecard

Comprehensive energy audit training was completed comprising of four modules - Basic and Intermediate energy auditing (Module 1 and 2) and Intermediate and Advanced energy auditing (Module 3 and 4) including practical on-site training and preparation of Investment Grade Audit Reports.

Output 3: Energy efficiency programs implemented effectively and sustainably in each participating country.

Under this component a total of 35 projects were designed in the 5 participating PDMCs. One project (Project Code 16) was not implemented as no bids were received from suppliers in the procurement phase. The Table 2.1 below provides a summary of the number of projects undertaken by each PDMC by category and the project funds allocated by the ADB for the EE equipment.

Table 2.1: Summary of EE Projects by Category

Summary by Country			Number of Implemented Projects by Activity Type				
	ADB Contract Value (US$)	Share	EE Street Lighting	EE Measure in Res., Com. and Gov. Sector	EE Measures Hotels and Com. Sector	EE Measures Public Sector	Total
Cook Islands	616,582	32%	4	2	1	2	9
PNG	316,978	17%	2	3	0	0	5
Samoa	349,895	18%	1	4	1	1	7
Tonga	261,478	14%	2	2	0	0	4
Vanuatu	311,950	16%	2	5	0	1	8
All	55,599	3%	-	1	-	-	1
TOTAL	**1,912,481**	**100%**	**11**	**17**	**2**	**4**	**34**

A summary of the project costs and associated savings are given in Table 2.2 below.

Table 2.2: Project Cost and Savings by Country

Country	Equipment budget cost (US$)	Actual Contract Price (US$)	Incremental Cost (US$)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (US$/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (tCO_2e/yr)
Cook Islands	671,100	616,582	(54,518)	525,223	321,285	153,312	471
PNG	470,325	316,978	(153,347)	428,384	122,494	108,190	685
Samoa	528,567	349,895	(178,672)	953,681	350,024	250,987	762
Tonga	478,250	261,478	(216,772)	638,924	232,021	109,973	582
Vanuatu	578,240	311,950	(266,290)	864,595	433,098	249,001	706
All	56,590	55,599	(991)	-	-	-	-
TOTAL	**2,783,072**	**1,912,481**	**(870,591)**	**3,410,807**	**1,458,922**	**871,463**	**3,204**

Output 4: Information on energy efficiency has been shared and public awareness of the benefits of energy savings has improved.

The outputs included design of a series of "Energy Saving" tips for printing at the back of electricity bills in the Cook Islands and PNG. Home Energy Guides providing information on electricity costs for common electrical appliances customized to each PDMC (using applicable electricity tariff) and energy saving tips for each electrical appliance were printed and shipped to each PDMC for distribution. A total of 72,000 copies of the Home Energy Guides in English, Samoan, Tongan and Bislama were printed and these have been distributed in several public awareness events.

Three regional workshops on the PEEP2 activities were conducted during the project period. Two of the workshops were in association with the Annual General Meeting of the Pacific Power Association (PPA) in Vanuatu (2012) and Tahiti (2014) which was attended by 23 Pacific Island member countries. A regional workshop titled "Promoting Energy Efficiency in the Pacific" was conducted jointly by the ADB and IIEC in March 2015 in Apia, Samoa to disseminate the outcomes of the PEEP2 activities and formulate policy recommendations for future acceleration of energy efficiency in the Pacific Region. The workshop was attended by over 90 delegates comprising of representatives of all PDMCs, donor agencies and other stakeholders.

As a part of PEEP2, three energy efficiency guidelines covering hotels, commercial buildings and street lighting were designed, published and copies distributed to each PDMC for awareness activities.

Output 5: Effective project management has been established.

An effective Project Management Unit (PMU) was established at IIEC Regional Office in Bangkok, Thailand for coordination with ADB, Implementing Agencies and International and National Experts of the IIEC project team. All project deliverables were provided according to the project schedule.

2.5 Recommendations

1. The policy scenarios (conservative, moderate and aggressive) developed in PEEP2 indicated high levels of achievable energy savings, ranging from 8% to 32% in the 5 PDMCs, relative to the baseline (business as usual) scenario by the year 2030. Given the significant potential, EE should be established as a high priority in the National Energy Policy in the respective PDMCs; and establish realistic targets for EE improvement.
2. Electrical appliances especially in the residential sector offer a significant opportunity for reducing energy costs through the market transformation from low efficiency (low star rating) to high efficiency (high star rating) units. The PALS program focused on regulations for minimum energy performance standards (MEPS) and the Fridge/Freezer Replacement Program (FFRP) demonstrated the benefits of high star rated units. There is scope for a regional energy standards & labeling program using the implementation models established under PEEP2. The need to finalize and implement a national EE building code is also emphasized.
3. One of the key outputs of the PEEP2 project is to support EE policy design and implementation as well as to explore the replication of these EE policies, programs, plans and projects across the Pacific and particularly the nine other ADB PDMCs not covered under PEEP2. The PEEP2 team therefore developed the concept of *EE Assessment Guidelines, Framework and Scorecard* to enable the PDMCs to understand and independently evaluate their policies, provide guidance on how they can improve energy efficiency in their countries, and provide a set of indicators/criteria to track their progress. It is recommended that ADB and/or other donors undertake regional programs to address the gaps identified (see Section 4.3.3.5) in this project relative to scaling up implementation of EE initiatives in the Pacific.
4. Based on the responses from the final workshop in March 2015, PEEP2 was one of very few projects (or arguably the only project) in the Pacific Islands that focused on implementation of EE projects on such a large scale (34 projects) covering most of the important end uses (lighting, AC, refrigeration etc); and cost effective savings have been demonstrated. There was significant interest among the workshop participants for the expansion of the program to all ADB PDMCs. The implementation models developed in PEEP2 are replicable and can now be considered for all the PDMCs.
5. The agencies responsible for EE in the PDMCs need to be well resourced (staffing and budget) if energy savings are to be achieved. The lack of adequate resources within the implementing agencies was evident in PEEP2. To this end, development of a National EE Strategy and Action Plan with clear mandates and responsibilities for the respective agencies is a basic requirement. The national governments need to "lead by example" by implementing EE in its facilities and other incentives (eliminating import duties of EE appliances etc) if the full potential is to be achieved.
6. Funding constraints have been a major barrier in promoting EE in all PDMCs. Hence, the establishment of an EE Revolving Fund or a Clean Energy Fund to finance EE projects should be considered. There are several examples of the funds in the Asia Pacific region.
7. The duration of PEEP2 (initially 3 years) was tight since the scope included data gathering, design, procurement, installation and M&V for the EE projects; and as a result only limited M&V could be conducted in some of the projects. Installation delays, mainly due to lack of funding from the host agencies, was also evident. It is recommended that future projects of this type a project period of at least four (4) years is considered.
8. In addition to scaling up EE implementation in other PDMCs, using the implementation models developed in PEEP2, the following regional actions could be considered to assist all PDMCs:
    a. Development of a template for a national energy efficiency law that can be adapted to the specific requirements of each country.

b. Preparation of the provisions for a standard energy efficiency building code for Pacific nations.
c. Development of guidelines for establishing and operationalizing an energy efficiency revolving fund.
d. Development of guidelines and procedures and suggested regulations for facilitating EE implementation in the public sector.
e. Development of legislative and regulatory guidelines requiring utility actions to promote EE through demand-side management (DSM) activities and/or energy efficiency obligations (EEOs).
f. Development of regional database and benchmarking of building energy consumption for different building types.
g. Development of a financing framework and guidelines to facilitate commercial financing for energy efficiency projects.
h. Preparation of guidelines for governments to incentivize EE project implementation both in the public and the private sectors.
i. Development of customized protocols for measurement and verification (M&V) of energy savings from EE projects.
j. Training and capacity building programs for energy service providers.

3 INTRODUCTION

Based on a consultation process conducted in 2007 on behalf of the Global Environment Facility (GEF) Pacific alliance for Sustainability, five Pacific developing member countries (PDMCs) — the Cook Islands, Papua New Guinea (PNG), Samoa, Tonga, and Vanuatu expressed interest in and assigned high priority to the reduction of fossil fuels. In response the Asian Development Bank (ADB) approved a regional Technical Assistance (RETA) for promoting Energy Efficiency (EE) in the Pacific in September 2008. This program was to be implemented in 2 Phases and the first phase which concluded in May 2011 focused on identifying a pipeline of specific energy efficiency projects for funding or co-financing by ADB, GEF and other sources.

The objective of Phase 2 (PEEP2) was to implement energy efficiency (EE) measures in the 5 PDMCs in order to contribute to achieving the overall goal reducing energy consumption in the residential, commercial and public sectors through the implementation of energy efficiency measures, and to establish the policy and implementation frameworks to move towards the goals of reducing fossil fuel imports, achieving total energy savings, reducing GHG emissions, and providing economic benefits to the countries.

The International Institute for Energy Conservation (IIEC), Thailand, was selected as the TA Consultant for the implementation of the PEEP2 project. The Notice to Proceed (NTP) was issued by the ADB to IIEC on 4 November 2011. The project commenced on 6 November 2011 and was originally scheduled to be completed by 5 November 2014. It was extended by six months and the contract completion date was set for 30 April 2015.

This Project Completion Report (Final Report), together with its Annexes, describes the activities undertaken and the outputs produced towards meeting the objectives of the Project.

4 PROJECT OVERVIEW

4.1 Project Objectives

The objectives of PEEP2 were to:

- Establish an energy database in the five PDMCs with provision for expansion to other PDMCs;
- Recommend national energy policies with practical and implementable EE targets;
- Establish government policies and procedures for use of EE appliances, incorporation of EE best practices in building codes, and capacity building of service providers;
- Implement EE projects in the residential, commercial and government sectors and in public lighting;
- Develop a comprehensive information dissemination program for all stakeholders; and
- Leveraging other regional energy programs to maximise benefits to all PDMCs.

4.2 Summary of Phase 2 Project Components

4.2.1 Output 1: Development of Energy Use Database

The main objectives of the task under this output are to design, develop and implement an Energy End-Use Database, provide access to the stakeholders, and implement procedures for maintaining and updating it. The database will provide relevant data and information for the implementation and monitoring of the activities under Outputs 2, 3 and 4. The main output will be an accessible database of energy use by sector and major appliance category in each of the five participating PDMCs.

In the development of the database the constraints in relation to data and data quality identified in PEEP1 will be addressed. Relevant data sources from other regional energy programs will be considered, namely, Pacific Regional Information System (PRISM) project, energy sector reviews by SPC Applied Geoscience and Technology Division (SOPAC) and Renewable Energy and Energy Efficiency Partnership (REEEP).

4.2.2 Output 2: Development of Energy Efficiency Policies and Procedures

Based on the initial assessment of EE policy measures in PEEP1 RETA, this task will review these assessments and define the institutional frameworks and the implementing regulations and procedures to establish targets and achieve the needed results to accomplish these targets. The main objectives of this task are to:

- Establish practical and implementable energy efficiency targets and incorporate these into national energy policies and plans;
- Suppress the sale and use of high-energy-consumption appliances and equipment through appropriate import regulations brought about by the development and enforcement of effective minimum energy performance standards (MEPS) and/or energy labeling;
- Improve energy efficiency best practices for newly built residential, commercial, and government buildings, including the establishment of simple, effective, and enforceable energy efficiency provisions in building codes for new buildings;
- Develop and implement training programs for local experts in undertaking energy audits and in providing energy efficient products and services; and
- Support the development of motivated and organized service providers that have incentives to implement energy efficiency activities.

The EE policies appropriate for each country will be designed to address the key EE barriers which are influenced by the EE needs and opportunities and the prevailing market conditions in the country.

4.2.3 Output 3: Implementation of Energy Efficiency Programs

The objective of this Component was to design and implement a range of Energy Efficiency and Conservation (EE&C) projects in the five PDMCs in meeting the overall project objectives of reducing fossil fuel consumption for electricity generation and the consequent reduction of greenhouse gas (GHG) emissions. The EE&C projects built on the results of the pilot programs in PEEP1. This task is aimed at large scale implementation of sustainable EE&C programs to achieve tangible benefits to the respective electricity utility, consumers and society as a whole. The emphasis was on replicability and scale-up opportunities, not only in the five PDMCs, but also in the other Pacific Island Countries (PICs). Accurate determination of program impacts was considered paramount and formal Measurement & Verification (M&V) protocols were adopted for each project.

This task comprised of the following activities:

I. Energy Efficient Street Lighting Program
II. Energy Efficient Lighting Program for Residential, Commercial and Public Sectors
III. Implementation of EE Measures in Hotels and Commercial Sectors
IV. Implementation of EE Measures in the Public Sector

4.2.4 Output 4: Information Dissemination and Public Awareness

The objective of this task is to implement a comprehensive information dissemination program to all stakeholders in the five PDMCs and to expand to other PDMCs using regional events. Public awareness and education programs using a variety of promotional channels are also included in this task. The basic approach to this task is both country specific (five participating PDMCs) and regional (all PDMCs) to ensure the widest promotion of the benefits of energy saving technologies using actual case studies and implementation models that would be relevant for all PDMCs.

This activity will be undertaken in collaboration with the Pacific Power Association (PPA) and other regional agencies to ensure participation of all PDMCs and leverage funds from other programs. In addition there will be in-country programs implemented the International and National EE Country Experts and short-term experts in various fields.

5 ACCOMPLISHMENTS BY COMPONENTS

5.1 Introduction

The accomplishments of PEEP2 in the five participating PDMCs are outlined in this Section. In addition to the specified project deliverables, various outputs are provided as Appendices to this report. The Appendices are contained in a separate CD attached to this report.

5.2 Output 1: Development of Energy Use Database

The energy use database was developed to provide access to information on electricity consumption and energy efficiency indicators at national and end-use sector levels in the five participating PDMCs. The information on end-use consumptions and energy efficiency indicators has been used to support design, implementation and monitoring of various project activities under Output 2, 3 and 4 of the PEEP2 project. In addition, the PEEP2 energy use database also provided substantial amount of data for the development the Pacific Regional Efficient Lighting Strategy (PELS), funded by the Australian Government and managed by the United Nations Environment Programme (UNEP), and the Secretariat of the Pacific Community (SPC).

The development process of the energy use database followed a phased step approach and the key activities included the following:

1. Review, compilation and validation of available data and data collection mechanisms
2. Conduct of in-country surveys to collect additional data
3. Design and development of the Energy End-Use Database and related mechanisms for providing access to stakeholders
4. Database population, update and maintenance

5.2.1 Review, Compilation and Validation of Available Data and Data Collection Mechanisms

The PEEP2 project team coordinated with the implementing agency in each PDMC to identify in-country resources for data compilation activities. The primary data resources in each country include the Energy office, the Customs office, the Statistics office, the electric utility and local business associations.

The PEEP2 project team also conducted a review of relevant regional efforts such as the Framework for Action on Energy Security in the Pacific (FAESP) project implemented by SPC to ensure that any overlapping efforts are minimized and the energy information delivered by the energy end-use database is complementary to the other past and ongoing efforts. Summarized below (Table 5.1) are mapping of data available and key data resources identified at the national and regional levels.

Table 5.1: Data Resources in each PDMC

Type of Data	Cook Islands	Papua New Guinea	Samoa	Tonga	Vanuatu
Import Statistics	Customs Office	Customs Office	Customs Office	Customs Office	Customs Office
Diffusion of Household Appliance	Statistics Office	Statistics Office	Statistics Office	Statistics Office	Statistics Office
Inventory of Street Lighting and Lighting Quality	Electric Utilities	Electric Utilities	Electric Utilities	Electric Utilities	Electric Utilities
Household Electricity End-Use	Statistics Office	N/A	N/A	N/A	N/A
Total Electricity Consumption & Load Profile	Electric Utilities	Electric Utilities	Electric Utilities	Electric Utilities	Electric Utilities
Electricity Consumption by End-Use Sector	N/A	N/A	Electric Utility	Electric Utility	N/A
Large Energy End-User	N/A	N/A	Electric Utility, Hotel Association	Electric Utility	N/A
National Level Energy Efficiency Indicators	FAESP	FAESP	FAESP	FAESP	FAESP
Sectoral and End-User Level Energy Efficiency Indicators	N/A	N/A	N/A	N/A	N/A

Note: Green = Sufficient data available; Orange = Data partially available (incomplete); Yellow = No data available

Cells highlighted with orange in Table 5.1 indicate that data available from the mentioned agencies is partially available (incomplete), while the yellow highlighted cells indicating no data available from any national or regional agencies. Compiling and publishing available energy related data summarized above are usually undertaken by the responsible agencies on an annual basis. However, as for those which are parts of Census and Household Income and Expenditure Survey (HIES), data will be published together with Census and HIES reports. National level EE indicators from FAESP are based on project deliverables and the latest set of EE indicators were published in 2012.

Review of the available data, especially those from electric utilities, have confirmed the significance of electricity consumption in the commercial and public sector end-use, the residential end-use, and street outdoor lighting end-use in the PEEP2 countries. To be specific, the commercial and public buildings sector, and the residential sector account for more than 70% of the total annual electricity consumption in each PEEP2 PDMCs. The findings are in line with the PEEP 1 report which indicated that the major electricity end-use sectors in all of the participating PDMCs include residential, commercial and hotel sectors.

To facilitate design and implementation of EE projects in these end-use sectors, and measurements of project implementation results, it is important to understand the energy use baseline at sectoral and end-use levels; and the proposed energy use baselines (or EE indicators) at the sectoral and end-use levels for the PEEP2 countries are summarized in Table 5.2.

Table 5.2: Proposed Sectoral and End-Use EE Indicators

End-Use Sector	Proposed Sectoral and End-Use EE Indicators
Residential Sector	• % ownership of key household appliances (e.g refrigerators, freezers, fans and lighting products) and average energy performance levels **(average annual energy consumption (in kWh) and average equipment efficiency)**
Building Sector	• **Annual energy consumption (in kWh or MJ /1) per unit of floor area (m^2)** or per room (in case of hotels) or per bed (in case of hospitals)
Street and Outdoor Lighting	• Penetration of different lighting technologies and **average lumen /2 per watt** of the overall street and outdoor lighting systems

Note: /1 Mega Joules (MJ) is used to reflect consumptions of non-electrical energy, such as gas and diesel
/2 Lumen is a unit to measure light output produced by light sources

To be able to establish meaningful EE indicators, the following data gaps shown in Table 5.1 need to be addressed:

- Diffusion of Household Appliance
- Inventory of Street Lighting and Lighting Quality
- Household Electricity End-Use
- Electricity Consumption by End-Use Sector
- Large Energy End-Users
- Economic Activities at Sectoral and End-Use Levels

5.2.2 Conduct of In-Country Surveys to Collect Additional Data

Based on the identified data gaps, the PEEP2 project team designed and conducted a number of in-country surveys to collect missing data and information on energy use by sector, major types of household appliances, technologies and inventories of street lighting, and information on end-use activities (e.g. building occupancy and pattern of use). These identified survey efforts were discussed with the implementing agencies to seek endorsements and support. Listing on in-country surveys is shown in Table 5.3.

Table 5.3: Listing of In-Country Surveys in the PEEP2 Countries

Country	In-Country Surveys
Cook Islands	• Energy consumption data of large energy end-users (historical energy consumption, floor areas, occupancy rate, equipment inventory) • Lighting quality of public and street lighting
Papua New Guinea	• Residential electricity end-use survey • Energy consumption data of large energy end-users (historical energy consumption, floor areas, occupancy rate, equipment inventory) • Lighting quality of public and street lighting
Samoa	• Residential electricity end-use survey • Energy consumption data of large energy end-users (historical energy consumption, floor areas, occupancy rate, equipment inventory) • Lighting quality of public and street lighting
Tonga	• Residential electricity end-use survey (carried out in collaboration with the Tonga Statistics Office) • Energy consumption data of large energy end-users (historical energy consumption, floor areas, occupancy rate, equipment inventory) • Lighting quality of public and street lighting
Vanuatu	• Residential electricity end-use survey (to be carried out in collaboration with UNDP) • Energy consumption data of large energy end-users (historical energy consumption, floor areas, occupancy rate, equipment inventory) • Lighting quality of public and street lighting

For each specific focus area (e.g. residential electricity end-use, or large energy end-users), the PEEP2 project team developed survey templates (included in Interim Report – Year 1), survey questionnaires and answering guidelines for enumerators, and conducted pre-survey training in Vanuatu, Tonga, Samoa and PNG prior to the large scale residential surveys in each country. Key activities and milestones of in-country surveys are summarized below:

5.2.2.1 Residential Electricity End-Use Surveys

Apart from the Cook Islands, the previous residential household surveys and census reports in other PDMCs did not include information on the saturation figures of household appliances and their energy efficiency performance. It should be noted that collaboration with the national statistics office for implementation of the nationwide residential surveys was recommended by the implementing agency in each country. However coordination with each national statistics office to finalize resources required and to conclude the implementation schedule was a lengthy and time consuming process, and this significantly impacted the schedules of residential household surveys in PNG, Samoa, and Tonga. Nationwide residential household surveys were conducted in Samoa, Tonga and Vanuatu in 2013. As for PNG, the residential household survey activity focused only in Port Moresby due to survey budget constraints and safety concerns, and the survey was completed in 2014. The Table 5.4 provides a summary of the survey sample and completion dates. These surveys collected and analyzed the following:

- % saturation of electrical equipment, appliances and lighting products in households
- Sizes and models of electrical equipment, appliances and lighting
- Usage patterns
- Origin of manufacture
- Consumer preferences and perceptions

Table 5.4: Residential Electricity End-Use Surveys in the PEEP2 Countries

Country	Sample Size / Completion
Cook Islands	Based on data from 2011 Census; However a mini HH lighting surveys was also conducted to support EE project developments.
Papua New Guinea	756 HHs surveyed (Port Moresby) – completed in 2014
Samoa	1,000 HHs surveyed (Upolu and Savaii) – completed in 2013
Tonga	500 HHs surveyed (Tongatapu) – completed in 2013
Vanuatu	1,567 HHs (Port Vila and Luganville) – completed in 2013

Highlights of residential electricity end-use survey activities are summarized below:

- **PNG:** The cost of professional services in PNG is extremely high. In order to conduct in-country surveys a number of private and public organizations were approached. However, the quotations provided were substantially higher than that allocation under the survey budget for PEEP2. After substantial delays, a suitable subcontractor was identified to conduct survey in late 2013, and subsequently the survey activities in Port Moresby were conducted from January to April 2014 with the target sample size of 756 households. The survey report was finalized in July 2014 and is given in **Appendix 1.1**.

- **Samoa:** The residential electricity end-use survey in Samoa was initially discussed as a joint-effort between the PEEP2 project and the Samoa Bureau of Statistics (SBS), however due to the delay in finalizing the cooperation agreement and budget constraints, the PEEP2 project decided to engage a subcontractor to implement the survey activities. The residential electricity end-use survey in Samoa was initiated in June 2013 and completed in August 2013. The survey covered a sample of 1,000 households in the islands of Upolu and Savaii. The survey results have been entered into a survey database and data analysis and report preparation were initiated in September 2013. The report was finalized in March 2014 and is given in **Appendix 1.2**.

- **Tonga:** The PEEP2 project carried out the residential electricity end-use survey in collaboration with the Tonga Statistics Department. The original intent was to undertake a sample size of 1,000 electrified households, but due to limited funding for the survey, the sample size was reduced to 500 households. For Tongatapu with its 12,917 households (2011 census), that can be considered as a reasonable sample size provided a truly random sample is surveyed. The survey activities were carried out in June and July 2013 with data entry completed in August. The survey report was finalized in early 2014 and given in **Appendix 1.3**.

- **Vanuatu:** The household appliance use and energy surveys were carried out in Port Vila and Luganville covering about 1,500 households (1,150 in Port Vila and 350 in Luganville). The Vanuatu National Statistics Office (VNSO) worked with the PEEP2 project team to ensure a random, representative sample and provided identification codes for specific homes to be surveyed. A preliminary survey report was prepared in June covering electricity use for lighting. The results of the lighting analyses were used to develop proposals for ADB support for residential energy efficient lighting improvements for both urban centres. The final survey report was completed in March 2014 and is given in **Appendix 1.4**.

Some key findings from the abovementioned residential electricity end-use surveys are summarized in Table 5.5 and Table 5.6. Other information produced by the PEEP2 HH surveys includes types of appliances, energy labeling, estimated energy use, ownership of small appliances, etc.

Table 5.5: Diffusion of Household Appliances in the PEEP2 Countries

Country	Fridges	Freezers	Washing Machines	ACs
Cook Islands	102%	77%	78%	5%
Papua New Guinea	66%	29%	48%	7%
Samoa	51%	30%	2%	5%
Tonga	49%	45%	65%	-
Vanuatu	44%	5%	6%	1%

Table 5.6: Diffusion of Lighting Technologies in the PEEP2 Countries

Country	CFLs	LFLs	ILs	Others
Cook Islands	48%	22%	26%	5%
Papua New Guinea	1%	95%	2%	2%
Samoa	23%	70%	7%	N/A
Tonga	22%	50%	28%	N/A
Vanuatu	47%	40%	11%	2%

Note: Others includes less common types such as halogen lamps, LEDs

5.2.2.2 Large Energy End-Users Surveys

Large energy end-user surveys in the PEEP2 countries were carried out to collect data necessary for establishment of energy efficiency indicators, and included historical energy consumption, floor areas, occupancy rate, and equipment inventory.

- **Cook Islands:** An energy survey covering large government buildings was conducted by the National consultant during the first quarter of 2013. General information, historical energy consumption data, and inventories of major energy using equipment of 22 main government buildings in Rarotonga were compiled. The survey results were validated and populated into the online database to illustrate the initial Energy Use Index (EUI) of government buildings in the Cooks Islands in comparison with other PEEP2 countries. Findings from the government buildings survey were also utilized in the preparation of an Energy Efficiency proposal for public buildings.

- **PNG:** The implementing agency, PPL, collected data from large hospitality/tourist accommodation entities. Such data was converted into electronic format and made available online around end of 2014.

- **Samoa:** Large energy end-users surveys in Samoa covered 3 major groups of buildings, i.e. accommodation buildings (hotels and accommodation facilities); government buildings; and commercial buildings. The accommodation surveys were completed in cooperation with the Samoa Tourism Authority (STA) and the Samoa Hotel Association (SHA). Data collected by the surveys included building characteristics (number and floor area of guest rooms, reception, function rooms, restaurants and internet café), energy consumption and activities data (occupancy rate). It was found that the most effective method to get hotels to complete the survey questionnaire is to have someone from the project team assist them. Very few hotels who received the questionnaire by email actually filled them out and returned them. This is an important lesson for future surveys for this project.

  Government Buildings Survey - A list of 63 government buildings was compiled and a survey of these buildings initiated. Electricity consumption data for most of these buildings was collected from EPC. Historical energy consumption data for some of these buildings, which are included in the large public buildings falling within the top 100 customers, was collected for 2011, and total consumption data was collected for all public customers for 2009, 2010 and 2011.

  EPC's GPS system was used to determine the floor space of these buildings. Once the estimates of floor space for the public buildings were developed, the indexes of electricity consumption per square meter were calculated. On-site surveys of some public buildings were conducted to obtain data on the lighting systems for 10 agencies in order to develop the government buildings efficient lighting project for submission to ADB.

Commercial Buildings Survey – The commercial buildings EE projects were designed using commercial customer data from EPC and Samoa Chamber of Commerce (SCC). Total energy consumption from 2009 to 2011 for the commercial sector was collected. The survey covered: floor areas and types of usage, occupancy rate, equipment inventory, lighting types.

- **Tonga:** Energy inventories for the 20 commercial and government buildings that have the highest energy use were carried out by the implementing agency, TERM-IU, under the direction of IIEC. Collection of energy consumption and inventories of energy using equipment were completed.

- **Vanuatu:** PEEP2 helped to consolidate existing data – which was scattered haphazardly among various computers – into a single hard drive but this was neither sufficiently organized nor comprehensive enough to constitute a useful and practical database. PEEP2 consultants helped arrange external funding for a study of transport energy end-use and worked with DEMM on building energy inventories and residential energy use. Elements of a demand-side database were developed over time.

Analysis of data collected from large energy end-users in the PEEP2 countries reveals energy efficiency indicators for buildings or Building Energy Use Index (EUI) in kWh/m^2/year as following:

- The Cook Islands: 117 kWh/m^2/year
- PNG: 147 kWh/m^2/year
- Samoa: 72 kWh/m^2/year
- Tonga: 81 kWh/m^2/year
- All PEEP2 countries: 110 kWh/m^2/year

Note that surveyed data from Vanuatu was not sufficient to construct the EUI for large buildings.

5.2.2.3 Street Lighting Inventory and Quality Surveys

Street lighting data collection and compilation to establish the energy efficiency benchmarks for street and outdoor lighting in each PDMC were completed, and the inventory and weighted average lamp efficacy of all street lighting in each PEEP2 country are shown in Table 5.7. It should be noted that the weighted average lamp efficacy will be dependent upon the percentage penetration of different lighting technologies, including energy efficient lighting technologies (such as Light-emitting Diodes (LEDs) lamps, High Pressure Sodium (HPS) lamps, Metal Halide (MH) lamps, Induction lamps) and conventional lighting technologies (such as Mercury Vapour (MV), fluorescent lamp, or even incandescent), and it does not reflect the street lighting quality in each PDMC.

Table 5.7: Street Lighting Inventories and Efficacies in the PEEP2 Countries

Country	No. of Street Lighting Light Points	Weighted Average Lamp Efficacy (Lumen/Watt)
Cook Islands	246	93
Papua New Guinea	65,321	72
Samoa	7,049	57
Tonga	1,974	100
Vanuatu	892	50

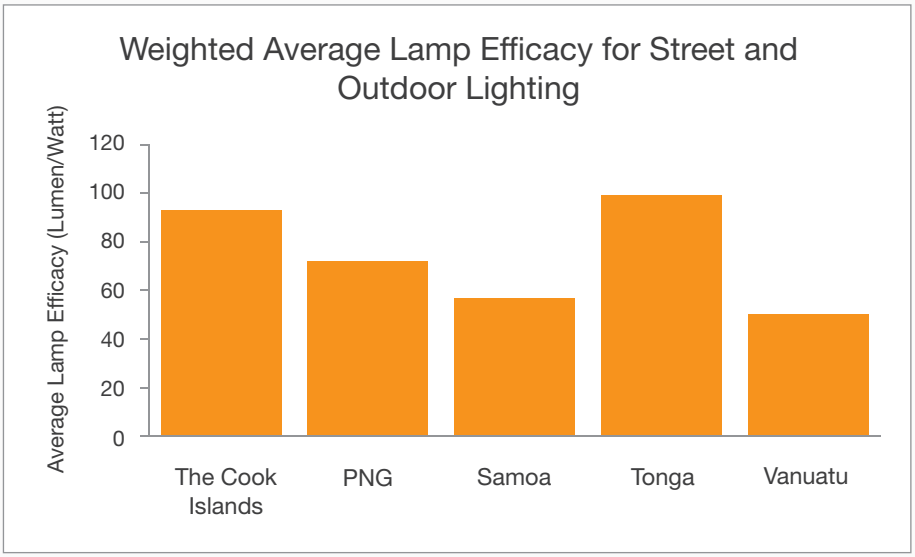

Figure 5.1: Weighted Average Lamp Efficiency for Street Lighting in the PEEP2 Countries

As shown in Figure 5.1, Tonga has the highest weighted average lamp efficacy for street lighting (almost 100 lumens per watt), as a result of higher percentage of HPS lamps and also LED luminaires (partially supported by ADB during the PEEP1 project). The weighted average lamp efficacy in the Cook Islands is also high (around 90 lumens per watt) because of replacements of MV lamps with induction lamps, however street lighting quality in the Cook Islands is relatively poor due to lower wattage and inadequate lumen output of the induction lamps.

The weighted average lamp efficacies for street lighting in PNG, Samoa and Vanuatu are lower than those in the Cook Islands and Tonga, due to the proliferation of inefficient lighting technologies in street lighting circuits. PNG has weighted average lamp efficiency of about 65 lumens per watt, as 90% of their street lighting is MV lamps and the remaining 10% are combination of HPS and fluorescent lamps. As for Samoa and Vanuatu, the weighted average lamp efficacies are below 60 lumens per watt, as over 95% of street lighting is still based on MV and fluorescent lighting technologies.

5.2.3 Design and Development of the Energy End-Use Database

IIEC designed and developed the energy end-use database system with the primary goal to support planning and implementation of the PEEP2 project. The database system was designed focusing primarily on the major end-use sectors in the five PDMCs, i.e. commercial and public sector buildings; residential sector, and street lighting. However, the database system is capable of accommodating future expansion to include additional end-use sectors and countries in the future, if needed.

The energy end-use database system was designed as a web-based system which is capable of operating in an “off-line” mode (or without Internet connection). The database system is accessible through the PEEP2 project website (www.ee-pacific.net/index.php/database). All the core system components are based on open source technologies which are cost-effective, in both development and maintenance, reliability proven and widely used around the world. The proposed database system divides its data entry and presentations into 2 parts, i.e. 1) static contents, and 2) dynamic contents, based on the nature of data compiled from secondary resources and in-country surveys. Schematic of the overall system design is shown in Figure 5.2, and highlighted in blue are inputs from various secondary resources while highlighted in red are findings from in-country surveys.

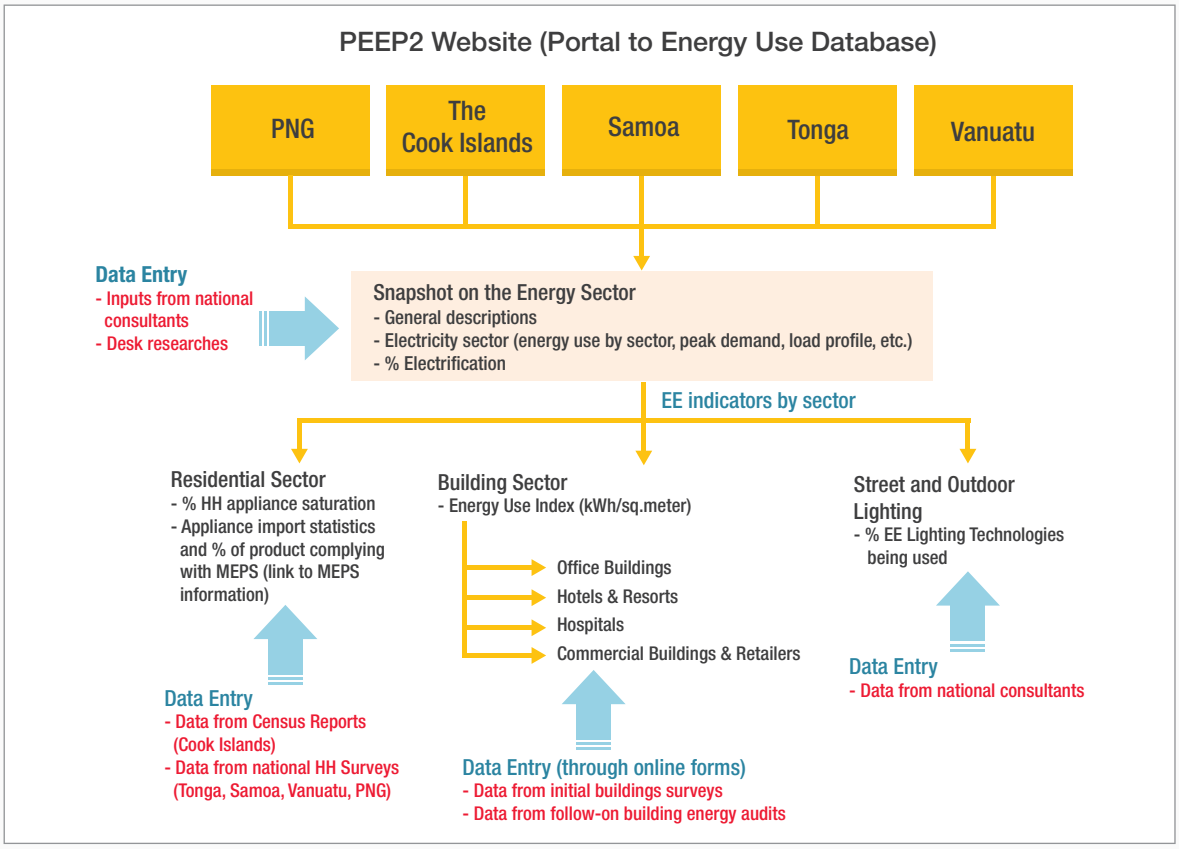

Figure 5.2: Design Concept of the PEEP2 Energy End-Use Database

Shown in Figure 5.3 is the user interface for viewing building EUI information generated by the PEEP2 energy end-use database.

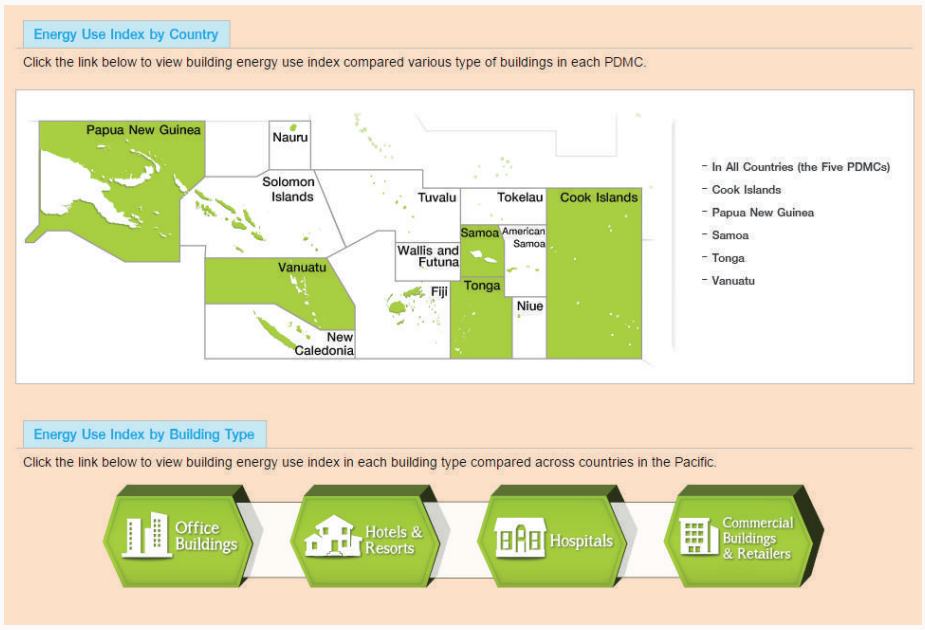

Figure 5.3: User Interface for Building Energy Use Index

Figure 5.4 shows a comparison of the EUI values of a specific type of building across the PEEP2 countries.

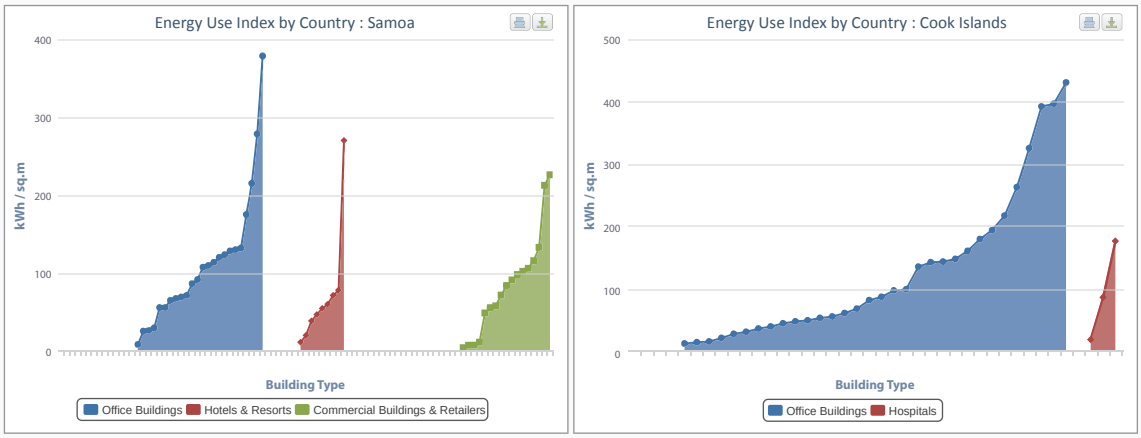

Figure 5.4: Samples of Building EE Indicators Comparison across the PEE2 Countries

5.2.4 Database Population, Update and Maintenance

Database population for the PEEP2 energy end-use database was performed through manual data entry and data import through Excel spreadsheets. Manual data entry is usually appropriate for static contents of the database which are consolidated from various secondary resources. Results of in-country surveys were transferred to the database system using Excel spreadsheets. During the PEEP2 project period, database population, update and maintenance was undertaken by the PEEP2 project team. A training program on data import using Excel spreadsheet was conducted for the PEEP2 countries as a part of the energy audit training program. Following the conclusion of the PEEP2 project, an "offline" version of the database together with a guideline on type of data to be compiled from various resources, data collection templates and data entry instructions was distributed to all the PEEP2 countries so that additional updates and system maintenance can be performed by the responsible agency.

5.3 Output 2: Development of Energy Efficiency Policies and Procedures

5.3.1 Energy Policy and Energy Efficiency Targets

The PEEP2 project team developed Energy Efficiency (EE) targets for 5 pacific island countries viz. Cook Islands, Papua New Guinea (PNG), Samoa, Tonga and Vanuatu. The timeline when the EE targets were developed by the PEEP2 team is shown in the Table 5.8 below:

Table 5.8: Timeline for Submission of EE Targets for Pacific Countries

Name of the Country	Submission Timeline
Cook Islands	July 2013
Papua New Guinea	August 2014
Samoa	February 2015
Tonga	June 2014
Vanuatu	July 2014

The project team developed a generic tool that allows capturing data from the surveys and allows specific default values to be used in carrying out the analysis. This spreadsheet tool helps determine energy efficiency targets for the years 2020, 2025 and 2030 for the PDMCs. Based on data inputted for a set of energy and economic parameters, the end-use energy savings for each PDMC are projected for three scenarios – conservative, moderate and aggressive. The methodology used for projecting the energy savings for each of the scenarios is explained in detail below: [1]

1 Only for Samoa, most of the required data was available. Hence bottom-up approach was used i.e. category level consumption was projected first. However, in case of other 4 PDMCs the data availability was limited. Hence top-down approach was used i.e. total (all the categories) consumption was projected first and apportioned to each category based on available data or assumptions.

Step 1: Assemble historical data on electricity consumption by end-use sector
This step involves assembling annual data on electricity consumption and number of customers for the period 2000 to 2012.

Step 2: Calculate energy consumption per customer
Using the data on electricity consumption and number of customers, the average use per customer is calculated for the historical years.

Step 3: Conduct statistical analysis of the consumption data
Conduct regression analysis to develop the best fit for the total consumption and consumption per customer by sector using the historical data. The variables used in the regression analysis include number of customers, price, year, and GDP/capita. Identify the best equation that fits the historical data. Simultaneously, also calculate the compounded annual growth rate (CAGR).

Step 4: Select the approach for developing baseline forecast of energy use by sector
The baseline forecast can be made, depending on the results of the regression analysis, using any of the following methods:

- Projecting the growth in energy consumption per customer and the number of customers using the CAGR.
- Projecting the growth in energy consumption using the results of the regression analysis.
- Projecting the growth in energy consumption per customer using CAGR and projecting the number of customers using the results of the regression analysis.

The baseline forecast will provide energy consumption (in MWh) by sector. The sectors used in the analysis are:

- Residential
- Commercial
- Government
- Hotels
- Other (includes industrial, religious and schools)

Step 5: Estimate energy consumption by end use
For each sector estimates of the percentage of the total by end use are developed using available data. For example, for the Residential sector, the estimates are based on the results of the end use survey.

Step 6: Develop projections of energy consumption by end use
Using the percent distribution by end use from Step 5 and the sector projections from Step 4, estimates of energy use by end use by sector are then developed.

Step 7: Calculate technical potential for energy efficiency
The technical potential defines the maximum energy savings possible if all existing and new energy using devices were installed with the best available technologies. Based on a review of available technologies, limited data available from PEEP1 and other studies and reports, available reports and studies from other Pacific island countries, estimates of the percent technical potential have been made.

Step 8: Define policy scenarios
Three different policy scenarios have been defined. These are abeled as:

- Conservative
- Moderate
- Aggressive

As indicated by their names, these scenarios represent different levels of actions on the part of the government.

Step 9: Calculate economic potential for energy efficiency
The economic potential defines the portion of the technical potential that can be economically implemented by the energy user. This reflects the fact that some of the technical potential is not economic due to prices, implementation constraints, lack of available financing, and other barriers. Estimates of economic potential have been made using the project team's knowledge, experience and judgment.

Step 10: Calculate achievable potential for energy efficiency
For each policy scenario, the levels of "achievable" energy savings (in percent) are defined for existing and new appliances or equipment based on the policies included in the scenario. This is done separately for existing appliances and equipment and new appliances and equipment as described below.

The existing appliances and equipment will "decay" over time as old appliances and equipment end their lifetime, and are replaced by new ones. Therefore the methodology assumes "vintaging" and allows for some of the existing appliances to be retired each year (by a percentage represented by one over the lifetime in years) and added to the new appliances and equipment for that year. Applying the percentages for technical, economic and achievable savings to the stock of existing and new appliances and equipment provides the savings estimates for each policy scenario.

Step 11: Selecting the policy scenario and related energy savings targets
In the final step, the appropriate mix of policy options (scenario) is selected and the corresponding energy savings then provide the targets for energy savings.

The Figure 5.5 provides an overview of the methodology.

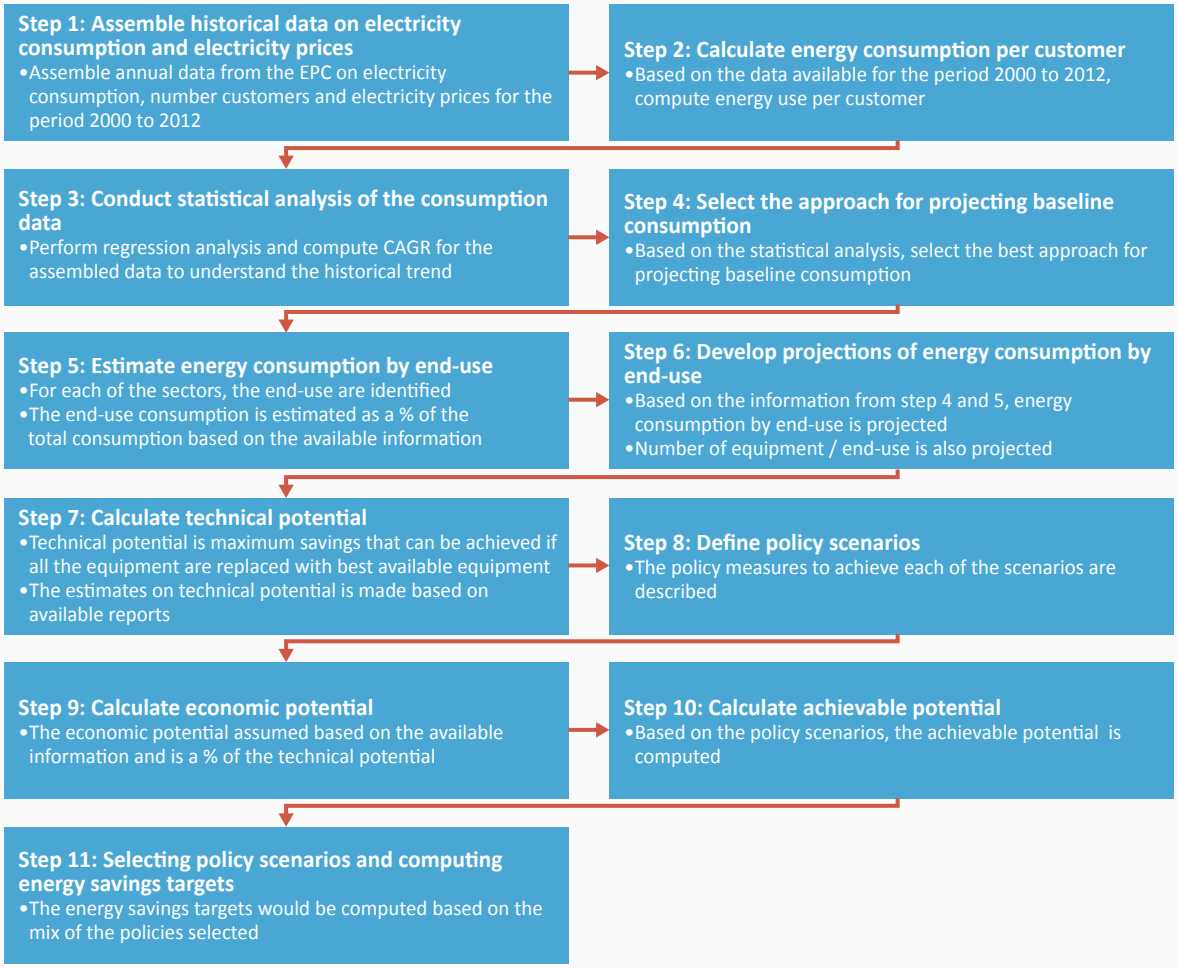

Figure 5.5: Overview of the Methodology

The results generated based on the methodology above and the data available are summarized for the 5 PDMCs in the Figure 5.6 below:

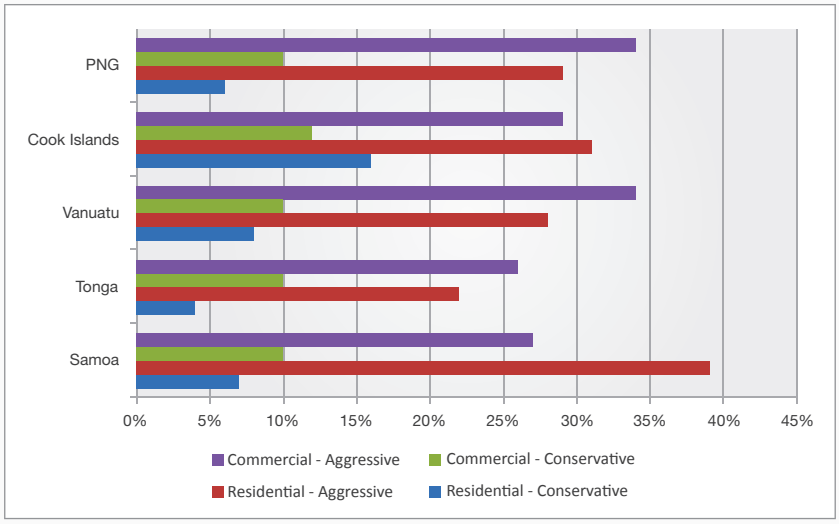

Figure 5.6: Range of EE Targets for Pacific Island Countries

A summary of range of EE targets for each of the pacific island countries under various scenarios is shown in the Table 5.9 below:

Table 5.9: EE Targets Range for Various Countries

Country	Residential Consumption Growth Rate	Residential EE Targets Range	Commercial Growth Rate	Commercial EE Target Range
Cook Islands	2.9%	16% – 31%	2.9%	12% – 29%
PNG	10.6%	6% – 29%	5.0%	10% – 34%
Samoa	3.1%	7% – 39%	3.9%	10% – 27%
Tonga	2.2%	4% – 22%	2.2%	10% – 26%
Vanuatu	7.3%	8% – 28%	5.0%	10% – 34%

5.3.1.1 Cook Islands

The EE targets were developed for Cook Islands based on the spreadsheet model developed for the activity. Under the business as usual scenario, the total energy consumption is projected to increase from 33,500 MWh in 2013 to 54,800 MWh in 2030. As the sectoral information was not available, it was assumed that residential consumption is 40% of the total consumption, commercial consumption is 45% of the total consumption and consumption from other categories is 15% of the total consumption. Based on these assumptions and the projections for total consumption, the residential consumption is expected to increase from 13,400 MWh in 2013 to 21,900 MWh in 2030. Similarly, the commercial consumption is expected to increase from 15,000 MWh in 2013 to 24,670 MWh in 2030.

Assumptions were taken on improvements in inefficient appliances and growth rate in efficient and inefficient appliances for residential category and on improvements in specific energy consumption for commercial category. Accordingly, EE savings were projected for various categories for 3 scenarios viz. conservative, moderate and aggressive. The results thus obtained are shown in Figure 5.7 to Figure 5.9 below:

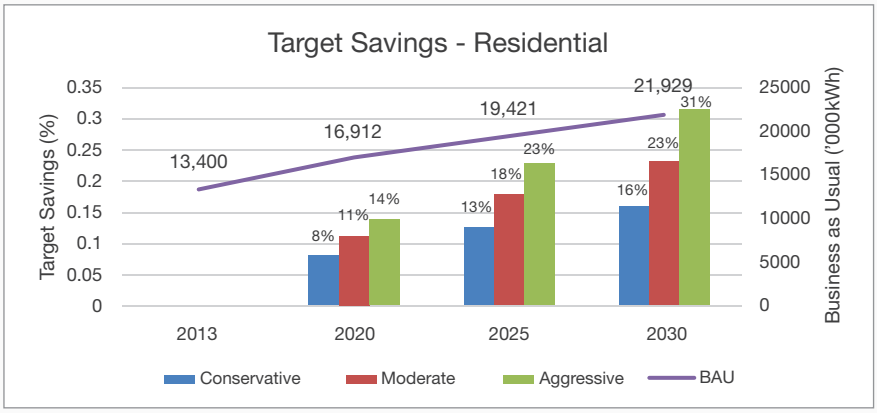

Figure 5.7: EE Targets for Residential Category in the Cook Islands

By 2030, in the residential sector the savings is projected to be 16% in conservative scenario and about 31% in aggressive scenario.

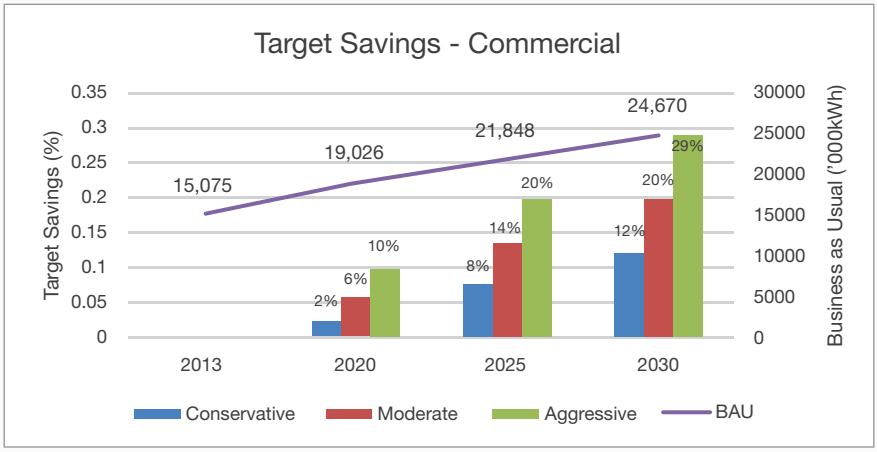

Figure 5.8: EE Targets for Commercial Category in the Cook Islands

For commercial sector, the savings in 2030 is projected to be 12% and 29% for conservative and aggressive scenarios respectively.

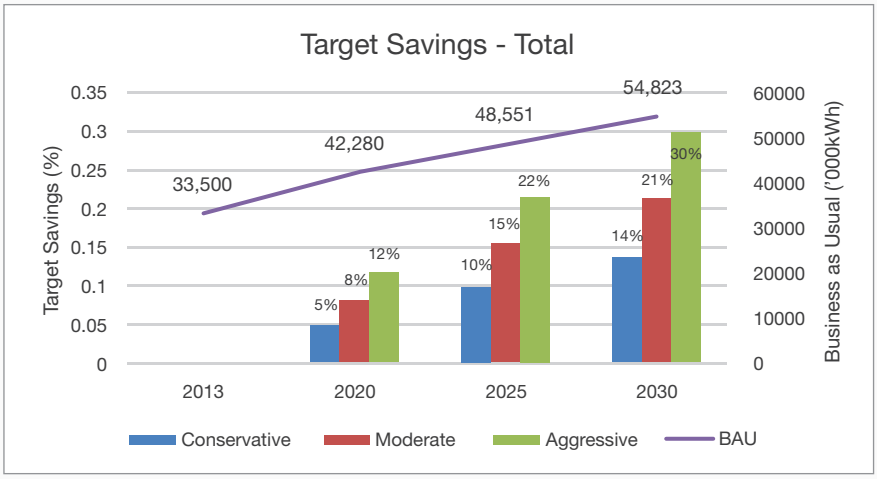

Figure 5.9: EE Targets for the Cook Islands

The savings in 2030 for Cook Islands is projected to be 12% and 29% for conservative and aggressive scenarios respectively. The Energy Efficiency Targets Report for the Cook Islands is given in **Appendix 2.1**.

5.3.1.2 Papua New Guinea

Under the business as usual scenario, the total energy consumption is projected to increase from 829,500 MWh in 2013 to 2567,400 MWh in 2030. Sectoral information was available for 3 years based on which the residential consumption was assumed as 19% of the total consumption, commercial consumption was assumed as 59% of the total consumption and consumption from other categories was assumed as 22% of the total consumption. Based on these assumptions and the projections for total consumption, the residential consumption is expected to increase from 161,200 MWh in 2013 to 889,700 MWh in 2030. Similarly, the commercial consumption is expected to increase from 486,500 MWh in 2013 to 1114,900 MWh in 2030.

Assumptions were taken on improvements in inefficient appliances and growth rate in efficient and inefficient appliances for residential category and on improvements in specific energy consumption for commercial category. Accordingly, EE savings were projected for various categories for 3 scenarios viz. conservative, moderate and aggressive. The results thus obtained are shown in Figures 5.10 to 5.12.

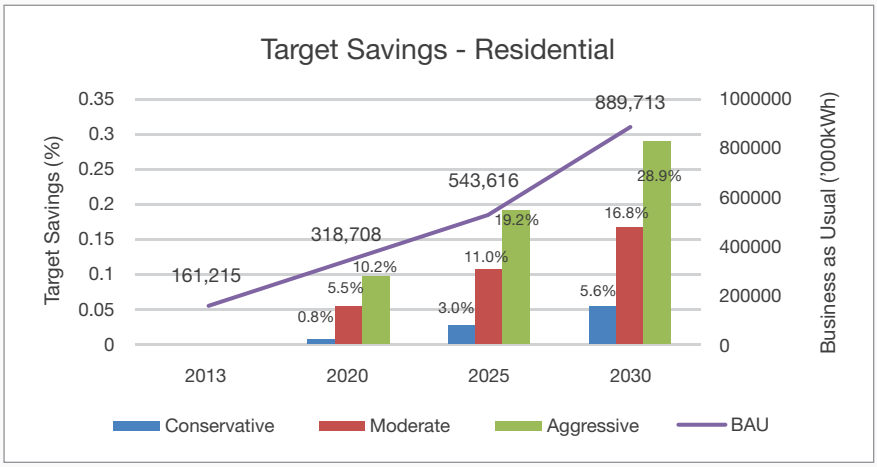

Figure 5.10: EE Targets for Residential Category in PNG

By 2030, in the residential sector the savings is projected to be 6% in conservative scenario and about 29% in aggressive scenario.

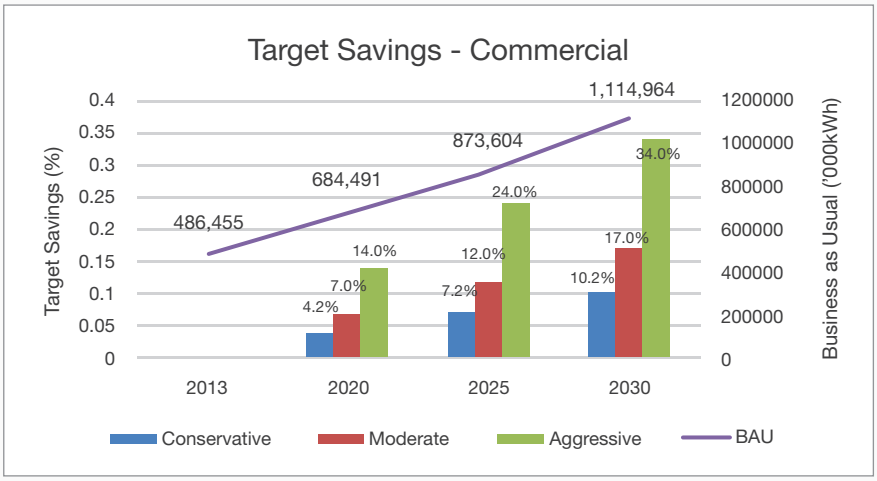

Figure 5.11: EE Targets for Commercial Category in PNG

For commercial sector, the savings in 2030 is projected to be 10% and 34% for conservative and aggressive scenarios respectively.

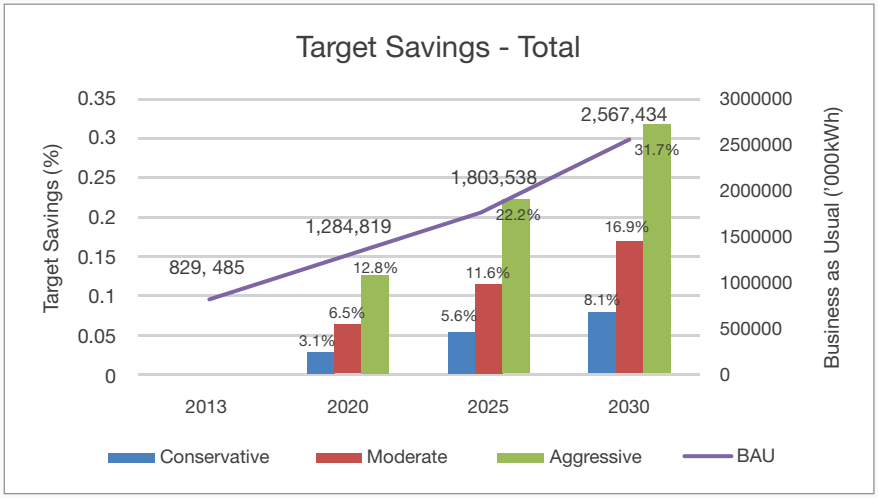

Figure 5.12: EE Targets for PNG

The savings in 2030 for PNG is projected to be 8% and 32% for conservative and aggressive scenarios respectively. The Energy Efficiency Targets Report for Papua New Guinea is given in **Appendix 2.2**.

5.3.1.3 Samoa

Sectoral data was available for Samoa and the consumption under the business as usual was projected till 2030 based on specific energy consumption and number of customers. For the residential sector, the consumption is expected to increase from 27,000 MWh in 2013 to 45,100 MWh in 2030. For the commercial sector, the consumption is expected to increase from 40,500 MWh in 2013 to 78,100 MWh in 2030. The total energy consumption is expected to increase from 92,000 MWh in 2013 to 154,300 MWh in 2030.

Assumptions were taken on technical potential, economic potential and achievable potential for each sector, scenario and end-use. Accordingly, EE savings were projected for various categories for 3 scenarios viz. conservative, moderate and aggressive. The results thus obtained are shown in Figures 5.13 to 5.15 below.

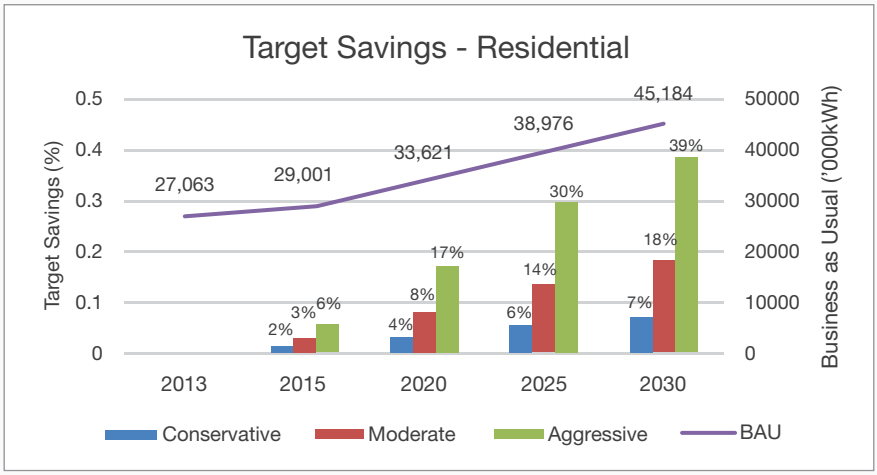

Figure 5.13: EE Targets for Residential Category in Samoa

By 2030, in the residential sector the savings is projected to be 7% in conservative scenario and about 39% in aggressive scenario.

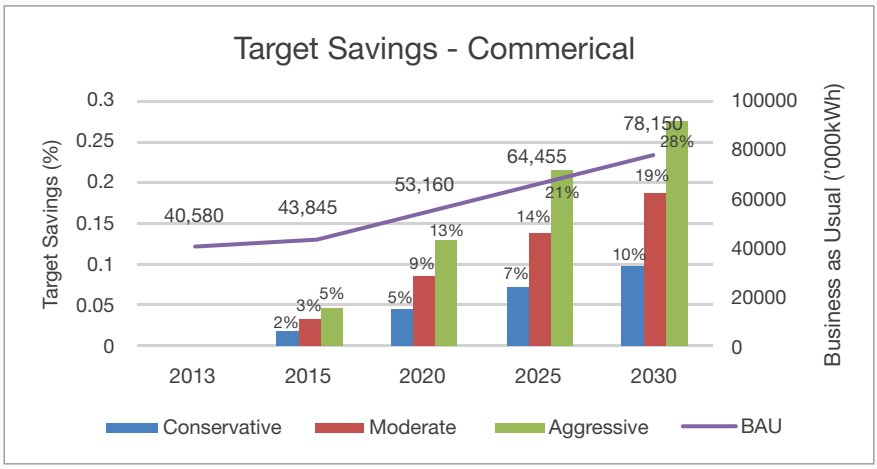

Figure 5.14: EE Targets for Commercial Category in Samoa

For commercial sector, the savings in 2030 is projected to be 10% and 28% for conservative and aggressive scenarios respectively.

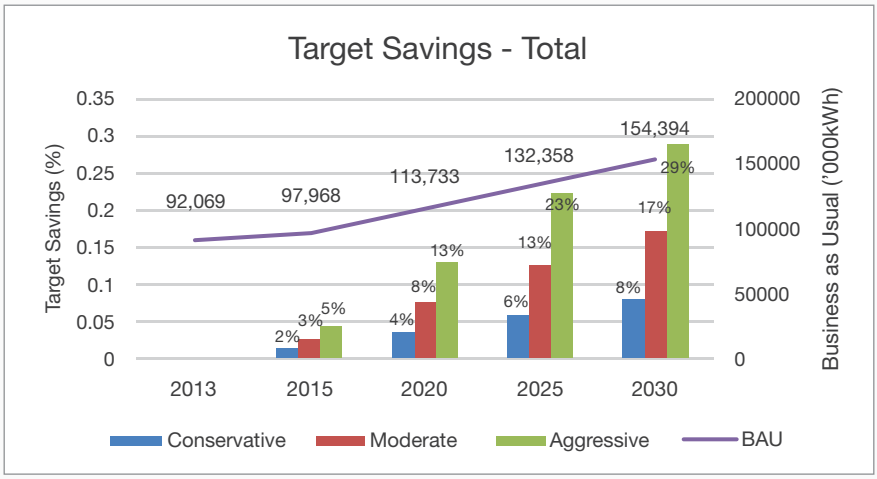

Figure 5.15: EE Targets for Samoa

The savings in 2030 for Samoa is projected to be 8% and 29% for conservative and aggressive scenarios respectively. Samoa Energy Department is now moving forward with a 17% EE target. The Energy Efficiency Targets Report for Samoa is given in **Appendix 2.3**.

5.3.1.4 Tonga

Under the business as usual scenario, the total energy consumption is projected to increase from 50,500 MWh in 2013 to 72,600 MWh in 2030. As the sectoral information was not available, it was assumed that residential consumption is 42% of the total consumption, commercial consumption is 28% of the total consumption and consumption from other categories is 30% of the total consumption. Based on these assumptions and the projections for total consumption, the residential consumption is expected to increase from 21,200 MWh in 2013 to 30,400 MWh in 2030. Similarly, the commercial consumption is expected to increase from 14,100 MWh in 2013 to 20,300 MWh in 2030.

Assumptions were taken on improvements in inefficient appliances and growth rate in efficient and inefficient appliances for residential category and on improvements in specific energy consumption for commercial category. Accordingly, EE savings were projected for various categories for 3 scenarios viz. conservative, moderate and aggressive. The results thus obtained are shown Figure 5.16 to 5.18 below.

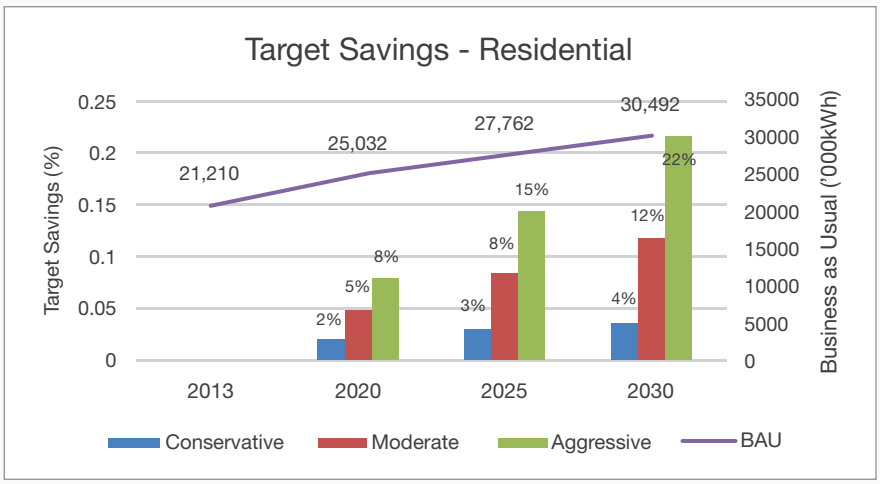

Figure 5.16: EE Targets for Residential Category in Tonga

By 2030, in the residential sector the savings is projected to be 4% in conservative scenario and about 22% in aggressive scenario.

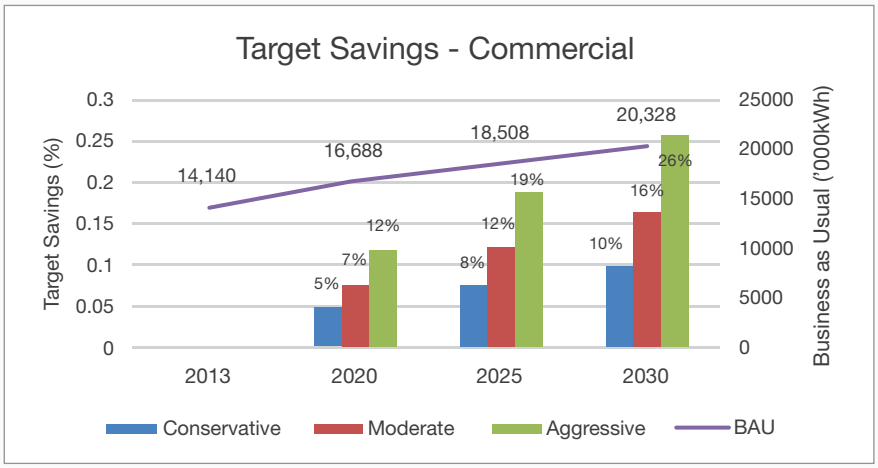

Figure 5.17: EE Targets for Commercial Category in Tonga

For commercial sector, the savings in 2030 is projected to be 10% and 26% for conservative and aggressive scenarios respectively.

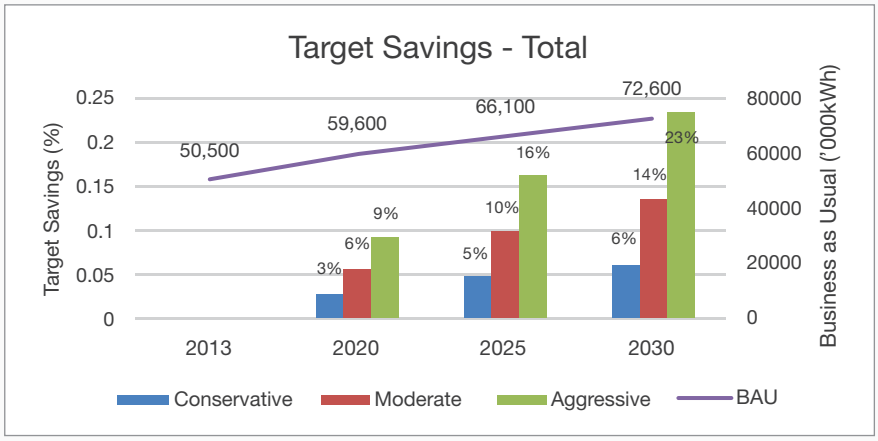

Figure 5.18: EE Targets for Tonga

The savings in 2030 for Tonga is projected to be 6% and 23% for conservative and aggressive scenarios respectively. The Energy Efficiency Targets Report for Tonga is given in **Appendix 2.4**.

5.3.1.5 Vanuatu

Under the business as usual scenario, the total energy consumption is projected to increase from 62,000 MWh in 2013 to 166,300 MWh in 2030. As the sectoral information was not available, it was assumed that residential consumption is 35% of the total consumption, commercial consumption is 55% of the total consumption and consumption from other categories is 10% of the total consumption. Based on these assumptions and the projections for total consumption, the residential consumption is expected to increase from 21,700 MWh in 2013 to 71,400 MWh in 2030. Similarly, the commercial consumption is expected to increase from 34,000 MWh in 2013 to 78,200 MWh in 2030.

Assumptions were taken on improvements in inefficient appliances and growth rate in efficient and inefficient appliances for residential category and on improvements in specific energy consumption for commercial category. Accordingly, EE savings were projected for various categories for 3 scenarios viz. conservative, moderate and aggressive. The results thus obtained are shown in Figures 5.19 to 5.21.

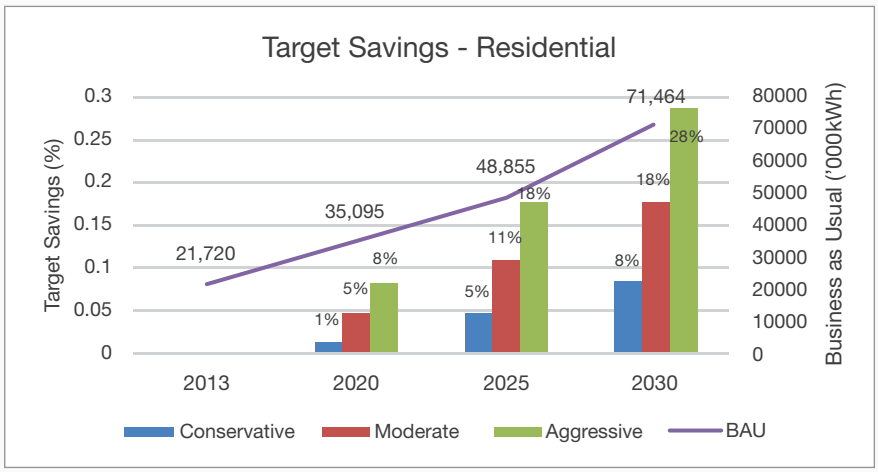

Figure 5.19: EE Targets for Residential Category for Vanuatu

By 2030, in the residential sector the savings is projected to be 8% in conservative scenario and about 28% in aggressive scenario.

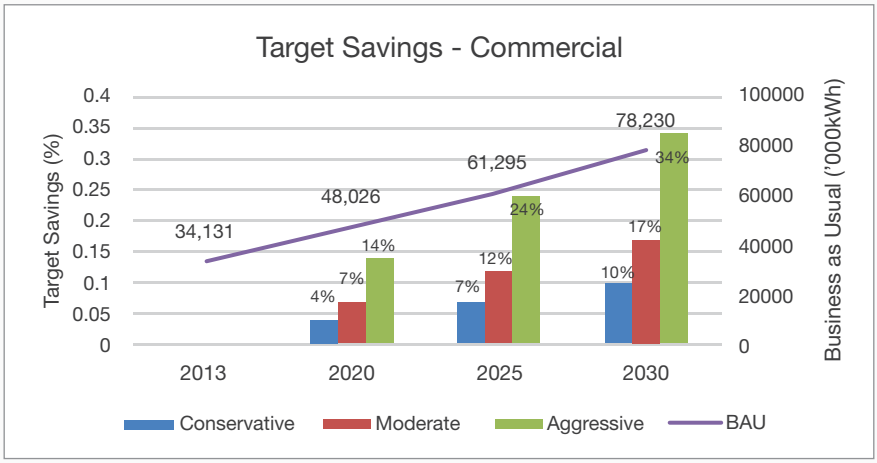

Figure 5.20: EE Targets for Commercial Category for Vanuatu

For commercial sector, the savings in 2030 is projected to be 10% and 34% for conservative and aggressive scenarios respectively

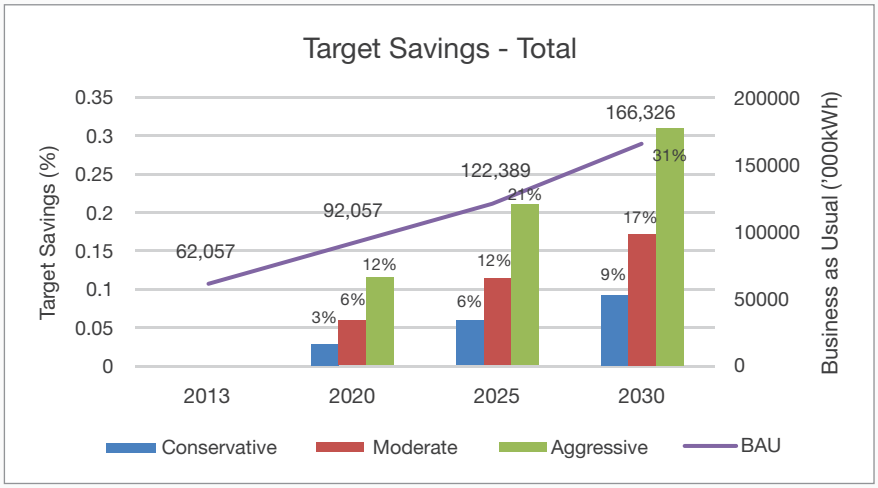

Figure 5.21: EE Targets for Vanuatu

The savings in 2030 for Vanuatu is projected to be 9% and 31% for conservative and aggressive scenarios respectively. The Energy Efficiency Targets Report for Vanuatu is given in **Appendix 2.5**.

5.3.2 Energy Performance Standards for Appliances

This activity overlapped with the Pacific Appliance Labeling and Standards (PALS) program being implemented by the Secretariat for the Pacific Community (SPC) and funded by the Australian Government. PALS was endorsed by 11 Pacific Island Countries and Territories (PICTs) including the PEEP2 countries and focused on developing regulations for minimum energy performance standards (MEPS) for a range of electrical appliances based on the Australia/NZ standards. From the perspective of PEEP2, and to avoid overlap, it was decided to provide any technical assistance to the focal points in the five PDMCs, only if requested. No formal requests for assistance have been made from any of the five PDMCs. A representative from the PEEP2 project team was included in the PALS steering committee and provided inputs to the regular meetings.

5.3.3 Energy Efficiency Building Codes and Best Practices

The outputs are summarized below.

5.3.3.1 Energy Technology Assessment

This assessment report included 4 sub-reports: i) small air conditioners ii) medium and large air conditioners including VRV/VEF systems, iii) water heaters including heat pumps and iv) summary report. The reports identified the various energy efficient technologies that are applicable in case of the PDMCs and presented findings of the assessment of these technologies. A spreadsheet tool was developed for conducting the assessment which can be uploaded to the PEEP2 website for wider use. The technology assessment was based on Cost of Conserved Energy (CCE), Net Present Value (NPV), and Internal Rate of Return (IRR) using the spreadsheet model. The evaluation of the proposed energy efficient technologies was undertaken for two scenarios, namely, (i) replacement of old technologies by new technologies, and (ii) purchase of new technologies for new installations. This document presents the summary of findings for the assessment of the proposed energy efficient technologies undertaken for the PDMC's. The 4 sub-reports and spreadsheet tool are provided in **Appendix 2.6**.

5.3.3.2 International Best Practices in New Construction

This activity included the review of existing building codes in the five PDMCs and identified opportunities to include energy efficiency attributes in those codes. This review considered the climatic conditions in the respective countries and recommendations to include energy efficiency components in the codes considering construction practices, material use and operational parameters for prevalent building types (centrally air-conditioned or otherwise).

However, the building codes in force are old, or they are poorly enforced, or they might only be applicable to certain types of buildings. Keeping this in mind, the PEEP2 team developed a proposal on building energy efficiency that has two distinct parts:

- Broad recommendations (guidelines) on energy efficiency measures for designing highly energy efficient buildings considering the Pacific region climate zones. These recommendations are based on a high-level understanding of the climate zones and desktop research to identify appropriate energy efficiency measures.

- Review of existing building codes from the PDMCs and identification of specific clauses within the codes where energy efficiency requirements could be included OR identification of an appropriate building energy efficiency code for customization and adaptation based on stakeholder input.

The report and a summary presentation are given in **Appendix 2.7**.

5.3.3.3 Green Hotels Rating Schemes

There are currently many certification schemes available for green hotels around the world. Several of them are regional certification schemes like Green Seal, Certification for Sustainable Tourism (CST), etc. Others are globally well known such as Green Globe, Green Key, Sustainable Tourism Eco-certification Program (STEP), etc. This report describes the key characteristics of major certification programs available worldwide to identify their applicability and suitability to the Pacific island nations being addressed in PEEP2. The strengths and weaknesses of the programs were analysed and a table comparing the different schemes was prepared to understand their similarities and differences and to determine the most appropriate scheme for the PDMCs. Three programs were shortlisted, namely, EarthCheck, Green Globe and Green Key; and a detailed review were conducted.

A detailed analysis of the three shortlisted schemes led to the recommendation of *EarthCheck* as the most appropriate for the PDMCs. A roadmap for implementation was prepared, including information on stakeholder participation and roles. One of the major hurdles to implementation of such a scheme is the lack of funding and hence, the importance of funding and marketing to increase awareness has been addressed and potential funding mechanisms have been identified. The report and summary presentation are included in **Appendix 2.8**.

5.3.3.4 Green Buildings Scheme

The purpose of this study was to recommend the regional adoption of a voluntary green building rating scheme in the South Pacific, adapted from an appropriate, current green buildings rating program. Green building rating schemes provide a framework for assessment and third-party verification of the environmental performance of a building; more often than not, this includes a strong emphasis on the energy performance of the building.

After conducting a comprehensive survey of the broad landscape of green building rating schemes, the focus of this study was to identify international rating schemes that are easy to use and have a low cost of implementation, and are being used in other countries besides their own and schemes that are popular and globally recognized, as well as regionally developed rating schemes. In keeping with these criteria, six rating schemes were compared so as to gain a better understanding of their characteristics and differences:

- Building Environmental Assessment Method (BEAM) (Hong Kong),
- Building Research Establishment Environmental Assessment Method (BREEAM) (UK),
- Comprehensive Assessment System for Built Environment Efficiency (CASBEE) (Japan),
- Green Mark (Singapore),
- Green Star (Australia), and
- Leadership in Energy and Environmental Design (LEED) (USA).

Based on these exploratory comparisons, three rating schemes, i.e. **Green Mark, Green Star** and **LEED** were chosen for a closer look and consideration for adoption in the PEEP2 Pacific Developing Member Countries (PDMCs). Following a careful consideration of all of the aspects that reviewed under this study, the PEEP2 team recommended that the LEED rating system be adopted for use in the PEEP2 PDMCs (and possibly in other PDMCs and PICs as well). Over time, the PEEP2 team recommended the approach of licensing LEED from USGBC for adoption, customization and use in the PDMCs, accompanied perhaps by the formation of a Pacific Green Building Council (including but not limited to the 5 PEEP2 PDMCs). The report and summary presentation are included in **Appendix 2.9**.

5.3.3.5 EE Assessment Guidelines, Framework and Scorecard

One of the key outputs of the PEEP2 project is to support EE policy design and implementation as well as to explore the replication of these EE policies, programs, plans and projects across the Pacific and particularly the nine other ADB PDMCs not covered under PEEP2. The PEEP2 team developed the concept of EE Assessment Guidelines, Framework and Scorecard to enable the PDMCs to understand and independently evaluate their policies, provide guidance on how they can improve energy efficiency in their country, and provide a set of indicators/criteria to track their progress.

Such an EE Assessment Framework and Scorecard has been successfully applied by the World Bank in the Western Balkan countries in Europe (World Bank 2013). Another international assessment framework for country level EE assessment was developed by the American Council for an Energy Efficient Economy (ACEEE 2012). Also the International Energy Agency (IEA) has developed the IEA International Scorecard. Based on a review of these three frameworks, the World Bank framework was selected as the basis to develop a specific assessment framework, along with a guideline and scorecard suited to the Pacific. In addition, the framework developed in this project can provide an additional benefit because the EE Assessment and

Scorecard report specifies general and country-specific recommendations which illustrate how governments and other key stakeholders can further improve EE implementation.

The principal objectives of this activity were to:

- Review the research on EE Frameworks and Scorecards developed by the World Bank for the Western Balkan countries, the ACEEE International EE Scorecard for developed countries, and the IEA International Scoreboard, and define how these frameworks can be modified and adapted to the PDMCs.
- Assess the current situation in each participating PDMC and develop the information and criteria for selecting the key elements of the Framework.
- Develop a customized Assessment Framework and develop the Scorecard to identify the progress made by each PDMC towards effective implementation of EE projects.
- Provide Guidelines on the Assessment Framework to inform the PDMCs how they can improve their EE Scorecard.
- Identify the key gaps and recommend actions to overcome these.

The assessment conducted in this project lead to the identification of a number of common gaps or deficiencies across the five PEEP2 PDMCs with respect to scaling up EE implementation. Figure 5.22 illustrates these.

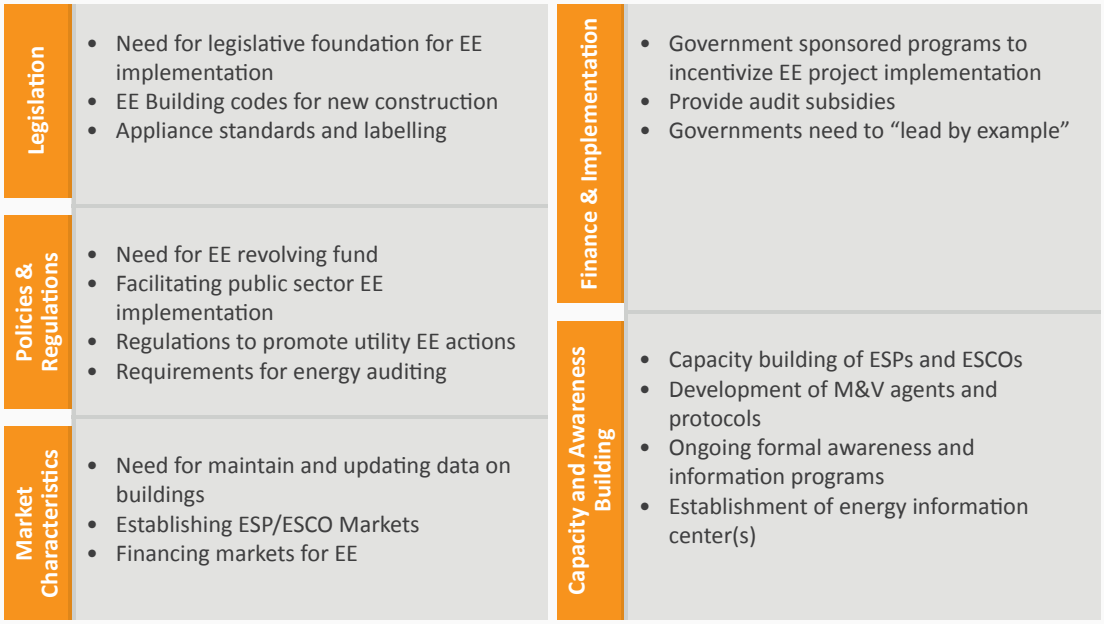

Figure 5.22: Common Gaps to Scaling up EE Implementation

It is quite likely that these gaps also exist in the other 9 ADB PDMCs. Most of the PDMCs are likely to need donor assistance to bridge these gaps.

Potential Regional Initiatives to facilitate and Promote EE Implementation

The Pacific region provides many examples of regional initiatives that can benefit some or all PDMCs. For example, the SPC has led the donor-assisted PALS program (SPC 2013), utility benchmarking program (PPA 2011), and the development of the Framework for Action on Energy Security in the Pacific: 2010-2010 (SPC 2011). It is recommended that ADB and/or other donors undertake regional programs to address the gaps identified in this project relative to scaling up implementation of EE initiatives in the Pacific.

Specifically, it is recommended that the following regional actions be initiated to assist all the PDMCs:

1. Development of a template for a national energy efficiency law that can be adapted to the specific requirements of each country.
2. Preparation of the provisions for a standard energy efficiency building code for Pacific nations.
3. Development of guidelines for establishing and operationalizing and energy efficiency revolving fund.
4. Development of guidelines and procedures and suggested regulations for facilitating EE implementation in the public sector.
5. Development of legislative and regulatory guidelines requiring utility actions to promote EE through demand-side management (DSM) activities and/or energy efficiency obligations (EEOs).
6. Development of regional database and benchmarking of building energy consumption for different building types.
7. Development of a financing framework and guidelines to facilitate =commercial financing for energy efficiency projects.
8. Preparation of guidelines for governments to incentivize EE project implementation both in the public and the private sectors.
9. Development of customized protocols for measurement and verification (M&V) of energy savings from EE projects.
10. Training and capacity building programs for energy service providers.

The EE Assessment Guidelines, Framework and Scorecard Report is given in **Appendix 2.10**.

5.3.4 Energy Audit Training and Capacity Building

The implementation of energy efficiency in the PDMCs requires substantial capacity building, and one of the main areas identified is energy auditing. Under the PEEP2 project, a comprehensive energy audit training program covering the whole energy Project Development Cycle, as shown in Figure 5.23, was designed and implemented over a two year period. The energy audit training program focused on walk-through, detailed and investment grade energy audits and these modules were implemented in the five (5) PDMCs from July 2013 to October 2014.

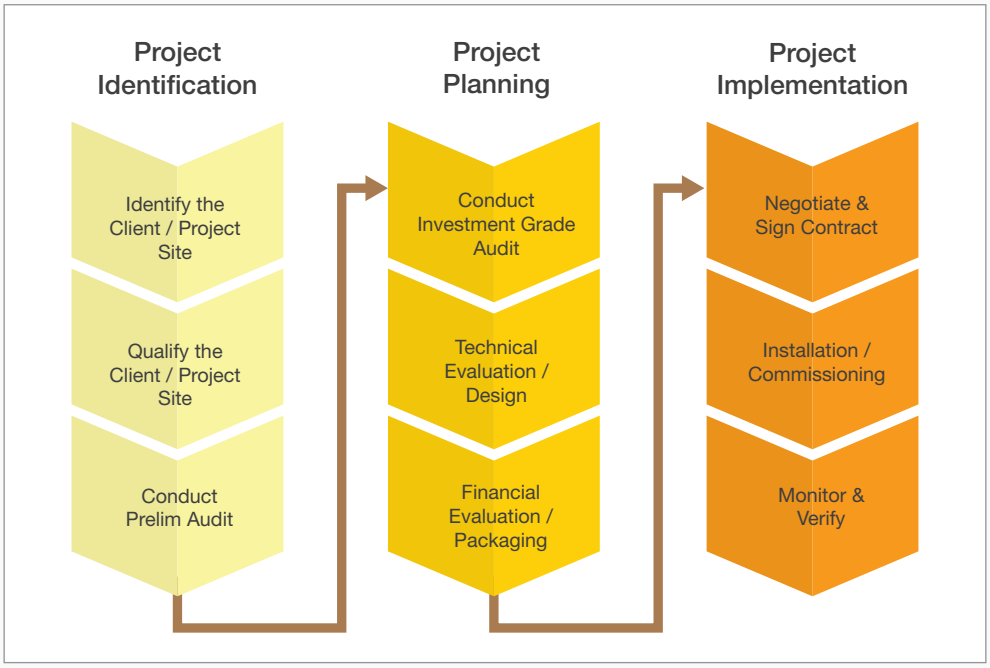

Figure 5.23: Energy Project Development Cycle

5.3.4.1 Proposed Energy Audit Training Program

The overall objective of the training program is to build capacity of the professionals on the five (5) PDMCs on energy auditing skill sets so that the local experts can provide continuous support to the government departments, building owners, industries and households to conduct energy audits. Prior to development of the energy audit training program, the PEEP2 project team conducted quick walk-through audits at some sites during the in-country visits to gain an understanding on the type of skill sets the local experts should possess in order to conduct meaningful audits. Based on the information and data acquired, the proposed energy audit training program was designed to address the whole energy Project Development Cycle.

5.3.4.2 Structure of the Energy Audit Training Program

The proposed structure of the Energy Audit Training Program consisted of three basic to intermediate training modules and one advanced training module. Each of the basic-intermediate training modules included a combination of classroom training, field visits (or on-the-job training), and assignments during/after the field visits. As for the advanced training module, (focusing on Investment Grade Audit or IGA), the content focused on hands-on training, measurement of energy use, analysis of measurement results, and preparation of IGA reports. The basic structure of the energy audit training program is summarized in Table 5.10 below.

Table 5.10: Basic Structure of the Energy Audit Training Program

Module	Classification	Description	Duration	Participants (maximum)
1	Basic	Walk-Through Energy Audit Training	2 days	30
2	Intermediate	Technical and Financial Evaluation	2 - 4 days	30
3	Intermediate	Contracting, Project Management, and Measurement & Verification of Energy Efficiency Projects	3 days	15
4	Advanced	Detailed Energy Audit (Investment Grade Audit – IGA)	3 - 4 days	15

Note: Duration of each module was adjusted depending upon number of audit sites and on-site exercises included in the training.

The overall energy audit training program was separated into two separate training courses of about a week's duration each, described below:

- Basic and Intermediate Energy Auditing (Module 1 and 2): and
- Intermediate and Advanced Energy Auditing (Module 3 and 4).

The training program was designed to be practical in nature by selecting an actual site in each PDMC. At the end of each training course, trainees were required to prepare reports/presentations to demonstrate their understanding and findings from on-site energy audit activities. As for Module 3 and 4, a detailed audit report or an IGA Report was prepared for the selected site in each PDMC at the end of training. However, this was dependent upon an agreement established with the project site owner. Basic contents of each training module are described in **Appendix 2.11**.

5.3.4.3 Implementation of the Energy Audit Training Program

The energy audit training program was conducted by a team of International Training Consultants as summarized in Table 5.11 below.

Table 5.11: Training Consultants for the Energy Audit Training Program

Training Consultant	Position
Mr. Sommai Phon-Amnuaisuk	Energy Audit and EE Project Specialist (Team Leader)
Ms. Angelica Dealino	Economic and Finance Specialist
Mr. Arturo Zabala	Energy Audit Equipment and Monitoring and Verification Specialist
Ms. Sirikul Prasitpianchai	Energy Technology and Procurement Specialist
Mr. David Morgado	Energy Project Management Specialist

The training courses for Module 1 and 2 were organized from the week of 29 July 2013 to the week of 30 September 2013. It should be noted that Tonga made a request to the PEEP2 project team for an initial audit training in Tongatapu to create awareness and stimulate interest among local stakeholders. This initial audit training was conducted in February 2013. The final training schedules in the five PDMCs are given in Table 5.12 below.

Table 5.12: Final Training Schedules in the Five PDMC

Country	Training Schedule	No. of Trainees
Modules 1 ad 2		
Tonga /1	29 July – 1 August 2013	7
Samoa	20 – 23 August 2013	25
Papua New Guinea	27 – 30 August 2013	17
Cook Islands	23 – 26 September 2013	20
Vanuatu	1 – 4 October 2013	19
Modules 3 ad 4		
Cook Islands	2 – 9 April 2014	14
Tonga	21 – 28 May 2014	12
Papua New Guinea	11 – 18 June 2014	21
Vanuatu	2 – 9 July 2014	9
Samoa	17 – 24 September 2014	14

Note: /1 The initial energy audit in Tonga was organized in Tongatapu from 21 – 22 February 2013

5.3.4.4 Evaluation of the Training

Evaluation of the Modules 1 and 2 training in each PDMC focused on:

- **Participants' reaction**: This evaluation aims at measuring the participants' satisfaction to the training course, conduct of the course, course content, etc, and provides an immediate feedback on the level of success of the program.
- **Learning from training**: This is to measure the benefits the participants received (learning) from the training course. This includes concepts, facts and techniques absorbed by the participants for use, which provides evidence on the training program's effectiveness.

After completion of each training module, the training consultant team distributed training evaluation forms/questionnaires to assess the trainees' reaction to the training and also to assess the amount of

learning that has taken place. Findings from the evaluation forms show that all trainees in the five (5) PDMCs were highly satisfied with the Module 1 and 2 training course, and more than 95% of the trainees rated the training between "Good" and "Excellent". The overall ratings of the Module 1 and 2 training are illustrated in Figure 5.24. As for the amount of learning taken place per the training objectives, the trainees have indicated that their levels of knowledge have been greatly enhanced as shown in Figure 5.25 and Figure 5.26.

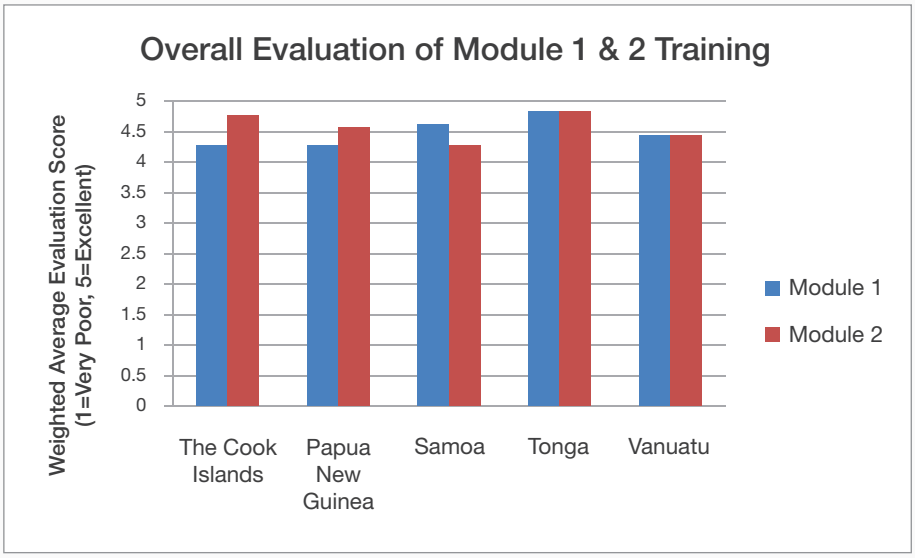

Figure 5.24: Overall Evaluation of Module 1 and 2 Training

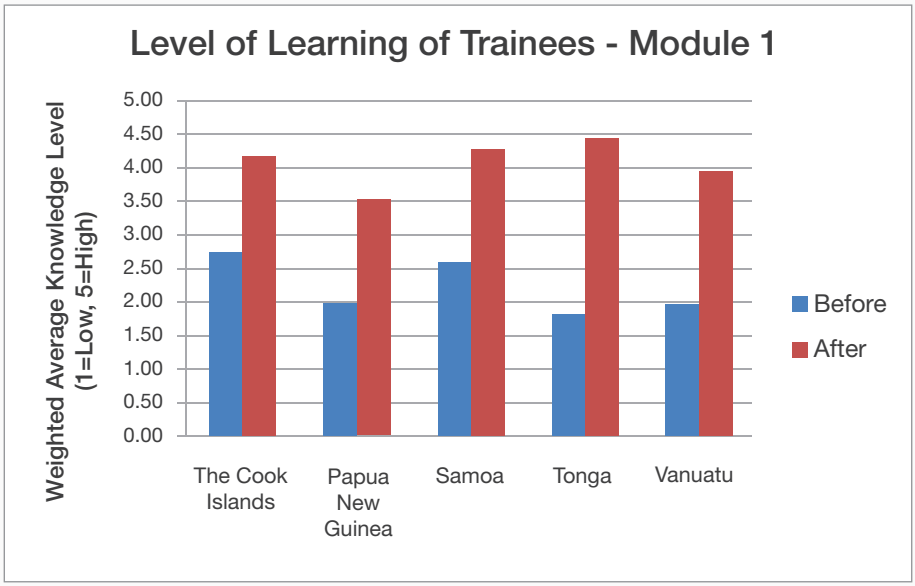

Figure 5.25: Level of Learning of Trainees – Module 1

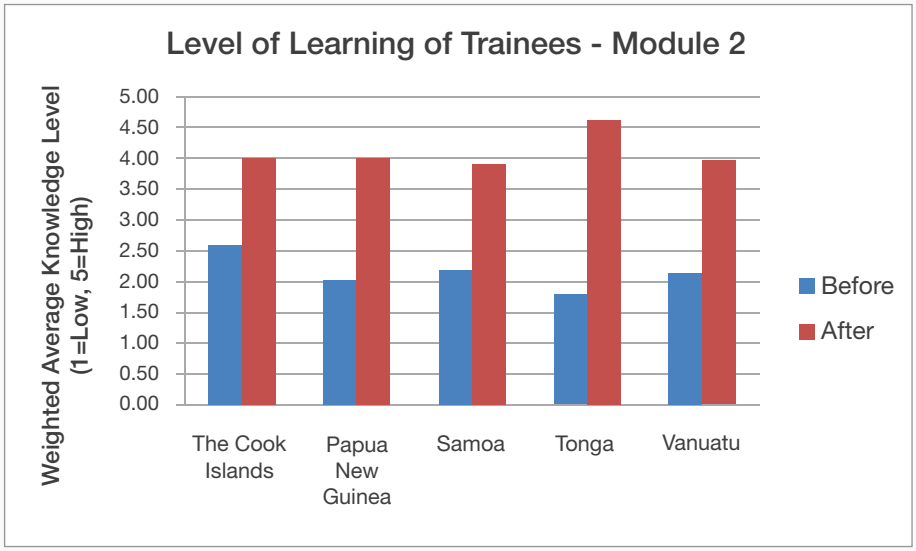

Figure 5.26: Level of Learning of Trainees – Module 2

The trainees also provided additional comments/suggestions on following up activities that the energy audit training program should consider for improvement of the effectiveness of the training program. Based on the trainees' feedback, there is clearly a need to develop additional tools/materials for trainees to revisit after completion of the energy audit training, and the high priority training tools/materials include: energy audit manual, and energy audit training kits and interactive exercises, as shown in Figure 5.27.

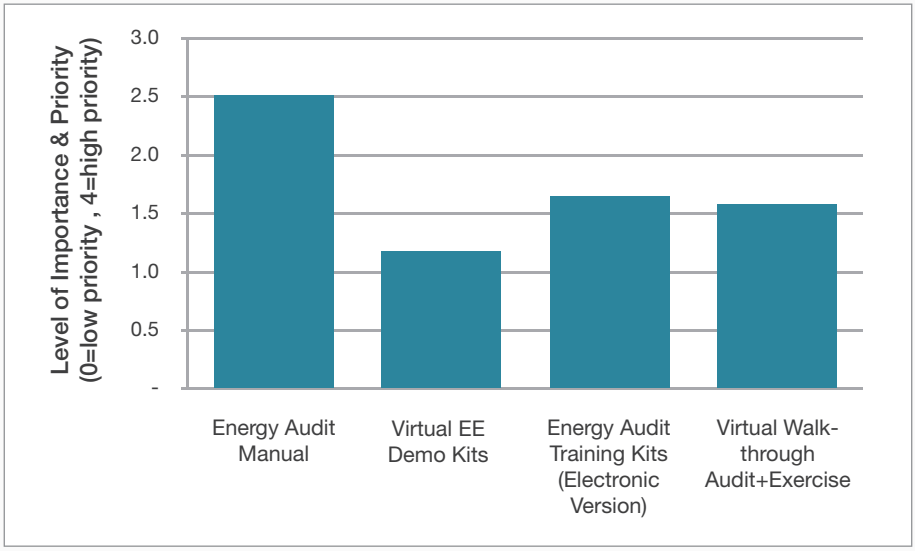

Figure 5.27: Comments to Enhance Effectiveness of the Energy Audit Training Program

Evaluation of Modules 3 and 4 training in each PDMC focus on the Learning from training which measures the benefits which the participants received as far as the learnings obtained from the training course to determine the effectiveness of the training program. The Figures 5.28 and 5.29 provides a summary of the evaluations.

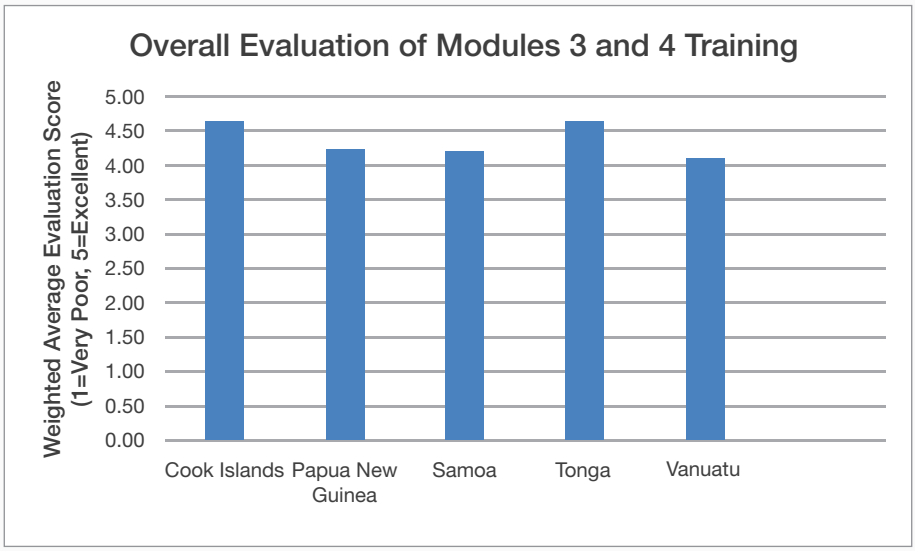

Figure 5.28: Overall Evaluation of Modules 3 and 4 Training

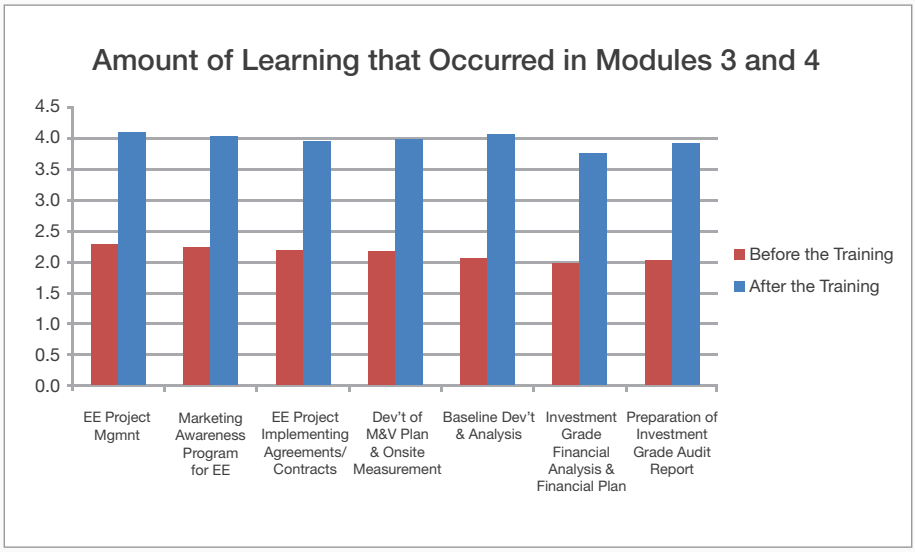

Figure 5.29: Level of Learning of Trainees – Modules 3 and 4

5.3.4.5 Country Activities

5.3.4.5.1 Cook Islands

In September 2013, an energy audit training workshop was held in the Cook Islands at Edgewater Resort. This workshop covered Module 1 (Walk-Through Energy Audit) and Module 2 (Technical and Financial Evaluation), and the workshop was declared open by the Prime Minister of the Cook Islands (Honorable Henry Puna), and 20 trainees attended this 4-day workshop during 23 – 26 September 2013 (Figure 5.30).

Figure 5.30: Attendees of the Energy Audit Training Modules 1 and 2 in the Cook Islands

The walk-through energy audit exercises focused on various facilities within the Edgewater Resort compound, and, although Edgewater Resort has endeavored to be energy efficient hotel, the initial data collection from the walk-through audit exercises have identified several EE opportunities through implementation of housekeeping and simple EE measures, such as EE lighting. The energy audit training workshop in the Cook Islands was mentioned throughout the week in the local newspapers and TV as shown in the Figure 5.31 below.

Figure 5.31: News Articles on the Energy Audit Training Workshop in the Cook Islands

Seven months after, in April 2014, an energy audit training workshop covering Modules 3 and 4 was held in the Cook Islands also at Edgewater Resorts. The Module 3 covered Contracting, Project Management, and Measurement & Verification of Energy Efficiency Projects while Module 4 covered Detailed Energy Audit (Investment Grade Audit – IGA. Fourteen (14) trainees attended this 6-day workshop during 2 – 9 April 2014 (Figure 5.32). The Module 3 was specifically scheduled Wednesday to Friday of the 1st week, while

Module 4 was held Monday to Wednesday of the next week. This is to enable the trainees to have their measurement and verification hands-on training to cover weekdays as well as weekend period for monitoring and analysis.

Figure 5.32: Attendees of the Energy Audit Training Modules 3 & 4 in the Cook Islands

Figure 5.33: Group Exercises and Hands on Training on M&V in the Cook Islands

Hands-on training for the Measurement and Verification activities were conducted in the facilities of Edgewater Resorts as well as in the Cook Island's General Hospital (Figure 5.33).

5.3.4.5.2 Papua New Guinea

The energy audit training course for Module 1 and Module 2 in PNG was conducted during the last week of August 2013 (27 – 30 August 2013). The training course was organized at the PPL's training center in Port Moresby, and attended by 17 trainees from PPL, Department of Petroleum and Energy (DPE), University of Papua New Guinea (UPNG), and St. John Hospital (Figure 5.34).

Figure 5.34: Attendees of the Energy Audit Training Modules 1 and 2 in Papua New Guinea

Through PPL's coordination, UPNG and St. John Hospital allowed the training workshop to use their facilities during the on-site walk-through energy audit sessions. Following the completion of both training modules, recommendations on EE measures together with financial evaluations were presented by groups of trainees and the findings were also shared with the representatives from UPNG and St. John Hospital (Figures 5.35 and 5.36).

Figure 5.35: Walk-Through Energy Audit Exercise in St. John Hospital (PNG)

Figure 5.36: Group Exercise and Presentation at Energy Audit Training in PNG

Eight months after, Modules 3 and 4 were conducted in PNG. This was during 11 – 18 June 2014. There were 21 participants in PNG mostly coming from the PPL and the University of PNG (Figure 5.37 and 5.38).

Figure 5.37: Attendees of the Energy Audit Training Modules 3 and 4 in PNG

Figure 5.38: M&V Activities for A/C and Lighting Systems Conducted in UPNG

5.3.4.5.3 Samoa

The Module 1 and 2 energy audit training workshop in Samoa was held at the TATTE Building in Apia during 20 – 23 August 2013. The workshop was officially opened by, Taule'ale'ausumai Laavasa Malua, the CEO of MNRE, and 25 trainees from government and private sector organizations attended this 4-day workshop (Figure 5.39 and 5.40). The Regulators office and the MNRE office buildings were designated as the walk-through audit sites. Findings from walk-through energy audit exercises and recommendations on EE measures were forwarded to MNRE for consideration.

Figure 5.39: Attendees of the Energy Audit Training Modules 1 and 2 in Samoa

Figure 5.40: Classroom Energy Audit Training and Group Exercises in Samoa

In Samoa, Modules 3 and 4 were conducted from the 17 – 24 September 2014. There were 14 participants. As in the earlier modules, the training workshop in Samoa was held at the meeting room on level 3 of TATTE Building in Apia. The hands-on training on Measurement and Verification was conducted in the office facilities of the Scientific Research Organization of Samoa (Figure 5.41 and 5.42).

Figure 5.41: Attendees of the Energy Audit Training Modules 3 and 4 in Samoa

Figure 5.42: Group Exercise and M&V in the Scientific Research Organization of Samoa

5.3.4.5.4 Tonga

The PEEP2 project team conducted an introductory energy audit workshop in Tongatapu during 21 – 22 February 2013, and the more comprehensive energy audit training course for Module 1 and 2 was organized later from 29 July to 1 August 2013. Participants of the Module 1 and 2 training were from TPL, government agencies and electrical contractors (Figure 5.43). During the walk-through audit session, trainees were assigned to conduct actual walk-through audits at the Royco building (where the TERM-IU office is located), and the Scenic Hotel (Figure 5.44).

Figure 5.43: Attendees of the Energy Audit Training Modules 1 and 2 in Tonga

Figure 5.44: Walk-Through Energy Audit at Scenic Hotel (L) and Royco Building (R)

Modules 3 and 4 were conducted in Tonga from the 21 – 28 May 2014. This was held in Tongatapu. There were 12 participants coming from the government sector, utility, academe and the private sector (Figure 5.45). The hands-on training of Measurement and Verification were conducted in the facilities of the Scenic Hotel as well as in head office of the Tonga Development Bank (Figure 5.46).

Figure 5.45: Attendees of the Energy Audit Training Modules 3 and 4 in Tonga

Figure 5.46: M&V Activities at Scenic Hotel (L) and Tonga Development Bank (R)

5.3.4.5.5 Vanuatu

Modules 1 and 2 of the PEEP2 energy audit training were carried out in Port Vila from 1 – 4 October 2013 with 19 participants, divided equally among private sector and government trainees (Figure 5.47). As part of the training, there was an updated walk-through audit of the Meteo complex (scheduled for EE lighting refits through PEEP2), the Melanesian hotel (which benefitted from PEEP1 EE support) and the DEMM offices (Figure 5.48).

Figure 5.47: Attendees of the Energy Audit Training Modules 1 and 2 in Vanuatu

Figure 5.48: Walk-Through Energy Audit Group Exercise and Presentation in Vanuatu

Modules 3 and 4 were conducted in Port Vila from the 2 – 9 July 2014. It was held at the Office of the Vanuatu Meteorological and Geo-Hazards Department which included 9 participants (Figure 5.49). The on-site monitoring & verification (M&V) activities were undertaken at the Vanuatu Meteorological and Geo-Hazards Department (Figure 5.50).

Figure 5.49: Attendees of the Energy Audit Training Modules 3 and 4 in Vanuatu

Figure 5.50: M&V Activities at Vanuatu Meteorological and Geo-Hazards Department

5.3.5 Assistance to Energy Service Providers

There was no progress in this activity in all five PDMCs primarily due to the status of the energy services industry in the Pacific. There are no known ESCOs due to the lack of demand for these services. This activity was subsequently cancelled.

5.4 Output 3: Implementation of Energy Efficiency Programs

Under this component a total of 35 projects were designed in the 5 participating PDMCs. The Project Code 16 was not implemented as there were no bidders in the procurement phase. The rest of the projects were implemented and a summary of the scope, procurement, costs & benefits and implementation schedule for each project is detailed in this section.

5.4.1 Summary of Implemented Projects

Project Code	Category	Project Name	Country
1	EE Street and Public Lighting	EE Lighting in Rarotonga Airport	Cook Islands
2	EE Street and Public Lighting	EE Lighting in Punanga Nui Market	Cook Islands
3	Residential EE Program	EE Fridge/Freezer Replacement Program	Cook Islands
4	EE measures in Public Sector	EE Air Conditioning using VRF Technology	Vanuatu
5	EE Street and Public Lighting	EE Street Lighting in Port Moresby	PNG
6	EE Street and Public Lighting	EE Lighting in Marina and Wharf	Cook Islands
7	EE measures in Public Sector	EE Measures in Public Buildings	Cook Islands
8	EE Lighting in Public Sector	EE Lighting in PPL Head Office	PNG
9	EE Lighting in Public Sector	EE lighting in Public Sector Buildings	Vanuatu
10	EE Street and Public Lighting	EE Street Lighting in Apia	Samoa
11	EE Lighting in Public Sector	EE lighting in Government Buildings	Samoa
12	EE Street and Public Lighting	EE Street Lighting in Outer Islands	Tonga
13	EE Street and Public Lighting	EE Street Lighting in Tongatapu	Tonga
14	Lamp Waste Management	Lamp Waste Treatment Equipment	All PDMCs
15	EE in Commercial Sector	EE Measures in Edgewater Resort & Spa	Cook Islands
16	EE measures in Public Sector	EE Rooftop Retrofit in PPL Head Office	PNG
17	EE Lighting in Residential Sector	Residential EE Lighting Program	Cook Islands
18	EE Street and Public Lighting	EE Street Lighting in Luganville	Vanuatu
19	EE Lighting in Residential Sector	Residential EE Lighting in Luganville	Vanuatu
20	EE Street and Public Lighting	EE Street Lighting in Port Vila	Vanuatu
21	EE Lighting in Residential Sector	Residential EE Lighting in Port Vila	Vanuatu
22	EE Lighting in Residential Sector	Residential EE Lighting in Outer Islands	Tonga

Project Code	Category	Project Name	Country
23	EE Street and Public Lighting	EE Street Lighting in Outer Islands	Cook Islands
24	EE Lighting in Public Sector	EE Luminaires in Government Buildings	Samoa
25	EE in Commercial Sector	Demonstration of EE AC Technologies	Samoa
26	EE in Commercial Sector	EE Lighting in the Commercial Sector	Samoa
27	EE in Commercial Sector	EE air Conditioning in Hotels	Samoa
28	EE Lighting in Residential Sector	Residential EE Lighting	Samoa
29	EE Lighting in Public Sector	EE lighting in Public Sector Buildings	Tonga
30	EE Lighting in Public Sector	EE Lighting in Provincial, Public Sector & Schools	Vanuatu
31	EE Lighting in Residential Sector	Residential EE Lighting in Tongatapu	Tonga
32	EE Street and Public Lighting	EE Street Lighting in Alotau	PNG
33	EE Lighting in Public Sector	EE Lighting in Port Moresby Hospital	PNG
34	EE Lighting in Public Sector	EE Lighting & Ventilation at UPNG	PNG
35	EE in Public Sector	Solar Water Heating at Rarotonga Hospital	Cook Islands

5.4.2 Project Descriptions

5.4.2.1 Project Code 1 – EE Lighting in Rarotonga Airport (Cook Islands)

Rationale

The existing lighting system for the Rarotonga airport car park was a mix of double-arm luminaires, High Pressure Sodium (HPS) flood light luminaires and stand-alone solar Light Emitting Diodes (LED) lighting systems. Double-arm luminaires and HPS flood light luminaires are connected to the grid, however most of the double-arm luminaires are not functional, and the HPS flood light is only switched on during arrival and departure of early morning flights. A total of 7 stand-alone solar LED lighting systems have been recently installed and dispersed throughout the car park area. The current lighting levels was found to be inadequate with the existing Solar/PV systems have a minimum horizontal illuminance level of 1 lux.

Design

The design approach was to install higher capacity solar lights that would provide uniform lighting to the whole car park and that would eliminate the need for flood lights and functioning double-arm mercury vapour lamps. The existing 7 solar lamps will be relocated to other areas which are inadequately lit (e.g. airport entrance) or as replacement for existing fluorescent public lighting fixtures. The design option aimed to meet IESNA RP-20-98 requirements of basic minimum horizontal illuminance and uniformity ratio (maximum to minimum) which provides an average horizontal illuminance of 5.8 lux is more than adequate to meet the lighting requirements and the design was accepted by the Airport Authority. The design incorporates LED luminaires with higher lumen output (54W – 6000 lumen) and higher mounting poles (11 meters) and is summarized in Table 5.13. The existing LED luminaires (30W – 3000 lumen) will be relocated to the airport entrance area which currently has no lighting. The Project Proposal, Design Report and other attachments are given in **Appendix 3.1**.

Table 5.13: Airport Car Park Lighting - Design Parameters

Description	Design Parameters
LED Luminaire	**8 x 54 Watt LED Luminaire (6,000 lumen)**
Solar Panel	2 x 130 Watt
Battery	2 x 150 AH
Luminaire Mounting Height	**11 meters**
No. of Lighting Poles	**8** /1
Minimum Horizontal Illuminance	2 lux
Uniformity Ratio, Maximum to Minimum	12:1
Average Value of Horizontal Lux	5.8 lux

Note: /1 Lighting poles with single mass-arm

Procurement

The project was approved by the ADB in January 2013. Bids for the lighting systems were received from 3 Suppliers and Philips Electronics (New Zealand) was selected as the contractor and the contract was awarded on 31 July 2013. The supply and erection of the lighting poles was initially in the scope of the recipient (Airport Authority); however, it was found that the poles had to be sourced from New Zealand and to a much stringent specification (category 5 cyclone) and exceeded the initial budget. As a result the supply of poles was included in ADB's scope and the poles were procured from Alrite Steel & Services (NZ).

Although the lighting systems were delivered in December 2013 the installation was delayed due to the separate procurement of poles. The installation was completed in January 2015. The layout of the solar/LED lights at the airport car park is shown in Figure 5.51 and photos of the installed system are shown in Figure 5.52.

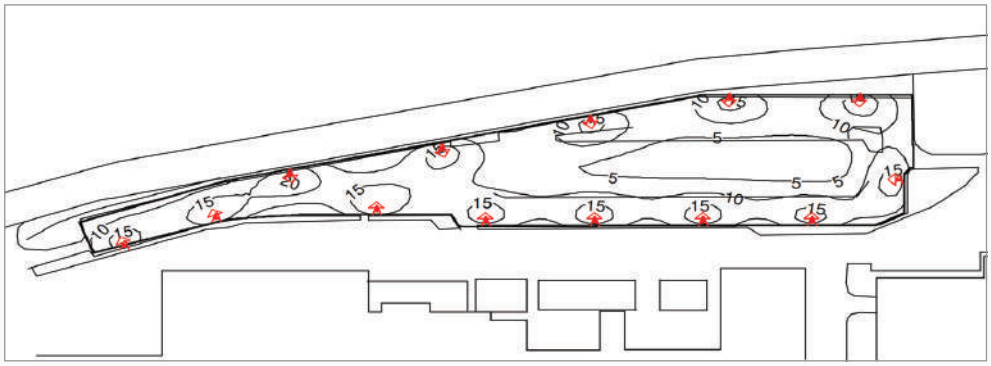

Figure 5.51: Layout of the Solar/LED Lights

Figure 5.52: Solar/LED Installations at the Airport Car Park

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
Solar/LED – Airport Car Park – Cook Islands	22,520	8,150	2,190	4.6	6.7

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	January 2013
Solar/LED Lighting System	
ADB Approval of Bid Evaluation Report	25 April 2013
Date of Contract Award	31 July 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	12 December 2013
Lighting Poles	
ADB Approval of Bid Evaluation Report	23 November 2013
Date of Contract Award	7 January 2014
Name of Supplier	Alrite Steel & Services NZ Ltd
Delivery	September 2014
Installation and Commissioning	
Status of Installation	Completed in January 2015

5.4.2.2 Project Code 2 – EE Lighting in Punanga Nui Market (Cook Islands)

Rationale

The lighting systems currently installed at Punanga Nui Market were not adequate and cover only walkway area near the main road and playground area. The existing lighting luminaires were of the double-arm globe type and there were only 7 luminaires. The rest of the market area had no permanent lighting and the market management have to hire temporary lighting and a generator for "Night Markets". Lighting measurements undertaken showed that the area under the globe luminaires covered only 14-meter span along the longitudinal direction and 10-meter span along the transverse direction as the illuminance values beyond the measurement area were negligible (lower than 1 lux). These levels do not comply with IESNA lighting design guidelines.

Design

The proposed design aimed to comply with IESNA RP-20-98 with the recommended average illuminance (11 lux for major activity area and 5 lux for minor activity area), and uniformity ratio (average to minimum, better than 3:1 for major activity area and 6:1 for minor activity area). The design divides the whole market area into 4 activity areas as follows: Playground, Middle open area, Walkway near main road and Road/Walkway around the market area.

The design proposed the installation of 21 units of 54W (6,000 lumen) Solar LED Lighting systems at 2 levels of mounting height, i.e. 10-meter (with single mast-arm) and 12-meter (double mast-arm), depending upon the illumination and uniformity required by each specific activity area. The proposed luminaire numbers and locations are shown in Figure 5.53 and the scope is summarized in Table 5.14. The Project Proposal, Design Report and other attachments are given in **Appendix 3.2**.

Figure 5.53: Proposed Luminaire Locations, Punanga Nui Market

Table 5.14: Punanga Nui Market – Design Parameters

Description	Design Parameters
Major Activity Area (Children Playground)	
Solar LED Lighting System /1	4 x 54 Watt LED Luminaire (6,000 lumen)
Luminaire Mounting Height	12 meters
No. of Lighting Poles	2 /2
Average Value of Horizontal Lux	11 lux
Uniformity Ratio, Average to Minimum	3:1

Description	Design Parameters
Minor Activity Area (Middle Open Area)	
Solar LED Lighting System /1	**8 x 54 Watt LED Luminaire (6,000 lumen)**
Luminaire Mounting Height	**12 meters**
No. of Lighting Poles	**4 /2**
Average Value of Horizontal Lux	7 lux
Uniformity Ratio, Average to Minimum	5:1
Minor Activity Area (Walkway and Road)	
Solar LED Lighting System /1	**9 x 54 Watt LED Luminaire (6,000 lumen)**
Luminaire Mounting Height	**10 meters**
No. of Lighting Poles	**9 /3**
Average Value of Horizontal Lux	6 lux
Uniformity Ratio, Average to Minimum	5:1

Notes: /1 Each Solar LED Lighting System includes 1x54W LED luminaire; 2x130W solar panel, and 2x150AH battery
/2 Lighting poles with double mast-arm
/3 Lighting poses with single mast-arm

Procurement

Bids for the lighting systems were received from 3 Suppliers and following the approval of ADB, Philips Electronics (New Zealand) was selected as the contractor. The supply and erection of the lighting poles was initially in the scope of the recipient (Punanga Nui Market); however, it was found that the poles had to be sourced from New Zealand and to a much stringent specification (category 5 cyclone) and exceeded the initial budget. As a result the supply of poles was included in ADB's scope and the poles were procured from Alrite Steel & Services (NZ).

Although the lighting systems were delivered in December 2013 the installation was delayed due to the separate procurement of poles. The installation commenced in February 2015 and will be undertaken in two phases due to budgetary constraints for civil works. The first phase includes the installation of 7 light points in March 2015 and the second phase will include the remaining lights (8) in July 2015. The lighting systems erected in the first phase are shown in Figure 5.54 below.

Figure 5.54: Solar/LED Lighting System at Punanga Nui Market

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
Solar/LED Lighting – Punanga Nui Market, Cook Islands	108,510	7,250	2,190	6.1	6.6

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	January 2013
Solar/LED Lighting System	
ADB Approval of Bid Evaluation Report	25 April 2013
Date of Contract Award	31 July 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	12 December 2013
Lighting Poles	
ADB Approval of Bid Evaluation Report	23 November 2013
Date of Contract Award	7 January 2014
Name of Supplier	Alrite Steel & Services NZ Ltd
Delivery	September 2014
Installation and Commissioning	
Status of Installation	Phase 1 – Completed in March 2015
	Phase 2 – Completion in July 2015

5.4.2.3 Project Code 3 – EE Fridge/Freezer Replacement Program (Cook Islands)

Rationale

The objective of this project was to promote the sales of high efficiency units which would result in reducing energy consumption in refrigeration by around 20%-30% on average; and as a result reducing diesel generation costs. Hence, the goal was to transform the refrigerator and freezer market from low efficiency to high efficiency units that would result in significant savings in household electricity costs. In addition, increase the awareness of the public of the benefits of high efficiency appliances. The strategy was to encourage households with old refrigerators and freezers (> 7 years) to surrender their units and provide the opportunity to purchase a high efficiency unit (around 3 to 4 star) at the current market price for low efficiency units (1 to 2 stars). The associated incremental costs were borne by ADB funding under PEEP2.

Design

Expressions of Interest (EOI) for participation was sought from retailers and the selection criteria included agency for Australia/NZ energy star rated appliances, service capability in Rarotonga and Outer Islands, capacity to offer hire purchase options to customers. Two retailers were selected, namely Cook Islands Trading Corporation (CITC) and Motor Centre and these two retailers account for over 85% of the refrigerator market in the Cook Islands.

The proposed rebate as calculated considering the capacity of the units, incremental purchase cost, annual energy savings and the estimated residual value of the old unit. Approaches used in similar programs in Australia and Brazil were also considered. The rebates ranged from NZ$ 200 – 500 depending on the capacity and type of unit. A summary of the rebates offered is given in Table 5.15.

Table 5.15: Calculations of Rebate for Fridges and Freezers

Type	Capacity (litres)	Incremental Purchase Cost (NZ$)	Energy Savings (NZ$/year)	Residual Value of old unit (NZ$)	Incremental Cost – Benefits + Residual Value	Rebate (NZ$)
Refrigerator	< 200					
	200 - 300	325	200	50	175	200
	300 - 400	440	240	75	275	300
	400 - 520	640	275	100	465	450
F/F (Freezer on Top)	150 - 300	385	200	100	285	300
	300 - 400	500	240	125	385	400
	400 - 500	701	275	150	576	500
F/F (Fridge on Top)	150 - 300	375	200	100	275	250
	300 - 400	438	240	125	323	300
	400 - 500	665	275	150	540	500
Freezer (Vertical)	150 - 300	299	190	75	184	200
	300 - 400	718	215	100	603	500
	400 - 500	788	240	150	698	500
Freezer (Chest)	200 - 300	269	190	100	179	200
	300 - 400	362	215	125	272	300
	400 - 500	462	240	150	372	400

Note: Incremental purchase cost is 25% of the average cost of the 1 to 2.5 star rating units in the particular capacity range provided by the participating suppliers

The design incorporated a safe de-gassing and disposal plan for the old units. A separate contract was executed with Cook Islands Recycling for this task. The retailers delivered the old units to a specified site in Rarotonga where the degassing and disposal was undertaken. The degassing complied with the guidelines of the National Environmental Services (NES) of the Cook Islands. The Project Proposal, Design Report and other attachments are given in **Appendix 3.3**.

Prior to the program launch, the PEEP2 Consultants provided training to the two participating retailers. The Program Brochure and the Application Form is shown in Figure 5.55.

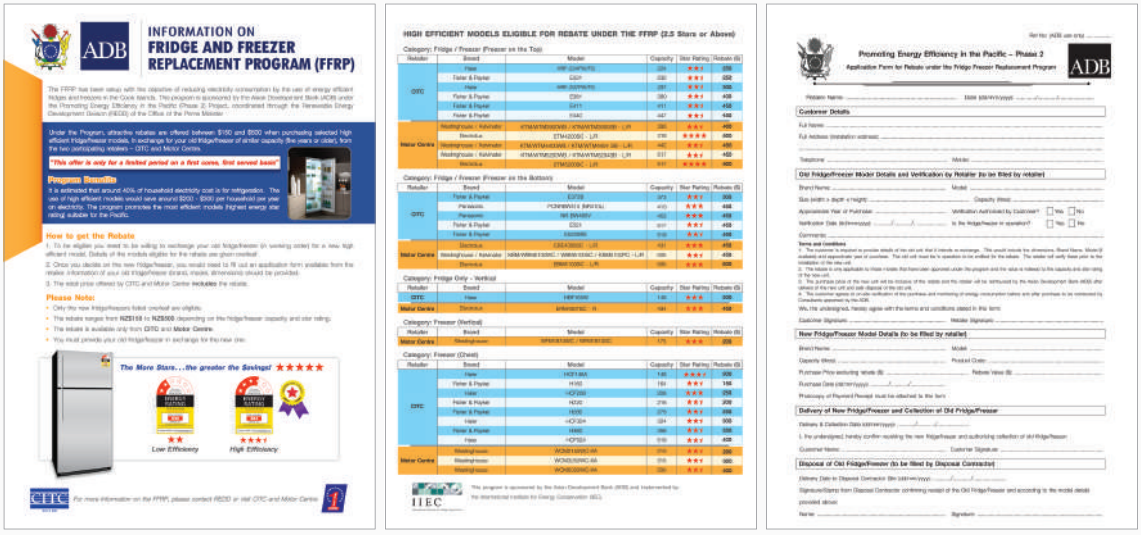

Figure 5.55: FFRP Brochure and Application Form

Program Implementation

The program was launched on 1 May 2013 and was closed on 28 February 2014. The Table 5.16 provides a summary of the monthly sales from the two retailers.

Table 5.16: Summary of Monthly Sales under the Program

Month	Retailers	
	CITC	Motor Centre
May 2013	33	6
June 2013	20	15
July 2013	16	13
August 2013	13	3
September 2013	11	13
October 2013	15	9
November 2013	12	11
December 2013	14	9
January 2014	10	5
February 2014	31	36
TOTAL	175	120
GRAND TOTAL	295	

The monitoring included the comparison of electricity bills immediately before and after the delivery of the new unit. The monetary savings from the selected sample ranged from NZ$24 – NZ$60 per month. The Figure 5.56 show a newspaper article (Cook Islands Herald) with testimony from one of the participants.

COOK ISLANDS HERALD NEWS 17 JULY 2013 6

Big drop in power costs under fridge/freezer upgrades

By Charles Pitt

The Fridge/Freezer exchange programme promoted in the Cook Islands via Asia Development Bank (ADB) funding as part of the Pacific Energy Efficiency Programme phase 2, known as PEEP2, looks like it is on its way to becoming a stunning success.

Although PEEP2 (2 because the programme is now in stage 2) was to focus on street and residential lighting, the ADB granted approval for the Cook Islands to trial a fridge/freezer exchange programme as these appliances were using a great deal of electricity.

The programme involved two local outlets, CITC and the Motor Centre upgrading household's fridges and freezers to more energy efficient models in order to reduce energy consumptions and also save costs. The incentive for householders was a subsidy from the ADB.

The PEEP2 project team for the Cook Islands, Felix Gooneratne, team leader and Terekino Vaireka, local expert, report that since the exchange programme was launched in May, the two outlets involved have sold 80 units. This is especially encouraging as in the whole of last year, 120 units were sold. The team has a target of 275 to 300 units being exchanged for more energy efficient models as sufficient ADB funds remain for this number.

On Tuesday, the team spoke with two happy clients, Mrs Lena Hoff and Russell Thomas, who both agreed to their details about cost savings on power usage, being made public.

Hoff upgraded her freezer and said that previously, with her old freezer, her power bill was around $319. She did the upgrade in May and last month noticed that her bill had dropped to $253, a cost saving of $66 and just for part of the month. She is now considering getting her fridge exchanged.

Russell Thomas upgraded his fridge/freezer. His power bill was previously about $120 to $140. His last bill came to $95 and that was for part of the month.

Felix said the team now had a list of those who had upgraded and may write to them for details about their savings so a before and after comparison can be made.

Felix said the team initially estimated the yearly saving on power costs could be $300 to $400 per year but now it looks like savings of around $500 a year may be possible. This is very encouraging he said.

The team now wants to expand the programme to the outer islands and on Friday the team along with representatives from CITC and Motor Centre will be travelling to Aitutaki.

Felix reported that along with the hire purchase terms offered by the two retail outlets, the BCI was keen to provide loan finance for outer islanders and will make a formal announcement in the near future.

Mrs Lena Hoff with Felix

As regards progress with other projects under the PEEP2 programme, Felix reported that there is a slight delay in contracts with suppliers for the Airport car park and Punanga Nui market solar lighting. Contracts are now expected to be finalized next week.

As regards solar lighting at the Marina, the team is currently evaluating the five bids to supply and install. The bids have come from Australia and NZ. The selected bid will then be referred to the ADB for signing of the contract.

Tenders for the projects involving public buildings retrofit to (a) replace lights with energy efficiency bulbs and (b) install new air conditioner timer controls which will prevent extended use, close at the end of the month.

As regards energy efficiency assistance for residential buildings, this will be tendered out soon.

In relation to outer islands, Felix said a proposal for a programme to install solar lighting in Aitutaki and Mangaia has been finalized and sent to the ADB for approval.

Felix said of the five Pacific nations taking part in the programme, the Cook Islands is well ahead. While other nations are focusing mainly on introducing legislative changes, the Cook Islands is actually implementing change. Felix believes the Cook Islands could become a model for other Pacific nations and the fridge/freezer upgrade concept could be extended to other electrical appliances.

Figure 5.56: Article in Cook Islands Herald on FFRP

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
Fridge/Freezer Replacement Program – Cook Islands	113,150	83,284	24,450	2.1	66.4

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	January 2013
Program Period	1 May 2013 to 28 February 2014
Names of Retailers	Cook Islands Trading Corporation (CITC) Motor Centre (MC)
Units Sold (28 February 2014)	295
Total Program Costs	US$ 113,150

5.4.2.4 Project Code 4 – EE Air Conditioning using VRF Technologies (Vanuatu)

Rationale and Design

The proposal was to replace old inefficient air conditioning (A/C) at two locations within the Ministry of Finance and Economic Management (MFEM) in Port Vila with efficient new variable refrigerant /variable flow (VR/VF) systems that are expected to reduce electricity use by at least 25% with increased comfort levels. The VR/VF systems self-correct operations based on the occupancy level and the heat load within the cooled areas of i) the office of the Minister and his support staff, and ii) the Vanuatu National Statistics Office (VNSO). The existing ACs in the two locations is shown in Figure 5.57.

Figure 5.57: Existing AC Units at MFEM

The Project Proposal, Design Report and other attachments are given in **Appendix 3.4**.

Procurement

The invitation for bids was issued to eight suppliers in Vanuatu, Fiji and Australia on 13 May 2013 and bids were received from 3 suppliers in Vanuatu. Following evaluation the contract was awarded to Supercool Vila Ltd on 22 October 2013.

The initial tenders were well above the approved budget of $68,000 so there was a requirement to negotiate with the bidders. The revised offers, based on slightly modified technical specifications, were lower with the lowest still 5.7% above the budget. Unfortunately, the technical specifications were not met for the VNSO system so only the ministers' A/C system was approved, with the winning tenderer responsible for supply, delivery, installation, commissioning, monitoring and operations for two years. The new installation is shown in Figure 5.58.

Figure 5.58: New VRF Installation at Minister's Office

Although the system was delivered early in 2014, project completion was slow as various issues had to be resolved (unacceptable choice of condenser location by the installer, the installation of other new A/C equipment at the same location, damage by the installer to the main MFEM distribution board and responsibilities for additional costs.

Program Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Air Conditioning using VRF Technology – Vanuatu	48,673	14,400	2,794	5.9	11.5

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	7 September 2013
Date of Contract Award	22 October 2013
Name of Supplier	Supercool Vila Ltd
Delivery	January 2014
Installation	Completed – November 2014

5.4.2.5 Project Code 5 – EE Street Lighting in Port Moresby (PNG)

Rationale

Currently, around 76% of Street Lighting luminaires in PPL's jurisdiction are 80W Mercury Vapour (MV) lamps, mostly installed in residential areas. PPL does not have up-to-date street lighting inventory data, however analysis of the PPL's billing data suggests that there are around 50,000 MV lamps currently installed in the PPL's street and outdoor lighting circuit nationwide. This project was aimed at retrofitting inefficient MV street lighting luminaires in the PPL's network.

Design

The project replaced existing 160 sets of 80W Mercury Vapour lamps and luminaires in residential streets with 30W White LED luminaries. The Figure 5.59 shows the current luminaires at the selected site. Standard LED luminaires with similar or better light distribution profiles was procured to replace the existing 80W MV lamps and luminaires. The new LED luminaires was installed on the existing mast-arms; hence on-site civil or mechanical works was not required. The Project Proposal, Design Report and other attachments are given in **Appendix 3.5**.

Figure 5.59: Existing Street Lighting Luminaire in PNG

The area of Hohola was selected for the target replacement as it was considered to be the best compromise between affluent and very poor areas (mainly middle class). Secondly, due to security concerns, the installation (to be carried out by PPL staff) was deemed less risky in this area. This is because people in poor areas would perceive that PPL staff is there to check on their illegal connections.

It was anticipated that after successful implementation of this project, PPL can use it to showcase the success of EE projects to its management and replicate the success throughout PPL's jurisdiction areas. In addition, PPL can showcase the success to other stakeholders and consequently generate interest in implementation of similar street and outdoor lighting applications by other private and public sector consumers. The existing MV luminaires was disposed in the HID lamp eater procured under this project.

Procurement

The invitation for bids was issued to 15 suppliers on 5 July 2013 and bids were received from 4 suppliers prior to the closing date. Following evaluation the contract was awarded to Philips New Zealand Ltd on 31 October 2013. The new installation is shown in Figure 5.60.

Figure 5.60: LED Street Lighting Installations in Port Moresby

As part of monitoring and evaluation process, lighting levels and energy consumption were measured before and after the replacement.

Program Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting in Port Moresby – PNG	45,899	36,680	10,135	2.1	26.5

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	22 October 2013
Date of Contract Award	31 October 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	April 2014
Installation	Completed – June 2014

5.4.2.6 Project Code 6 – EE Lighting in Marina and Wharf (Cook Islands)

Rationale

The existing lighting system (Figure 5.61) in the Marina Area consists of double-arm luminaires with mercury vapour lamps and two-standalone solar/LED lights near the boat ramp area. At the time of inspection, most of the luminaires were not functional. The concrete pavement area and the parking area above the rock revetment are totally dark at night presenting a potentially hazardous situation. The current lighting level of the solar/LED lights was found to be inadequate with a minimum horizontal illuminance level of 1 lux. In Wharf Area 1 there are five double-arm globe type luminaires and in Area 2 there is no lighting at present.

As a result this whole area is inadequately lit and the Ports Authority has deferred any improvements till the whole area has been developed. Major development of the wharf area is planned including a new building housing a museum and a recreational area with restaurants.

Figure 5.61: Existing Double – Arm Globe Type Luminaires

Design

The design approach was to install higher capacity Solar/LED lights that would provide uniform lighting to the whole area (Marina and Wharf) and that would eliminate the need for the use of existing grid connected lights. The existing 2 solar/LED lights will be relocated to other areas which are inadequately lit.

The design option was for a stand-alone Solar/LED units aimed to comply with IESNA RP-20-98 requirements of basic minimum horizontal illuminance and uniformity ratio (maximum to minimum). The selected option provides an average horizontal illuminance of 7-8 lux and is more than adequate to meet the lighting requirements and the design was accepted by the Ports Authority. The design incorporates LED luminaires with a high lumen output (54W – 6000 lumen) and mounting poles of 9 and 12 meters. The layouts of the Marina and Wharf areas are shown in Figure 5.62. The Project Proposal, Design Report and other attachments are given in **Appendix 3.6**.

Figure 5.62: Layout of the Marina (1) and Wharf Areas (2&3)

The design proposed the installation of 20 units of 6,000 lumen output Solar LED luminaires at mounting heights from 9 meters to 12 meters depending upon the illumination and uniformity required by each specific activity area. The scope is summarized in Table 5.17.

Table 5.17: Marina and Wharf Lighting Design Parameters

Description	Design Parameters
MARINA AREA	
LED Luminaire	**13 x 6,000 Lumen Output LED Luminaire**
Luminaire Mounting Height	**11 meters**
No. of Lighting Poles	**9 /1**
Minimum Horizontal Illuminance	2 lux
Uniformity Ratio, Maximum to Minimum	20:1
Average Value of Horizontal Lux	7.8 lux
WHARF 1 AREA	
LED Luminaire	**3 x 6,000 Lumen Output LED Luminaire**
Luminaire Mounting Height	**9 meters**
No. of Lighting Poles	**3**
Uniformity Ratio, Average to Minimum	2.3:1
Average Value of Horizontal Lux	8 lux
WHARF 2 AREA	
LED Luminaire	**3 x 6,000 Lumen Output LED Luminaire**
Luminaire Mounting Height	**9 meters**
No. of Lighting Poles	**4**
Uniformity Ratio, Average to Minimum	2.3:1
Average Value of Horizontal Lux	8 lux

Note: /1 Four (4) of the 11-meter lighting poles will be equipped double mast-arm, the remaining will be with single mast-arm

Procurement

Bids for the lighting systems were received from 3 Suppliers and Philips Electronics (New Zealand) was selected as the contractor. The supply and erection of the lighting poles was initially in the scope of the recipient (Ports Authority); however, it was found that the poles had to be sourced from New Zealand and to a much stringent specification (category 5 cyclone) and exceeded the initial budget. As a result the supply of poles was included in ADB's scope and the poles were procured from Alrite Steel & Services (NZ).

Although the lighting systems were delivered in December 2013 the installation was delayed due to the separate procurement of poles. The installation commenced in February 2015 and will be undertaken in two phases due to budgetary constraints for civil works. The first phase includes the installation of 9 light points in March 2015 and the second phase will include the remaining lights (7) in July 2015. The solar/Led installations in the first phase are shown in Figure 5.63.

Figure 5.63: Solar/LED Lighting System at the Marina & Wharf – Cook Islands

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
Solar/LED – Marina & Wharf – Cook Islands	84,925	8,634	2,175	9.1 *	6.9

* Project scope larger than existing area

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	January 2013
Solar/LED Lighting System	
ADB Approval of Bid Evaluation Report	10 August 2013
Date of Contract Award	14 August 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	12 December 2013
Lighting Poles	
ADB Approval of Bid Evaluation Report	23 November 2013
Date of Contract Award	7 January 2014
Name of Supplier	Alrite Steel & Services NZ Ltd
Delivery	September 2014

Parameter	Details
Installation and Commissioning	
Status of Installation	Phase 1 – Completed in March 2015
	Phase 2 – Completion in July 2015

5.4.2.7 Project Code 7 – EE Program in Public Buildings (Cook Islands)

Rationale

Reduction of energy cost in the public sector is one of the main priorities of the government and the REDD had earmarked several Ministries for implementation of EE measures.

Design

The selection of buildings was undertaken in consultation with REDD and Cook Islands Investment Corporation (CIIC). The CIIC is the responsible agency for the maintenance of all public buildings. The criteria for selection of buildings included ownership (government owned), occupancy (government agencies only) and historical energy consumption. A total of 37 buildings from 21 government ministries and agencies were selected. The EE measures selected are:

- Replacement of existing T8 Fluorescent Tube Lights (FTLs) with T5 FTLs with integrated electronic ballast.
- Installing timer controls in AC units to reduce operating hours especially overnights and weekends.

The program design included the direct replacement of existing 2 foot and 4 foot fluorescent tubes lights (T8) with T5 lamps of similar lengths. In addition, the survey results showed that there are 5-foot FTLs in some buildings, especially the Rarotonga Hospital, Bank of the Cook Islands (BCI) and Ministry of Finance and Economic Management (MFEM). The Figure 5.64 shows the existing lamp types and the proposed T5 lamp.

T8 – 60 inches *T8 – 48 inches* *T8 – 24 inches* *T5 with integrated ballast*

Figure 5.64: Existing Lighting and Proposed T5 Lamp

The timers that were proposed for the AC units will allow operation for a fixed period (set based on the office hours and occupancy patterns). The period is normally set for a fixed number of hours, for example, for an office that operates from 8 am to 5 pm, the setting will be for 4 hour periods so that the units are switched off during the lunch period (12am – 1pm). The Inventory of Equipment is given in Table 5.18. The Project Proposal, Design Report and other attachments are given in **Appendix 3.7**.

Table 5.18: Bill of Quantities for Public Buildings in the Cook Islands

Lamp Type	Fitting Type	Number	Proposed EE Measures	Actual (incl. Contingency)
CFL	BS	310	Excluded from Program	
	ES	415		
2ft Fluorescent T8	H-Type	725	Replace with 2ft T5 and H-Type	760
	V-Type	30	Replace with 2ft T5 and V-Type	40
4ft Fluorescent T8	H-Type	4,903	Replace with 4ft T5 and H-Type	5,125
	V-Type	126	Replace with 4ft T5 and H-Type	175
5ft Fluorescent T8	H -Type	312	Replace with H-Type 4ft T5 lamps and luminaire	450
	V-Type	100		
AC Timers		165		175

All the old fluorescent light fittings removed will be delivered to the Bulb Eater located at MOIP for safe disposal.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 21 August 2013 and 3 bids were received by the closing date of 17 September 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014 and the installation was undertaken by the Cook Islands Investment Corporation (CIIC) which is the entity responsible for the maintenance of all public buildings in Rarotonga. The installation of the light fittings in the 37 buildings was completed in January 2015.

Following the inspection of the existing of the existing wiring and the types of AC timers available in the market it was decided not to proceed with the procurement of AC timers.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting – Public Buildings – Cook Islands	94,080	196,950	57,890	0.7	176

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	5 April 2013
ADB Approval of Bid Evaluation Report	13 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Completed – January 2015

5.4.2.8 Project Code 8 – EE Lighting in PNG Power Ltd Head Office (PNG)

Rationale

PNG Power Ltd (PPL), the Implementing Agency for the PEEP2 project, decided to implement a number of energy efficiency (EE) projects to demonstrate the practicality and viability of EE projects within its own system. It was anticipated that after successful implementation of this project, PPL can use it to showcase the success of EE projects to other stakeholders and consequently generate interest in implementation of similar projects by other private and public sector consumers.

Design

The aim of the project was to achieve cost effective energy savings through the replacement of standard 36W T8 fluorescent lamps and electromagnetic ballasts together with existing twin tube non-reflective luminaries, with diffuser type coverings, with 28W T5 fluorescent lamps and electronic ballasts in highly reflective single tube luminaires. The existing floor lighting at PPL head office is based on 30 year old lighting technology and design concepts. With majority of the office used for desk work, banks of twin T8 housing luminaires with diffuser type acrylic covers, run through the length of the building. Only a few centralized electrical switches are used to manually control the lighting of entire floor area. The project aimed at replacing the existing 1,120 luminaire sets of 2 x 36W T8 recessed lighting with old style diffuser type luminaries fittings on 4 floors of the building, with high efficiency reflective luminaire sets with single 28W T5 lamps with electronic ballasts. The Figure 5.65 shows the current layout of lighting at the office. The Project Proposal, Design Report and other attachments are given in **Appendix 3.8**.

Figure 5.65: Layout of Existing Fluorescent Lamp Luminaires in the PPL Head Office

Further energy savings will be achieved, by installing zoned controls (switches) throughout the floor areas and motion sensors in low occupancy rooms/areas e.g. management offices, utility areas etc. In addition, programmable lighting load "kill" switches will be installed on each floor. These switches will turn off the entire lighting load on a floor, except the lights in corridors and stairs.

Procurement

Following the approval of the project proposal, Invitation for Bids was issued on 21 August 2013 and 3 bids were received by the closing date of 17 September 2013. Following evaluation of bids the contract was awarded to Pierlite Australia Ltd on 16 May 2014. The lighting equipment was delivered to site in August 2014 and the installation was undertaken by the maintenance staff at PNG Power Ltd. The installation of the light fittings was completed in January 2015 and the installed lighting is shown in Figure 5.66.

Figure 5.66: New Lighting Installation at PPL Head Office

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in PPL Head Office – PNG	92,428	218,188	51,124	0.9	535

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	05 April 2013
ADB Approval of Bid Evaluation Report	13 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Pierlite Australia Ltd
Delivery	August 2014
Installation	Completed – January 2015

5.4.2.9 Project Code 9 – EE Lighting in Public Buildings (Vanuatu)

Rationale

In 2012, the Vanuatu Minister of Finance directed government departments to reduce electricity use within the public sector as a priority. Recent PEEP (and other studies) between 2010 and 2013 show that lighting in Public Sector Buildings is generally inefficient and that lighting is a significant portion of overall electricity use; and there are significant opportunities for wide-scale cost-effective reductions in energy use, energy expenditure and greenhouse gas (GHG) emissions.

Design

This project is to replace a wide range of inefficient lighting with cost-effective energy efficient lighting in six national government and government-owned enterprise buildings: Meteorology, Ministry of Finance, Parliament, Port Vila international air terminal, the Department of Energy and the Port Vila library. Excluding some unused external lights, 2,432 lights were counted at the six facilities. Of these, over 2,000 (nearly 84%) were recommended for cost-effective replacement, including over 1,327 Fluorescent Tube Lights (T8 and T12 FTLs) and nearly 500 incandescent lamps. Figure 5.67 shows the existing luminaires in some of the selected buildings.

Figure 5.67: Existing Lighting in the Parliament and National Statistics Office

The Project Proposal, Design Report and other attachments are given in **Appendix 3.9**.

Procurement

The Invitation for Bids was issued to 23 suppliers in Australia, New Zealand, Fiji, PNG, Thailand and Vanuatu on 21 August 2013; and a total of 3 bids were received prior to the closing date. The contract was awarded to Poly Products (Fiji) Ltd on 16 May 2014 and the equipment was delivered in October 2014.

The installation commenced in December 2014 and as of March 2015 around 90% of the installation was completed. The remaining lights (Port Vila International Air Terminal) are scheduled for installation by April 2015.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Public Sector Buildings – Vanuatu	82,934	122,000	37,440	1.12	101

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	13 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Poly Products (Fiji) Ltd
Delivery	October 2014
Installation	90% completed in March 2015

5.4.2.10 Project Code 10 – EE Street Lighting in Apia (Samoa)

Rationale

EPC serves around 40,000 customers in all the end-use sectors. The two largest islands (Upolu and Savaii) consume about 95% of the total electricity generation in Samoa. EPC also provides street lighting services to the general public, and there are approximately 7,000 street and outdoor lighting luminaires installed in Samoa. Approximately 70% of street lighting luminaires in EPC's jurisdiction are mercury vapour (MV) lamps and retrofitting existing MV street lighting lamps and luminaires with high efficiency LED street lighting lamps and luminaires will result in significant reduction in electricity consumption. In addition, after successful implementation of this project, EPC can use it to showcase the success of EE projects to its management, and also the Government of Samoa, and replicate the success throughout EPC's jurisdiction areas.

Design

The onsite measurements show that the current setups of 80W MV luminaires on most major access roads in Apia are not able to provide illumination and uniformity as per the CIE 180:2007 requirements, due to relatively long pole spans and low mounting heights. Therefore, the project aims to provide equivalent or better illuminance and uniformity than the current setups. The current luminaires are shown in Figure 5.68.

Figure 5.68: Current MV Luminaires in Apia, Samoa

Currently there are more than 5,000 street and outdoor lighting luminaires installed in Upolu Island; however, the project proposes to retrofit 152 Cobra Type Luminaires with 80W MV Lamps. The project will procure a single wattage of energy efficient 31W LED systems with 2,800 lumen output to replace the existing 80W MV luminaires. The new LED luminaires will be procured with mast-arms; and hence on-site civil or mechanical works will be minimal. The existing MV lamps will be consolidated by EPC and disposed in the bulb eater, procured separately to this project. The Project Proposal, Design Report and other attachments are given in **Appendix 3.10**.

A map showing the location of the luminaires to be replaced is shown in Figure 5.69 below.

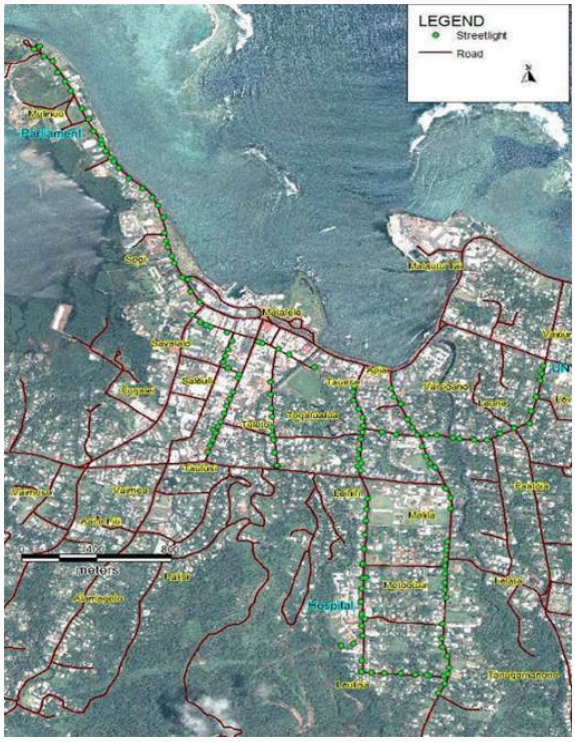

Figure 5.69: Proposed LED Street Lighting Installation in Apia

Procurement

The invitation for bids was issued to 15 suppliers on 5 July 2013 and bids were received from 4 suppliers prior to the closing date. Following evaluation the contract was awarded to Philips New Zealand Ltd on 31 October 2013. The new installation is shown in Figure 5.70.

Figure 5.70: New Installation of LED Street Lighting in Apia

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting in Apia – Samoa	114,222	45,233	11,967	5.6	36.2

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	22 October 2013
Date of Contract Award	31 October 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	April 2014
Installation	Completed

5.4.2.11 Project Code 11 – EE Lighting in Government Buildings (Samoa)

Rationale

Most government buildings in Samoa have standard T8 lamps with magnetic ballasts. These lamps are usually in two-lamp or three-lamp fixtures. Each T8 lamp has a rated energy consumption of 36 watts and the magnetic ballast adds another 10 watts for a total consumption of 46 watts per lamp. Around 35% savings can be achieved in retrofitting with more efficient lighting.

Design

The aim of the project is to achieve cost effective energy savings in government facilities through replacement of standard T8 fluorescent lamps with magnetic ballasts, with T5 retrofit lamps with electronic ballasts that have a rated power consumption of 28 watts for the lamp and 2 watts for the ballast (or a total of 30 watts). The savings per replaced lamp are therefore 16 watts (34.8%). These are the same type of lamps that have been tested in Samoa prior to the design of this project. The Figure 5.71 shows the details of the T5 lamp.

Figure 5.71: Proposed T5 Retrofit Lamp

The project includes a number of government buildings and has made an inventory of the number of T8 lamps to be replaced with T5 retrofit lamps in each building. The existing T8 lamps will be consolidated by the staff and provided to the Ministry of Natural Resources and Environment (MNRE – Implementing Agency), who will be responsible for ensuring the safe disposal of the lamps as well as the operation and management of the bulb eater, procured separately to this project. The Project Proposal, Design Report and other attachments are given in **Appendix 3.11**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 21 August 2013 and 3 bids were received by the closing date of 4 October 2013. The scope included EE lighting and light loggers. The contract for the EE lighting was awarded to Philips New Zealand Ltd. The light loggers were procured separately from MicroDaq (USA). The Figure 5.72 shows the type of T5 lamp procured and its installation.

Figure 5.72: Installation of T5 Lamps

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Government Buildings – Samoa	50,124	405,829	107,362	0.3	324.7

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	May 2013
ADB Approval of Bid Evaluation Report	13 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Completed – January 2015

5.4.2.12 Project Code 12 – EE Street Lighting in Outer Islands (Tonga)

Rationale

Tonga Power Limited (TPL), a state-owned enterprise, has the concession and operates four independent grids in Tonga: the largest on Tongatapu, and three smaller grids on the main outer islands of Vava'u, Ha'apai and Eua islands. TPL is currently serving around 20,500 customers in all the end-use sectors in the 4 main island groups. TPL also provides street lighting services to general public, and currently there are around 1,800 street lighting luminaires installed in Tonga. Currently 80% of street lighting luminaires in TPL's jurisdiction are HPS lamps. The electricity demands in Tonga have 2 salient peaks, i.e. late morning to early afternoon peak and evening peak. The latter one, which clearly reflects contributions from the residential end-uses and street lighting, is the maximum daily peak demand, especially in Vava'u, Ha'apai and Eua islands; and this project aims at retrofitting HPS street lighting luminaires in the TPL's network in Vava'u, Ha'apai and Eua islands with high efficient LED street lighting luminaires. It is anticipated that after successful implementation of this project, TPL can use it to showcase the success of EE projects to its management and replicate the success throughout TPL's jurisdiction areas.

Design

The aim is to achieve cost effective energy savings through replacement of 100/150/250 watt High Pressure Sodium (HPS) lamps together with existing luminaires installed in Vava'u, Ha'apai and 'Eua islands with high efficiency Light-Emitting Diode (LED) Luminaires. The Figure 5.73 shows a typical HPS luminaire in the Outer Islands.

Figure 5.73: Typical HPS Street Lighting in Ha'apai, Tonga

Table 5.19 provides details of the number of light points in the four islands in Tonga.

Table 5.19: Number of Light Points for Street and Outdoor Lighting in Tonga

Lighting Technology	Wattage	Tongatapu	'Eua	Ha'apai	Vava'u	Total	%
High Pressure Sodium	**250W**	339	20			**359**	**20%**
	150W	258	3	24	38	**323**	**18%**
	100W	438	25	69		**532**	**29%**
	75W			6		**6**	**0%**
	70W	159	59			**218**	**12%**
	55W	22				**22**	**1%**
Fluorescent Tube	**36W**	104		61		**165**	**9%**
	18W	202		1		**203**	**11%**
Total Light Points		**1,522**	**107**	**161**	**38**	**1,828**	**100%**

Source: TPL, March 2013

In total, the project aims to replace existing 161 sets of 100/150/250 W luminaires in "Major Access Roads, Distributors and Minor Main Roads" with 8,000 lumen output White LED luminaries in Vava'u, Ha'apai and Eua islands. According to CIE 180:2007, these types of roads shall have average illuminance of around 8 lux with uniformity (minimum to average illuminance) of 0.4. The project will procure a single wattage of energy efficient with 8,000 lumen output LED luminaires to provide better light levels delivered by the existing HID luminaires. The total power consumption of the new LED luminaires shall not exceed 90W. The breakdown of the scope in the three islands is given in Table 5.20 below. The Project Proposal, Design Report and other attachments are given in **Appendix 3.12**.

Table 5.20: Number of Light Points Replaced in the Projecct

Lighting Technology	Wattage	'Eua	Ha'apai	Vava'u	Total
High Pressure Sodium	**250W**	20			**20**
	150W	3	24	38	**65**
	100W	20	56		**76**
Total		**43**	**80**	**38**	**161**

Procurement

The invitation for bids was issued to 15 suppliers on 5 July 2013 and bids were received from 4 suppliers prior to the closing date. Following evaluation the contract was awarded to Philips New Zealand Ltd on 31 October 2013.

The project has not yet been completed in the Ha'apai group because of the severe damage to the grid due to the passage of a cyclone in 2014 that has not yet been fully repaired.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting in Outer Islands – Tonga	50,328	45,189	13,520	1.9	41

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	22 October 2013
Date of Contract Award	31 October 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	April 2014
Installation	Ongoing

5.4.2.13 Project Code 13 – EE Street Lighting in Tongatapu (Tonga)

Rationale

Tonga Power Limited (TPL), a state-owned enterprise, has the concession and operates four independent grids in Tonga: the largest on Tongatapu, and three smaller grids on the main outer islands of Vava'u, Ha'apai and Eua islands. TPL is currently serving around 20,500 customers in all the end-use sectors in the 4 main island groups. TPL also provides street lighting services to general public, and currently there are around 1,800 street lighting luminaires installed in Tonga. Currently 80% of street lighting luminaires in TPL's jurisdiction are HPS lamps. The electricity demands in Tonga have 2 salient peaks, i.e. late morning to early afternoon peak and evening peak. The latter one, which clearly reflects contributions from the residential end-uses and street lighting,; and this project aims at retrofitting HPS street lighting luminaires in the TPL's network in Tongatapu with high efficient LED street lighting luminaires. It is anticipated that after successful implementation of this project, TPL can use it to showcase the success of EE projects to its management and replicate the success throughout TPL's jurisdiction areas.

Design

Similar to the project in the Outer Islands, the aim of this project is to achieve cost effective energy savings through replacement of 100/150/250 watt High Pressure Sodium (HPS) lamps together with existing luminaires installed in Tongatapu island with high efficiency Light-Emitting Diode (LED) Luminaires.

The project aims at retrofitting HPS street lighting luminaires in the TPL's network in Tongatapu with high efficient LED street lighting luminaires. In total, the project aims to replace existing 135 sets of 100/150/250 W luminaires in "Major Access Roads, Distributors and Minor Main Roads" with 8,000 lumen output White LED luminaries. The Figure 5.74 shows the typical HPS street lighting in Tongatapu.

Figure 5.74: Typical HPS Street Lighting in Tongatapu, Tonga

The project will procure a single wattage of energy efficient with 8,000 lumen output LED luminaires to provide better light levels delivered by the existing HPS luminaires. The total power consumption of the new LED luminaires shall not exceed 90W. The new LED luminaires will be installed on the existing mast-arms, hence on-site civil or mechanical work will not be required. The scope of supply for the Project is given in Table 5.21.

The Project Proposal, Design Report and other attachments are given in **Appendix 3.13.**

Table 5.21: Number and Wattage of HPS Luminaires for Tongatapu

Lighting Technology	Wattage	Total
High Pressure Sodium	250W	44
	150W	34
	100W	57
Total		135

Procurement

The invitation for bids was issued to 15 suppliers on 5 July 2013 and bids were received from 4 suppliers prior to the closing date. Following evaluation the contract was awarded to Philips New Zealand Ltd on 31 October 2013. The new LED Street lighting installations is shown in Figure 5.75.

Figure 5.75: LED Street Lighting Installations in Tongatapu

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting in Tongatapu	42,963	52,030	15,568	1.4	47

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	22 October 2013
Date of Contract Award	31 October 2013
Name of Supplier	Philips New Zealand Ltd
Delivery	April 2014
Installation	Completed

5.4.2.14 Project Code 14 – Lamp Waste Management (All PDMCs)

Under PEEP2, there will be several EE lighting projects covering the public, commercial and residential sector as well as street lighting. As a result, IIEC prepared a Lamp Waste Management Strategy report which was included in the Interim Report – Year 1. The Lamp Waste Management Strategy (LWMS) report recommends a practical approach for the disposal of lamp waste using a bulb eater for the five PEEP2 countries.

Overall, there is a need to safely dispose of old fluorescent lamps and other mercury containing lamps. The bulb eater offers the most cost-effective solution suitable for the Pacific Islands and with minimum negative impact on the environment compared to landfills, incineration or even transport for recycling in other countries.

The bulb eater is basically a lamp crushing machine that safely processes old fluorescent lamps and/or other mercury containing lamp types into small fragments. Most models can process all types of fluorescent lamps - Compact Fluorescent Lamps (CFLs), Fluorescent Tube Lamps (FTLs) of different lengths, U-shaped lamps and High Intensity Discharge Lamps (HIDs) such as Mercury Vapour and High Pressure Sodium Lamps used in street lighting. The proposal for the bulb eaters is included in **Appendix 3.14** and the equipment procured for each country is listed below:

- 1 x Bulb Crusher / Lamp Compactor
- 1 x 10 Drum Filter Pack (Included with each machine)
- 1 x Entry Tube (included with each machine)
- 1 x Safety Kit
- 1 x Special Electrical
- 1 x Extra 10 Drum Filter Pack
- 1 x HEPA Filter
- 1 x Drum Dolly

The bulb eater equipment was procured from WasteCare Corporation and shipped to each country during November 2013. The Figure 5.76 shows the bulb eater operation in Tonga and the Cook Islands.

Figure 5.76: Bulb Eater Operation in Tonga (L) and the Cook Islands (R)

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	May 2013
ADB Approval of Bid Evaluation Report	23 July 2013
Date of Contract Award	23 July 2013
Name of Supplier	WasteCare Corporation – Bulb Eater Equipment Leo Logistics – Transportation to PDMCs
Delivery	November 2013
Installation	January 2014

5.4.2.15 Project Code 15 – EE in Edgewater Resort & Spa (Cook Islands)

Rationale

The Hotels and Commercial sector in the Cook Islands accounts for around 25% of the total electricity consumption in Rarotonga and more than 75% in the Outer Islands (Aitutaki). The main operating cost in hotels is energy supply (electricity and other fuels) and many hotel operators have been exploring various options to reduce energy consumption. Tourism plays a vital role in Cook Islands economy and hence, measures that will improve the services and competitiveness in this sector will have a significant impact on the overall economy.

Design

Expressions of Interest (EOI) were sought in August 2012 from hotels and private commercial buildings for inclusion in the program. One of the key factors considered for site selection is the interest in implementation and the availability of funding sources. The Edgewater Resort & Spa was selected from the 14 respondents on this basis

The scope of the project was limited to **Block 900 (Mitiaro) and Block 1000 (Nassau)** which have been earmarked for refurbishment (Figure 5.77). These blocks have 75 identical rooms (45 in Block 900 and 30 in Block 1000) in terms of size and electrical equipment.

Figure 5.77: Blocks 900 and 1000 with Existing Window AC Units

The equipment details and current operation is summarized below:

- **AC Unit:** This is a window – type unit using R22 refrigerant (which will be banned in the Cook Islands from 2014). The rated electrical capacity is around 660W which is considered to be under-rated for the cooling capacity required for the room size. The current cooling capacity is around 7,000 BTU/hr (around 2 kW). Metering of 2 rooms for 24 hours revealed that units operated continuously on full load and unable to cool the room below 22^{o}C. The average daily electricity consumption was 14.74 kWh (NZ$12.40)

- **Lighting:** Consists of a mixture of incandescent bulbs (IBs), Compact Fluorescent Lamps and T8 fluorescent tubes with opaque luminaires. Each room has 3 CFLs/IBs and 2 T8 tube lights.

- **Controls:** Some rooms are equipped with key-tag switches that only control the AC and the refrigerator. The type of switch in use could be easily tampered with and there is no guarantee the units are switched off when the room is unoccupied.

- **Insulation:** The ceiling is bare wood and painted, as is the floor of the upper room plus tiles. The entrance door has around a 1 inch gap at the bottom with significant air infiltration.

The proposed EE measures included the following:

- Split Inverter Type AC unit with adequate capacity for the required cooling load
- EE Lighting – CFLs, T5 fluorescent lights / luminaires
- Controls – Tamper-proof key tag switches that switched off AC, TV and lights (except entrance area). Adjusting thermostats in the fridge for optimum operation.
- Insulation – Plasterboard on the ceiling recess and door seals

The initial scope of ADB supply was the ACs and the key tag switches. However, the latter was considered incompatible with the existing wiring system and was not included. The Project Proposal, Design Report and other attachments are given in **Appendix 3.15**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued in 3 July 2013 and 4 bids were received by the closing date of 18 July 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The AC equipment was delivered to site in November 2013 (Figure 5.78) and installation was undertaken by the maintenance staff at the Edgewater Resort & Spa. The installation was completed in March 2014.

Figure 5.78: Delivery of Electrolux Inverter Type AC Units at Edgewater Resort

Following completion of installation, the Edgewater Resort decided to replace all other existing window-type AC units and the PEEP2 project team provided the specifications and assisted in the procurement of the additional units.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Measures in Hotels – Edgewater Resort & Spa, Cook Islands	56,183	57,587	16,930	1.5	94.9

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	June 2013
ADB Approval of Bid Evaluation Report	23 August 2013
Date of Contract Award	30 August 2013
Name of Supplier	Motor Centre
Delivery	November 2013
Installation	Completed – March 2014

5.4.2.16 Project Code 16 – EE Rooftop Retrofits in PPL Head Office (PNG)

The aim of the project was to achieve cost effective energy savings through improved thermal enveloping of the building. This project aims at renovations associated with improving the thermal properties of the building/office space, conducting aggressive maintenance of Air Handling Units (AHU) and adopting a regular AHU maintenance program, and applying intelligent control systems on HVAC.

The roof insulation proposal is part of the overall air conditioning performance improvement project of the PPL Headquarters. The other proposal addresses ceiling renovation, insulation of air con ducts, and repair and maintenance of air handling units. The overall project is broken down into two proposals due to the nature of the activity and availability of single contractor to perform such activity.

The PPL head office is comprised of a large building with 4 floors, with an estimated 6,000 m^2 of covered office and other utility/service space. The building HVAC system is comprised of 2 chillers of 495 kW and 617 kW of cooling capacity. Total connected load for the two systems is 165 kW and 212 kW for the chillers, in addition to two 11 kW chilled water pumps and fourteen 4 kW rated air handling units. There are 14 air handling units (AHUs), each having an operating load of 4kW.

The assessment of the system established that the system capacity is just about optimum for the building size, purpose and usage. However, the detailed inspection of HVAC system and the building identified that due to poor maintenance of AHUs, inappropriate chilled water circulation design, deteriorating ceiling, and heat introduced by the metal roof and large gaps in ceiling tiles the top floor area are causing substantial wastage of cooling produced by the HVAC system. The assessment has established that between 10% and 15% energy used for HVAC could be saved by taking the following measures; Thoroughly clean and service the AHU system; Change the existing ceiling tiles on all 4 floors; and Water proof and insulate the metal roof on top of the 4^{th} level.

Following project approval from ADB and issue of invitation for bids, no bids were received for this project and therefore the project was cancelled. The Project Proposal, Design Report and other attachments are given in **Appendix 3.16**.

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	July 2013
ADB Approval of Bid Evaluation Report	Project Cancelled – No Bids Received

5.4.2.17 Project Code 17 – Residential EE Lighting Program (Cook Islands)

Rationale

It was estimated that around 35% of the residential energy consumption was due to lighting and there was scope for reduction by using more energy efficient lighting products. Household lighting comprises of Incandescent Bulbs (IBs), Compact Fluorescent Lamps (CFLs), and Fluorescent Tube Lighting (FTLs); and to a lesser extent Light Emitting Diodes (LEDs). A CFL program (replacing existing IBs) was implemented in 2010 under Phase 1 of Promoting Energy Efficiency in the Pacific (PEEP1). The results of the Cook Islands Census of 2011 show that the penetration of CFLs is only around 49% with IBs contributing around 22%; while the contribution of FTLs was 22%. The PEEP2 survey results showed the following breakdown: IBs – 15%, CFLs – 56% and FTLs (2ft and 4ft) – 28%. Therefore, a significant saving potential existed by replacing IBs with CFLs in high usage areas; and also from the introduction of higher efficiency FTLs (T5 lamps) for the replacement of the existing T8 FTLs.

Design

The TAU (Electric Utility) undertook a direct replacement program of IBs with CFLs and procured 10,000 CFLs utilising its own funds. Therefore, the proposed project focused only on the direct replacement of existing T8 FTLs with T5 FTLs (Figure 5.79) in high use (average 3 hours per day) areas. All the old fluorescent light fittings removed will be delivered to the Bulb Eater (procured separately under PEEP2) and located at Ministry of Infrastructure and Planning (MOIP) for safe disposal. The Project Proposal, Design Report and other attachments are given in **Appendix 3.17**.

Figure 5.79: T5 Retrofit Lamp

According to TAU, there are around 3,500 genuine households under their "residential" tariff. While, the other consumers registered under this category include small guest houses, community centers, vacant households etc. The lighting inventory was based on a total of 3,500 households and summary is given in Table 5.22.

Table 5.22: Lighting Inventory

Existing Lamp Type	Fitting Type	Number	Proposed Lamp Type	Actual Quantities
2ft Fluorescent T8	H-Type	7,000	Replace with 2ft T5 and H-Type	7,000
4ft Fluorescent T8	H-Type	3,500	Replace with 4ft T5 and H-Type	3,500

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014 and the installation was to be undertaken by the Cook Islands Investment Corporation (CIIC) with budgetary support from the Office of the Energy Commissioner. The installation was delayed due to funding availability and allocation of funds is currently being considered by the Ministry of Finance and Economic Management (MFEM). It is expected that installation will commence in the second quarter of 2015.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting – Residential Sector, Cook Islands	51,741	141,800	41,685	0.6	95

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	April 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	15 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Pending – expected to commence in April 2015

5.4.2.18 Project Code 18 – EE Street Lighting in Luganville (Vanuatu)

Rationale

Vanuatu Utilities and Infrastructure Ltd (VUI) is a privately-owned power utility, part of the international Pernix Group, which also operates in several other PDMCs. VUI has the electric power concession for supplying Luganville on the island of Espiritu Santo, the commercial and administrative hub for the northern half of Vanuatu, and Vanuatu's largest island. The grid-connected street lights in Luganville are nearly all inefficient mercury vapour (MV) lamp technology and significant savings could be achieved by retrofitting with energy-efficient LED lighting.

Design

The aim of the project is to achieve cost effective energy savings through replacement of 75 watt and 125 watt Mercury Vapour (MV) lamps and existing luminaires installed in Luganville with high efficiency Light-Emitting Diode (LED) Luminaires. There are around 238 street lights of which about 215 are connected to the grid, the remainder being stand-alone street lights with solar PV units. The 215 grid-connected street lights in Luganville are nearly all inefficient mercury vapour (MV) lamp technology, of which 54% are 75W units with about 2,600 lumens output and 46% are 125W units with a light output of about 4,400 lumens. The Figure 5.80 shows the current lighting fixtures.

Figure 5.80: Typical Installation of Street Lighting Luminaires in Luganville

This project will retrofit 160 of these (74% of the total) with 70W high-quality energy-efficient Light Emitting Diode (LED) luminaires which will produce a better quality and quantity of light, at least 6,000 lumens. All 100 x 125W MV lamps and 60 x 75W MV lamps are to be replaced. It is anticipated that after successful implementation of this project, VUI will consider LED technology for its street-lighting expansion plans. The Table 5.23 provides an inventory of the Luminaires that would be replaced with LEDs. The Project Proposal, Design Report and other attachments are given in **Appendix 3.18**.

Table 5.23: Number and Wattage of MV Luminaires to be Retrofitted in Luganville

Existing Lighting Technology	Wattage	Units
Mercury Vapour	75W	60
	125W	100
Total		160

Procurement

The Invitation for Bids was issued to a total of 16 suppliers on 28 October 2013 and 6 bids were received by the closing date. Philips New Zealand Ltd was awarded the contract on 16 May 2014 following ADB approval of the bid evaluation report on 12 February 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting – Luganville	52,975	36,179	10,635	7.0	34

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	July 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	October 2014
Installation	Completed

5.4.2.19 Project Code 19 – Residential EE Lighting Program in Luganville (Vanuatu)

Rationale

A household energy use survey was carried out by PEEP2 (with SPC/GIZ support) in April 2013. The results, based on a statistically representative sampling of about 12% of electrified households, indicated that most lighting is of generally poor quality (CFLs) or inefficient (older fluorescent tube lights or FTLs; incandescent bulbs or IBs).

Design

The immediate goal was retrofitting existing inefficient lighting in private homes in Vanuatu's second urban centre of Luganville, on the country's largest island, Espiritu Santo. Luganville is the key business, market and administrative centre for northern Vanuatu. The potential outcomes will be lower electricity consumption for lighting, lower lighting costs, decreased GHG emissions, higher quality lighting, and possibly improved night-time home security. The range of current lighting used is shown in Figure 5.81.

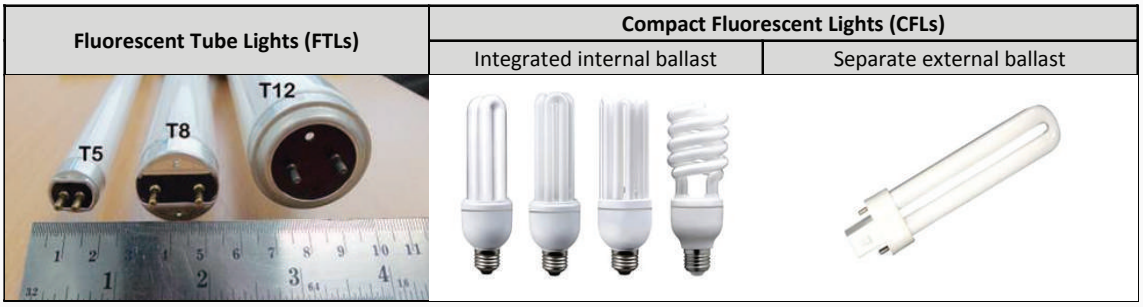

Figure 5.81: Fluorescent Lighting Types in Luganville

The project includes the replacement of around 4,800 residential lights for about 2,200 Luganville households: T12 and T8 Fluorescent Tube Lights (78% of replacements) by T5 retrofit kits and incandescent lights (12%) replaced by 14w high-quality Compact Fluorescent Lights (CFLs). Nearly 50% of all lights to be replaced are the older least-efficient T12s. Ten light loggers were included for monitoring and verification (M&V) of results (also to be used for other PEEP2 M&V in Vanuatu). The Bill of Quantities is given in Table 5.24.

Table 5.24: Bill of Quantities for Residential Lighting in Luganville

Bill of Quantities	Total (Units)	Spares (Units)	Total units including spares
T12 to T5 Retrofit Sets 28W	1,043	53	1,096
T12 to T5 Retrofit Sets 14W	1,304	66	1,370
T8 to T5 Retrofit Sets 28W	147	8	155
T8 toT5 Retrofit Sets 14W	1,210	61	1,271
14W CFLs (E27 screw-in)	1,050	53	1,103
Light loggers	10	0	10
B22-E27 (pin to screw-in) adapters	629	32	661
TOTAL Lights	**4,754**	**241**	**4,995**

Participating households would pay a nominal fee of 100 vatu (about US$1) each, with the remaining installation costs met by the Luganville power utility VUI. The Project Proposal, Design Report and other attachments are given in **Appendix 3.19**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014 and the installation was to be undertaken by the Luganville Power Utility VUI.

By early March 2015, only around 100 lights had been installed as VUI reported that demand was well below expectations. It appears that low-cost CFL lighting, which was not widely available in Luganville at the time of project design in 2013, is now common. VUI is conducting awareness campaigns on the better quality, longer lifetime and cost-effectiveness of the PEEP2-suppplied lights. The DoE (with PEEP2 support) visited Luganville in late February 2015 to meet with the power utility (VUI), government officials and the municipality. DoE/PEEP2 held consultations with a number of householders and learned that VUI's awareness had been ineffective, with most of those present confused about the programme and its benefits for them. Subsequent discussions with VUI are expected to increase the rate of installations, which are being managed by VUI which was to charge 150 vatu (about US$1.50) per household for up to two lights per household. Although this has not been confirmed by DoE or VUI in writing, it is understood that VUI now (post the March 2015 Hurricane Pam) proposes installing lighting at no cost to recipients, with VUI bearing the distribution and installation costs.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Residential Sector - Luganville	20,698	136,000	35,695	0.6	112

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	15 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.20 Project Code 20 – EE Street Lighting Project in Port Vila (Vanuatu)

Rationale

Union Electrique du Vanuatu Ltd (UNELCO) is a privately-owned power utility, part of the GDF SUEZ Group, which also operates in several other PDMCs and globally. UNELCO has the electric power concession for supplying Port Vila, on Vanuatu's main island of Efate, and on the islands of Malekula and Tanna. All of the existing street lighting luminaires in Port Vila are based inefficient Mercury Vapour (MV) lamp technology and significant savings could be achieved by retrofitting with energy-efficient LRD lighting.

Design

The aim of the project was to achieve cost effective energy savings through replacement of 125 watt Mercury Vapour (MV) lamps installed in Port Vila with high efficiency Light-Emitting Diode (LED) Luminaires. There are about 670 street lighting luminaires in Port Vila, all of which are based on inefficient Mercury Vapour (MV) lamp technology with three lamp wattages, i.e. 125 watts (≈86% of all luminaires), 250 watts (≈ 11%) and 400 watts (≈3%). Operation is divided into a number of circuits controlled by 60 street lighting

control panels. The Port Vila Municipality owns street lighting luminaires and is responsible for electricity costs, while UNELCO is contracted by the municipality to install and maintain these street lighting luminaires. The Figure 5.82 shows the current installation and the luminaire span.

Figure 5.82: Typical Installation of Street Lighting Luminaires and Span in Port Vila

This project is to retrofit 160 of the 125W MV luminaires (about 28% of the 125W lamps installed and 24% of all street lights in Port Vila) with high-quality 70W energy-efficient Light Emitting Diode (LED) luminaires. These will produce a better quality and quantity of light, at least 6,000 lumens, compared to the 4,200 lumen output of the existing lamps. In Port Vila, street lights currently operate 6 hours daily but the municipality hopes to increase this to 11 hours. Expected energy savings are about 50% for the lights replaced. It is anticipated that after successful implementation of this project, the municipal authorities may consider LED technology for replacing other street-lighting. The Project Proposal, Design Report and other attachments are given in **Appendix 3.20**.

Procurement

The Invitation for Bids was issued to a total of 16 suppliers on 28 October 2013 and 6 bids were received by the closing date. Philips New Zealand Ltd was awarded the contract on 16 May 2014 following ADB approval of the bid evaluation report on 12 February 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting – Port Vila, Vanuatu	52,975	46,016	13,527	6.0	24

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	July 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	October 2014
Installation	Completed – February 2015

5.4.2.21 Project Code 21 – Residential EE Lighting in Port Vila (Vanuatu)

Rationale

A household energy use survey carried out by PEEP2 (with SPC/GIZ support) in April 2013, The results, based on a statistically representative sampling of about 12% of electrified households, indicated that most lighting is of generally poor quality (Compact Fluorescent lights or CFLs) or inefficient (older fluorescent tube lights or FTLs; incandescent bulbs or IBs). Retrofitting existing inefficient lighting in private homes in Vanuatu's capital, Port Vila, will be lower electricity consumption for lighting, lower lighting costs, decreased GHG emissions, higher quality lighting, and improved night-time home security.

Design

Based on a household energy use survey carried out by PEEP2, about 9,200 residential lights were proposed for replacement in about 8,200 households. Two types of new lighting were proposed: all 4 foot T12 Fluorescent Tube Lights (the least efficient FTLs) replaced with T5 retrofit kits and all incandescent lights with high-quality 14w screw-in CFLs, with adapters where required for converting pin-type fittings to screw-in type. This should allow at least one new light per household. In the event that some cannot be accommodated, lower-income users and high-usage lights are to be targeted. 50% of all proposed replacements are T12 FTLs and 50% are incandescent lights. Light loggers to be ordered for other investments (e.g. Government & Luganville lighting) will be used for monitoring and verification (M&V) of results. The proposed Bill of Quantities is given in Table 5.25.

Table 5.25: Bill of Quantities for Residential Lighting in Port Vila

Bill of Quantities	Total (Units)	Spares (Units)	Total units including spares
T5 FTL retrofits (28w)	4,656	163	4,819
CFL 14w screw-in	4,586	161	4,747
Total lights	***9,242***	***324***	***9,566***
B22-E27 (pin to screw-in) adapters	3,414	216	3,630

Under base case assumptions, residential electricity use for lighting is expected to drop by 24%, overall residential electricity use by 10%, peak demand by 174 kW and GHG emissions by 380 tonnes per year. The proposal includes a fee-for-service option proposed by ADB where a nominal fee of 100 vatu (~ US$1) is charged from the households to supplement installation costs. The Project Proposal, Design Report and other attachments are given in **Appendix 3.21**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014.

By February 2015, the Department of Energy (which is administering the project) had begun replacing lights in homes, charging 250 vatu (about US$2.50) per household for two lights maximum, with an emphasis on lower-income families and those which use T12/T8 FTLs outside for night-time security lighting. Installations were expected to increase considerably by late March but were not expected to be completed until several months after the PEEP2 closure, at the end of April. However, a cyclone (Pam, at Category 5 the worst in nearly 40 years) struck Vanuatu on 12 – 13 March 2015 causing considerable damage in Efate with substantial damage to homes in Port Vila, particularly lower-income dwellings. The impacts and aftermath are expected to considerably slow down delivery of the residential lighting. In the event of unused EE lights in Port Vila and Luganville (Project Code 19), the DoE reportedly plans to provide some of the EE lighting to homes on the smaller grids on the islands of Tanna and Malekula.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Residential Sector – Port Vila, Vanuatu	27,612	319,000	98,780	0.3	264

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	15 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.22 Project Code 22 – Residential EE Lighting in the Outer Islands (Tonga)

Rationale

Each of the outer islands in Tonga generates electricity using diesel generators at a high cost per kWh delivered due to relatively low efficiency of generation by the small diesel plants and high fuel costs due to the remote locations. The retrofitting of existing inefficient lighting in private homes on the largest outer islands of Tonga will be lower electricity consumption for lighting, lower lighting costs, decreased greenhouse gas (GHG) emissions, and higher quality lighting.

Tonga has a universal tariff with outer island customers charged the same as those in urban areas. However, the cost of generation and distribution on the outer islands is substantially greater than that on urban Tongatapu. Therefore any reduction in the customer energy use will also reduce the amount of the cross subsidy being provided to outer island customers.

Design

In March 2013, a household lighting survey was conducted on each of the three islands by TPL, and the results, indicated that most primary lighting is by standard T8 fluorescent tube lamps (FTLs) using magnetic ballasts. The Figure 5.83 shows the typical lighting fixtures in households in the Outer Islands.

Figure 5.83: Types of Existing Lighting Products in Households in Outer Islands, Tonga

The project entails the replacement of the existing T8 FTLs with more efficient T5 FTLs and the proposed bill of quantities is given in Table 5.26 below. The Project Proposal, Design Report and other attachments are given in **Appendix 3.22**.

Table 5.26: Bill of Quantities for Residential Lighting in Outer Islands, Tonga

Existing Lamp Type	Proposed Lamp Type	Vava'u (2,254 HHs)		Ha'apai (1,008 HHs)		'Eua (692 HHs)		Proposed minimum BoQ
		No. of Total Lamps	High Use Areas	No. of Total Lamps	High Use Areas	No. of Total Lamps	High Use Areas	
75W IBs	**15W CFLs**	68	–	1,229	**1,008**	1,384	**692**	**1,700**
T8 FTLs – 2ft	**T5 FTLs – 2ft**	4,007	**2,930**	315	**504**	273	**346**	**3,780**
T8 FTLs – 4ft	**T5 FTLs – 4ft**	4,075	**2,254**	1,449	**1,008**	1,929	**1,384**	**4,646**

Under base case assumptions, household energy (kWh) consumption for lighting in the outer islands of Tonga is expected drop by 35% and overall household electricity use by 11%. The TPL will collect a nominal fee of 2 TOP per household (approx. 1.1 US$) from the households where lights are installed, and provide a record of the users' fees collected per household. The fee collected will be used to off-set installation costs of TPL.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014.

The project has not been completed in the Ha'apai group because of the severe damage to buildings and the grid due to the passage of a cyclone in 2014 with many buildings yet to be replaced or repaired

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Residential Sector – Outer Islands, Tonga	50,060	233,533	–	0.8	213

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	15 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.23 Project Code 23 – EE Street Lighting in Outer Islands (Cook Islands)

Rationale

The existing lighting systems in Aitutaki consist of single and double arm luminaires with 70W high pressure sodium lamps. The light poles spans are inconsistent and far apart that areas between poles are totally dark. The existing luminaires in Aitutaki are installed on roads that are categorized as "Largely Residential, but some motorized vehicles". According to CIE 180:2007, these types of roads shall have average illuminance of 5 lux with a uniformity ratio of 0.2. The onsite measurements show that the current lighting in Aitutaki has both illuminance and uniformity below the recommended values, due to long pole spans.

The existing lighting systems in Mangaia consist of single arm 18W fluorescent luminaires. Some of the luminaires are not functioning while some are operated 24 hours due to malfunctioning of the control system. The road areas between the existing lamps are dark at night and prone to road hazards for both pedestrians and motorists. The existing lighting levels are well below the international standards.

Design

The proposed design approach was to install higher capacity LED lights that would improve lighting level and uniformity to the road area in Aitutaki and Mangaia. To improve road safety, the proposed design will replace single mast arms with double mast arms at all road intersections. It is also proposed to install additional 5 single mast arms on power distribution poles in Aitutaki and 4 new poles in Mangaia to maintain uniformity in lit areas to comply with international standards.

The project will procure energy efficient LED luminaires with 5,400 lumens and power consumption less than 50W for Aitutaki and 2,300 lumens with power consumption below 30W for Mangaia. Most of the new LED luminaires will be installed on the existing mast-arms. The installation of new poles and replacement of single mast-arms with double mast-arms will be responsibility of the APS and MIA. The proposed layout at the two sites is shown in Figure 5.84 and the basic specifications in Table 5.27. The Project Proposal, Design Report and other attachments are given in **Appendix 3.23**.

Aitutaki *Mangaia*

Figure 5.84: Proposed Layout of Lighting in Aitutaki and Mangaia

Table 5.27: Basic Specifications of the Proposed LED Luminaires

Description	Proposed LED Luminaire for Aitutaki	Proposed LED Luminaire for Mangaia
Total Luminaire Lumen Output	≈ 5,500 lumen	≈ 2,800 lumen
Total Luminaire Power Consumption /1	≈60 watts	≈30 watts
Luminaire Efficacy	≈90 lumen/watt	≈90 lumen/watt
Lamp Life	50,000 hours	50,000 hours
Light Distribution Profile	IES Type II or equivalent	IES Type II or equivalent

Note: /1 The total luminaire power consumption includes lamp wattage and power losses in control gears

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 28 October 2013 and 5 bids were received by the closing date of 11 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014 and the installation was undertaken by the Aitutaki Power Supply Co (APS) and Mangaia Island Administration (MIA). Installation at Aitutaki was completed in January 2015 while the installation of Mangaia is currently ongoing (the delay being to the breakdown of the crane in the island). The LED lights installed in Mangaia are shown in Figure 5.85.

Figure 5.85: LED Lights in Mangaia

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting – Outer Islands, Cook Islands	16,045	4,680	1,400	5.5	4

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	September 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Aitutaki – Completed in January 2015 Mangaia – Ongoing

5.4.2.24 Project Code 24 – EE Luminaires in Government Buildings (Samoa)

Rationale

Most government buildings in Samoa have standard T8 lamps, some with magnetic ballasts and others with electronic ballasts. These lamps are usually in two-lamp or three-lamp fixtures. New luminaires with three T5 lamps and electronic ballasts can be used to replace the existing old luminaires. Each new luminaire has 3 T5 lamps with a rated capacity of 28 watts each plus 9 watts for the electronic ballast. The total consumption of the new luminaire is 93 watts. The new T5 luminaires will therefore provide savings of 12 watts or about 11%.

Design

The objective of this project is to achieve cost effective energy savings in government facilities - the Development Bank of Samoa (DBS) and National University of Samoa (NUS) - through replacement of inefficient lighting fixtures (luminaires) with efficient luminaires.

National University of Samoa (NUS): NUS has a large number of old two-lamp luminaires with two T8 lamps and magnetic ballasts. The rated energy consumption of each T8 lamp is 36 watts and the magnetic ballast adds another 10 watts. The total consumption per luminaire is therefore 92 watts. The Figure 5.86 shows a sample of the existing luminaries at NUS building.

Figure 5.86: Current Luminaires at NUS

The T5 lamps with electronic ballasts can be used to replace the T8 lamps. Each T5 lamp has a rated capacity of 28 watts plus 3 watts for the electronic ballast, with the total consumption being 31 watts. Therefore, the new T5 luminaire with two lamps has a total rated consumption of 62 watts, thereby providing savings of 30 watts or about 34.8%.

Development Bank of Samoa (DBS): DBS has a large number of old three-lamp luminaires with three T8 lamps and electronic ballasts. The rated energy consumption of each luminaire is about 105 watts. The Figure 5.87 shows a sample of existing luminaires at DBS.

Figure 5.87: Current Luminaires at DBS building

New luminaires with three T5 lamps and electronic ballasts can be used to replace the existing old luminaires. Each new luminaire has 3 T5 lamps with a rated capacity of 28 watts each plus 9 watts for the electronic ballast. The total consumption of the new luminaire is 93 watts. The new T5 luminaires will therefore provide savings of 12 watts or about 11%. The Project Proposal, Design Report and other attachments are given in **Appendix 3.24**.

Scope of Supply: NUS – replacement of 400 two-lamp T8 luminaires with the same number of two-lamp T5 luminaries; and DBS – replacement of 680 existing three-lamp T8 luminaires with the same number of three-lamp T5 luminaries.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 18 November 2013 and 2 bids were received by the closing date of 2 December 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd on 16 May 2014. The luminaires was delivered to site in August 2014. The luminaires installed in the Development Bank of Samoa are shown in Figure 5.88.

Figure 5.88: Luminaires at Development Bank of Samoa

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Luminaires in Government Buildings – Samoa	93,438	86,769	22,512	2.4	68

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	September 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Completed

5.4.2.25 Project Code 25 – Demonstration of EE Air Conditioning Technologies (Samoa)

Rationale

Energy consumption and peak load information from the Electric Power Corporation (EPC) shows that air conditioning represents about 50% of the energy consumption in government buildings and contributes about 40% of EPC's peak load. Improving the efficiency of ACs is therefore a high priority in Samoa. Most of the ACs in government buildings is standard split units that have rated EERs in the range of 2.3 to 2.9 W/W. For older units, the EER may be lower.

Design

The project will replace some of these existing split AC units with energy efficient inverter ACs or solar ACs that will have EERs of 3.6 W/W. Also the project will install smart controllers on a selected number of ACs to improve the operational efficiency of existing ACs.

The project will be carried out in six public buildings/government agencies, namely:

- Mapufagalele: Little Sisters Of The Poor
- National health Service (NHS)
- National University of Samoa (NUS)
- Samoa National Provident Fund (SNPF) Building
- Ministry of Natural Resources and Environment (MNRE)
- Scientific Research Organization of Samoa (SROS)

Inverter AC

Typical EERs of inverter type ACs are around 3.6 W/W while the EERs of existing ACs in Samoa range from 2.3 to 2.9 W/W. Therefore the replacement of existing air conditioners with efficient inverter units can provide savings of about 20% to 30%.

Figure 5.89: Example of Inverter Type Air Conditioner

Four government agencies are included in this project for replacing existing AC units with inverter type ACs. For each agency, detailed inventories of the existing ACs were prepared and, using nameplate data on cooling capacity and input power, the EERs were calculated for each unit. A number of the less efficient units were then targeted for replacement under the project. The Table 5.28 below shows the numbers and sizes of the ACs to be replaced by inverter type units.

Table 5.28: Inventory of AC Units to be Replaced with Inverter ACs in Public Buildings

Agency	2.6 kW	3.5 kW	5.3 kW	7.0 kW	Total
Little Sisters of the Poor	6	1	1	0	8
National Health Service	1	0	9	1	11
National University of Samoa	0	0	5	7	12
SNPF Building	7	7	1	0	15
Total	**14**	**8**	**16**	**8**	**46**

Solar Hybrid ACs

This project will replace the existing split AC units that have EERs in the range of 2.3 to 2.9 with energy efficient solar hybrid AC that will have EERs of 3.6 W/W, in two of the following Samoa government agencies:

- Ministry of Natural Resources and Environment (MNRE)
- Scientific Research Organization of Samoa (SROS)

As a part of the PEEP2 project, measurements of energy consumption in existing air conditioners and solar hybrid ACs were conducted by the PEEP2 project team at Mapuifagalele - Little Sisters of the Poor using data loggers. The results showed that the solar hybrid AC saved about 23% of energy compared to existing ACs. In addition, PEEP2 has prepared a report on technology assessment of energy efficient technologies for the Pacific Island nations. All of these sources have confirmed that solar hybrid ACs are generally 20% to 30% more efficient than standard window or split ACs. The Figure 5.90 shows the Solar AC unit installed at the Mapuifagalele - Little Sisters of the Poor.

Figure 5.90: Example of Solar Hybrid Air Conditioner

For the two government agencies included in this project, inventories of the existing ACs were prepared and, using nameplate data on cooling capacity and input power, the EERs were calculated for each unit. The Table 5.29 below shows the numbers and sizes of the ACs to be replaced.

Table 5.29: Inventory of AC Units to be Replaced with Solar Hybrid ACs in Public Buildings

Agency	2.6 kW	3.5 kW	5.3 kW	7.0 kW	Total
Ministry of Natural Resources and Environment (MNRE)	3	1	0	3	7
Scientific Research Organization of Samoa (SROS)	0	0	1	3	4
Total	**3**	**1**	**1**	**6**	**11**

Smart Controllers

A smart controller is a device that decreases the energy consumption of an AC by reducing the run times on the air conditioning unit's compressor. It has embedded in it smart technology to analyze the temperature of the unit and control its operation to prevent overcooling.

The smart controller contains software that can be continually and dynamically applied to any cooling unit during its operation. The controller will use its connected sensor to compare the cooling unit's actual performance against the software model and determine how to optimize the operation. The Figure 5.91 shows a photo of the proposed Smart Controller.

Figure 5.91: Example of Smart Controller for ACs

As the comparison model is continuously and dynamically applied the controller will automatically adjust its optimisation to compensate for any variance between theoretical load and maximum load, and will also automatically compensate for variances in actual dynamic applied load to the cooling unit. Thus for any installation the operation of the controller will be seen at different points and at different periods in the cooling unit's operational period and load cycle. The smart controller is likely to work best when the AC is oversized or when there is a considerable change in the cooling load during the day or a season.

As part of the PEEP2 project, three smart controllers were obtained and tested at three locations in Samoa. The tests indicated varying levels of savings, from 3% to 34%. The cost of the controller is low and even at low levels of energy savings it can be cost effective. For example, even if the savings are just 5% for a unit with cooling capacity of 5 kW operating 2,000 hours per year, the typical payback is likely to be about 2.5 years.

This project will purchase and install 20 smart controllers on air conditioners in two government agencies - 10 units each in the National University of Samoa (NUS) and Samoa National Provident Fund (SNPF) Building. The Project Proposal, Design Report and other attachments are given in **Appendix 3.25**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 6 November 2013 and 8 bids were received for Lot 1 (Inverter ACs), 3 bids for Lot 2 (Solar Hybrid ACs) by the closing date of 2 December 2013. Following evaluation of bids the contract was awarded to Apia Electrical Traders Ltd (Lot 1) and GreenCo (Lot 2). The procurement for Lot 3 (Smart Controllers) was sole-source and awarded to Fouress Company who are the sole manufacturers of the controllers. The equipment was delivered to site in August 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
Demonstration EE Air Conditioning Technologies – Samoa	88,435	96,629	25,362	2.5	77.3

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	September 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (Inverter Units)	Apia Electrical Traders
Name of Supplier (Solar Hybrids)	GreenCo Energy Savers
Name of Supplier (Smart Controllers)	Fouress Company
Delivery	Delivered
Installation	Completed

5.4.2.26 Project Code 26 – EE Lighting in Commercial Sector (Samoa)

Rationale

Many commercial buildings in Samoa have T8 lamps with magnetic ballasts. These lamps are usually in one-, two- or three-lamp fixtures. The T8 lamps come in different lengths and have different levels of rated energy consumption. Replacement with EE lighting (T5 lamps with electronic ballasts) will provide significant savings.

Design

The aim of the project is to achieve cost effective energy savings in the commercial sector through replacement of five-foot T8 fluorescent lamps with magnetic ballasts, which have a rated power consumption of about 58 watts for the lamp and 12 watts for the ballast (or a total of 70 watts), with four-foot T5 lamps with electronic ballasts that have a rated power consumption of 28 watts for the lamp

and 3 watts for the ballast (or a total of 31 watts). In the Yazaki (EDS) Samoa Limited facility, there are over 1,300 five-foot lamps. Most of these are hanging from a bar over the work area and some are in offices. The rated energy consumption of these lamps is 58 watts for the lamp plus about 12 watts for the ballast or about 70 watts total.

The objectives of this project were to achieve cost effective energy savings in the commercial sector through replacement of five-foot T-8 fluorescent lamps with magnetic ballasts, which have a rated power consumption of 76.9 watts (including ballast power losses) with energy efficient LED battens that have a total rated power consumption of 28.8 watts (including LED driver), in order to achieve cost effective energy savings of over 60% of electricity used for indoor lighting.

Procurement of reflective luminaires, each of which with a complete set of one T5 lamp and an electronic ballast will be divided into 2 lots with the same quantities, and the same technical specifications. A single successful bidder will be selected but two supply and delivery contracts will be arranged with Yazaki and ADB for lot 1 and 2 respectively. The Project Proposal, Design Report and other attachments are given in **Appendix 3.26**.

Procurement

The project was implemented at Yazaki EDS. A total of 1,300 energy-efficient four-foot LED lamps (Philips GreenUp LED Batten BN 108C) were procured to replace the existing T8 fluorescent tubes.

Following the approval of the project proposals, Invitation for Bids was issued on 18 November 2013 and 2 bids were received by the closing date of 2 December 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd on 16 May 2014. The lighting was delivered to site in August 2014. The installation of the LED Battens at Yazaki Ltd (Host site) is shown in Figure 5.92.

Figure 5.92: Lighting Installations at Yazaki

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in the Commercial Sector – Samoa	71,440	145,003	38,058	1.3	116

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (Inverter Units)	Philips New Zealand
Delivery	Delivered
Installation	Completed

5.4.2.27 Project Code 27 – EE Air Conditioning in Hotels (Samoa)

Rationale

Air conditioners (ACs) represent a large energy cost to hotels. Most of the ACs in hotels in Samoa is standard split air conditioning units or window units that have rated Energy Efficiency Ratios (EERs) in the range of 2.1 to 2.9 W/W. For older units, the EER may be lower. The aim of the project is to achieve cost effective energy savings in hotels through replacement of existing split air conditioners with efficient inverter air conditioners.

Design

The project will replace the existing split and window AC units, which have EERs in the range of 2.1 to 2.9 W/W with energy efficient inverter ACs that will have EERs of 3.6 W/W, in two of the following hotels, namely, Pacific Pearl Hotel (PPH) and Vaisala Hotel (VH).

As a part of the PEEP2 project, measurements of energy consumption in existing ACs and inverter type ACs were conducted by the Australia Pacific Technical College (under a subcontract from PEEP2) at the National University of Samoa (NUS) and the Ministry of Natural Resources and Environment (MNRE), using data loggers. The results showed that inverter type ACs saved 20% to 25% of energy compared to the existing ACs. In addition, PEEP2 has prepared a report on technology assessment of energy efficient technologies for the Pacific Island nations. All of these sources have confirmed that inverter ACs are generally 20% to 30% more efficient than standard window or split ACs.

The Table 5.30 below shows the numbers and sizes of the ACs to be replaced. Additional details on the numbers and sizes of units to be replaced are provided in the Project Proposal and Design Report in **Appendix 3.27**.

Table 5.30: Inventory of AC Units to be Replaced at Pacific Pearl and Vaisala

Hotel	2.6 kW	3.5 kW	5.3 kW	7.0 kW	Total
Pacific Pearl	4	4	2	7	**17**
Vaisala	4	0	3	0	**7**
Total	**8**	**4**	**5**	**7**	**24**

The procurement will be conducted in two lots, Lot 1 paid by ADB and Lot 2 by the hotels. The competitively selected supplier will deliver the Lot 1 equipment to the implementing agency (MNRE), who will be responsible for clearing the units through customs and the respective duty and tax exemptions (including VAGST). The Lot 2 equipment will be paid by and delivered to the hotels.

The hotels will be responsible for installation of the new inverter type ACs. After replacement of the old units, MNRE will collaborate with the hotels to arrange for the refrigerants to be removed from the replaced units and the hotels then will send the units to a disposal facility.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 6 November 2013 and 2 bids were received by the closing date of 22 November 2013. Following evaluation of bids the contract was awarded to Apia Electrical Traders Ltd on 16 May 2014. The AC Units was delivered to site in August 2014. The installation of the AC units at Pacific Pearl Hotel (one of the host sites) is shown in Figure 5.93.

Figure 5.93: AC Installation at Pacific Pearl Hotel

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Air Conditioning in Hotels – Samoa	33,610	19,703	5,171	4.6	15.8

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (Inverter Units)	Apia Electrical Traders Ltd
Delivery	Delivered
Installation	Completed

5.4.2.28 Project Code 28 – Residential EE Lighting (Samoa)

Rationale

Energy consumption information from Electric Power Corporation shows that the residential or domestic sector had 33,707 customers (including both prepayment and non-prepayment customers) and used 26,530 kWh of electricity. This sector is therefore a very significant energy consuming sector, representing about 84% of the customers and 30% of the electricity consumed. Lighting represents one of the major end uses

of electricity. While there is a range of different lighting types used in households and there is scope to achieve cost effective energy savings in the residential sector through replacement of inefficient lamps with efficient lamps.

Design

As a part of the PEEP2 project, a set of pilot installations of T5 lamps were made in a number of government buildings in Samoa (including the Development Bank of Samoa) to demonstrate the benefits of replacing the T8 lamps with T5 lamps. Measurements of the illuminance levels were taken with a lux meter before and after the replacement, and these measurements demonstrated that the T5 lamps provided approximately 10 to 15% improvements in the lighting levels. The Figure 5.94 shows examples of existing lighting in households.

Figure 5.94: Examples of Existing Household Lighting

The project will purchase 4,000 four-foot and 4,000 two-foot T5 lamps (with electronic ballasts). In addition, 240 spare lamps (3%) - 120 each of the four-foot and two-foot types - will be purchased. The proposed T5 lamp with integrated ballast is shown in Figure 5.95 below.

Figure 5.95: Typical T5 Lamp with Integrated Ballasts

The distribution of the T5 lamps will be carried out by MNRE. It is proposed that EPC collect ST3.00 per lamp from the participating customers as MNRE, as a government ministry, do not have the provision to collect funds from the public. The Project Proposal, Design Report and other attachments are given in **Appendix 3.28**.

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. The scope included EE lighting and light loggers for use in M&V. Following evaluation of bids the contract for EE Lighting was awarded to Philips New Zealand Ltd; and the contract for light loggers was awarded to MicroDaq (USA). The lighting equipment was delivered to site in August 2014 and the installation was coordinated though the Electric Power Corporation (EPC).

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Residential Sector – Samoa	71,783	154,515	40,555	1.2	123.6

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	August 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.29 Project Code 29 – EE Lighting in Public Sector Buildings (Tonga)

Rationale

Most government buildings in Nuku'Alofa, Tongatapu Island have standard T8 Fluorescent Tube Lamps (FTLs) with magnetic ballasts. These lamps are usually in two-lamp or three-lamp fixtures. Each T8 4-foot lamp has a rated energy consumption of 36 watts and the magnetic ballast adds another 10 watts for a total consumption of 46 watts per lamp. The aim of this project is to retrofit existing inefficient lighting systems, in a number of buildings owned by the Government of Tonga, with high-quality energy-efficient lighting systems. The results will be lower electricity consumption for lighting, lower lighting costs, decreased GHG emissions and in some cases higher quality lighting.

Design

The program design includes the direct replacement of all existing T8 FTLs (2 and 4-foot) with LED Tubes (2 and 4-foot) in selected buildings. Lighting surveys conducted have identified the following buildings for inclusion in the project: Ministry of Lands, Ministry of Environment, Viola Hospital, Police Department and Fire Department. The LED Tubes will come with integrated LED drivers, and the physical dimensions of the LED Tubes are identical to the existing T8 FTLs so that they can be directly fitted into the existing T8 lamp holders (referred to as G13 pin type by relevant IEC standards). The proposed bill of quantities is given in Table 5.31. The Project Proposal, Design Report and other attachments are given in **Appendix 3.29**.

Table 5.31: Bill of Quantities for EE Lighting in Public Buildings, Tonga

Government Agency	LED Tube 20W (4-foot)	LED Tube 10W (2-foot)
Ministry of Lands	129	82
Ministry of Environment	76	–
Viola Hospital	884	7
Police Head Office	187	29
Police Training Center	136	110
Police Building Mu'a and Vaini	1	8
Police Building Nuku'nuku	7	13
Fire Department	38	8
Total	**1,476**	**257**

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 18 November 2013 and 2 bids were received by the closing date of 2 December 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd on 16 May 2014. The lighting was delivered to site in August 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Public Sector Buildings – Tonga	63,118	158,706	41,655	1.3	144.7

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	November 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (Inverter Units)	Philips New Zealand Ltd
Delivery	Delivered
Installation	Ongoing

5.4.2.30 Project Code 30 – EE Lighting in Provincial, Public Sector and Schools (Vanuatu)

Rationale

Vanuatu government sector lighting is generally inefficient, with lighting often 50% of electricity use. For most public buildings general, lighting is the highest user of electricity. There are significant opportunities for wide-scale cost-effective reductions in energy use, energy expenditure and greenhouse gas (GHG)

emissions. This proposed project is to provide energy-efficient lighting for provincial buildings, municipalities, primary and secondary schools, and some national government facilities on the main island of Efate and the northern island of Espiritu Santo.

Design

The project is to improve the efficiency of lighting for 40 buildings on the islands of Espiritu Santo and Efate (14 local, provincial & national government facilities and 26 schools), replacing over 4,900 lights of which 60% are for private or government schools. Over 75% of proposed replacements are T5 kits replacing 36w T8 linear fluorescent tube lights. The Table 5.32 provides a summary of the scope of the project. The Project Proposal, Design Report and other attachments are given in **Appendix 3.30**.

Table 5.32: Lighting Inventory for Provincial, Public and Schools in Vanuatu

Type of Light	Watts	Number	% of lights	To be replaced?
Incandescent (screw type E27)	50 average	24	< 1	no
Incandescent (screw type E40)	300	30	<1	**yes**
Incandescent (bayonet type B22)	50 average	82	2	no
Fluorescent Tube T8 (two feet	18	740	14	**yes**
Fluorescent Tube T8 (four feet)	36	4,084	76	**yes**
Fluorescent Tube T8 (five feet)	58	12	<<1	no
Fluorescent Tube T12 (4 feet)	40	82	2	**yes**
Compact Fluorescent Light (CFL E27)	15-17, 65 /1	207	4	no
Compact Fluorescent Light (CFL E40)	65	76	1	no
Spot Light (PAR) and others	80	7	<<1	no
Total	-	**5,344**	**100%**	
Total to be replaced		***4,936***	***92%***	

Note: /1 Only 3 of these are 45 watts

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 18 November 2013 and 2 bids were received by the closing date of 2 December 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd on 21 May 2014. The lighting equipment was delivered to site in August 2014.

By early March 2015, installations were under 60% completed but scheduled to be finished by April 2015. However, given the extent of the devastation caused by cyclone Pam, the stakeholders are likely to consider other priorities more important than energy efficient lights.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Public Sector – Vanuatu	26,083	191,000	50,130	0.5	159

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	8 October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	21 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.31 Project Code 31 – Residential EE Lighting in Tongatapu (Tonga)

Rationale

Recent surveys indicate high penetration of inefficient lighting in private homes on the main island of Tonga. Tongatapu generates electricity using diesel generators at a high cost per kWh delivered due to high fuel costs. There is significant scope to retrofitting with EE lighting in the residential sector that will result in lower electricity consumption for lighting, decreased greenhouse gas (GHG) emissions, and higher quality lighting.

Design

During the PEEP1 project, a household lighting survey was conducted on Tongatapu by the project team. The results, based on a survey of a random sample of electrified households, indicated that most primary lighting is by standard T8 fluorescent tube lamps (FTLs) using magnetic ballasts. Hence, replacing the existing T8 FTLs with more efficient T5 FTLs will significantly reduce energy use and GHG emissions. The project design includes the following:

- Although the hours of usage vary substantially, only lighting replacements in high end use areas were chosen for replacement and a conservative 3 hour per day usage was assumed for those lights.
- Approximately 42% of the nearly 12,200 households in Tongatapu will receive high efficiency lights for high end use areas, typically two lights per home.
- The power utility, TPL, will install the new energy efficient lights, remove old lights, and arrange their transportation to as designated site for safe disposal of the old lights using the bulb eater procured under PEEP2.
- The nominal fee of TOP 2, that is collected, will partially offset the installation cost, which is estimated at US$ 3, and will also ensure that recipients do not associate the lights received as without a real value as could be the case if provided without charge. TPL will provide an account of the money received for the lights.

The proposed bill of quantities is based on the proposed lamps per household is based on the survey (2ft-FTL: 1.5 and 4ft FTL: 2) and the intended scope to cover 5,100 households with maximum 2 lamps per household. A summary of the proposed minimum Bill of Quantities (BoQ) is given in Table 5.33. The Project Proposal, Design Report and other attachments are given in **Appendix 3.31**.

Table 5.33: Bill of Quantities for Residential EE Lighting in Tongatapu

Existing Lamp Type	Proposed Lamp Type	Total no. of Lamps in Household	No. of Total Lamps Replaced	Contingency (2%)	Proposed minimum BoQ
T8 FTLs – 2ft	**T5 FTLs – 2ft**	18,300	4,500	**366**	**4,866**
T8 FTLs – 4ft	**T5 FTLs – 4ft**	23,586	5,800	**472**	**6,272**

Procurement

Following the approval of the project proposals, Invitation for Bids was issued on 11 November 2013 and 2 bids were received by the closing date of 25 November 2013. Following evaluation of bids the contract was awarded to Philips New Zealand Ltd. The lighting equipment was delivered to site in August 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Residential Sector – Tongatapu	55,008	149,466	39,230	0.7	136

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	24 October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	15 May 2014
Name of Supplier	Philips New Zealand Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.32 Project Code 32 – EE Street Lighting in Alotau (PNG)

Rationale

Currently, nearly 100% of Street Lighting lamps in Alotau are 80W Mercury Vapour (MV) lamps. These lamps were very popular during the 1970's due to their bright white light with relatively good lighting quality because of their higher Colour Rendering Index (CRI) value compared with high pressure sodium lamps (HPS). Although, these lamps have relatively long life (>20,000 hours), they are known to have rapidly deteriorating lighting output and low efficacy. Replacing these lamps with EE lighting (LED luminaires) will result in significant reduction in electricity consumption for street lighting.

Design

Currently with the exception of 1x125W High Pressure Sodium (HPS) lamp, all 178 street lighting luminaires in Alotau are 80W Mercury Vapour (MV) lamps. This project aims to replace all 178 sets of 80W Mercury Vapour lamps and luminaires, in high traffic/visibility streets, with 30W White LED luminaries. The onsite measurements show that the current setup of MV street lighting in PNG are not able to provide illumination and uniformity as per the CIE 180:2007 requirements, due to relatively long pole spans and high mounting heights.

Standard LED luminaires with similar or better light distribution profiles will be procured to replace the existing 80W MV lamps and luminaires. The new LED luminaires will be installed on the existing mast-arms, hence on-site civil or mechanical works will not be required. Installation of street lighting in PNG will be undertaken by PPL, and the luminaires are generally affixed on distribution poles with relatively short mast-arms, as shown in Figure 5.96. The Project Proposal, Design Report and other attachments are given in **Appendix 3.32**.

Figure 5.96: Installation of Street Lighting Luminaire in Alotau, PNG

The Table 5.34 below summarizes basic specifications of the existing luminaires and the proposed LED luminaires.

Table 5.34: Basic Specifications of Existing HID Luminaires and Proposed LED Luminaires

Description	Existing 80W MV Luminaire	Proposed LED Luminaire
Total Luminaire Lumen Output	2,300 lumen /1	2,630 lumen /2
Total Luminaire Power Consumption /3	~90 watts	31 watts
Luminaire Efficacy	25 lumen/watt	85 lumen/watt
Lamp Life	20,000 hours	50,000 hours
Light Distribution Profile	N/A	IES Type II or equivalent

Note: /1 Estimated based on average 3,600 lumen output of 80W MV lamp and 0.64 Light Output Ration (LOR) luminaire
/2 Estimated based on average 2,800 lumen output of 31W LED luminaire with 0.94 LOR
/3 The total luminaire power consumption include lamp wattage and power losses in control gears. For MV luminaire, power loss in control gear is about 15% of lamp wattage.

Procurement

Following approval by ADB, Invitation for Bids was issued on 6 February 2014 and a total of 3 bids were received by the closing date. The contract was awarded to Philips New Zealand on 16 May 2014.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Street Lighting in Alotau	61,000	46,025	17,200	3.5	45

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	8 October 2013
ADB Approval of Bid Evaluation Report	6 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (EE Lighting)	Philips New Zealand Ltd
Delivery	August 2014
Installation	Completed

5.4.2.33 Project Code 33 – EE Lighting in Alotau General Hospital (PNG)

Rationale

The public hospitals in PNG rely on government funding to meet their operational expenses, as they are required to charge very little to their patients. Cost of electricity constitutes a substantial proportion of overall operational expenditure of a public hospital. As energy savings result in substantial financial savings that can be used towards improved and increased health services.

Design

The core objective of the project was, to achieve cost effective energy savings through replacement of various existing standards lighting technologies with high efficiency alternates, including standard 36W T8 lamps and electromagnetic ballasts together with existing twin tube non-reflective luminaires, with 28W T5 fluorescent lamps and electronic ballasts in highly reflective single tube luminaires. More specific objectives included:

1. To achieve cost effective energy savings of more than 62% of electricity used for lighting.
2. To implement a showcase project for future replications.
3. To create awareness among general public and within General Hospital staff about the benefits and usefulness of energy efficiency.
4. To provide better quality lighting in public and general service areas in a basic service centre.

The scope of the project includes:

1. Replacement of 450 sets of single T8 lamps and electromagnetic ballast in non-reflective coarse suspended luminaires, installed in wards, with SINGLE 28W T5 lamp and electronic ballasts in mirror reflectors surface mounted luminaires with no cover.
2. Replacement of 150 sets of single and twin lamp 18W T8, enclosed in non-reflective surface luminaires with translucent acrylic cover, installed in outpatient clinics and utility areas of wards, with SINGLE 14W T5 lamp and electronic ballasts in mirror reflectors surface luminaires with no cover.
3. Installation of photo-sensors on all 150 sets of lighting units installed in corridors.
4. Installation of motion sensors lighting controls in 50 specialty services rooms that are frequently left vacant for longer periods of times.

This project was originally developed for Port Moresby General Hospital (POMGEN). At the time of the development of the project, POMGEN had planned a thorough renovation of one of its building blocks. As such PEEP2 offered to provide EE lighting as proposed EE projects. A detailed energy audit was conducted and equipment identified, together with detailed project design and cost benefit assessment. However, due to substantial delays on procurement and delivery of the project equipment, by the time the project equipment was procured and supplied, POMGEN had already completed its planned renovations. Consequently, the project was transferred to Alotau General Hospital (AGH), which offered almost similar equipment requirements as POMGEN. The Project Proposal, Design Report and other attachments are given in **Appendix 3.33**.

Procurement

Following approval by ADB, Invitation for Bids was issued on 6 February 2014 and a total of 3 bids were received by the closing date. The scope of supply included EE lighting, photocell sensors and motion sensors. The contract for the EE lighting was awarded to Pierlite Australia on 16 May 2014. The contracts for the photocell and motion sensors were awarded to Powerade Co Ltd and Acoustic & Lighting Pte Ltd respectively.

Alotau General Hospital (AGH) was chosen as the alternate EE project site due to keen interest of PNG Power Ltd (PPL), considering the substantial economic savings due to disparity between tariffs and cost to supply electricity. The equipment was shipped to Alotau in February 2015 but the installation is yet to be completed. PPL is assisting AGH with all logistics to ensure installation of the equipment by a qualified contractor. In this regard, the DSM Cell at PPL had agreed to provide funding for equipment installation.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting in Public Sector – Alotau Hospital	63,804	43,904	10,312	3.4	27

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	8 October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (EE Lighting)	Pierlite Australia Ltd
Name of Supplier (sensors)	Powerade Co Ltd & Acoustic & Lighting Pte Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.34 Project Code 34 – EE Lighting and Ventilation at University of PNG (PNG)

Rationale

During the inception of PEEP2 interaction was made with UPNG to establish whether some EE activities and research could be conducted. This prompted the academic staff of UPNG to be interested in EE and with the help and encouragement of PEEP2, UPNG started engaging its students in EE activities e.g. conduct basic energy audits, write assignments on EE etc. UPNG offered its staff, premises and resources during the capacity building training conducted in PNG. This training included conducting detailed energy audits of Science Building of the university; and the audit identified a number of cost-effective EE measures.

Design

The EE measures identified included:- replacement of standard technology lighting with high efficiency alternates, replacing low efficiency ceiling fans and electromagnetic regulators with high efficiency fans and electronic dimmers, replacing poor performance air conditioning units with more efficient units and improving thermal performance of the building to reduce consumption on air conditioning. EE lighting was selected as the implementable EE project. The project scope includes the following:

1. Replacement of 375 sets of twin lamp 36W T8, in non-reflective surface mounted luminaires, installed in high usage areas e.g. laboratories, classrooms and offices, with SINGLE 28W T5 lamp and electronic ballasts in mirror reflectors recessed luminaires with no cover.
2. Replacement of 195 sets of single lamp 36W T8, in non-reflective surface mounted luminaires without acrylic cover, installed in installed in high usage areas e.g. laboratories, classrooms and offices, with SINGLE 28W T5 lamp and electronic ballasts in mirror reflectors recessed luminaires with no cover.
3. Installation of photo sensors on all 100 sets of lighting units installed in corridors.
4. Installation of motion sensors lighting controls in 20 specialty services rooms that are frequently left vacant for longer periods of times.

The Project Proposal, Design Report and other attachments are given in **Appendix 3.34**.

Procurement

Following approval by ADB, Invitation for Bids was issued on 6 February 2014 and a total of 3 bids were received by the closing date. The scope of supply included EE lighting, photocell sensors and motion sensors. The contract for the EE lighting was awarded to Pierlite Australia on 16 May 2014. The contracts for the photocell and motion sensors were awarded to Powerade Co Ltd and Acoustic & Lighting Pte Ltd respectively.

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
EE Lighting and Ventilation at UPNG	63,804	83,587	19,419	1.8	51

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	8 October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier (EE Lighting)	Pierlite Australia Ltd
Name of Supplier (sensors)	Powerade Co Ltd & Acoustic & Lighting Pte Ltd
Delivery	August 2014
Installation	Ongoing

5.4.2.35 Project Code 35 – Solar Water Heaters for Rarotonga Hospital (Cook Islands)

Rationale

Rarotonga hospital on Rarotonga Island is the main and only hospital in the Cook Islands. Rarotonga hospital can treat most of the basic health conditions, while serious health injuries patients are transferred to New Zealand with support from the government budget. Rarotonga hospital was officially opened in August 1972 and currently has 6 wards with 85 beds. The hospital services are mostly subsidized by the government and minimal user fee is applied only to cover partial funds. As health budget is not adjusted for inflation, the budget currently received hardly meets its operating expenditures. Energy bills account for a large share of total annual operating costs. The Energy Commissioner of the Cook Islands approached the PEEP 2 team to develop a project to reduce the high energy consumption required for water heating at the hospital.

Design

A simulation of the water heating shows that it consumes approximately 12,464 kWh per year or 29% of the total energy consumption 43,500 kWh per year. By replacing the electric water heater with a solar water heater, the hospital can potentially save 9,238 NZ$ per year from the average monthly electric bill at 27,000 NZ$. The current high energy consumption of the existing electric water heaters is due to their low efficiency, lack of insulation, and overheating of water to unnecessary high temperature of 80^{o}C.

Sizing of the solar water heater is based on the sizing recommendation in ASHRAE (2011) Chapter 50: Service Water Heating. The daily average hot water usage in health care services is 69.7 liters per bed per day. The Rarotonga hospital has a total of 85 beds with an average 40% occupancy rate. At the consumption rate of 69.7 liters per bed per day, the hot water demand at tap (40^{o}C) is 2,380 liters per day and therefore, water demand at 60^{o}C is 1,058 liters per day. For 2 days back up, the total hot water demand of the solar system is 2,116 liters. The solar fraction in this design is 71% for an occupancy rate of 40%.

The project proposes 7 units of thermosyphon systems (2 x 1.98 m^2 collectors with 300 liters water storage tank) to replace the electric water heaters. The thermosyphon system is common in the Pacific islands as it less labour intensive and easy to install as compare to a large system. The Project Proposal, Design Report and other attachments are given in **Appendix 3.35**.

Procurement

Following approval by ADB, Invitation for Bids was issued on 15 September 2014 and a total of 2 bids were received by the closing date of 30 September 2014. The contract was awarded to Rarotonga Plumbing Contractors Ltd on 17 November 2014. The units were delivered in January 2015 and the installation was completed in March 2015. The installation in the Medical Ward is shown in Figure 5.97.

Figure 5.97: Solar Water Heaters and Monitors Installed at Medical Ward

Project Costs and Benefits

Project	Net Project Cost (US$)	Annual Energy Savings (kWh)	Diesel Savings (litres/year)	Simple Payback (years)	CO_2 Savings (tons/year)
SWH at Rarotonga Hospital, Cook Islands	26,828	16,888	4,432	2.2	14

Project Implementation Schedule

Parameter	Details
ADB Approval of Project Proposal	8 October 2013
ADB Approval of Bid Evaluation Report	12 February 2014
Date of Contract Award	16 May 2014
Name of Supplier	Rarotonga Plumbing Contractors Ltd
Delivery	January 2015
Installation	Completed – March 2015

5.4.3 Summary of Implemented Projects and Benefits

This section provides a summary of the project costs (EE equipment funded by ADB) and the benefits for each country.

5.4.3.1 Cook Islands

			A	B	B - A	Estimated (to be verified during M&V)			
Project Code	Project Name	Category	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (Ton CO_2e/year)
1	Energy Efficient Lighting in Rarotonga Airport	Energy Efficient Street Lighting Program	36,800	44,120	7,320	8,150	4,985	2,190	6.7
2	Energy Efficient Street Lighting Project for the Punanga Nui Market	Energy Efficient Street Lighting Program	96,600	108,510	11,910	7,250	4,435	2,160	6.6
3	Energy Efficient Fridge/Freezer Replacement Program	Residential Energy Efficient Program	100,000	113,150	13,150	83,284	50,946	24,450	66.4
6	Energy Efficient Lighting in Marina and Wharf	Energy Efficient Street Lighting Program	92,000	105,925	13,925	8,634	5,282	2,175	6.9
7	Energy Efficiency Program in Public Buildings	Implementation of EE Measures in the Public Sector	98,200	94,080	(4,120)	196,950	120,477	57,890	176.0
15	Energy Efficiency in Edgewater Resort & Spa	Energy Efficiency Measures in Hotels and Commercial Buildings	82,500	56,183	(26,317)	57,587	35,227	16,930	94.9
17	Residential Energy Efficient Lighting Program	Energy Efficient Lighting in Residential, Commercial and Government Sectors	98,000	51,741	(46,259)	141,800	86,741	41,685	95.0
23	Energy Efficient Street Lighting Project in the Outer Islands, Cook Islands	Energy Efficient Street Lighting Program	39,000	16,045	(22,955)	4,680	2,863	1,400	4.0
35	Solar Water Heaters for Rarotonga Hospital, Cook Islands	Implementation of EE Measures in the Public Sector	28,000	26,828	(1,172)	16,888	10,331	4,432	14.0
			671,100	**616,582**	**(54,518)**	**525,223**	**321,285**	**153,312**	**470.5**

5.4.3.2 Papua New Guinea

			A	B	B - A	Estimated (to be verified during M&V)			
Project Code	Project Name	Category	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (Ton CO_2e/year)
5	Energy Efficient Street Lighting Project in Residential Streets of Port Moresby	Energy Efficient Street Lighting Program	96,000	45,899	(50,101)	36,680	10,488	10,135	26.5
8	Energy Efficient Lighting at Papua New Guinea Power Limited (PPL) Head Office	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,125	92,428	(6,697)	218,188	62,390	51,124	535.0
16	Energy Efficiency Rooftop Retrofit at Papua New Guinea Power Limited (PPL) Head Office	Implementation of EE Measures in the Public Sector	NO BIDS RECEIVED		-	-	-	-	-
32	Energy Efficient Street Lighting Project in Residential Streets of Alotau	Energy Efficient Street Lighting Program	80,000	61,000	(19,000)	46,025	13,161	17,200	45.0
33	Energy Efficient Lighting for Port Moresby General Hospital	Energy Efficient Lighting in Residential, Commercial and Government Sectors	95,325	63,804	(31,521)	43,904	12,554	10,312	27.0
34	Energy Efficient Lighting and Ventilation at Science Faculty Building (Science 1), University of PNG	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,875	53,847	(46,028)	83,587	23,901	19,419	51.0
			470,325	**316,978**	**(153,347)**	**428,384**	**122,494**	**108,190**	**684.5**

5.4.3.3 Samoa

			A	B	B - A	Estimated (to be verified during M&V)			
Project Code	Project Name	Category	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (Ton CO_2e/year)
10	Energy Efficient Street Lighting Project in Apia, Samoa	Energy Efficient Street Lighting Program	95,200	62,732	(32,468)	45,233	16,602	11,967	36.2
11	Energy Efficient Lighting in Government Buildings, Samoa	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,150	40,023	(59,127)	405,829	148,949	107,362	324.7
24	Energy Efficient Luminaires in Government Buildings, Samoa	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,170	82,638	(16,533)	86,769	31,846	22,512	68.0
25	Demonstration of Energy Efficient Air-Conditioning Technologies in Samoa	Implementation of EE Measures in the Public Sector	84,647	73,115	(11,532)	96,629	35,465	25,362	77.3
26	Energy Efficient Lighting in the Commercial Sector, Samoa	Energy Efficient Lighting in Residential, Commercial and Government Sectors	32,500	36,340	3,840	145,003	53,220	38,058	116.0
27	Energy Efficient Air Conditioning in Hotels, Samoa	Energy Efficiency Measures in Hotels and Commercial Buildings	18,700	14,490	(4,210)	19,703	7,231	5,171	15.8
28	Residential Energy Efficient Lighting in Samoa	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,200	40,557	(58,643)	154,515	56,711	40,555	123.6
			528,567	**349,895**	**(178,672)**	**955,681**	**350,024**	**250,987**	**761.6**

5.4.3.4 Tonga

			A	B	B - A	Estimated (to be verified during M&V)			
Project Code	Project Name	Category	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (Ton CO_2e/year)
12	Energy Efficient Street Lighting for Outer Islands, Tonga	Energy Efficient Street Lighting Program	98,400	50,328	(48,072)	45,189	16,410	13,520	41.0
13	Energy Efficient Street Lighting for Tongatapu, Tonga	Energy Efficient Street Lighting Program	84,000	42,963	(41,037)	52,030	18,894	15,568	47.0
22	Residential Energy Efficient Lighting in the Outer Islands, Tonga	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,000	50,060	(48,940)	233,533	84,806	-	213.0
29	Energy Efficient Lighting in Public Sector Buildings, Tonga	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,850	63,118	(36,732)	158,706	57,633	41,655	144.7
31	Residential Energy Efficient Lighting in Tongatapu, Tonga	Energy Efficient Lighting in Residential, Commercial and Government Sectors	97,000	55,008	(41,992)	149,466	54,278	39,230	136.0
			478,250	**261,478**	**(216,772)**	**638,924**	**232,021**	**109,973**	**581.7**

5.4.3.5 Vanuatu

			A	B	B - A	Estimated (to be verified during M&V)			
Project Code	Project Name	Category	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO_2 Savings (Ton CO2e/year)
4	Energy Efficient Air-Conditioning System Using Variable Refrigerant Volume/Flow Technologies	Implementation of EE Measures in the Public Sector	66,000	48,673	(17,327)	14,400	7,213	2,794	11.5
9	Implementation of Energy Efficient Lighting in Public Sector Buildings	Energy Efficient Lighting in Residential, Commercial and Government Sectors	96,920	82,934	(13,986)	122,000	61,113	37,440	101.0
18	Energy Efficient Street Lighting Project in Luganville, Vanuatu	Energy Efficient Street Lighting Program	98,615	52,975	(45,640)	36,179	18,123	10,635	34.0
19	Residential Energy Efficient Lighting, Luganville	Energy Efficient Lighting in Residential, Commercial and Government Sectors	60,000	20,698	(39,302)	136,000	68,126	35,695	112.0
20	Energy Efficient Street Lighting Project in Port Vila, Vanuatu	Energy Efficient Street Lighting Program	96,170	52,975	(43,195)	46,016	23,051	13,527	24.0
21	Household Energy Efficient Lighting, Port Vila	Energy Efficient Lighting in Residential, Commercial and Government Sectors	99,000	27,612	(71,388)	319,000	159,795	98,780	264.0
30	Energy Efficient Lighting for Provincial, Local Public Sector and School Buildings in Vanuatu	Energy Efficient Lighting in Residential, Commercial and Government Sectors	61,535	26,083	(35,453)	191,000	95,677	50,130	159.0
			578,240	**311,950**	**(266,290)**	**864,595**	**433,098**	**249,001**	**705.5**

5.4.3.6 Overall Project Costs and Benefits

Country	Equipment budget cost (USD)	Actual Contract Price (USD)	Incremental Cost (USD)	Annual Energy Savings (kWh/year)	Annual Energy Cost Savings (USD/year)	Annual Diesel Savings (litres/yr)	Annual CO2 Savings (tCO2e/yr)
Cook Islands	671,100	616,582	(54,518)	525,223	321,285	153,312	471
PNG	470,325	316,978	(153,347)	428,384	122,494	108,190	685
Samoa	528,567	349,895	(178,672)	953,681	350,024	250,987	762
Tonga	478,250	261,478	(216,772)	638,924	232,021	109,973	582
Vanuatu	578,240	311,950	(266,290)	864,595	433,098	249,001	706
All	56,590	55,599	(991)	-	-	-	-
Total	2,783,072	1,912,481	(870,591)	3,410,807	1,458,922	871,463	3,204

5.5 Output 4: Information Dissemination and Public Awareness

5.5.1 Common Activities for all PDMCs

5.5.1.1 Media and Communication

Energy Savings Tips

During the project, the Consultants coordinated with the electric utilities in each PDMC to include energy saving tips in their utility bills or other related/supporting documents/materials. In the Cook Islands, the energy savings tips were included on the back of the TAU utility bill. A total of twenty energy saving messages were produced and the first energy saving tips were issued in October 2013 (one message per month). The **Appendix 4.1** includes the samples of the energy savings tips produced for the Cook Islands. In Papua New Guinea, the PPL opted to produce a brochure with the energy saving tips for dissemination to residential customers. The draft samples of the energy saving tips for PNG are included in **Appendix 4.2**. No progress was been made in Vanuatu, Samoa and Tonga in incorporating energy saving tips in electricity bills due to different constraints.

Home Energy Guides

To complement the energy saving tips mentioned above, a Home Energy Guide was designed and developed by IIEC. The Home Energy Guide included information on the electricity cost of using common electrical appliances per hour according to the electricity tariff in each PDMC and includes energy saving tips for each electrical appliance. The Home Energy Guides were designed and printed for all five PDMCs and are shown in **Appendix 4.3** to **Appendix 4.7**.

The Table 5.35 provides a summary of Home Energy Guides printed and shipped to each PDMC.

Table 5.35: Summary of Home Energy Guides Provided to each PDMC

Country	Language	No. of Copies
Papua New Guinea	English	20,000
Samoa	English	8,000
	Samoan	7,000
Tonga	Tongan	19,000
Vanuatu	English	500
	Bislama	11,500
Cook Islands	English	6,000

PEEP2 Website

The main objective of the PEEP2 website was to serve as a communication resource and channel for the PEEP2 project as well as to:

a. Establish a good presence in the online communities for promotion and dissemination of PEEP2 activities throughout the three year period.
b. Provide online access to key and ongoing project information including project activities and outcomes.
c. Establish an online repository for project documents for public access.
d. Enable online dissemination of project events including but not limited to training programs, seminars, and workshops.

The website design and content preparation commenced in August 2012 and the website was formally launched in April 2013 on ***http://www.ee-pacific.net*** and is hosted in Australia allowing for faster access in the Pacific region.

Since April 2013, the IIEC Project team has been raising awareness and disseminating information with news articles, list of projects approved by ADB, training workshops and other relevant information and materials developed under PEEP2 on the website. All approved PEEP2 outputs are uploaded to the website.

The website usage was tracked using Google Analytics. A total of 6,027 visits were recorded from 1 July 2014 to 31 March 2015 of which approximately 79% are new visits as shown in the Figure 5.98 below. The top 3 countries to access the website came from Australia, United States and New Zealand (see the Table below). The number of individuals or unique visitors accessing to the website during the given period was 4,782.

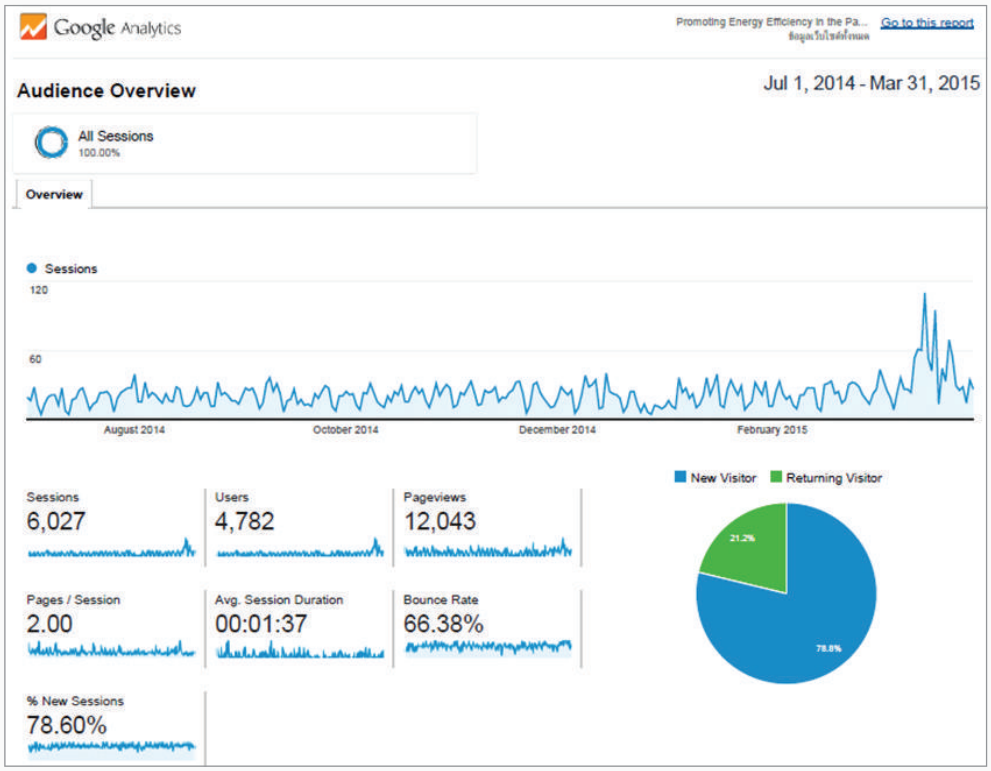

Figure 5.98: PEEP2 Website Audience Overview from 1 July 2014 to 31 March 2015

	Jul'14	Aug'14	Sep'14	Oct'14	Nov'14	Dec'14	Jan'15	Feb'15	Mar'15
Visits/Sessions	560	607	595	640	616	566	658	618	1,167
Users	428	492	505	510	512	477	533	518	1,020
Page views	1,327	1,237	1,246	1,342	1,286	1,023	1,344	1,194	2,044

Country	Visits
Australia	1,615
United States	717
New Zealand	408
Brazil	267
Thailand	257
Papua New Guinea	238
India	216
United Kingdom	207
Vanuatu	155
Fiji	129

5.5.1.2 Knowledge Products

As part of PEEP2, three energy efficiency guidelines were designed, printed and delivered to each PDMC. These included:

- Energy Efficiency Guidelines for Hotels in the Pacific (**Appendix 4.8**)
- Energy Efficiency Guidelines for Commercial and Public Buildings in the Pacific (**Appendix 4.9**)
- Energy Efficiency Guidelines for Street Lighting in the Pacific (**Appendix 4.10**)

The objective of these guidelines is to support the implementation of potential energy efficiency measures and projects in each PDMC as well as energy audit training activities. The guidelines was prepared in English and included information on the PEEP2 projects, importance of energy efficiency in the Pacific, energy management, energy efficiency measures, energy efficient technology, international standards, case studies from each PDMC, cost-benefit analysis and/or checklists.

The guidelines were first distributed at the Regional Energy Efficiency workshop in Samoa in March 2015. Copies of the guidelines were provided to the implementing agencies for distribution to the relevant stakeholders and also uploaded in the PEEP2 website.

5.5.2 Pacific Power Association – Annual General Meeting

The PEEP2 project team was invited to present lessons learnt to date in implementing the Asian Development Bank's (ADB) Promoting Energy Efficiency in the Pacific - Phase 2 (PEEP2) Project at the Pacific Power Association (PPA) 23rd Annual Conference and Engineer's Workshop on 8 July 2014 in Papeete, French Polynesia. The IIEC presentations at the workshop are shown in Figure 5.99.

Figure 5.99: Presentations at the PPA Workshop – July 2014

The full day workshop, organized by the IIEC with support from the PPA included an overview and status of PEEP2, the benefits of energy efficiency in the Pacific Islands, energy efficient lighting programs, the Fridge-Freezer Replacement Program in the Cook Islands, field testing of AC technologies and energy efficiency in the hotels sector. The workshop was mainly attended by electric utility representatives and engineers from several Pacific Island Countries (PICs). The workshop agenda and copies of the presentations are given in **Appendix 4.11.**

5.5.3 Regional Energy Efficiency Workshop

The IIEC and the Asia Development Bank (ADB) conducted a Regional Energy Efficiency Workshop to disseminate the lessons learnt during the implementation of the second phase of Promoting Energy Efficiency in the Pacific (PEEP2) project. The workshop was attended by over 100 delegates comprising of stakeholders from all the Pacific Island Countries (PICs) and international donor agencies. The outcome was the formulation of policy recommendations for future acceleration of energy efficiency practices in the Pacific Region. The workshop program and presentations are given in **Appendix 4.12**.

The inaugural address was made by the Samoan Prime Minister – The Honourable Tuilaepa Fatialofa Lupesoliai Malielegaoi; and Michael Trainor, ADB Energy Specialist made the opening remarks on behalf of the ADB. The Figure 5.100 shows the group photo taken on Day 1 of the workshop.

Figure 5.100: Group Photo taken at the Regional Energy Efficiency Workshop

Overview

The first day examined the relevance of energy efficiency projects in the Pacific (a region that currently has the highest dependence on imported fossil fuels), and reviewed some of the 35 demand-side efficiency projects implemented under PEEP2. The second day focused on perspective from donor agencies highlighting funding outlooks for the coming years and discussion on methods for scaling and replicating project successes throughout the Pacific.

Day 1: Efficiency – Global Context and Pacific Implementation

The first panel covered the past, present, and future of energy efficiency at the global and national levels, identifying its growing role as tool for economic development and fuel-security. The Presenters highlighted the fact that energy savings achieved through demand-side management (DSM) has significant advantages in supply side planning and reduce consumer costs while also having positive environmental impacts. Subsequent presentations indicated a number of policy and market tools available to public and private sector stakeholders, focusing on best practices currently implemented throughout Asia and the Pacific.

Session 2 was led by members of the IIEC PEEP-2 project team, who discussed the use of policy tools and capacity building methods applicable to the specific needs of the five participating developing member countries (DMCs) – The Cook Islands, Papua New Guinea, Samoa, Tonga, and Vanuatu. Speakers in this session carried discussion forward by identifying unique features of the Pacific region's energy landscape, and describing ways in which international best practices had been tailored to address local needs. IIEC's managing staff signalled the importance of adapting successful approaches to address region-specific constraints, and discussed some of the methods used to do so.

Presentations in Session 3, highlighted several case studies covering efficient lighting, air conditioning and energy efficient appliances; and implementation models used throughout the project. Presenters supplemented this discussion with recommendations on how to extend results at both the national and regional levels. Day 1 concluded with country reports delivered by corresponding national Implementing Agencies.

Day 2: The Way Forward – Donors Discuss Replication Options

After establishing the relevance of demand-side efficiency methods in the Pacific and considering PEEP2's ability to meet the specific needs of the DMCs, panels and breakaway sessions on Day 2 discussed how to scale models, replicate outcomes, and anticipate constraints.

The morning session consisted of presentations by donor agencies interested in supporting continued clean energy development in Asia and the Pacific. Representatives noted ongoing projects, development strategies, and forthcoming funding priorities. Two themes permeated these presentations: 1) interest in building the policy and planning capacity of local stakeholders, and 2) leveraging national development plans to incorporate energy efficiency into national and regional growth.

Donor presentations were followed by group discussions – comprising of local stakeholders, policy makers, engineers, and representatives from bilateral and multilateral funding organizations. The Group presentations highlighted the current barriers in implementing EE projects and recommended a series of policy options to address these barriers and facilitate large scale implementation of EE projects in the region. The key barriers identified included:

1. Lack of legislative foundation for efficiency programs
2. Limited knowledge of benefits and lacking capacity among key stakeholders
3. Difficulty encouraging market penetration of efficient products and appliances
4. Difficulty procuring ongoing project funding
5. Lack of public knowledge and awareness of energy efficiency
6. Challenges of establishing long-term project sustainability.

Participants also received the 3-Volume Energy Efficiency Guidelines, published by IIEC and with funding through the PEEP2 program. These manuals provide instruction on how to improve demand-side efficiency in Hotels, Street Lighting, and Public Buildings. They are designed specifically for Pacific Island communities, and are expected to provide continued support for commercial and public sector stakeholders in their efforts to implement energy efficiency programs. The workshop agenda and the presentations are given in **Appendix 4.12**.

6 PROJECT MANAGEMENT, CONTRACTUAL AND IMPLEMENTATION ISSUES

6.1 Project Management

A Project Management Unit (PMU) was established at IIEC's Asia Regional Office in Bangkok, which handled all project administration including coordination with ADB and the Implementing Agencies in the five PDMCs. The PMU and the ADB were in regular communication on project activities and the timely responses to project issues by the ADB team are acknowledged.

6.2 Contractual Issues

6.2.1 Project Personnel

6.2.1.1 International EE Experts

In August 2012, the ADB approved the replacement of the original Team Leader, Christopher Cheatham, with Felix Gooneratne. Mr. Cheatham was unable to continue due to medical reasons. In addition to being the Team Leader, Felix Gooneratne continued in his role as the International EE Expert for the Cook Islands. The ADB also approved the appointment of David Morgado of IIEC, to provide project administration and coordination support to the Team Leader.

6.2.1.2 National EE Experts

The National EE Experts in Tonga, Vanuatu and Cook Islands were replaced during the project period due to resignations. All the replacements were approved by the ADB and endorsed by the respective Implementing Agencies.

6.3 Implementation Issues

6.3.1 Cook Islands

The National Steering Committee (NSC) chaired by the Energy Commissioner (EC) was regularly briefed on the status of project activities. The NSC has provided assistance in resolving some of the project implementation issues especially sourcing funds from agencies for the installation of lighting projects in the residential and public sectors.

The Public Lighting projects at the Airport Car Park, Ports Authority and Punanga Nui Market experienced significant delays due to the requirement for the poles to be sourced from New Zealand. At the request of the three agencies, ADB approved the inclusion of the cost of poles in their scope of supply due to the unforeseen increase in cost of installation (civil and electrical). The installation at the Airport Car Park was completed in January 2015 and the work is still ongoing at the other two sites primarily due to budget constraints for the civil works.

The Residential Lighting Program (Project Code 17) is still being implemented as the original budget allocated for the installation from the Energy Commissioner was no longer available at the time of equipment delivery and funds had to be requested from Ministry of Finance and Economic Management (MFEM).

6.3.2 Papua New Guinea

No major project management and contractual issues were encountered during the project. The Implementing Agency (IA), PNG Power Limited (PPL), has largely been supportive of project activities and has provided reasonable resources and support toward implementation of project activities. The fact that the national EE Expert is a member of IA, has immensely supported the coordination between project team, IA and other stakeholders.

A number of issues were encountered during the implementation of PEEP2. One of the root causes of these issues were lack of appreciation for Energy Efficiency in PNG due to lack of precedence in the area of energy efficiency. Another was political turbulence in the country at the inception of the PEEP2, which continued for most duration of the project implementation. More specifically following were the critical implementation issues that were faced during the implementation of PEEP2 activities in PNG:

1. With no previous EE activities in PNG, there was little awareness and appreciation for EE. This resulted in lack of cooperation by various stakeholders, especially from government side. Consequently, substantial efforts and resources were used to create awareness and resulting commitment among public stakeholders. As a consequence, policy related activities were most difficult to implement, due to reliance on stakeholders outside of the core project partners.
2. Political turmoil that started at the inception of the project also contributed to lack of commitment towards policy recommendations. The uncertainty at higher level of government meant that most of government officials remained less committed to new initiatives such as EE. Political issues also affected leadership at EA, which in turn affected EA's commitment towards implementation of PEEP2 activities. During the implementation of PEEP2, the CEO of PNG Power was replaced and the new CEO was twice suspended.
3. Delays in procurement of equipment resulted in dropout of important project partner, as well as resulted in inability to install the equipment in time. As such it was not possible to collect M&E data as well as necessary information to produce case studies.
4. Remote location of project implementation meant services for specialized EE projects could not be procured. For example a unique project involving insulation of metal roof, which are very common in pacific countries, could not be completed as the sole supplier in Australia refused to come to PNG for implementation of the project.

6.3.3 Samoa

During PEEP2 project implementation in Samoa, two key implementation issues were identified - (i) the availability of staff support from the implementing agency (MNRE) to help the national and international consultant carry out the planned activities; and (ii) an issue related to charging a fee to residential consumers for the energy efficient T5 lamps to be provided under the residential EE lighting program.

MNRE made a commitment to resolve the first issue and initiated activities to hire more staff so that MNRE can devote additional time and resources to assist the PEEP2 project team. Unfortunately due to the delays in hiring new staff, MNRE committed a significant portion of time for their existing staff to assist the PEEP2 team, particularly in the areas of the government and commercial buildings surveys.

The second issue related to ADB's suggestion that the residential T5 lamps should be given to program participants (in the residential EE lighting program) at a nominal charge. ADB suggested that a small fee be charged to the participants. Discussions with MNRE and MOF on this matter led to the conclusion that MNRE (the implementing agency for this program) did not have the institutional authority to collect a fee from consumers. This issue was resolved by the PEEP2 team by getting the Electric Power Corporation (EPC) to agree to collect a small fee from the program participants through their electric bill. An agreement was reached between EPC and MNRE, and an MOU signed among, EPC, MNRE and IIEC with respect to project implementation that includes the collection of a fee of SAT 3.00 for each T5 lamp.

MNRE co-hosted the Final Workshop held in Apia from 3 – 5 March 2015 and their assistance with workshop arrangements including the site visits is acknowledged.

6.3.4 Tonga

The procurement delays that occurred caused significant problems in Tonga because the distribution of residential lighting materials could not be completed before the year- end holiday season disrupted the program. As a result less than half the homes scheduled to receive upgraded lighting had been visited by 1 March 2015 and completion is likely to go beyond the end of March 2015. Fortunately, TPL is committed to completion of the project and is no longer tied to the PEEP2 project for that effort.

Although the implementing agency, TERM-IU, was able to provide excellent office space and meeting facilities for the PEEP2 team in 2012 – 2014, they were unable to provide the promised financial support for the household energy survey, the customs clearance of project materials, and for production and distribution of energy efficiency information to the public. As a result, TPL was forced to cover the cost of customs clearance for the project components – although finally allowed duty-free entry, there remained substantial storage, container rental and brokerage fees to pay – and the public information program was reduced to a few news articles in the local papers and distribution of the IIEC produced and funded Home Energy Guides.

6.3.5 Vanuatu

The issues below were identified by the Vanuatu DoE with PEEP2 consultants. These are edited from the presentation of the GoV during the ADB/PEEP2 Regional Energy Efficiency Workshop held in Samoa from 3 – 5 March 2015. They are not necessarily listed in order of priority.

- **Issue 1: Poor energy data and data management for assessing and developing EE opportunities.** PEEP2 has worked with the DoE to improve the energy database but this remains unresolved. It is hoped that this is addressed during 2015 as DoE staff levels increase.
- **Issue 2: Slow approval of project proposals, tendering/acquisition, shipping and customs clearance of equipment.** Most projects were designed by July/August 2013 but most equipment delivery was in October/November 2014, about 12-15 months later. Most lighting equipment was delivered to recipients by November 2014 but many employees/installers were on leave until late January 2015. Thus there was insufficient time for installation and effective monitoring and verification (M&V).
- **Issue 3: Some conditions changed between project design and subsequent equipment arrival.** Cheap, poor-quality Chinese CFLs have recently flooded market so PEEP2 lights appear to consumers to be less desirable for households, with very slow installations. Air terminal advised they want different lights after new lights that they had approved arrived. The DoE moved to new building with different lighting needs. One ministry (Climate Change) has 25% more staff since PEEP2's energy audit and a revised physical layout. Many T12s surveyed in 2013 had already replaced with T8s since 2013, etc. There may be a need to redirect some lights to government facilities and residences beyond those initially planned. For example, if there are remaining uninstalled EE residential lights (partly as a result of the March 2015 cyclone), these can be provided to residences connected to the smaller UNELCO grids of the islands of Tanna and Malekula.
- **Issue 4: Some Ministries were unaware of their obligations under Memoranda of Understanding (MoUs) that they had signed.** Thus, there were very limited staff and funds to transport, install lights, return old lights, etc. There have been discussions with those involved to remind them of their obligations. This is slowing down some installations but seems to be largely resolved.

- **Issue 5: There is no clear GoV responsibility for EE implementation.** This include carrying out energy audits, practical EE targets, EE legislation, EE regulations (except MEPS for refrigeration), and regular sources of EE finance (e.g. revolving fund). These have not been resolved in Vanuatu although work is scheduled during 2015 to develop practical EE goals and develop an EE financing fund. Some of the other issues are to be addressed in the forthcoming National Energy Roadmap implementation plan.
- **Issue 6: There will be delays in M&V reporting due in part to the March 2015 cyclone.** This report was prepared several days after the cyclone struck Vanuatu. It is expected that some buildings, schools and homes where EE lighting has been installed, but where M&V were not completed, have been damaged. The actions cannot be determined until the cyclone impacts have been verified.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

1. All project deliverables for the contract was submitted to ADB on schedule and the respective progress payments were also made on time. The project included 15 Contract Variations to accommodate the additional project activities, project extensions and staffing changes. The contract completion date was extended from 5 November 2014 to 30 April 2015.
2. The primary focus on Year 3 and the extended period was the procurement, installation and measurement & verification (M&V) of the approved 35 EE projects in the 5 PDMCs. In addition, all remaining tasks in Outputs 1,2 and 4 were completed.
3. The project experienced around a 6 month delay primarily due to the changes in contract management responsibilities for the EE projects from ADB to IIEC. The changes were effective for projects 11 to 35 where the contractual responsibilities were transferred to IIEC. One approved project for PNG (Code 16: EE Roof Top Retrofit of PPL Head Office) had to be cancelled as there were no bids from prospective contractors.
4. The equipment cost estimates (primarily EE lighting) used in the project proposals were based on budget quotes obtained from the major lighting suppliers in the region. However, the quotes obtained during procurement were on average 20% to 30% less thus significantly improving the cost effectiveness of the projects. The scope of several projects was limited to a threshold of $100,000 in order to keep within the Shopping Guidelines of the ADB. The initial budget (ADB component) for the 35 projects was $2,783,072 and the actual contract price was $1,912,481. The unspent amount from the original GEF allocation ($2,370,000) for equipment is $457,519. A letter highlighting the lower equipment budget was forwarded to ADB on 16 May 2014.
5. The procurement process highlighted some constraints in receiving adequate bids primarily due to the unfamiliarity of suppliers of the Pacific and smaller size of the individual projects. There were cases where over 20 Invitation for Bids (IFB) was issued and only around 3 bids received. However, the quality of the equipment procured was not compromised and all selected suppliers complied with the stringent technical specifications.
6. Overall the support received from the respective IAs was considered adequate. However, the significant financial contributions, as indicated in the MoUs, were not available in most cases. As a result, some of the activities related to installation and awareness was either delayed or could not be undertaken.
7. In the area of appliance energy standards and labelling, PEEP2 implemented the Fridge/Freezer Replacement Program (FFRP) in the Cook Islands and this scheme attracted several interests from many agencies in the region. There is potential for the application of the FFRP model in other Pacific countries and also support the current PALS (Pacific appliance and Labelling Standards) program implemented by SPC.
8. The energy audit training workshops comprising of 4 modules were successfully organized in all PDMCs from July 2013 to October 2014, and 88 trainees from the 5 PDMCs completed the training courses.
9. Energy Audits kits were procured and dispatched to all 5 PDMCs as a part of the equipment package. These kits were used in energy audit training and M&V activities of the implemented EE projects.

10. Overall the PEEP2 project has demonstrated the substantial benefits of improving energy efficiency in residential, commercial, public and street lighting sectors. Implementation models have now been established and there is scope for large scale replication in the Pacific region. Scaling up EE implementation in the 5 PDMCs will substantially reduce the cost of meeting future generation targets.
11. A regional workshop titled "Promoting Energy Efficiency in the Pacific" was jointly organized by ADB and IIEC in March 2015 in Samoa. The achievements of PEEP2 were highlighted at the workshop.

7.2 Recommendations

1. The policy scenarios (conservative, moderate and aggressive) developed in PEEP2 indicated high levels of achievable energy savings, ranging from 8% to 32% in the 5 PDMCs, relative to the baseline (business as usual) scenario by the year 2030. Given the significant potential, EE should be established as a high priority in the National Energy Policy in the respective PDMCs; and establish realistic targets for EE improvement.
2. Electrical appliances especially in the residential sector offer a significant opportunity for reducing energy costs through the market transformation from low efficiency (low star rating) to high efficiency (high star rating) units. The PALS program focussed on regulations for minimum energy performance standards (MEPS) and the Fridge/Freezer Replacement Program (FFRP) demonstrated the benefits of high star rated units. There is scope for a regional energy standards & labeling program using the implementation models established under PEEP2. The need to finalize and implement a national EE building code is also emphasized.
3. One of the key outputs of the PEEP2 project is to support EE policy design and implementation as well as to explore the replication of these EE policies, programs, plans and projects across the Pacific and particularly the nine other ADB PDMCs not covered under PEEP2. The PEEP2 team therefore developed the concept of EE Assessment Guidelines, Framework and Scorecard to enable the PDMCs to understand and independently evaluate their policies, provide guidance on how they can improve energy efficiency in their countries, and provide a set of indicators/criteria to track their progress. It is recommended that ADB and/or other donors undertake regional programs to address the gaps identified (see Section 4.3.3.5.) in this project relative to scaling up implementation of EE initiatives in the Pacific.
4. Based on the responses from the workshop, PEEP2 was one of very few projects (or arguably the only project) in the Pacific Islands that focused on implementation of EE projects on such a large scale (34 projects) covering most of the important end uses (lighting, AC, refrigeration etc); and cost effective savings have been demonstrated. There was significant interest among the workshop participants for the expansion of the program to all ADB PDMCs. The implementation models developed in PEEP2 are replicable and can now be considered for all the PDMCs.
5. The agencies responsible for EE in the PDMCs need to be well resourced (staffing and budget) if energy savings are to be achieved. The lack of adequate resources within the implementing agencies was evident in PEEP2. To this end, development of a National EE Strategy and Action Plan with clear mandates and responsibilities for the respective agencies is a basic requirement. The national governments need to "lead by example" by implementing EE in its facilities and other incentives (eliminating import duties of EE appliances etc) if the full potential is to be achieved.
6. Funding constraints have been a major barrier in promoting EE in all PDMCs. Hence, the establishment of an EE Revolving Fund or a Clean Energy Fund to finance EE projects should be considered. There are several examples of the funds in the Asia Pacific region.
7. The duration of PEEP2 (initially 3 years) was tight since the scope included data gathering, design, procurement, installation and M&V for the EE projects; and as a result only limited M&V could be conducted in some of the projects. Installation delays, mainly due to lack of funding from the host agencies, was also evident. It is recommended that future projects of this type a project period of at least four (4) years is considered.

8. In addition to scaling up EE implementation in other PDMCs, using the implementation models developed in PEEP2, the following regional actions could be considered to assist all PDMCs:
   a. Development of a template for a national energy efficiency law that can be adapted to the specific requirements of each country.
   b. Preparation of the provisions for a standard energy efficiency building code for Pacific nations.
   c. Development of guidelines for establishing and operationalizing and energy efficiency revolving fund.
   d. Development of guidelines and procedures and suggested regulations for facilitating EE implementation in the public sector.
   e. Development of legislative and regulatory guidelines requiring utility actions to promote EE through demand-side management (DSM) activities and/or energy efficiency obligations (EEOs).
   f. Development of regional database and benchmarking of building energy consumption for different building types.
   g. Development of a financing framework and guidelines to facilitate commercial financing for energy efficiency projects.
   h. Preparation of guidelines for governments to incentivize EE project implementation both in the public and the private sectors.
   i. Development of customized protocols for measurement and verification (M&V) of energy savings from EE projects.
   j. Training and capacity building programs for energy service providers.

8 APPENDICES

Appendix I – Output 1	
1.1	Energy Use Survey Report – Papua New Guinea
1.2	Energy Use Survey Report – Samoa
1.3	Energy Use Survey Report – Tonga
1.4	Energy Use Survey Report – Vanuatu
Appendix II – Output 2	
2.1	Energy Efficiency Targets Report – Cook Islands
2.2	Energy Efficiency Targets Report – Papua New Guinea
2.3	Energy Efficiency Targets Report – Samoa
2.4	Energy Efficiency Targets Report – Tonga
2.5	Energy Efficiency Targets Report – Vanuatu
2.6	Energy Efficiency Technology Assessment Report
2.7	International Best Practices in New Construction Report + Summary Presentation
2.8	Green Hotels Rating Scheme Report + Summary Presentation
2.9	Green Buildings Scheme Report + Summary Presentation
2.10	EE Assessment Scorecard, Framework & Guidelines Report
2.11	Energy Audit Training Modules + Evaluation Reports
Appendix III – Output 3	
3.1	Energy Efficient Lighting in Rarotonga Airport, Cook Islands (Project Code 1)
3.2	Energy Efficient Street Lighting for the Punanga Nui Market, Cook Islands (Project Code 2)
3.3	Energy Efficient Fridge/Freezer Replacement Program, Cook Islands (Project Code 3)
3.4	Energy Efficient Air-Conditioning System Using VRV/VRF in Vanuatu (Project Code 4)
3.5	Energy Efficient Street Lighting Project in Port Moresby, PNG (Project Code 5)
3.6	Energy Efficient Lighting in Marina and Wharf, Cook Islands (Project Code 6)
3.7	Energy Efficiency Program in Public Buildings, Cook Islands (Project Code 7)
3.8	Energy Efficient Lighting at Papua New Guinea Power Limited (PPL) Head Office (Project Code 8)
3.9	Energy Efficient Lighting in Public Sector Buildings , Vanuatu (Project Code 9)
3.10	Energy Efficient Street Lighting Project in Apia, Samoa (Project Code 10)
3.11	Energy Efficient Lighting in Government Buildings, Samoa (Project Code 11)
3.12	Energy Efficient Street Lighting for Outer Islands, Tonga (Project Code 12)
3.13	Energy Efficient Street Lighting for Tongatapu, Tonga (Project Code 13)
3.14	Lamp Waste Management Technology – Bulk Purchase of Bulb Eaters (Project Code 14)
3.15	Energy Efficiency in Edgewater Resort & Spa, Cook Islands (Project Code 15)

Appendix III – Output 3	
3.16	Energy Efficiency Rooftop Retrofit at PNG Ltd (PPL) Head Office (Project Code 16 – Canceled)
3.17	Residential Energy Efficient Lighting Program (Project Code 17)
3.18	Energy Efficient Street Lighting Project in Luganville, Vanuatu (Project Code 18)
3.19	Residential Energy Efficient Lighting, Luganville (Project Code 19)
3.20	Energy Efficient Street Lighting Project in Port Vila, Vanuatu (Project Code 20)
3.21	Household Energy Efficient Lighting, Port Vila (Project Code 21)
3.22	Residential Energy Efficient Lighting in the Outer Islands, Tonga (Project Code 22)
3.23	Energy Efficient Street Lighting Project in the Outer Islands, Cook Islands (Project Code 23)
3.24	Energy Efficient Luminaires in Government Buildings, Samoa (Project Code 24)
3.25	Demonstration of Energy Efficient Air-Conditioning Technologies in Samoa (Project Code 25)
3.26	Energy Efficient Lighting in the Commercial Sector, Samoa (Project Code 26)
3.27	Energy Efficient Air Conditioning in Hotels, Samoa (Project Code 27)
3.28	Residential Energy Efficient Lighting in Samoa (Project Code 28)
3.29	Energy Efficient Lighting in Public Sector Buildings, Tonga (Project Code 29)
3.30	Energy Efficient Lighting for Provincial, Public Sector and Schools in Vanuatu (Project Code 30)
3.31	Residential Energy Efficient Lighting in Tongatapu, Tonga (Project Code 31)
3.32	Energy Efficient Street Lighting in Alotau, PNG (Project Code 32)
3.33	Energy Efficient Lighting in Alotau Hospital, PNG (Project Code 33)
3.34	Energy Efficient Lighting & Ventilation at UPNG, PNG (Project Code 34)
3.35	Solar Water Heating at Rarotonga Hospital, Cook Islands (Project Code 35)
Appendix IV – Output 4	
4.1	Energy Saving Tips – Cook Islands
4.2	Energy Savings Tips – Papua New Guinea
4.3	Home Energy Guide – Cook Islands
4.4	Home Energy Guide – Papua New Guinea
4.5	Home Energy Guide – Samoa
4.6	Home Energy Guide – Tonga
4.7	Home Energy Guide – Vanuatu
4.8	Energy Efficiency Guidelines for Hotels in the Pacific
4.9	Energy Efficiency Guidelines for Commercial & Public Buildings in the Pacific
4.10	Energy Efficiency Guidelines for Street Lighting in the Pacific
4.11	Pacific Power Association Workshop Materials
4.12	Promoting Energy Efficiency in the Pacific Workshop Materials

Promoting Energy Efficiency in the Pacific (Phase 2)

sponsored by