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## Tongan Schools go Solar; Is it possible to deliver development projects with cost-effective partnerships?

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**Abstract:** In 2012 a group of volunteering University of Canterbury (UC) staff, students and alumni worked in partnership with the Kingdom of Tonga Ministry of Education and Training (MET), Tongan State-owned enterprise Tonga Power Ltd (TPL) and local contractors, to design, procure and install photovoltaic (PV) systems of 8 kW peak in five Tongan High Schools. The project was funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT) in an effort to assist Tongan high schools to reduce their relatively expensive utility related costs and to enable schools the financial freedom to invest in educational resources. The project was implemented in a unique multi party Public Private Non Profit Partnership model to utilise the resource pool of UC and provide practical academic opportunities to university students while providing overseas development assistance to Tonga. This paper presents the planning and execution of this project, and discusses the areas of challenges, opportunities, success and failure by revisiting the unique partnership model, in concept and in practice. To understand schools expectations and perspective from a beneficiary point of view, staff and students from each school were interviewed during the installation. Subsequently, staff from each school were surveyed as part of a monitoring and evaluation study. Analysis of stakeholder interviews and recipient schools' survey results are presented and discussed with recommendations to execute similar multi-party sustainable development projects effectively, particularly in small island developing countries.

**Keywords:** Tonga, Photovoltaic, Schools, Development, Public Private Non Profit Partnership.

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## 1. Introduction

The drive towards renewable electricity in Pacific Island countries is welcomed and supported by donor agencies, including New Zealand's Ministry of Foreign Affairs and Trade (MFAT). Renewable energy was first identified as a key support focus for the Pacific in 2010 in an effort to reduce Pacific Island nations' vulnerability to the high and fluctuating price of diesel, the main source of fuel for electricity generation [1]. New Zealand and the European Union, co-hosts of the Pacific Energy Summit in March 2013, announced a \$255 million grant fund and \$380 million in concessional loans to support over 40 proposed projects. The support comes from several donor partners including \$65 million in funding from New Zealand to advance and realize renewable energy projects across the Pacific [2].

In 2012, a group of volunteers from New Zealand worked in partnership with the Kingdom of Tonga, Ministry of Education and Training (MET), a Tongan state owned electricity utility enterprise - Tonga Power Ltd. (TPL) and in-country contractors, JH Electrical Contractor and Supplies (JH), to install solar PV power systems of 8 kWp at five Tongan high schools. The installations were a part of the Solar PV and ICT Pilot Programme (5 schools project) for Tongan schools coordinated by EcoCARE Pacific Trust (EcoCARE) in partnership with MET [3]. EcoCARE engaged University of Canterbury (UC) staff, student and alumni volunteers, initially only for technical design and installation purposes and later for project management support including procurement of goods and services and in official in-country works.

Engaging volunteers via UC provided capable and interested individuals to partially satisfy their academic, practical and personal interests while carrying out works required by the project. The project was initially conceptualised in 2009 by EcoCARE with the intention of installing solar power systems at all Tongan high schools to reduce the burden of electricity related costs in schools and to enable greater use of information and communication technologies (ICTs). The project was funded by the MFAT and financially administrated by Rotary New Zealand World Community Services Ltd. (RNZWCS), a limited liability company with representatives from Rotary organisations in New Zealand.

## 2. Project Background

### 2.1. Project Objective

The project proposal, that MFAT based its decision to fund the activity on, was reviewed to understand the original project intentions. The overall project objective (goal) is improved education facilities and academic progress for students through solar powered electricity [3]. The project was proposed as a pilot to install solar energy systems and evaluate its impact in five schools, before considering a national roll out of similar systems in every Tongan high school.

### 2.2. Needs Assessment

The project proposal highlights that Tongan schools are often closed numerous times each year because they don't have the required funds to pay for the electricity needed to pump water for drinking

and sanitation purposes. The proposal states that the cheap reliable electricity provided by the pilot project would enable the five schools and their communities to benefit from the use of Information and Communication Technologies (ICTs). The proposal promises a significant educational component as part of the pilot project to test the effectiveness of enabling students to use technology as an educational resource. The proposal also states that savings in energy cost, estimated to be “between TOP\$11.25 million and TOP\$15million” over the lifetime of the solar panels, could be spent in other areas of education, allowing some flexibility to the annual power budget of TOP\$750,000.

No formal needs assessments in the form of recipient community surveys or other methods were carried out to determine the worth for the proposed activity. The actual estimated energy cost savings in the proposal is also questionable given that there was no agreement on metering and pricing methodology for the generated electricity between any of the multi-party stakeholders.

### *2.3. Selection of Five Schools*

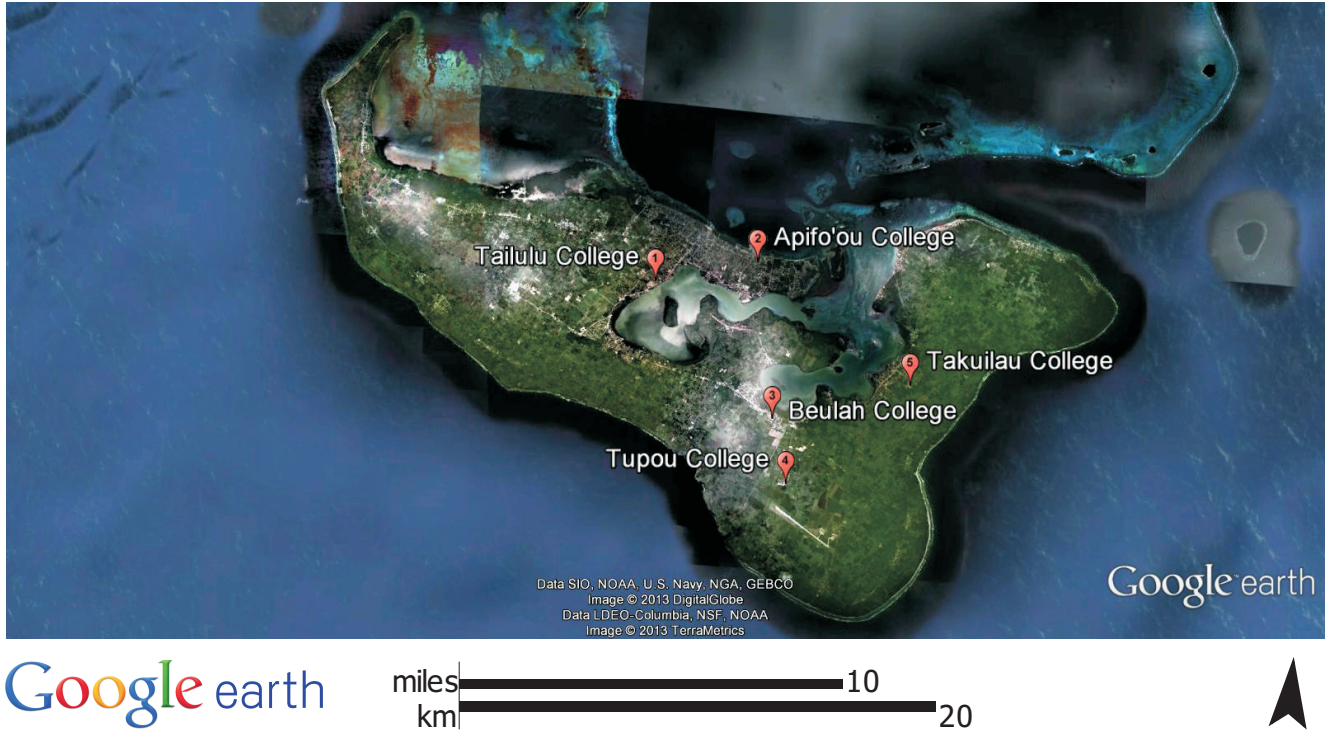
EcoCARE advised that the five schools which ended up receiving the 8kWp PV systems were selected by the MET as part of a proposed national roll-out project in Tonga. The selection of schools were based on a criteria from EcoCARE to select as diverse a group of schools as possible whilst being able to prove the capacity of EcoCARE to deliver the project as described in the project proposal. The donor, MFAT, recommended the pilot project of 5 schools to be carried out in schools located on the main island of Tongatapu. Concentrating on the comparatively well-resourced island of Tongatapu with easy access to infrastructure during the pilot stage of the project had advantages. Project partners would familiarize themselves with challenges and lessons that could be applied for works in the more remote and challenging islands at a later stage. Figure 1 shows the geographic locations of the five schools that were finally selected for implementation.

### *2.4. Proposed Stakeholder Relationship*

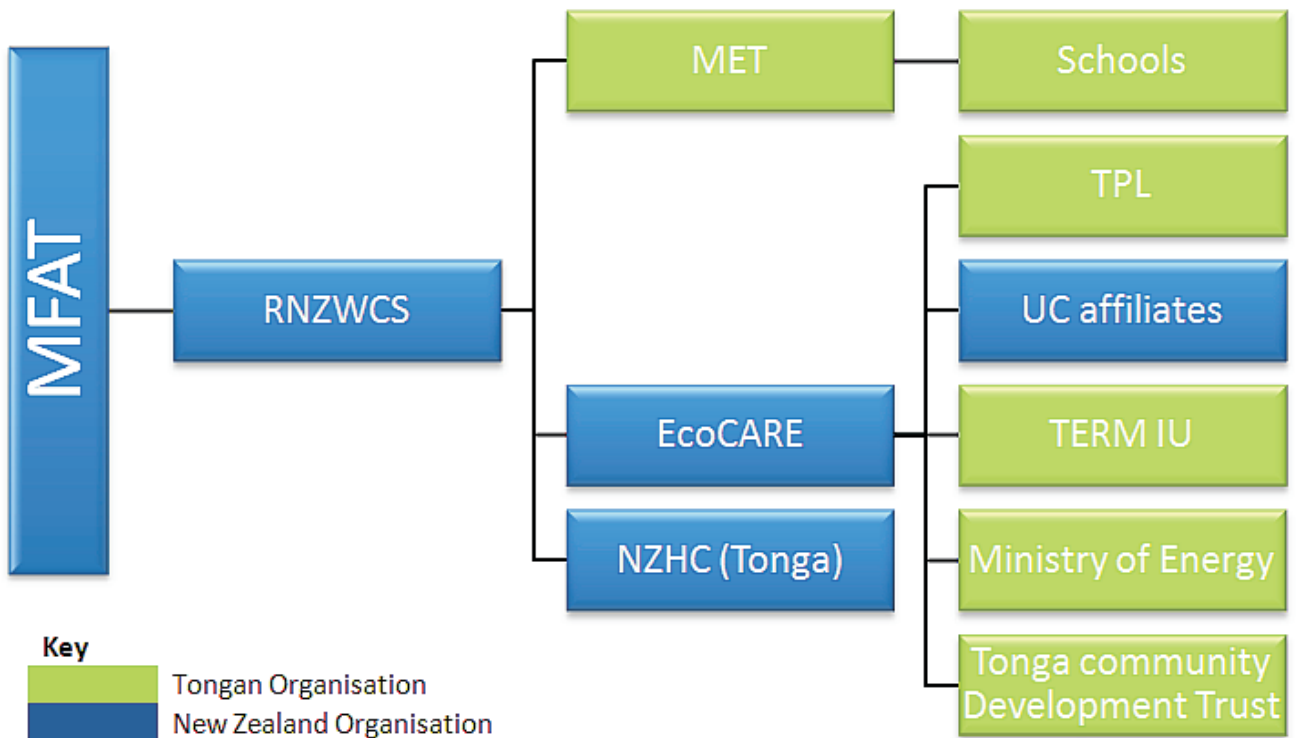
Figure 2 shows the proposed project participants relationship hierarchy. MFAT is the donor and RNZWCS as the principle recipient of the fund is responsible for all facets of day to day operation including project management, monitoring and evaluation. EcoCARE is to facilitate and coordinate groups and activities of the project, and in-country partner MET is to provide personnel, resources such as accommodation for volunteers and transport arrangements. University of Canterbury staff, students and alumni are to design technical systems and install them in Tonga together with contractors provided through TPL. Tongan and NZ government and agencies are said to provide support and assistance when required. Tonga Community Development Trust is said to support community aspects of the program.

The proposal does not clarify the ownership of the installed systems or discuss tariff agreements. It does however, mention that TPL will provide metering systems to enable schools to benefit from the produced power and a MoU is to be formalised. The proposal does not seem to support its participant agreements in any formally documented manner. It appears to be based on informal discussion agreements between EcoCARE and/or Rotary and in-country participants who agreed to assist with the delivery of the project.

**Figure 1.** Island of Tongatapu and location of five MET selected high schools to receive solar PV energy systems



**Figure 2.** Proposed stakeholder hierachy relationship



### 3. Project Execution

EcoCARE initiated the project and facilitated participants including MET and TPL in Tonga, UC affiliated volunteers and RNZWCS. EcoCARE's key strength was to bring various organisations and individuals and their skill sets together to execute the works. RNZWCS maintained that they remained a conduit between MFAT and EcoCARE from a funding perspective and EcoCARE was the responsible party to carry out the works.

Up to seven volunteers affiliated with the Department of Electrical and Computer Engineering (ECE) at UC contributed to the electrical system design, system procurement, in-country partnership agreements, logistics planning, installation management and installations of electrical systems. Two postgraduate students from the Macmillan Brown Centre at UC were independently involved and are carrying out their postgraduate research related to the topic, one of which is specifically focusing on the impact and influence of this project from a social perspective.

Seven JH employees worked on commercial terms together with volunteers from New Zealand during the installation phase of the project. JH had prior experience and expertise in low and high voltage electrical installation works and were enthusiastic about the opportunity to diversify and expand their portfolio to cover PV solar systems.

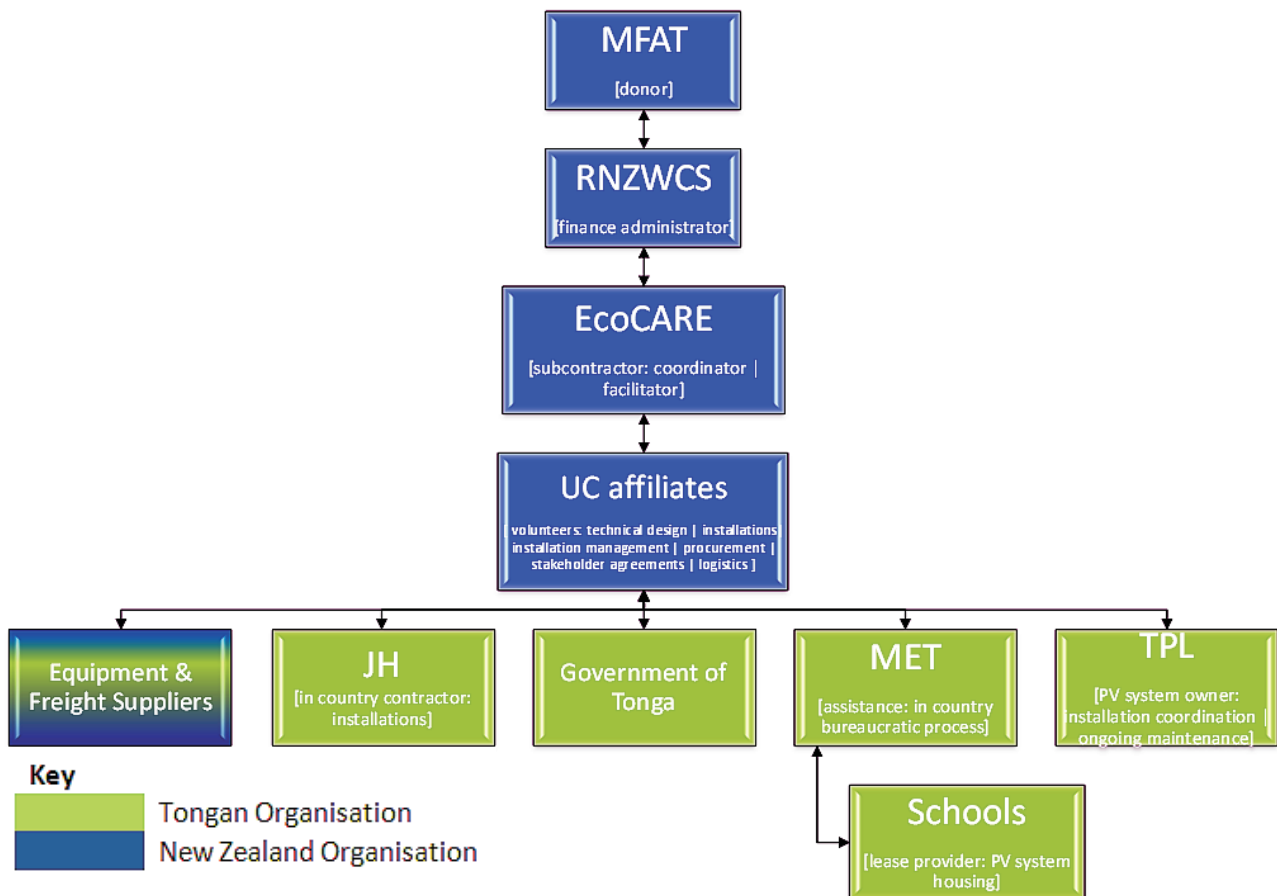
TPL staff members provided guidance and coordination support to the installation team and installation manager. TPL electrical engineers and network specialists worked with UC students to implement PV system metering and communications. The CEO of TPL worked together with the volunteer team to formalize a stakeholder memorandum of understanding and enabled success of the installations. A total of five TPL staff contributed time and effort towards this project.

#### 3.1. Project Manager and Installations Manager

EcoCARE initially engaged a part time project manager to professionally manage the project. However, a formal agreement between the project manager and EcoCARE was never established. This was further complicated by financial restrictions placed by RNZWCS where EcoCARE was unable to guarantee payment to the project manager on a timely basis. EcoCARE had no financial authority on the project, could not guarantee payment and forwarded all project related invoices to RNZWCS for payment, sometimes at the discretion of RNZWCS. This resulted in a confused contractual status between EcoCARE and the professional manager. As a result, an official project manager to deliver the overarching project was never announced.

A Master of Engineering student volunteer was formally appointed as team leader/installation manager for operations in Tonga. The voluntary appointment was made during a stakeholder meeting between TPL, NZ High Commission (Tonga), EcoCARE and UC affiliated volunteer representatives to better understand stakeholder roles and responsibilities at the commencement of the installation works. The appointed student had been heavily involved with technical, procurement, logistics and in-country partnership agreements following project commencement. The defined role followed a natural course towards the completion of the project and enabled Tongan stakeholders to confidently deal with a delegated project representative. EcoCARE's CEO was expected to be in Tonga during the installations

**Figure 3.** Stakeholder relationship, roles and communication flow during implementation



but could not be available due to health reasons. RNZWCS representatives were not anticipated to be available in Tonga during installations or during finalisation of stakeholder agreements.

### 3.2. Stakeholder Communication

EcoCARE was a central point of stakeholder communication during the planning stage. Weekly planning meetings were held at UC to discuss planning of the project and surrounding research projects that were undertaken by various UC students. Meetings were open to all involved in the project and to those who were interested in fulfilling academic or personal goals. An email group was established to include and ensure that everyone in the project was regularly receiving notifications.

Figure 3 presents the communication flow between stakeholders during the implementation phase of the project. UC volunteers, led by a ME student became a central hub during implementation of the installation works in Tonga.

### 3.3. Design & Procurement

The design team consisted of one postgraduate and two final year electrical engineering students. This team took the responsibility of assessing a range of available PV technology products and designing

technical systems suitable for 5 schools. Decisions were made to meet the time, budget and technical requirements inherited from project proposal requirements.

The design team, with the approval and financial coordination from EcoCARE, negotiated and procured equipment and materials required for the installation based on the following specific set of criteria;

1. Mature technology & brand.
2. Cost efficiency per Watt peak.
3. Meets all applicable and relevant standards & tests.
4. Recognised and endorsed by industry experts.

A combination of sea and air freight was used to transport equipment from various parts of the world to Nuku'alofa, Tongatapu.

#### *3.4. Import Tax and Duties Exemption*

A customs duty charge is applied on imported goods to Tonga. For electrical equipment, a duty fee of 15% of the goods' invoiced amount is usual. In addition to custom duties and charges, Tongan authorities charge a "consumption tax" (CT) on goods imported into the country. The CT of 15% is calculated on the duty inclusive value of goods plus international freight and/or insurances. In the case of this project, a total of NZ\$117,011 was spent on capital goods imported into Tonga. The inclusion of duties and CT would result in an additional cost of \$37,736, excluding CT charges on shipping and insurances.

Section 5.3(a) of the Consumption Tax Act allows the Minister responsible for revenue services, with the consent of Cabinet, to direct what shall be a CT exempt import [4]. Similarly, section 19(b) of the Constitution gives the Treasurer, with the approval of the Privy Council, the power to increase or decrease the taxes and/or custom duties [5].

A request with the support of MET was made to the authorities requesting an exemption of CT and duties on imported goods. The justification of the request was that imported goods were for the development of Tonga and for the benefit of Tongan people. The request was granted and duties and CT costs to the project were avoided.

#### *3.5. Installation Delay*

The commencement of installation was delayed by one week for three main reasons;

1. Custom duties and CT exemption on imported goods were not communicated adequately with in country partners and goods remained in holding at the wharf and Air NZ cargo storage, awaiting clearance. The process took two working weeks before Tongan authorities were able to grant formal exemption for custom duties and CT.
2. EcoCARE's CEO was unavailable to travel to Tonga during installation due to ill health. EcoCARE had prior knowledge of Tongan systems, had been in communication with all in country

partners and was originally expected to coordinate the installation team. Tonga and Tongan systems were new and an unfamiliar environment to volunteers on the ground.

3. A MoU agreement with in-country stakeholders had not been finalised. Stakeholder meetings needed to take place in order to discuss and agree on key issues including system ownership, clearly identified roles and responsibilities, and pricing methodology.

### *3.6. Summary of Installation Management*

On arrival in Tonga and following meetings with in country partners, the constraints of geographic distances between schools and the limited availability of transport to the team was realised. The initial plan to divide into separate teams and work on more than one school simultaneously was updated to focus on one school at a time. Two teams worked simultaneously, one team carried out works associated with the installation of rails and PV panels on the roof and the other carried out works associated with the inverter, switchgear and wiring. MET provided a dedicated team transportation vehicle, industrial vehicles were hired on a needs basis for equipment transport.

During installations, a daily half hour debriefing team meeting was held to review progress and issues from the day and to plan the following day's objectives, resources and logistics. A daily email update was sent to all concerning stakeholders and project team members. The daily update email highlighted project progress, upcoming plans, key constraints and risks to concerned parties in a transparent manner.

Installations in four of the five schools were carried out during school holidays, reducing disruption and mitigating construction hazards to school staff and students. Construction in the fifth school commenced towards the end of the holiday period and the school was required to close for one day during construction. Construction during school holidays was not a planned approach but one that happened to coincide with UC semester break and the project volunteers' arrival in Tonga. The PV system installation commenced on Friday 22 June and was completed on 10 July 2012. Each school took approximately 3 days to complete mechanical and electrical installation works including associated transport and logistics.

### *3.7. Financial; Budget and Expenditure*

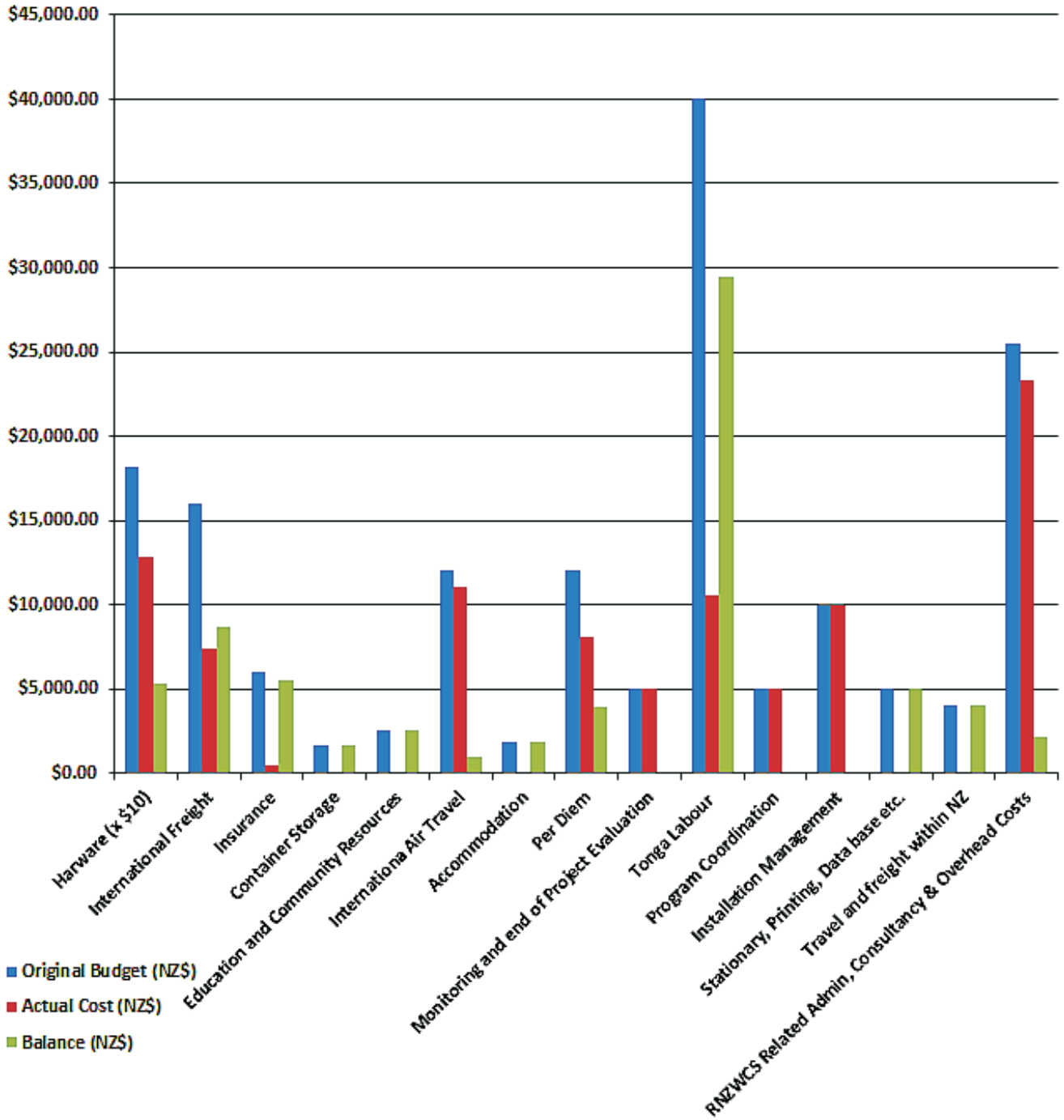
A total remaining balance of \$118,900 was in surplus and returned to MFAT by Rotary in April 2013, in completion of the project. The remaining balance was partially due to successfully negotiated equipment and materials purchase by project volunteers. The global wholesale cost of PV panels reduced over the course of the project, reducing overall equipment costs. The cost of the project comes to a total of \$209,430 resulting in a cost of \$5.14 per watt of capacity.

An industry equivalent commercial value of time provided by volunteers towards design, procurement, management, installation and documentation has not been factored into this per unit cost. Figure 4 details the categorised project budget, expenditure and balance.

### *3.8. Project Handover*



**Figure 4.** Total project budget, expenditure and remaining balance



A formal handover document consisting of relevant technical and general information was issued to TPL for review in completion of the installation. A separate handover document consisting of general information was issued to MET for review. Both documents were prepared and submitted to TPL and MET for review by a UC student and left in care of EcoCARE in completion of PV system installations.

#### 4. Recipient Schools' Response

As the controversy exists whether foreign aid is worth the money spent and whether the outcomes are good enough, this research shall strengthen the argument of foreign aid being beneficial - as long as it is implemented well. The assumption is that foreign aid works if the needs of the beneficiaries and the interests of the donor match. The research proposes a meeting of top-down and bottom-up approaches. Foreign aid recipients must be part of the decision making process how and what aid is being allocated, whereas donors need to be of assistance in how the receivers' needs could be met.

Even after generations of aid it still seems to be a struggle within foreign aid to match receivers needs and donors aspirations regarding the aid donated; therefore, this research aims to add to the effectiveness of aid. The gathered information shall assist the stakeholders to inform future projects and therefore, help to enhance the educational benefits for the schools in Tonga as well as help donors to improve their part, such as design, pre-analysis, preparation, set-up, implementation and follow-up

##### 4.1. Methodology

###### 4.1.1. Capability Approach as Framework

The Capability Approach (CA) has been chosen as the framework for this research. The approach has been developed by the economist Amartya K. Sen and focus is human well-being and people's capabilities. People's capabilities can lead to choices and therefore potential freedom for any individual. Capability, choices and freedoms are the central features of development in the eyes of the CA. Capability is defined as '*the various combinations of functionings (beings and doings) that the person can achieve. [...]*' Functionings are '*the various things a person may value doing or being*' [6]. Therefore a capability is a set of vectors of functionings, reflecting a person's freedom to live one way or another. It is these capabilities that allow a person to lead the life the person has reason to value. Functionings within this approach are the various things a person may value doing or being. Choices need to be accessible but they don't have to be taken by the individual. Regardless, it is important for people to have certain choices as only the choices lead to the freedom CA considers fundamental for every person's life. It's the equality of choices for everyone within a society that matters [7]. The capabilities, choices, freedoms and well-being of the Tongan stakeholders are the central interests of this research.

The CA considers every subject belonging to a society as an agent of their society. Thus, every member of a society has the same power and the same voice. As the CA allows for seeing anyone as an agent, the approach enables and empowers marginalised and often under-represented groups such as the poor, women, children and disabled people. The approach allows for giving a voice to these groups. The shift in power facilitates the amplification of the voices of marginalised people in such a way that they are

able to articulate their needs and demands and make their contribution to the construction of knowledge. Traditionally marginalised groups such as children, women and the disabled are given a forum through which they can express their views, needs and opinions based on their unique position on the periphery [8]. Dealing with schools means dealing with children. Giving aid to schools aims to improve children's education and therefore life. Using CA as a framework allows the research to value and use the voices of the final recipient, the children, as well.

#### 4.1.2. Participatory Research Approach as Methodology

As the CA asks to give people a voice, especially concerning children, the Participatory Research Approach (PRA) as methodology complements the CA very well. *“Participatory research methodologies have, since the 1970s, been used as a tool through which the voices of the most marginalized, impoverished and excluded in society can be heard and thus the garnering of more accurate information about communities in which development practitioners operate can be possible”* [8]. The CA demands for children to be seen as active agents in society, despite their young age and not fully reached maturity, and PRA allows adjusting the methods to the research subject child. Also, the CA's aim of empowerment of people is supported through the participation aspect of PRA, which is being followed up within this research through active participation of the participants during the data collection and data interpretation process.

The methods used within PRA are of great variety. As stated before, PRA allows the researcher to adapt to the situation and to changes within. Chambers, quoted by Zerdem et al., speaks of these methods as a *“family of approaches and methods to enable rural people to share, enhance and analyse their knowledge of life and conditions, to plan and to act”* [8]. Like the CA, *“[...] participatory techniques are designed to enable the disadvantaged and the poor to critically reflect upon their living conditions, learn the causes of their powerlessness and deprivation, and help them act to redress this power imbalance for meaningful outcomes”* [8]. Both approaches, CA and PRA, empower people because they consider them to be knowledgeable regarding their own lives and circumstances.

Both, framework and methodology found their application during two field trips and one follow up survey. The field trips were undertaken in June 2012 and March 2013, the survey as being conducted in January 2013.

During the first field trip all of the five participating schools were visited and at each school interviews were conducted as well as the Tongan Ministry of Education. For the initial field trip semi-structured group-interviews were conducted to get to know the situation of the participants. It also allowed the interviewees to get used to taking part in research and to being interviewed, which presumably was not an ordinary or common situation for the participants. The principals of all five schools were interviewed together in one group; a minimum of two and up to five teachers of each school were interviewed in a group per school; per school a minimum of three and up to five children were interviewed together in a group. The questions being asked during those semi-structured interview sessions ranged from the participants knowledge about the project itself, solar power as such to expectations and hopes regarding the project as well as the needs and problems of the schools on a daily basis. The aspect of possible savings due to the solar panel installations and the possibility of addressing issues at their schools was also discussed.

For the follow up trip the Tongan Ministry of Education and all five schools were visited and the same people (where possible) or the same number of people were being interviewed. Two schools had had a change of leadership which required re-introduction of the researcher and research purpose.

The survey was sent out to principals and teachers and asked about the status quo of the solar panels and problems or changes that had occurred since installations in June 2012. It tried to gather an understanding of the happenings since the installations as well as the perceived outlook on how useful the schools thought the panels to be.

For the second interview round, the focus lay mostly on the changes or problems having occurred or still occurring since installation of the solar panels. It was following up the survey results and trying to understand how the original expectations and hopes regarding the installations had changed in the meantime.

## 4.2. Findings

### 4.3. Summary of Findings

#### 4.3.1. Problems directly related to high power costs

- Lack of funds to expand class room amenities (schools cannot afford to pay for more lights).
- Inability to start or expand technical and vocational training for weak academic students. This training would be vital for students to find employment.
- Night classes to support weaker students cannot be held (schools cannot afford to pay for security and classroom lighting).
- Schools cannot increase their usage of computers and the internet.

#### 4.3.2. Issues related to power quality and reliability

- Poor power quality significantly shortens the lifespan of electronic devices such as computer.
- Electric motors to pump water cannot operate resulting in school closures for hygiene reasons.
- Frequency of power cuts and reconnection times are higher for schools located further away from the power station. During crucial periods such as examinations, schools utilise external printing resources from the town centre adding to the cost and inconvenience of operation.
- Tropical storm related power cuts can take up to one week to be resolved and supply reconnected.

#### 4.3.3. PV project issues affecting schools

- One school was not connected to the grid for several months following the installation of its solar PV system due to remaining works associated with TPL network and metering systems. The issue was not communicated and was of concern to the school.

- One school was asked to set up an internet connection to be able to access data and monitor power generation. Such costs could have been factored into the cost of the project.
- The principals would wait and see how much the system would save on power costs before addressing any of the school priorities.
- Schools were not informed about installation dates and times with adequate warning.
- No documentation was provided to schools. Documents including but not limited to the PV equipment's capability in windy conditions, maintenance regulations, a student educational module and stakeholder contact information would provide schools with more confidence.

#### 4.3.4. School priorities

- Increasing teacher wages to reduce high turnover.
- Security and exterior lights in order to run night classes and prevent theft.
- Human resources - employment of more teachers (particularly in boarding schools).
- More ICT literacy access to students in higher education as computer literacy is considered a core competency for people in the workforce.
- More internet access to teachers to allow access to educational resources and teacher training.

#### 4.3.5. Donor Priorities

- Increase computer and internet usage for students.
- Availability of computer facilities and internet for the wider community.

#### 4.4. Discussion

Recipient schools had previously considered alternative energy solutions including solar, to reduce their electricity costs. The necessary up front capital investment was a major factor in schools being unable to invest in PV solar energy systems. Although schools were interested in installing PV panels, this field research identified that schools' priority areas were not aligned with the donor's justification for installations.

Communication was a major concern from the schools' perspectives. Schools were unaware of the project participant and leader's roles and responsibilities (including their own). Schools were not given sufficient notice of their exact installation dates. Training and educational workshops were never provided by donor parties which were intended for delivery as part of the 5 schools project. A handover document prepared by volunteers with salient post installation information for the schools was not circulated and schools were left without project status updates for several months before the systems were connected to the grid.

Schools' priorities were found to differ from donor priorities. Schools were interested in addressing electrical lighting, human resources and teacher wages as well as ICT related activities on a needs basis for their staff and students only. The donor was interested in making ICT facilities available to school students and the wider community. Schools are presently reviewing their electricity related savings following the commissioning of the solar PV systems and anticipate addressing additional needs appropriately.

A number of related salient discrepancies between the RNZWCS project design proposal and the execution were noticed during this field research. The formal educational and training component of the project was never carried out and the formal monitoring and evaluation component of the project was based on independent academic works carried out by postgraduate students outside of project scope.

## 5. Key Recommendations

This pilot project has the possibility of future expansion to install solar energy systems in all Tongan high schools. Should this project expand, it would be crucial to understand and rectify issues that were faced by the volunteering project team during this project. The following key recommendations are derived from lessons learned through the experience of project delivery, stakeholder interviews and recipient school surveys.

1. *SMART Project Proposal:* The project proposal's aims, objectives, outputs, outcomes and methodology is not Specific, Measureable, Achievable, Realistic and Time bound (SMART). MFAT is encouraged to ask it's applicants to submit SMART methodologies in project proposals, especially if the proposal consists of multiple participants in multiple countries.
2. *Execution of defined responsibilities:* Responsibilities of leading donor partner organisations were not carried through. For example, educational training workshops were never held. A quarterly review between MFAT and New Zealand based project partners in multi partner projects is recommended to ensure thorough implementation of the scope of works outlined in the project design.
3. *Formal communication:* Formal Communication with in-country stakeholders was poor or non-existent. For example, recipient schools and in-country partners were not given sufficient formal notification of the installations. Handover documentation prepared by project volunteers was not forwarded through to the in-country stakeholders concerned. A mandatory monthly project report including but not limited to project status, stakeholder roles and responsibilities, contact information, outstanding issues and monthly objectives is recommended. The monthly report would be prepared and circulated to all concerned stakeholders including MFAT, by the principal recipient of funds to carry out the works.
4. *Recipient Priorities:* Donor priorities differed from those of recipient communities. For example, schools were not interested in holding community training sessions. A thorough baseline stakeholder survey is recommended before commencing a project. Isolated development goals may impede further development from a wider context.

5. *Participant Engagement:* In country stakeholders were not sufficiently engaged during project planning, stakeholder roles and responsibilities were not clearly communicated by leading partners. NZ based donor partners and the principal recipient of the project funds are encouraged to formally work together with in-country partners from commencement to completion. In addition to the circulation of stakeholder monthly project reports, all formal project design and specification documentation can be issued to recipient partners for approval prior to implementation.
6. *Roles and Responsibilities:* Providing clear and easy to understand roles and responsibilities to each stakeholder early on in the project would enable efficient execution. It was difficult for project participants and volunteers to clearly identify the role and responsibility of each participant. A senior project leader, capable of directing and managing the overarching project was never officially appointed and/or clearly communicated to the volunteering team. Officially hiring an experienced engineering project manager with decision making capabilities and financial authority is a must for future projects.
7. *Risk Management:* It is crucial to identify risks and manage them to mitigate or provide work around solutions early on in the project. For example, EcoCARE CEO became ill and was unavailable to travel during installation. The project volunteering team had to carry out all related works in Tonga, without EcoCARE or Rotary presence. A risk management strategy would have provided an officially appointed EcoCARE or Rotary representative in the volunteering team, authorised to make and approve decisions on project's behalf.
8. *Transparency:* The project proposal, budget structure and constraints must be made transparent to project volunteers and/or staff who wish to lead the project and progress with efficiency. The project budget sheet or proposal was never made available to project volunteers during (or after) the project. Similarly, a full project proposal was never made available to project volunteers. A more efficient financial planning and accurate spending becomes possible if day to day decision makers are aware of the proposed project and budget.
9. *Volunteer per diem allowance:* Project volunteers' were provided with meals in country but sundry expenses during their field work was not provided. Volunteer expense claim policy and items that qualified for expense claim were not clearly communicated to project volunteers. The most efficient way to get around this issue in the future is to set aside a daily per diem volunteer allowance that volunteers can spend towards sundry items and meals.
10. *Insurance:* Rotary and TPL insurance policies, terms and conditions were never made available to project volunteers. Consequently, insurance details were never investigated by the volunteering project team members; verification by those who make procurement and shipping decision is encouraged for future projects.
11. *Financial authority:* No project expense account or credit card was made available to the project team during installation. Two volunteers used their personal credit cards towards project expense in Tonga. This method delayed tightly scheduled installation works and relied on student volunteers to use their credit cards, without any guarantees of whether or not they would be reimbursed.

Opening up an in country project bank account, or providing a credit card with a limited amount of financial flexibility to an officially appointed engineering project manager and/or team leader would resolve such issues.

12. *Timely Invoice Payments:* In country caterers were not paid in advance and full payment was not received by caterers until September, two months following installation of works. This led caterers' to reduce the quality and quantity of meals served as an effort to reduce their own risk. It is crucial to look after the project volunteers as best as possible. An early deposit or advance payment would solve such issues in the future.
13. *Health and Safety:* Formal H&S briefings with documentation did not take place. A formal and documented H&S systems and procedures are crucial for future multi-party projects. Each stakeholder would need to practice their own H&S systems and the project director; in this case RNZWCS would need to enforce an overarching H&S project policy.

**6. Conclusion** The overall project objective (goal) of improving education facilities and academic progress for students through solar power electricity cannot be measured at this time. Periodic surveys from school teachers and principals and financial data concerning schools' operational budgets are required to determine the effect as a result of the PV installations. The project was successful in carrying out its technical component of the project to time, relevant standards and budget but failed to deliver social and educational components including stakeholder maintenance training sessions, mechanical and electrical workshops and lessons to students in schools.

In a development project with multiple organisations and volunteers involved, it is essential to ensure that clearly defined roles, responsibilities, project scope, budget and motivations at the very least are clearly and transparently defined, communicated and managed from conception to completion. The inability to do so pose risks that can impede in the goal of the overall project.

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### **Conflicts of Interest**

“The authors declare no conflicts of interest”.



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