Project Proposal to IUCN

Project Title: Feasibility Study and Design of a Sea Water Air Conditioning System for the USP Tuvalu Campus

Name of Organisation: The University of the South Pacific (USP)

Mail Address: Private Mail Bag, Suva, Fiji

Street Address: School of Engineering Building, Block A, Laucala Campus, Laucala Bay Road, Suva, Fiji

Principal Investigator: Prof. M. R. Ahmed

Email: ahmed_r@usp.ac.fj

Tel: +679-3232042

Fax: +679-3231538

Proposed Starting Date: We have already started the preliminary work on this project.

Proposed Completion Date: February 2018.

Funds Requested: US$9271 (incl. 15% USP Overheads)

Project Summary: Tuvalu, being a tropical country, requires large amount of energy to condition hot and humid climate conditions to required human comfort conditions. Increase in number of buildings with development makes it absolutely necessary to find new air conditioning techniques. Deep seawater has vast minerals and resources that can be used for aquaculture, desalination, energy production and cooling. Seawater air-conditioning system utilizes water from deep ocean which is at a relatively low temperature to provide cooling. This project focuses on feasibility study and design of seawater air-conditioning system for USP Tuvalu campus (existing plus proposed). The first phase of the project includes doing a feasibility study to see if the necessary resource which is cold enough seawater is available at a reasonable distance from the shore, calculating the total air-conditioning load using the air conditioning software CAMEL and sizing the major components of the system. The second phase

of the project will consist of sizing the remaining system components, using dimensional analysis to scale down the component size to model size, computational fluid dynamics analysis for the pipe, model construction and testing with cold water to ensure that the required cooling is obtained.

Description of Organisation:

Date established: 1968

Vision statement: Achieving excellence and innovation for sustainable development of the Pacific Island Countries.

Mission statement:

- To provide Pacific people with a comprehensive range of excellent and relevant tertiary qualifications;
- To deliver the benefits of advanced research and its applications;
- To provide communities and countries in the Pacific region with relevant, cost effective and sustainable solutions, including entrepreneurship, to their main challenges; and
- To be an exemplar of tertiary education for the Pacific Islands in quality, governance, application of technology and collaboration with national tertiary institutions.

Goals and/or objectives of the organization:

USP is a key contributor to the development of Pacific Island Countries and region's premier University providing a primary source of high quality graduates in the region. USP serves the regional needs of its 12 member Countries[1]. USP strives towards excellence in the provision of tertiary education and aims to build on and preserve the Pacific Heritage. It proactively engages with the region, its communities, and with international partners on major development issues relevant to the region. The University has positioned itself as a leader in research and education that is original, modern, and readily applicable in addressing the problems and challenges faced by its member countries. USP is one of the two regional Universities in the world and is not only a higher education institute, but also an active regional integration organisation. The steady supply of graduates has contributed to meeting the growing development needs of the region for almost 48 years.

[1] Cook Islands, Kiribati, Nauru, Samoa, Tokelau, Tuvalu, Fiji, Marshall Islands, Niue, Solomon Islands, Tonga, Vanuatu

Members in the organization: The University had a total of 1617 staff as at 31 December 2016 including 670 academic and comparable staff

Positions and name the persons who are on the executive of your group:

Mr Winston Thompson, Pro-Chancellor and Chair of Council;

Professor Rajesh Chandra, Vice-Chancellor and President;

Dr Giulio Paunga, Vice-President Regional Campuses & Properties and Facilities;

Professor Derrick Armstrong, Deputy Vice-Chancellor, Research and International;

Professor Richard Coll, Deputy Vice-Chancellor, Learning Teaching and Student Support;

Dr Anjeela Jokhan, Dean, Faculty of Science, Technology and Environment;

Dr Akanisi Kedrayate, Dean, Faculty of Arts and Law;

Professor Arvind Patel, Acting Dean, Faculty of Business and Economics; and

Mr Kolinio Boila, Executive Director Finance.

Relationship with IUCN: Four MOUs between USP and IUCN on initiatives related to PICCC training renewable energy and Beche-De-Mer (BdM) resources conservation project.

Description of the Project: Tuvalu, formerly the Ellice Islands in the Gilbert and Ellice Island colony, comprises nine islands. These are scattered over 1.2 million square kilometers of the Pacific Ocean stretching in a North-South direction between latitudes 5 and 11 degrees south and over longitudes 176 and 180 degrees east. The total land area is 25.6 square kilometers. The population of Tuvalu is ethnically Polynesian, estimated to be more 11,000 in 2009 in accordance to the household surveys undertaken by the Secretariat of Pacific Community. By 2020, the Pacific island state of Tuvalu aims to become the first country in the world to generate 100 percent of its electricity from renewable sources such as solar, wave, wind, and biofuel. According to the Tuvalu infrastructure strategy and investment report, Funafuti the capital of Tuvalu produces power by means of three 750kVA generators and 40KW solar system where as remaining outer islands generate 148-220KW of power. Generators consume large amount of fuel (diesel) and also emit carbon dioxide which have adverse health and environmental effects. According to Tuvalu renewable energy study report, consumption of electricity for specific uses (e.g. lighting, domestic appliances, refrigeration, cooling, etc.) represents 13% of final energy consumption - cooling appliances already accounts for one third of this category and their use in Tuvalu is growing rapidly.

Establishment of a sea water air conditioning system (SWAC) at the University of the South Pacific (USP) Tuvalu campus would minimize power consumption since SWAC systems require relatively low amount of energy when compared to other conventional units e.g. vapor-compression refrigeration system and vapor absorption system. Seawater air conditioning system utilizes cold water from the deep sea (4-5°C at a depth of 1000m) for cooling purposes. Seawater air conditioning system operates on two loops. One loop consists of a pump which draws out cold water from the sea which is than fed to the heat exchangers and then discharged to the ocean. The other loop carries cooling water which is also fed to the heat exchangers. Heat from the cooling water is transferred to the sea water in the heat exchangers and the chilled water is circulated throughout the buildings for cooling.

SWAC is a cooling system which replaces energy intensive electrical air conditioning system with use of cold sea water. Cold water from depth of 700m-1000m is pumped onshore through high-density polyethylene (HDPE) pipes with the use of a pump. Sea water is than fed to a cooling station (heat exchanger unit) which absorbs heat from the closed loop fresh water after which the seawater it is pumped back to the ocean. This cold water can be used in two different ways to provide cooling.

Firstly, a central AHU can be used which contains a fan coil unit. The chilled water passes through the coil and with the help of the fan the cold air is blown across it. This cold air is then supplied through ducts to the rooms in the building to be cooled. The second method of utilization of this cold water is by pumping it to different rooms where each room contains its own fan coil unit known as terminal units.

A schematic of a SWAC system using the latter approach is shown in Figure 1.

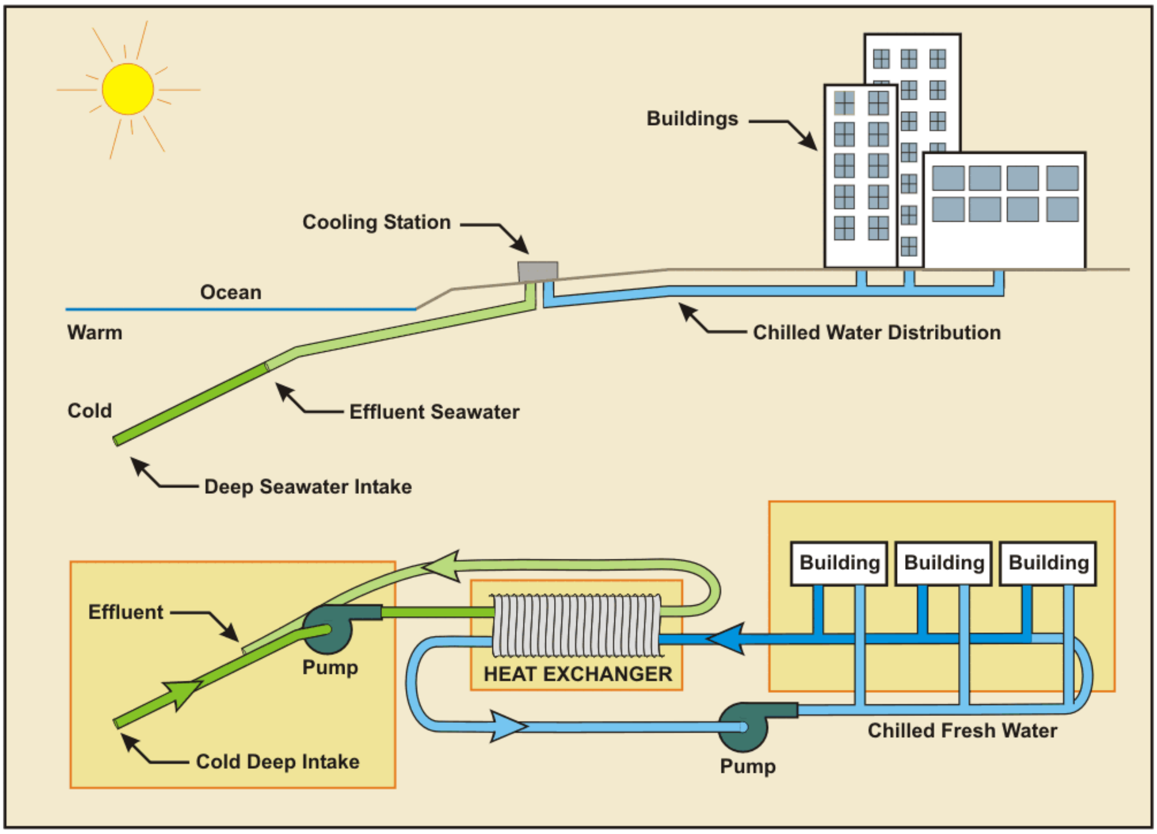

Fig. 1. Schematic diagram of a SWAC system

The use of this system may not be economical if the cooling load is less than 1000 TR. In this case, there are other means through which the sea water can be utilized to reduce the energy costs which are associated with air conditioning. One of the methods is the use of a seawater cooled chiller. Sea water at a depth of 1000m is about 4°C-5°C and as the depth decreases the water temperature increases. If a site does not have access to Deep Ocean than the temperature of the sea water would not be adequate for cooling. Near shore water can be utilized to cool the condenser of a conventional system rather than using evaporative cooling towers or cooling with air. Shallow sea water is much cooler than air temperature and would provide better cooling which would result in energy saving. Figure below shows a conventional system condenser being cooled by shallow sea water.

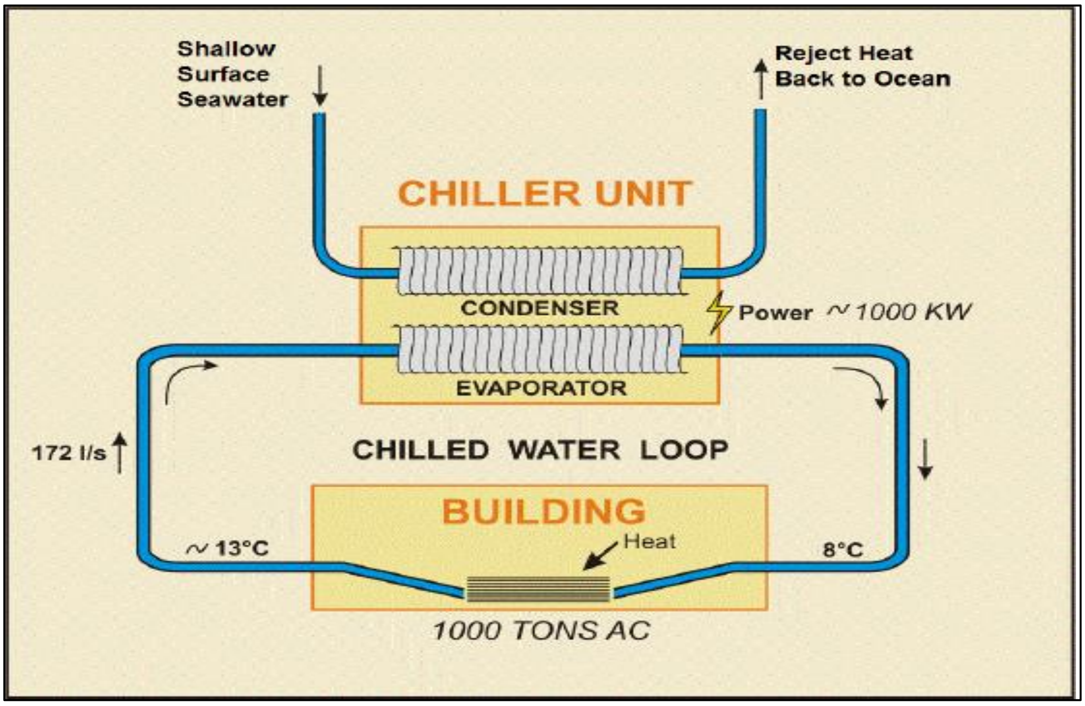

Fig. 2. Schematic diagram of a seawater cooled conventional air conditioning condenser.

The project will include estimating the cooling load of the present as well as the proposed buildings of the USP Tuvalu campus using CAMEL, selecting the right component and material of the SWAC model system including HDPE pipe, seawater pump, heat exchanger. The heat exchanger will be designed and fabricated in the Mechanical engineering Workshop of USP. The entire system will then be assembled and tested for performance.

Objectives

The objectives for the first phase of the project include:

I. To check the feasibility of implementing a SWAC system in Tuvalu. The feasibility studies would include:

   a. Determining the sea depth at which cold-enough sea water is available for the cooling application.

II. Calculating the total air conditioning load of the USP Tuvalu campus.

III. To check which type of SWAC system is appropriate with regards to the studies done earlier.

IV. Once the feasibility studies are completed the design phase of the project starts whereby necessary calculations would be done to size different elements of the cooling system. These calculations are independent of the type of system selected. Some of the calculations include:

a. The size of sea water suction pipe required i.e. the length and diameter.

b. The size of the seawater pump as well as the chilled fresh water pump.

c. The size of the heat exchanger required to accomplish effective heat transfer.

V. Other calculations depending on the type of system selected. These may include:

a. The duct sizing calculations i.e. cross sectional area and pressure losses together with overall length of the ducts.

b. Fan sizing calculations i.e. total fan power required to deliver cool air to building rooms.

VI. To construct a scaled-down model of the entire air conditioning system and the buildings and study the cooling.

VII. Finally a comparison could be done against the conventional AC system and SWAC system which would show the initial capital cost of each system and the maintenance or running cost. It could also show the payback period of the SWAC system.

Methodology

The following steps would be undertaken to complete the project:

1. **Data Collection**
   - Obtain the building plans and details of the USP Tuvalu campus
   - Detailed literature review for the state of the art in SWAC
   - Measurement of sea temperature at different depths (up to 700 m)
2. **Calculating the total air conditioning load for the building using CAMEL software.**
   - Electrical load
   - Sensible heat load
   - Latent heat load

- Occupancy load

3. **Doing necessary calculations to size the components.**
   - Size of the seawater and fresh water pumps.
   - Size of the heat exchanger.
   - Diameter and length of the suction pipe.
4. **Construction of a scaled down model of the entire air conditioning system in the laboratory.**
   - Construction of a heat exchanger.
   - Pumps for both sea water and fresh water loops, pipes, fasteners, fan and other necessary materials would be bought.
5. **Testing the model in the laboratory and comparing the results to calculated theoretical values.**

Material Required:

1. Pumps for both cold water pumping and fresh water pumping.
2. Sheet metals to build a suitable heat exchanger and ducts.
3. Pipes and fasteners.
4. Copper pipes to construct the cooling coil.
5. Fan to circulate air past the cooling coil.
6. Perspex glass to construct model of campus.

Budget:

Item/components	**Cost (USD)**
Airfare for 3 (return Suva-Funafuti)	1833
Per diem for 3 for 7 nights in Funafuti	2625
Extra luggage charges (CTD probe and winch)	350
Boat hire in Funafuti (2 days)	504
Material: 2 pumps, sheet metal, Perspex, pipes, fan and glue	1900
Payment to Technicians (2)	600
Miscellaneous (local travel, color printing, contingencies)	250
Sub-total	8062
USP Overheads (15%)	1209
TOTAL	9271

Appendix 1

Brief CV of the Principal Investigator

Dr. M. Rafiuddin Ahmed is a Professor of Mechanical Engineering at USP. He has held full-time and visiting positions in Japan, New Zealand, India and South Korea apart from his current position at USP. His area of interest is energy science and engineering. He is working in this area for well over fifteen years and has nearly 100 international publications with half of them in reputed international journals. He was an invited speaker at a number of international conferences, a member of the International Advisory Boards/Technical Committees of the International Symposium on Fluid Machinery and Fluid Engineering, International Symposium on Low Carbon and Renewable Energy Technology, Asia-Pacific Forum on Renewable Energy (2011-2017) and the IAHR Symposium to be held in Beijing in October 2017. He was a member of the Organizing Committee for ASME International Mechanical Engineering Congress and Exposition (IMECE2013) held in San Diego, USA and also of the Asian Wave and Tidal Energy Conference Series (AWTEC2012, 2014 and 2016). He has received best-paper awards at international conferences. He is a reviewer for many reputed international journals. He was also a reviewer of the IPCC report on Renewable Energy Sources and Climate Change Mitigation. He is working on a number of projects in the areas of wind and ocean energies and has given invited lectures at a number of universities and research centres. He is the leader of the Renewable Energy Research Group at USP and was instrumental in attracting a US$2 million project from KOICA in the area of renewable energy. He is the Coordinator of the Mechanical Engineering programme at USP for a long time. He is a life member of the American Society of Mechanical Engineers (ASME), a Senior Member of the American Institute of Aeronautics and Astronautics (AIAA) and a member of the World Renewable Energy Network (WREN).

List of Publications/citations available on Google Scholar and ResearchGate:

https://scholar.google.com/citations?user=PZdWKK0AAAAJ&hl=en&oi=ao

https://www.researchgate.net/profile/MRafiuddin_Ahmed

Appendix II

Bathymetry Chart for Funafuti, Tuvalu