

Proposal for Student Research During the Summer of 2006

Research at OCEES International, Inc., Kaimuki/Hawai`i Kai, island of Oahu, HI
under Dr. Hans Krock, Professor Emeritus of Ocean & Resources Engineering at the
University of Hawai`i

Submitted by:
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Duration and Location of Research:

- Starting: May 22nd, 2006
- Duration: 10-weeks
- Location: OCEES International, Inc., Kaimuki, Hawai`i. Research will be conducted under Dr. Hans Jürgen Krock, Professor Emeritus of Ocean & Resources Engineering at the University of Hawai`i and President of OCEES International, Inc. OCEES International and its strategic partners are “recognized as the world’s leaders in, all aspects, from theoretical to technical to design and operations, of Ocean Thermal Energy Conversion (OTEC) technologies.” – www.ocees.com

Proposed Research:

A brief introduction of Ocean Thermal Energy Conversion (OTEC) is useful in motivating my proposed research. An OTEC facility is essentially a heat engine that produces energy by utilizing the thermal energy gradient that exists between cold water (about 4°C at a depth of about 1000 m) and warm surface water (27°C to 30°C near the equator). Due to the small temperature difference between the two liquids, a simple calculation of the maximum efficiency under maximum power output conditions reveals a low thermal efficiency of about 4%. This is a clear motivation to maximize the thermal transmission coefficient for the heat exchangers utilized in this process.

Current designs for OTEC facilities utilize materials such as aluminum to achieve desirable performance. Metal heat exchangers, though, face corrosion problems under constant exposure to salty ocean water. Thanks to advances in materials engineering, there exist new plastic materials with significantly high thermal transmission coefficients. Therefore, the proposed research will investigate the possibility of utilizing these newly developed plastics as an alternative to current heat exchanger materials. Because this has not been applied in any current OTEC systems, the goal for the proposed research is to develop a computational model for an OTEC system using this material.

The first step will be to determine the specific portion of the system that I will examine. Time-constraints require a focused study. I will first identify the parts of the system that will use the new heat exchanger materials. Identifying these parts will limit the model to a manageable size for the 10-week period. I will look to Dr. Krock for much of this advice because of his experience and familiarity with OTEC system design.

The next step will be to apply changes to the desired areas of the system. In this portion of the research, the system will go to software to be modeled. Depending on the material properties, different issues may be more or less important. These may be heat transfer coefficients, flow dynamics, and limited formability. Again, because of time-constraints, only the most significant of these may be studied. This will be determined by which issue(s) is most important to the materials application in OTEC. The preparation and modeling are expected to dominate the bulk of the 10-week period.

The final step will be to compare the modeled results with data obtained from pre-existing aluminum/metal models and implementations. This will allow an approximation of the feasibility and tradeoffs associated with each new material. The extent to which conclusions can be made will depend upon the strength of the model.

If any time remains, materials might be obtained for testing, and a site visit to an OTEC facility will be arranged. The site of interest is in Kailua-Kona, Hawai'i (the island) and is an operational OTEC facility. Though not producing energy for commercial consumption, the facility makes the cold-water available for use. Various groups in research, pre-commercial, and commercial roles are utilizing the cold-water for aquaculture, cold-water agriculture, fresh-water production, and marine biotechnology efforts. These derivatives or "co-products" are of interest since they can serve as additional revenue sources and novel products, increasing the feasibility and appeal of OTEC facilities. If no time remains within the 10-week period, the site visit will be done after the 10-week research period. A multi-day visit to the site would be ideal. However, scheduling a visit beyond those offered to the general public will require further correspondence.

Feasibility

As a student abroad, I took two courses with relevance to my proposed research. One course, Thermofluids 2, dealt with thermodynamics and fluid mechanics, which will both be relevant to this modeling. The second course, Hydrology and Hydraulic Engineering, also dealt with fluid mechanics and water flow. I will also have completed the Continuum Mechanics, Structural Mechanics, Materials, and the Energy and the Environment courses here at HMC. As a student in Energy and the Environment, my final research focused on OTEC technology, which gives me additional background in OTEC in general. The courses I have taken and the research I have done should provide me with the necessary general background that might be expanded upon during my research this summer.

Finally, Dr. Hans Krock is considered a leader in this field. He has a vast wealth of knowledge and experience in fields related to OTEC technology. Since 1980, he has been working on the optimization of OTEC system design. Given my background, with Dr. Krock as my mentor for the duration of my project, I see no reason why this is not feasible.

Educational Value

The value of this project to my personal and educational goals is extremely high. In terms of career goals, having experience under a recognized leader in OTEC development will be extremely useful and pertinent towards my advancement within this field of study. Conducting research within this field would be an amazing opportunity for learning. In terms of general skills, gaining further knowledge and experience in modeling physical systems will be very useful. In particular, the additional experience with the use of computers to do this modeling will also be very significant. Finally, a site visit will be very valuable because of the opportunity to see a facility in operation. While theory and study can provide an understanding of a system, one's understanding of a physical system is often incomplete or unclear without seeing it in action. Commercial co-products are very important to the general appeal and commercial feasibility of OTEC facilities. Thus, it will be very useful to make contacts within this community and to survey, firsthand, the current efforts in this area.

Significance

The significance of any alternative, renewable energy resource cannot be overstated. With supply limitations and pollution problems in fossil fuels, the ability to produce a commercially feasible, low-impact energy source is essential for the maintenance and/or improvement of current global living standards. OTEC is close to an ideal source of energy for tropical communities because of its ability to co-products (fresh water in particular) along with energy. Increasing the effectiveness of this renewable energy, decreasing its cost and decreasing environmental impact can directly increase the probability of large-scale OTEC development. Therefore, this research is clearly significant to environmental causes.

Proposed Budget

The following is an itemized budget for the 10-week period:

Item	Cost calculation	Total
Travel during the 10-week period to the NELHA OTEC site in Kailua-Kona.	\$150 Round-trip airfare. \$390 for 3 days/2 nights for Accommodations, food, and transportation.*	\$540
Transportation (fuel)	\$5/day x 50 days	\$250
Misc. Costs**	\$250	\$250
EXPENSES		\$1040
STIPEND/ SUMMER SALARY		\$4000
TOTAL		\$5040

*This is based upon current standard airfare between Honolulu and Kona. The cost of hotel is estimated to be approximately \$75/night; food is estimated at \$30/day; transportation is estimated at \$50/day, which assumes that I will need to rent a car to reach the facility's remote location.

**It is expected that OCEES will provide software licenses and any other modeling tools. However, in the case of purchasing sample material, pertinent research reports, or other necessary supplies, this fund will be used.

External Funding

No other external funding is currently available. If funding does become available through OCEES International, the Center for Environmental Studies will be notified accordingly. No other sources of funding are currently anticipated.