

Recommendations for Improving Operation and Maintenance of CCAT Appropriate Technology Systems

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Recommendations for Immediate Action

- Hire a second engineering technician to develop O&M manuals and job shadow the current technician.
- Post hard copy of an O&M calendar in the CCAT office and electronic copy online.
- Develop formal job descriptions for co-directors and employees that include specific tasks and responsibilities.

Introduction

The purpose of this investigation is to develop recommendations for improving the operation of appropriate technology systems at the Campus Center for Appropriate Technology (CCAT). A broader-scale analysis of CCAT's guiding principles and goals was performed in the 2006 CCAT Strategic Plan.¹ Some of our recommendations mirror those in the strategic plan, but our recommendations are directed specifically towards the operation and maintenance of the appropriate technology systems.

The information and recommendations in this study are largely based on conversations with seven individuals who represent a broad spectrum of affiliations with CCAT. The individuals include two co-directors (Toby Haskett and Jesse Shrader), one employee (Nathan Chase), the faculty advisor (Lonny Grafman), and three members of the steering committee (Peter Lehman, John Meyer and Ben Scurfield). A brief outline of the immediate actions that we recommend is provided on the cover page to give you a taste of what we feel would greatly improve the operation and maintenance of CCAT's appropriate technologies (AT). These and other recommendations are expanded on in detail at the end of our report. Following this introduction, we have provided background information describing: (1) the institutional framework of CCAT and how we see this is affecting the operation and maintenance (O&M) of their appropriate technology systems; (2) the existing O&M procedures and; (3) an O&M assessment of several systems identifying factors we feel are contributing to the project's success or failure. It is in consideration of this background information that we feel our outlined set of recommendations has the potential to greatly enhance the functionality of CCAT's AT systems.

Before proceeding, it is important to recognize that CCAT has been successfully functioning and fulfilling its mission for over 30 years. The intention of our recommendations is to enhance the current framework regarding O&M, but we also want to highlight the things that have likely contributed to the good O&M habits observed. Interspersed throughout our report you will find we recognize these positive attributes.

CCAT the Institution

The Campus Center for Appropriate Technology was established in 1978 and continues to operate as a "living laboratory for experiential learning opportunities by designing, creating, and testing numerous appropriate technologies, green building designs, and sustainable living techniques."² CCAT has maintained its standing over the years with

¹ CCAT Draft Strategic Plan. 2006. < <http://www.humboldt.edu/~ccat/strategicPlan.php>>.

² <http://www.humboldt.edu/~ccat/about.php>

the help of its three annually replaced co-directors, student employees, volunteers, the organizations steering committee, and support from HSU and the surrounding community. One of the unique principles that CCAT was founded under is something that co-founder Peter Lehman likes to call, “giving too much responsibility to the students and seeing what they do with it.”³ CCAT’s institutional framework continues to function by means of this concept. This principle is one in which we consider with great respect as we address the concern about system operation and maintenance at CCAT.

After having conversations with co-directors, employees, the faculty advisor, and members of the steering committee, a sense for how CCAT operates was established and problem areas were identified in regards to the O&M of appropriate technology systems. Before discussing the specific systems and highlighting their respective successes and challenges, we first outline a few observations made at the institutional level that may be affecting the O&M of technology systems, and through which addressing may lend itself toward a plan of action to improve system O&M. All of the following statements are made in light of our interviews with the prior mentioned CCAT affiliates.

Though we will highlight several institutional level concerns that may be affecting O&M there are also several things intrinsic to the CCAT institutions that have likely contributed to the successful functionality of some of the AT systems. These traits (The Good) will be highlighted first before proceeding onto outlining our observations of the limitations (Our Concerns).

The Good

- Having the co-directors work with the employees and volunteer, and the faculty adviser and steering committee providing a backbone of support for the co-directors links together nicely all the different categories of people involved in CCAT. This has resulted in,
- Cohesion and cooperation among people involved in CCAT, necessary for CCAT to be successful in general.
- Having a steering committee serve as the source for institutional knowledge and continuity in light of frequent co-director and employee turnover.

Our Concerns

- A formal job description for all employees does not exist, and upon applying for a position, no detailed description of qualifications is outlined.
- Upon being hired, there is no consistent training routine.
- No person(s) is outright identified to oversee the O&M of the energy systems.

³ Lehman, Peter (2010). Personal Interview. 8 April 2010.

- Before CCAT was integrated into the HSU curriculum there were fewer systems that required maintenance and the co-directors, who were often engineering students, assisted with the O&M. Since the quantity of projects has increased and co-director responsibilities have expanded, they do not have the time to learn technical skills and directly assist in the O&M.
- The co-directors have limited time to complete all of their assumed duties.
- A major role of the co-directors is to delegate tasks to other employees, a skill in which the co-directors often cultivate throughout their term, but do not have coming into the position.
- There is minimal oversight of co-director and employee duties.
- Continuity of institutional knowledge from year to year is disrupted as co-directors are replaced on an annual basis.
- The steering committee and advisor help to improve the institutional memory; however, their role is removed from the daily operations of CCAT.
- The methods for archiving information and storing protocol manuals are disorganized.
- Procedures for system O&M are often inaccessible to all employees because they are written in a manner too formal, clouded by technical jargon.
- There is no consistent schedule (daily, weekly, monthly, etc.) reminding co-directors and employees when certain tasks need to happen.
- There are no highly visual feedback mechanisms to inform people about the state of CCAT's AT systems.
- Some employees prefer not to use computers.
- A focus of the organization is to foster student learning through "trial by fire,"⁴ and there is a concern that too much structure may hinder this learning approach central to CCAT.

The next sections examine the appropriate technology systems associated with CCAT, identifying what is and is not functional and pointing out the strengths and challenges attributed to the O&M of each system.

Current Status of CCAT Appropriate Technology Systems

An examination of the existing appropriate technology systems and current O&M procedures is necessary for developing recommendations for improvement. The purpose of this section is to briefly outline the current status of select CCAT appropriate technology systems and their maintenance processes.

⁴ Grafman, Lonny (2010). Personal Interview. 9 April 2010.

Since the appropriate technology at CCAT places an emphasis on systems with minimal maintenance, the institution has been able to keep most of the systems operational. The primary CCAT appropriate technology systems reviewed in this study are identified in Table 1. The systems were identified during discussions with the CCAT co-directors, employees, advisor and members of the steering committee mentioned in the introduction. All but one of the systems, the grey water marsh, are currently functional. While most systems are functional, they are not operating at peak performance.

Periodic inspection and maintenance of system components can improve the performance. An O&M manual is a tool that often identifies what, when and how components of a system should be inspected and used. However, an O&M manual is only a useful tool if an employee is responsible for overseeing the procedures identified in the manual. Table 1 also summarizes if an O&M manual is available and if an employee has been assigned to perform maintenance tasks.

Furthermore, our review found that funding is not hampering the ability to perform O&M. Funds are available to purchase broken equipment, tools or, if necessary, hire outside contractors.

Table 1. Summary of Primary AT Systems at CCAT

| Appropriate Technology System | Operational Status | O&M Manual Available | Are the O&M tasks formally assigned to a CCAT employee? |
|---------------------------------------|-------------------------------|---------------------------------|--|
| Mobile Energy Operations Wagon (MEOW) | Functional | No ⁵ | Partially |
| solar thermal hot water system | Functional | No | Yes |
| yurt photovoltaic system | Functional | Yes | Yes |
| grid intertied photovoltaic system | Functional | ? | Yes |
| pedal power machines | Functional and Non Functional | No | No |
| bubble box | Functional | Yes | No |
| grey water marsh | Standby | No | No |

⁵ An O&M manual is currently being developed by the spring 2010 ENGR 535 Development Technology class

System-specific O&M Analysis

Our recommendations have been generated from interviews with the aforementioned CCAT stakeholders, providing us with the previously outlined institutional functionality and status of CCAT's AT systems, as well as through analyses of specific systems. Here we address the solar thermal system, Mobile Energy Operations Wagon (MEOW), grey water marsh, and the photovoltaic (PV) systems in the yurt and main house. By discussing the design intent, successes, and challenges of operation and maintenance on a case-by-case basis, we intend to further illustrate how we arrived at our recommendations and how they may be implemented in the future.

Solar Thermal System

“The Solar Thermal Project seeks to install two evacuated tube panels on the roof of the Campus Center for Appropriate Technology, as well as a monitoring and data-collection system, and interpretive display. The project will showcase solar technologies and offer a unique set of educational opportunities for students and the public to learn about appropriate technologies, while providing heat and hot water to the CCAT building and reducing CCAT's environmental impact of energy usage.”⁶ “The solar thermal system was funded by HEIF and responsibility for the system was placed in the hands of the CCAT engineering technician, whose explicit responsibilities include the continued monitoring, analysis and publication of solar thermal and other CCAT system data, involving other students in the process.”²

The solar thermal system is currently functional and appears to be well maintained. We were unable to locate an O&M manual during our inspection, yet a binder containing some documents related to the system components was located with the system. A schematic drawing (although slightly incorrect) was also available. A search of the CCAT website and Appropedia yielded a general system overview, a link to the HEIF proposal document, and some explanations of radiant floor heating and the Phoenix Solar Water Heater.

The fluid flow directions have been labeled on most of the system piping, but there is no educational or maintenance-related labeling of what fluids are in each pipe (e.g. domestic cold/hot water, propylene glycol to/from panel array, etc.). Labeling is also non-existent for system components, system setpoints, and typical operating conditions (e.g. temperatures, pressures, flow rates, glycol content, etc.) The system has redundant data logging capacity and it is unclear what is being recorded. Furthermore, the system

⁶ Hughes, Laura. 2008. HEIF application for CCAT solar thermal project.
<http://www.humboldt.edu/~heif/proposals/CCAT_solar_thermal_fall_08.pdf>

performance digital readout is not in a location that is convenient for frequent observation.

MEOW

The purpose of this project is to showcase renewable energy technologies through a portable trailer, connecting people with the information and organizations necessary to implement appropriate technologies into their own life for sustainable living.⁷ It has been utilized at music venues, HSU campus events, and community events to educate students and community members about appropriate technology. In addition, it also provides a renewable source of electricity for CCAT.

Currently, the MEOW is functional, yet is in need of several internal and external repairs. Minimal system information is available on the CCAT website and there is currently no O&M plan. Additionally, there is no component labeling or visible system schematic for repair or educational use. The MEOW was designed to be durable, with many of the system components planned to last for 20-50 years or more with only minor system adjustments.⁷ The trailer is quite robust, yet the project designers did not set forth a plan for dealing with general wear and tear, organization of associated tools and equipment, and regular maintenance tasks. We were unable to identify a clearly defined caretaker of the MEOW.

Grey Water Marsh

It was the hope of the organization to construct a grey water treatment marsh for self-sufficiency, water conservation, and to demonstrate grey water treatment and reuse at the facility. The grey water marsh was intended to enrich years of future demonstration and learning opportunities about wastewater management. CCAT hopes that future projects will benefit from the treatment system for end-use irrigation and landscaping on the CCAT site.⁹

Currently the grey water marsh is not functional, and is in fact turned off. Interviews with CCAT employees suggested that the system is not working due to the relatively high levels of maintenance required. To keep the marsh operating properly, the filters and grease trap should be cleaned weekly. Interviewees also commented that below grade access to the filters and settling tanks is inconvenient. The grey system components that require frequent maintenance are not at a location that is conducive to easy monitoring.

In contrast to the MEOW, the grey water marsh is well documented on the Appropedia website. The information available electronically is quite thorough. Schematic

⁷ Padget, Michael. 2003. Mobile Renewable Energy Trailer Proposal, An Engineering 305 Group Project at Humboldt State University. <<http://www.humboldt.edu/~ccat/meow.php>>

⁹ CCAT Greywater Marsh. <[http://www.appropedia.org/CCAT_greywater_marsh_\(current\)](http://www.appropedia.org/CCAT_greywater_marsh_(current))>

diagrams and a maintenance video accompany a well-written description of the system intent, construction and layout. The system documentation on Appropedia has the potential to serve as a training and reference tool for CCAT employees. Additionally, a more formalized O&M manual should accompany the tools and equipment necessary for conducting regular maintenance tasks.

CCAT Grid-tied Photovoltaic (PV) System

The grid-tied PV system is currently functional, yet it is unclear exactly how well the system is performing. There is a digital readout of the system performance, but it is connected to only one of the inverters, so the output and full functionality of the system cannot be confirmed. Additionally, the monitoring system display is located next to the inverters in the basement, which is inconvenient for frequent performance monitoring. The system's two inverters are assumed to be operational, but a recent inspection with Ben Scurfield suggests that only one of the inverters may be currently functioning. Finally, educational signage for the PV system is not being displayed.

While inspecting the system, we were unable to locate either an O&M manual or a schematic diagram. We did find an article written about the system design and installation on the CCAT website, but to our knowledge, no other electronic documentation of the PV system is available.¹⁰

Yurt PV System

“The CCAT Solar PV Lighting System is comprised of a solar panel (also known as a photovoltaic module), a charge controller, and a battery that provides power for both lights and electrical outlets. This project had two main goals: to demonstrate an off-grid photovoltaic (PV) system and to provide power for lighting and an outlet for AC devices.”¹¹

The yurt PV system is currently functional, yet appears to be in need of some minor maintenance and upkeep. Of all the systems inspected, the yurt PV system seems to require the least amount of regular maintenance. Ironically, it is the only system with a sufficient O&M manual located with the system. It was clear, however, that the convenient placement of an O&M manual did not result in improved O&M. The PV panel was extremely dirty and a great deal of tools and other obstructions blocked access to the system components. A search of the CCAT website and Appropedia yielded a

¹⁰Zoellick, Jim. 2002. Getting On the Grid. Home Power. Issue #90.

< http://www.humboldt.edu/~ccat/renewableenergy/HomePwr_Aug02_CCAT_PV.pdf>

¹¹Burke et al. 2006. CCAT Yurt Solar PV Users Manual.

design document for the yurt PV system, but it is unclear if it is related to the user's manual created in 2006.¹²

Recommendations

Although most of the appropriate technology systems at CCAT are functioning, we feel that the following recommendations would improve their operation. The recommendations would affect not only how the systems are managed but also the institutional structure of CCAT. Although many of the recommendations will seem familiar to co-directors, the steering committee, and other people involved with CCAT, it is our hope that the concise list will still be helpful.

- Develop formal job descriptions for co-directors and employees
 - Identify the employee responsible for each AT system.
 - The employee would be responsible for either performing or delegating the maintenance.
 - Update the employee job description to ensure that new employees are aware of their maintenance duties.
- Institute semester performance reviews for employees and co-directors.
 - Co-directors should conduct reviews for employees and the CCAT advisor can review the co-directors. Employees not meeting duties defined in job descriptions should be warned, reviewed again in one month's time and reprimanded if performance does not improve.
 - Penalization may include withholding of employee pay until duties are fulfilled.
- Formalize a training program for co-directors and employees
 - Develop O&M training videos for each AT system. The videos would be a training tool for new employees and a method to help improve the transfer of knowledge between employees. The videos posted on Appropedia for the grey water marsh serve as a great example.
 - Institute mentorship and/or job shadowing
 - Emphasize teaching and developing skills necessary for delegating tasks.
 - Hire new co-directors and employees with 1 month of time to job shadow.
- Organize and inventory of tools / equipment
 - Include tool maintenance tasks
 - Inventory list should be pinned on the yurt door where tools are stored and include a check-in and check-out column.

¹² Yassemi, Idyath. CCAT Yurt: L.E.D.'s Light the Future.
<<http://www.humboldt.edu/~ccat/renewableenergy/yurtledlights/index.html>>

- O&M Manual development
 - Hire a second engineering technician to focus on creating O&M manuals for the AT systems currently lacking documentation.
 - Refer to the O&M manuals for the yurt PV system and the MEOW for successful examples.
 - Three manuals (two hard copies and one electronic) should be created for each system. One manual should be stored near the system in a container with all the necessary tools to perform the maintenance. The second manual should be filed at CCAT and the electronic manual could be posted online at either CCAT's website or Appropedia.
- Establish an O&M calendar
 - Each O&M manual should include a maintenance schedule.
 - Post a large white board that shows the dates for each maintenance task. Install the white board next to the time sheets to make it highly visible.
 - The maintenance schedules could be posted on CCAT's website to remind co-directors and employees of their duties. This could be easily integrated into the successfully implemented calendar currently on the website.
 - An online schedule (similar to Google Calendar) that shows task due dates and sends reminder messages to CCAT employees might encourage a quick response.
- Install convenient system performance displays
 - Install data collection and logging system with a public display of critical system measurements to provide immediate feedback regarding operational status.
 - Public display of PV and solar hot water system performance metrics, placed in a highly visible location, could generate increased involvement from other CCAT employees or volunteers.
- Embed O&M procedures into the curriculum of engineering classes and/or provide O&M classes for the community.
 - Co-directors are busy and sometimes do not have time to provide oversight ensuring that each employee completes the tasks described in their job description. Developing community classes shifts the oversight from co-directors to the community.
- Require O&M manual for all new CCAT projects

- This should be directly stated in the Appropedia page titled “Potential ENGR 305 Projects at CCAT”¹³
- Refer to the O&M manuals for the yurt PV system and the MEOW for successful examples.
- Possibly no change – continue to “learn by doing” with minimal structural framework.
 - CCAT has been highly functional and has successfully fulfilled its mission for over 30 years under a less formalized structure.
 - Although “learning by doing” has educational merit, we feel that if the systems are not properly maintained, significant educational opportunities for employees and the community may be lost.

Closing Comments

These recommendations are intended to improve the state of the AT systems at CCAT. It is our hope that this document can serve as a catalyst for discussing the sustainable operation of CCAT. A well-integrated O&M plan can empower CCAT to achieve their goal of “finding solutions to human and environmental problems through sustainable living.”

¹³ “Potential ENGR 305 Projects at CCAT”.
<http://www.appropedia.org/Potential_Engr305_projects_at_CCAT>