

HEIF RFP Spring 2008 Cover Page

Proposal Title: Old Music Building Photovoltaic Project

Applicants:

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Abstract:

We propose the installation of a photovoltaic system and an associated artistic display on the Old Music Building roof. We present three alternative designs: 3.5, 5.3 and 10.5 kW systems at \$45,468, \$58,256, and \$95,943, respectively. Student participation will include student PV installer interns hired by a contractor selected by Plant Operations, student interns developing interpretative signage, student art interns installing a piece of art as part of the system's tilted racking, and student interns who administer awardee implemented portions of the grant.

Budget Request: \$45,468, \$58,256, or \$95,943 (depending on selected alternative)
Indicate: both HSU Implemented & Awardee Implemented

Starting Date (mo/yr): March/2008 **Completion Date (mo/yr):** December/2008

Partners

Name Arne Jacobson **E-mail:** arne@humboldt.edu **Tel:** (707)826-3184
Indicate: Student / Faculty / Staff *Commitment to Project:* Confirmed / Anticipated

Name Tim Moxon **E-mail:** moxon@humboldt.edu **Tel:** (707) 826-5909
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PROPOSAL NARRATIVE

Project Description:

We propose a solar photovoltaic (PV) array installation project for the Old Music Building roof. The effort includes two parts, a technical and an artistic element that combine both HSU-implemented and student-implemented components. The student-implemented parts of the project will be administered and coordinated by the proposal authors under the auspices of the Renewable Energy Student Union (RESU), in cooperation with the HEIF committee. This project will be implemented in two parts, with three RFP's to select additional project partners:

1. RFP from Plant Operations for PV contractor to install a PV array that includes stipulations for inclusion of HSU student interns (HSU Implemented Project, target work completion date: early fall 2008)
- 2a. RFP from RESU for partners in student implemented work on an art installation that is incorporated in the structure and/or space of the array (Awardee Implemented Project, target work completion date: late fall 2008)
- 2b. RFP from RESU for partners in student implemented work on an interpretive educational display about the PV system and HEIF project (Awardee Implemented Project, target work completion date: late fall 2008)

Part 1 consists of the technical component of the project, which will be overseen by Plant Operations. Plant Operations will select a C-46 solar licensed contractor to carry out the installation and stipulate in the project's RFP that the contractor hire two to five student workers for the installation process. The contractor chosen for the job will train the student workers in the design and construction of grid-connected solar PV systems and oversee the installation work.

We have specified three sizes for the PV system (Table 1). The systems were designed entirely by the authors, using knowledge gained during ENGR 475, Renewable Energy Power Systems. The alternatives allow for appropriate scaling depending on available funds. All the systems are composed of Mitsubishi 165W¹ polycrystalline modules, one or more Sunny Boy inverters, and Unirac tilted racking sized to fit the array. The cost estimate for each alternative includes funds for an artistic display and interpretive installation.

¹ California Energy Commission rating: 146.9 W at Normal Operating Conditions

Table 1: Alternative PV Systems Summary

Alternative	1	2	3
# Modules	24	36	72
Array DC Power	3,500 W	5,300 W	10,500 W
Array Configuration	2 rows of 12	3 rows of 12	6 rows of 12
(#) Inverter Type	(1) SB4000US	(1) SB6000US	(2) SB6000US
HEIF Initial Cost (total requested)	\$45,468	\$58,256	\$95,943
HEIF Future Cost	\$11,380	\$15,279	\$28,754
Life Cycle Cost ²	\$29,237	\$32,284	\$42,214

Part 2 of the project will be overseen by RESU, with design and mounting help from Plant Operations. One feature of part 2 will be a solar-themed art installation (mural, metalwork, etc.), displayed on the back of the PV array. A team of student artists, likely from the Art department, will be chosen as project partners based on a design contest. The team will be provided a materials budget of \$3,000 for the work.

The project will also include an interpretative sign and/or display on the Old Music Building. Students with training in interpretive and educational displays, likely from the Natural Resources Planning and Interpretation (NRPI) department, will be chosen as project partners. The team will work with RESU to generate content and signs, with a \$3,000 materials budget. Real-time system performance reporting will be a goal of the installation.

HEIF / Plant Operations are invited to be partners during the administration of the Student-Implemented part of the project, providing feedback on the design contest and on the design and aesthetic rules for HSU campus.

Need Statement:

Photovoltaic (PV) systems are an effective way to harness the sun's abundant energy, creating electricity with little environmental impact. As electricity consumption increases worldwide and concern for climate change grows, the development of renewable electricity generation is imperative. Solar electric systems have been a practical way of obtaining this goal for years.

A PV system will address HEIF's mission to reduce the environmental impact of energy use at HSU and provide students with a hands-on opportunity in PV installation. Furthermore, *this project fulfills four of the five HEIF goals.*

² Life Cycle Cost includes the estimated present value of future avoided electricity and carbon dioxide emissions over 25 years (module warranty period), along with continuing maintenance and equipment replacement.

The central aim of our project is in line with HEIF's *first goal*. The proposed photovoltaic system is designed and will be implemented by HSU students. Students will continue their involvement throughout and beyond the installation process by working under the contractor, developing artwork, developing interpretative signage, and routinely monitoring and maintaining the system.

The project addresses both HEIF's *second and third goals* through its monitoring and maintenance plan. Maintenance will be overseen by Plant Operations, but students will be routinely involved. The photovoltaic system will be a useful working tool for students in energy engineering courses, including ENGR 305 (Appropriate Technology) and Engineering 475 (Renewable Energy Power Systems). For example, a lab assignment for ENGR 475 might involve making measurements about the system operation to evaluate its electrical and economic performance.

The photovoltaic system will be strategically located to maximize its visibility and to highlight the artistic display; the system will be clearly visible from the university center (main quad). The artists' goal will be to interpret the concept of sustainable energy and convey the spirit of HEIF. This design strength addresses HEIF's *fifth goal* – to publicize the system's accomplishments through visual media. Furthermore, interpretative signage located on the side of the old music building will enhance the educational impact of the system's strong presence.



Figure 1: View of Old Music Building roof from main quad

Outcome:

The PV project is expected to have *benefits to HSU students* on multiple levels:

- **HEIF Logistics Pilot Project:** The project, if selected, will be one of the first hardware installation projects funded by HEIF. A framework with the goals of HEIF in mind is set forth for choosing a contractor/educator, involving students in design and labor, documenting feedback from the project participants and project

implementation³. The project can serve as a template for the planning and implementation of future HEIF projects if it is successful.

- **Student Learning and Training:** Student workers will be trained in safe work practices, basic PV design, and PV installation. Art and NRPI Students will apply and grow their skills on the project.
- **Establish Student Ownership of HEIF:** The Old Music Building roof is in a prominent visual location on campus. The sight of students installing one of the first HEIF funded projects in addition to the ongoing presence of the array and its artwork will serve as reminders to the student body that HEIF is making a direct impact on energy use at HSU.

The PV project is expected to have *fiscal benefits to Humboldt State University* from avoided electricity costs offset by the solar electricity that is generated. The following table summarizes the expected lifetime (25 year) energy generation and cost offsets by the project alternatives.

Table 2: Expected Energy Generation Metrics for Project Alternatives

Project Alternative	3.5 kW (Alt. 1)	5.3 kW (Alt. 2)	10.6 kW (Alt. 3)
Est. 25 year Energy Generation (kWh)	120,200	180,300	360,500
Value of Energy Generated (Present \$)	\$20,700	\$31,000	\$62,000
Energy Unit Cost (Initial HEIF \$/kWh)	\$0.38	\$0.32	\$0.27

Finally, the PV project is expected to have *environmental benefits* related to avoided greenhouse gas (GHG) emissions from electric power generation. Manufacturing solar modules with current manufacturing and energy generation technology requires electricity and heat energy inputs that result in GHG emissions, commonly referred to as embedded energy and emissions. Carbon-neutral solar electricity generated by the modules will offset fossil-based electricity that would otherwise be purchased by HSU. For each project alternative, we estimate it will take about two years to offset the embedded energy and emissions. The following table summarizes the predicted cumulative GHG impact for each project alternative.⁴

Table 3: Estimated Greenhouse Gas Impact of Project Alternatives

GHG Parameter	Alt. 1	Alt. 2	Alt. 3
Embedded CO ₂ , Array (tonnes)	+3.7	+5.6	+11.2
Net CO ₂ impact (tonnes)	-71	-107	-214
CO ₂ Mitigation Unit Cost (Initial HEIF \$/ton)	\$637	\$544	\$448

³ See Appendix D for details

⁴ See Appendix G for details

Student Involvement:

We specify five methods for student involvement.

Table 4: Student Involvement in Project

Student Involvement Roles	# of Students	Expected Learning / Benefits
1. Design Proposal Team	5	Grant writing, solar PV design, project framework development (already realized)
2. Hands-On Installation	3-5	Deepened solar PV knowledge, safe work practices, electrical work
3. Art and Interpretive Installations	2-4	Hands-on design and installation of artistic/informative work
4. Long Term Maintenance, Data, & Monitoring	10-50	Students learn solar PV basics, use data in engineering, economics, etc. class work
5. Ownership/Awareness of Solar PV, HEIF	HSU at large	Increases the awareness and knowledge of solar PV with prominent location, interpretive signing, and art.

Hands-On Installation

Students will implement the design as intern employees of a licensed C-46 solar contractor, who will act as a teacher. Students will get training on solar energy system design and hands-on installation experience, deepening their understanding of solar electric power generation. We have already identified two potential contractors that are teachers at the College of the Redwoods, and are installers for Scurfield Solar and Trinidad Electric, respectively.

Art and Interpretive Installations

Student art and interpretive interns will be chosen through design contests as partners in the project. They will design and install their work with the help of RESU and other stakeholders.

Maintenance and Monitoring Opportunities

Plant Operations will oversee the maintenance of the system, but there should be routine student inspections and opportunities for access. Maintaining the system includes monitoring the system's output, cleaning the modules, and checking for weathering damage.

Project Interface with Curriculum

The project integrates a diverse blend of the University's curriculum. Future engineering classes might inspect the PV system as a useful way to gain close-up exposure to the technology. Additionally, students will be able to analyze data collected by the system's monitoring equipment. Economics students might be interested in using the system as a model for studying renewable energy generation. Interpretative design methods from the NRPI program will be used to create signage as an educational piece – a medium from which the whole student body can learn. Likewise, the art and design process will be harnessed to create an aesthetic, eye-catching work of art.

Support from HSU Faculty and Staff

To realize this project, support is needed from Dr. Arne Jacobson, Plant Operations, the Art program, and the NRPI program. Dr. Arne Jacobson's support is needed as an advisor during the grant administration by RESU (a role he already plays as RESU's faculty advisor). Plant Operations will play a large role in the installation of the PV system on the Old Music Building roof. This includes providing access to the roof and necessary circuits, choosing an appropriate C-46 licensed solar contractor/ teacher, mounting the art and interpretive projects, and overseeing maintenance of the system. Support from the Art and NRPI programs is needed to contact and coordinate with potential student interns.

Implementation:

Part 1: Installation of PV Array

The PV implementation will involve Plant Operations, the chosen contractor, and students who are hired as project implementation interns. The involvement and teaching of students will be paramount to the installation process. The authors of this proposal are interested in working with Plant Operations and the HEIF committee to develop an RFP for the project and select the most appropriate contractor.

The equipment specified in this proposal is meant as a guide, and the contractors who bid on the project should incorporate equal or better performing equipment in their proposals. Some preliminary work on such an RFP can be found in Appendix D. The contractor will choose students to work for him or her through a standard hiring process. The number of students is not to exceed what is deemed a safe number for such working conditions. The contractor will obtain the specified equipment and conduct the installation in a training workshop model. Afterward, feedback from the students, contractor, and Plant Operations will be gathered to inform future HEIF projects.

Many details about student involvement in the installation are preliminary. For instance, the pay received by student workers should be equitable to them and not break union or other institutional rules at HSU. We have spoken with Tim Moxon, and he supports the idea of stipulating in the RFP that the contractor must hire students at prevailing wages to work in the installation (est. \$26.50/hour for PV installation).

Part 2: Art and Interpretive Installations

After the installation of the PV system, the art mural will be created and secured to the system's racking. The interpretative signage will be created and mounted to the side of the Old Music Building. Student interns will be chosen for the art and interpretive projects with the help of our Art and NRPI faculty partners, through design contests or via RFP's administered by RESU. Dr. JoAnne Berke and Dr. Teresa Stanley of the art program have agreed to aid in advertising the solar-themed art opportunity. Dr. Carolyn Ward of the NRPI program has agreed to aid in advertising the interpretive signage opportunity. The HEIF committee is invited to provide direction during the design contest and/or RFP judging part of the process. Additionally, Plant Operations will be a required project partner during the design, specification, and installation phases of the installations. The student teams whose designs are winners and who are chosen as

project partners will be provided a \$500 stipend per team, and the members of RESU who administer the grant and aid in development of the installations will also be provided a \$500 stipend.

Partners:

Project partners include Plant Operations, the students writing this proposal, the contractor, the students hired by the contractor, the student(s) creating the interpretative signage, the student(s) creating the solar-themed art, Dr. Arne Jacobson, Dr. JoAnne Berke, Dr. Teresa Stanley and Dr. Carolyn Ward. Plant Operations will oversee the entire project – selecting the contractor, being accessible throughout installation, and overseeing the system maintenance. The students writing this proposal will contribute to Part 1 RFP development and some could be hired as installer interns by the chosen contractor. The student workers will participate in the installation under the supervision of the contractor. The contractor will be the installation leader, obtaining materials and ensuring compliance with building and safety codes. The contractor will also act as a teacher to the hired students. Art and Interpretation students will design and install their projects with the help of Dr. Joanne Berke (Art), Dr. Teresa Stanley (Art) and Dr. Carolyn Ward (NRPI). Dr. Arne Jacobson will advise on grant administration.

Timeline:

We have attached the project timeline/outcome table as Appendix A.

Sustainability:

It is common for solar modules to operate for 25-30 years or more; however, it is unsure how long the PV modules in this project will continue to perform well. Many of the first solar modules built in the 1950s are still in operation today. The proposed solar modules come with a 12-year warranty for 90% of the original power output and a 25-year warranty to guarantee 80% original efficiency. The inverter is the only component in need of scheduled replacement, approximately every 15 years.

There are essentially two durability issues with solar modules: cracked glass and loose wire connections. Glass is fragile and may break or crack in large hailstorms. The glass can sometimes be removed and replaced in the event of damage. The wires can last indefinitely if shaded from sunlight, but the connections may separate in strong wind. Soldering the diodes with stained glass tape or other solder that has 2% silver will quickly fix the problem. The rack is made of aluminum alloy and should outlast the solar modules. Minor maintenance may be required to retain waterproofing at the points of penetration where the rack is mounted to the roof. The areas around the feet of the rack can be resealed with UV/outdoor grade polyurethane or silicon based caulk.

The PV modules may last longer than the building they are mounted on, and can be moved if necessary with costs approximately equal to the labor cost for Part 1 of the project. However, someday they will need to be disposed of. If the modules are still

functional but under-performing, they could be sold on the secondary market. According to the Department of Energy, the possibility of recycling solar panels is growing rapidly. By the time these panels need to be disposed, recycling facilities should be common. Most modules made with current technology are not considered hazardous waste because they are insoluble and encased in glass.⁵ Thus, they can be disposed of in a landfill as a last resort.

Assessment:

Our proposed design will facilitate efforts to monitor the performance of the system over time. The system will include a monitoring system (SMA Sunny Web Box monitoring equipment) that will allow students, staff, and others to access information about system performance from any networked computer through SMA's Sunny Portal software (www.SunnyPortal.com). The software supplies the historical and current energy output of the user's system as well as estimates of the CO₂ reductions and revenue obtained by the system. These estimates are good quantitative data to assess HSU's energy and GHG reduction on an ongoing basis, and would provide useful learning tools.

The software can, therefore, be used to test / verify our estimates of the reductions in the environmental impact of energy use at HSU associated with the use of the system (see Tables 2 and 3, above for our estimates).

There are many approaches to *assessing the quality of students' learning experience*. The quality of the art and interpretive installations will serve to assess the learning and experience gained by students who work on them; however, assessing those working under the contractor may be challenging. We find it most appropriate to assess these students' project experience with post-work questionnaires and by requiring them to give a presentation about their experiences installing the PV system to the HSU community. The presentation will give them the opportunity to pass their knowledge to others.

⁵ U.S. Department of Energy: Energy Efficiency and Renewable Energy, Solar Energy Technologies Program, Updated: 1/05/06, accessed: 2/18/08, http://www1.eere.energy.gov/solar/panel_disposal.html

BUDGET BREAKDOWN

We have constructed a budget for each alternative and have attached the budgets in Appendix B.

SUPPORT MATERIAL

Appendix A presents our timeline/outcome table.

Appendix B shows budgets for all three PV alternatives.

Appendix C discusses reasons for choosing the old music building roof.

Appendix D addresses our concerns the RFP in identifying an appropriate PV contractor.

Appendix E illustrates the PV layout on the old music building roof.

Appendix F illustrates the schematic diagram of how system components are connected.

Appendix G is a table of engineering and economic assumptions, with rationale.

Appendix H contains draft RFPs for Art and Interpretive design contest.

Additionally, equipment specification and data sheets are attach

Agreement to Grant Terms

(Adapted from the Humboldt Area Foundation RFP)

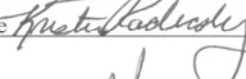
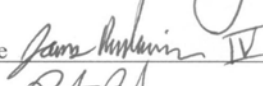


By signing this application form, the applicant enters into an agreement with HSU and HEIF that would take effect should the grant be awarded. The applicant attests that:

1. **Accuracy:** The information contained in this application and in any attachments thereto is true and correct to the best of your knowledge.
2. **Use of Funds:** Understands and agrees that, where applicable, all grant funds will be applied to the project in accordance with the description and budget provided in this application as set forth in the award letter. Any significant change in the use of these funds will require prior approval by HEIF. Requests for changes must be submitted in writing. If the revisions are not accepted or funds are not expended for the purpose and the manner agreed to by the grantee, HEIF reserves the right to cancel the grant and any further payments and said funds must be returned to the Foundation. All funds must be spent in accordance with State financial rules and regulations.
3. **Expiration:** Understands and agrees that, where applicable, grants must be paid within one year, unless otherwise specified. Any requests for extensions of time must be submitted in writing prior to the expiration date. Grants not paid or granted an extension can be cancelled without notice after the expiration date.
4. **Grant Report(s):** Understands and agrees that, where applicable, report(s) will be submitted to HEIF by the phase or date specified in the grant award letter. Report guidelines will be forthcoming.

To indicate acceptance of the foregoing terms and conditions, please sign below. Please retain a copy of this agreement for your files.

Applicants:

Primary Contact

Print Name	KRISTEN RADECKSKY	Signature		Date	3/3/08
Print Name	James Robinson IV	Signature		Date	3/3/08
Print Name	PETER JOHNSTONE	Signature		Date	3/3/08
Print Name	Nathan Chase	Signature		Date	03/02/08

Appendix A: Timeline/Outcome Table

Project Title: Old Music Building Photovoltaic Project

Activity	Expected number of weeks to complete	Expected outcome	Responsible party	Approximate completion Date
Develop RFP	4	Finalize a design and course of action	Students writing proposal and Plant Operations	April 11 th
Assess contractors under the Bid-Build process	2	Contractor selected	Plant Ops	April 25 th
Select contractor	1	Suitable contractor selected	Plant Ops	May 2 nd
Contractor hire student workers	3	Two or three students hired based on skill and interest in project	Contractor	May 23 rd
Order materials	5	All materials ordered and delivered	Contractor	July 1 st
Move all materials on-site	1	PV materials and rack on old music building roof	Contractor/employee	August 15 th
Advertise for mural and interpretative sign opportunities	1	Art and NRPI students apply	Students writing proposal and Art/NRPI Depts.	August 29 th
Construction	2	System Completion	Contractor/employees	August 29 th
Select art/interp. design contest winners	3	Commencement of art/interp. projects	RESU	September 19 th
Art and interp. student interns proceed in projects	11	Art and interp. complete installation	Selected art/interp. student interns	December 5 th

Appendix B: Design Alternatives

Project Title Old Music Photovoltaic Project

HSU / Awardee Implemented Project Budget

Alternative 1: 24 modules, 3.5 kW

Category (list major items)	Units	Cost per unit	Total cost	Amount requested from HEIF	Matching contribution to be provided by applicant or other source	Who/what is the other source?	Is the matching contribution confirmed or potential?
Durable equipment							
Mitsubishi MF165EB3	24	\$834.55	\$20,029	\$20,029			
SMA SB4000US	1	\$3,750.00	\$3,750	\$3,750			
Rack/Mounting Cost	1	\$3,400.00	\$3,400	\$3,400			
Wire / Misc. Equip Cost	1	\$1,000.00	\$1,000	\$1,000			
Sunny Portal (Web Box)	1	\$900.00	\$900	\$900			
Consumable Supplies							
Misc. Consumables	1	\$200.00	\$200	\$200			
Wages for Student Participants							
Student Worker Labor (hours)	300	\$26.50	\$7,950	\$7,950			
Stipends for Art, Interp, Admin	1	\$1,500.00	\$1,500	\$1,500			
Other							
Primary Labor (contractor hours)	80	\$50.00	\$4,000	\$4,000			
Art Materials and Installation	1	\$3,000.00	\$3,000	\$3,000			
Interpretive Materials, Install	1	\$3,000.00	\$3,000	\$3,000			
Rebates / Incentives					\$6,099	Cal. Solar Init.	Potential
Taxes and Shipping Charges	10.00%	of material \$	\$2,838				
Indirect Costs	0.00%	of outlay \$	\$0				
TOTAL:			\$51,567	\$45,468	\$6,099		

Project Title Old Music Photovoltaic Project

HSU / Awardee Implemented Project Budget

Alternative 2: 36 modules, 5.3 kW

Category (list major items)	Units	Cost per unit	Total cost	Amount requested from HEIF	Matching contribution to be provided by applicant or other source	Who/what is the other source?	Is the matching contribution confirmed or potential?
Durable equipment							
Mitsubishi MF165EB3	36	\$834.55	\$30,044	\$30,044			
SMA SB6000US	1	\$5,277.00	\$5,277	\$5,277			
Rack/Mounting Cost	1	\$5,100.00	\$5,100	\$5,100			
Wire / Misc. Equip Cost	1	\$1,100.00	\$1,100	\$1,100			
Sunny Portal (Web Box)	1	\$900.00	\$900	\$900			
Consumable Supplies							
Misc. Consumables	1	\$200.00	\$200	\$200			
Wages for Student Participants							
Student Worker Labor (hours)	325	\$26.50	\$8,613	\$8,613			
Stipends for Art, Interp, Admin	1	\$1,500.00	\$1,500	\$1,500			
Other							
Primary Labor (contractor hours)	90	\$50.00	\$4,500	\$4,500			
Art Materials and Installation	1	\$3,000.00	\$3,000	\$3,000			
Interpretive Materials, Install	1	\$3,000.00	\$3,000	\$3,000			
Rebates / Incentives					\$9,149	Cal. Solar Init.	Potential
Taxes and Shipping Charges	10.00%	of material \$	\$4,172				
Indirect Costs	0.00%	of outlay \$	\$0				
TOTAL:			\$67,405	\$58,256	\$9,149		

Project Title Old Music Photovoltaic Project

HSU / Awardee Implemented Project Budget

Alternative 3: 72 modules, 10.6 kW

Category (list major items)	Units	Cost per unit	Total cost	Amount requested from HEIF	Matching contribution to be provided by applicant or other source	Who/what is source?	Is the matching contribution confirmed or potential?
Durable equipment							
Mitsubishi MF165EB3	72	\$834.55	\$60,088	\$60,088			
SMA SB6000US	2	\$5,277.00	\$10,554	\$10,554			
Rack/Mounting Cost	1	\$10,200.00	\$10,200	\$10,200			
Wire / Misc. Equip Cost	1	\$2,200.00	\$2,200	\$2,200			
Sunny Portal (Web Box)	1	\$900.00	\$900	\$900			
Consumable Supplies							
Misc. Consumables	1	\$200.00	\$200	\$200			
Wages for Student Participants							
Student Worker Labor (hours)	350	\$26.50	\$9,275	\$9,275			
Stipends for Art, Interp, Admin	1	\$1,500.00	\$1,500	\$1,500			
Other							
Primary Labor (contractor hours)	100	\$50.00	\$5,000	\$5,000			
Art Materials and Installation	1	\$3,000.00	\$3,000	\$3,000			
Interpretive Materials, Install	1	\$3,000.00	\$3,000	\$3,000			
Rebates / Incentives					\$18,298	Cal. Solar Init.	Potential
Taxes and Shipping Charges	10.00%	of material \$	\$8,324				
Indirect Costs	0.00%	of outlay \$	\$0				
			TOTAL:	\$114,241	\$95,943	\$18,298	

Appendix C: Why the Old Music Building?

1. **Flat Roof** – The flat roof allows for safe installation for student workers
2. **Visibility** – Central location on campus. The rooftop is visible from the University Center Quad, and the area between the Art/Music buildings and Van Duzer Theater. While students are working on the project, they will be in view of the student body at large.
3. **Solar Window** – The solar window is estimated to be one of the best on campus of those buildings that meet the first two criteria (flat roof, visibility). Having a good solar window means that the site has superior solar exposure; it encounters little shading from buildings and trees.

The music building is marked as “temporary” on the Master Plan, but assurances have been provided by Plant Operations and Facilities Management personnel that it is not slated for demolition for at least a decade. If it were demolished before the functional life of the PV system is over, the system could be moved to another site on campus (ex: BSS, Library Roof).

Shading Analysis

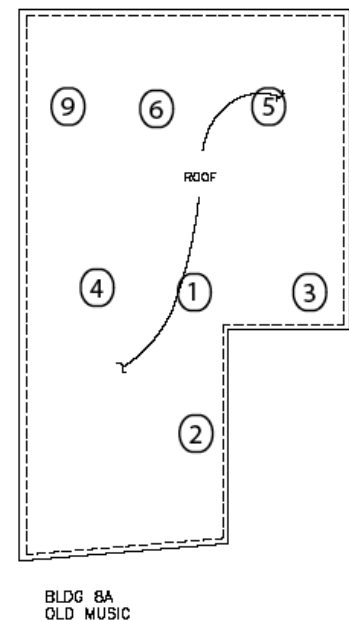
A “Solar Pathfinder” instrument was used to measure the shading of the Old Music building roof at nine locations, noted in Figure C1.

The table below shows the estimated percentage of available solar energy (based on shading) for each measurement location.

Table C1: Percentages of solar energy available at each tested site for each month of the year.

Month	Site 1	site 2	site 3	site 4	site 5	site 6	site 9
Jan	89.3	85.6	84.6	94.4	87.2	83.2	78.3
Feb	95.8	91.1	93	97.7	84.1	79	72.1
Mar	94.6	96.9	91.4	93.9	91.9	88.4	68.4
Apr	92.8	98.8	92	90.6	97.4	100	99.6
May	94.2	96.2	95.1	88.4	96.8	99.7	99.6
Jun	99.6	94.8	97.6	90	94.6	98.6	98.5
Jul	94.4	95.8	97.6	88.5	96.6	99.6	99.5
Aug	94.1	97.4	92.6	93.2	98	99.9	99.6
Sep	93.2	99.3	91	93.5	97.4	90.4	81
Oct	94.8	98	93.3	97.2	84.4	79.2	73.6
Nov	94.4	86.1	89.2	93.6	85.4	80.2	75.7
Dec	81.5	85.1	82	93.8	86.8	79.7	78.3

Figure C1: Shading Measurement Locations



Appendix D: Framework for Project Implementation

Draft Rules for Contractors Regarding Student Involvement

The following rules regarding student involvement are proposed for contractors who wish to bid on the **Old Music Building PV Project**, referred to hereafter as “the project”. The completion by the contractor of tasks related to student involvement should be included in the bid package.

The contractor shall abide by CSU workplace rules (no discrimination, safe workplace, etc.)

Student Involvement with Implementation:

Installation Interns:

The contractor will be required to hire 2-5 student intern workers, and should specify how many interns they will hire in their bid package.

- *Intern Training / Project Involvement:* The contractor shall provide training on relevant workplace safety (roof, electrical, etc.) to the interns. Before the construction process begins, the contractor shall provide no less than two hours of instruction to the interns on the basic design principles for the project. According to the skill level of each individual intern, the contractor shall assign installation tasks to her or him during project implementation. Each student intern should perform at least 15 hours of supervised work during implementation.
- *Choosing Interns:* The student interns must be currently enrolled HSU students throughout the project. The contractor, with the help of the HEIF committee, should advertise the internships for at least three weeks via fliers on the HSU campus and/or other methods prior to hiring. The applications shall be sent to the HEIF committee for initial screening. Those that pass HEIF committee criteria will be passed on to the contractor. If they wish, the contractor may set up interviews with potential interns. The contractor should notify the committee of their intern choices within one month of receiving the applications.
- *Compensation:* The interns will be paid by the contractor at a rate that is compatible with HSU’s prevailing wage policies.

Sample Questionnaire, **DRAFT**

HEIF Intern: _____

Project Name: _____

Date: _____

To the Intern: Your responses to this questionnaire will be used to evaluate the teaching effectiveness of the contractor(s) you worked with. Your responses will be kept anonymous.

Assign scores to the contractor(s) for the following evaluation criteria by placing an “x” in the appropriate boxes on the right:

Statement to evaluate (1 = low score, 5 = high score)	1	2	3	4	5
No-Discrimination, Diversity-Friendly Workplace					
Safe Working Conditions, Appropriate Training					
Quality of Knowledge and Experience You Gained					
Approachability of Contractor with Questions					
Overall Quality of the Implementation Intern Experience					

Based on my experience, HEIF and HSU should consider this contractor _____ favorably for future service learning contracts.

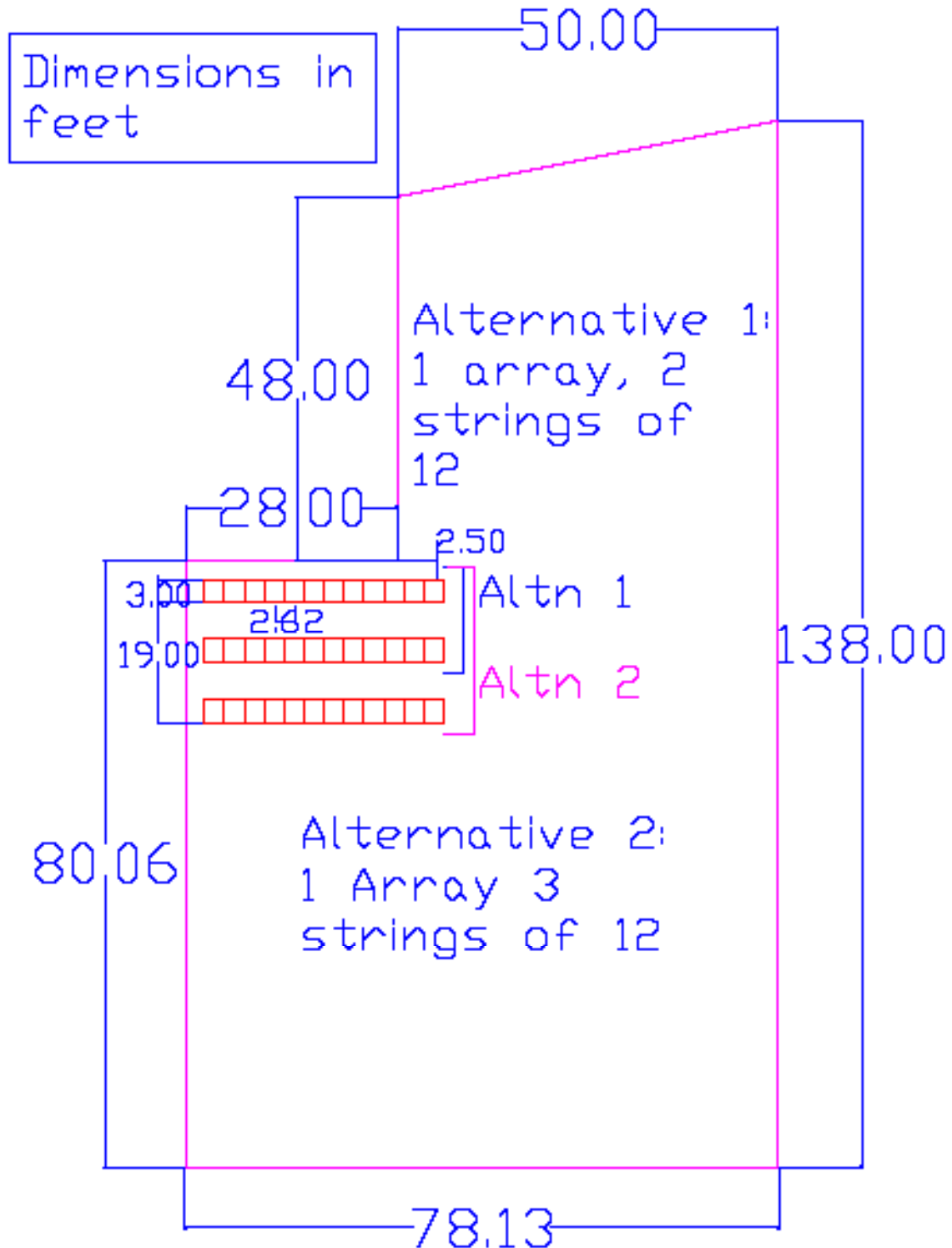
Fill in the Blank (CIRCLE ONE):

MORE NEUTRALLY LESS

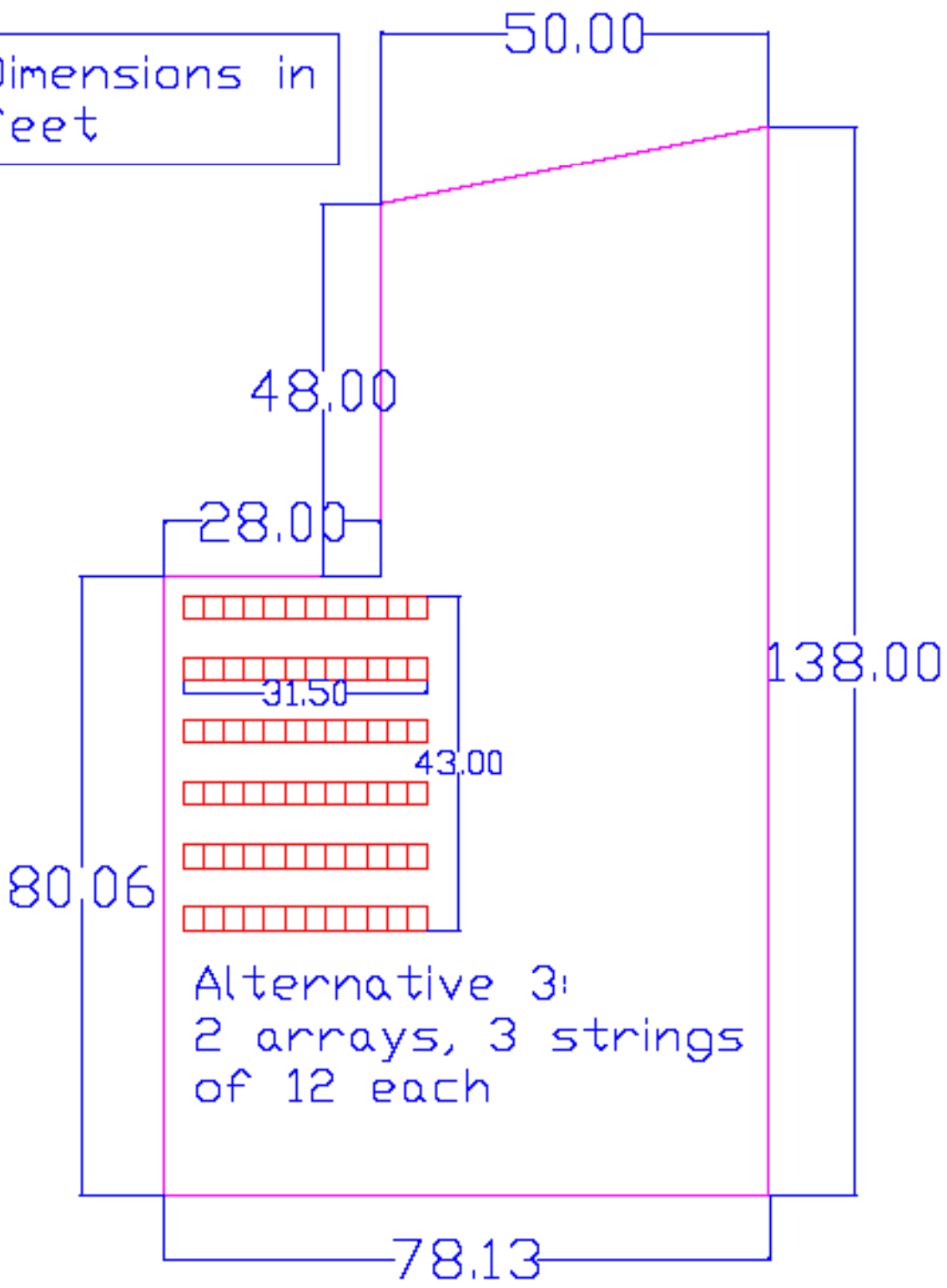
Additional Comments are Welcome and Encouraged Below:

Appendix E: Roof Layout Models

The first graphic below illustrates how the 3.5 and 5.3 kW PV systems (alternatives 1 and 2) will lay out on the Old Music Building roof. The second graphic illustrates the 10.5 kW system (alternative 3).

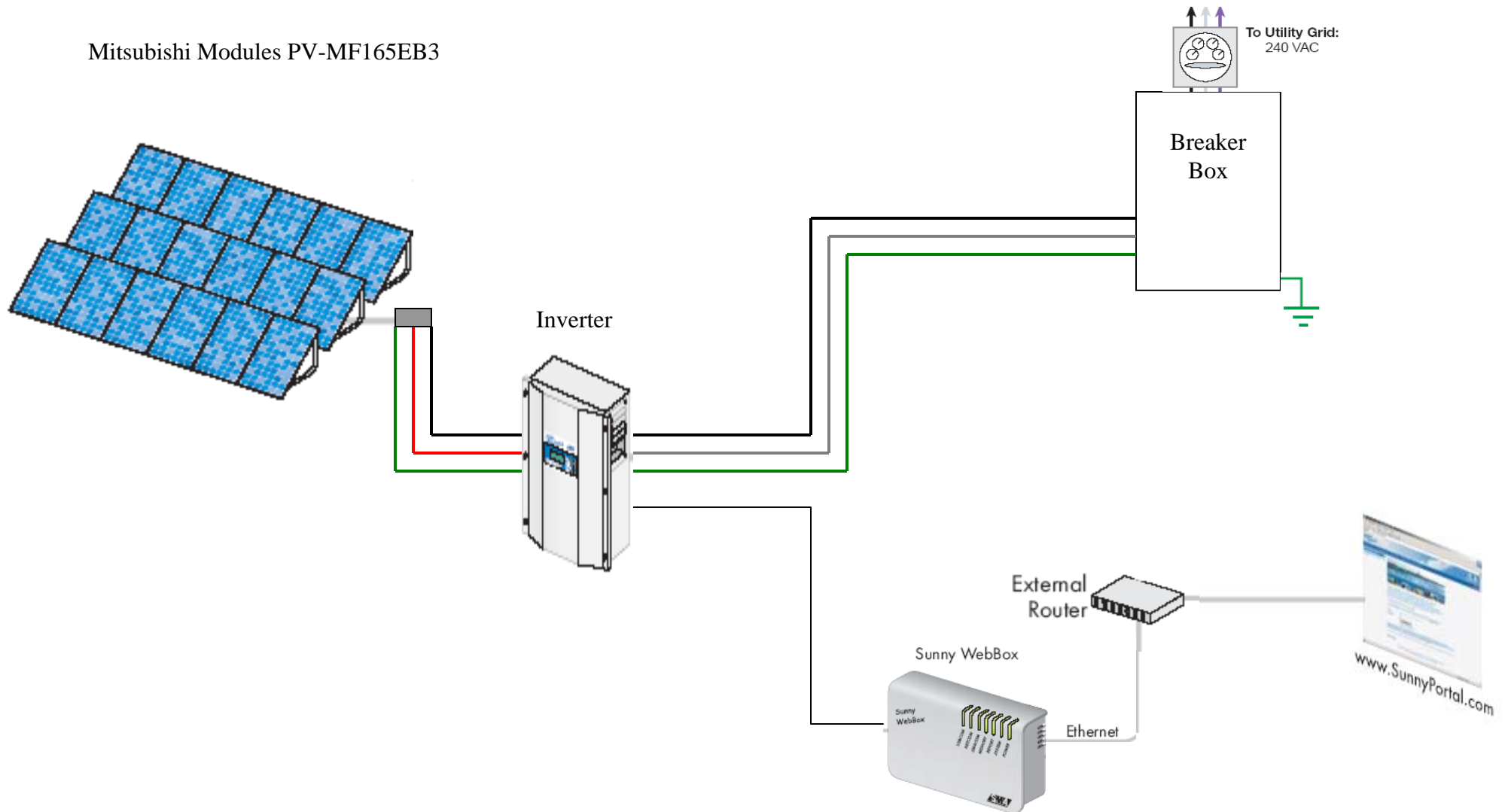


Dimensions in feet



Appendix F: General System Schematic

Mitsubishi Modules PV-MF165EB3



Appendix G: Assumptions

Economic and Energy Values:

The authors of this proposal assumed that the electricity is worth \$0.12/kWh, with an escalation in value of 2% over the expected 2% yearly inflation rate. We further assumed that the alternative investment rate is 3%, leading to a 1% net discount rate. No provision was made for the added time-of-use value of photovoltaic electricity; instead a flat rate was applied. The assumed project duration is equal to the warranty for the PV modules, 25 years.

Greenhouse Gas:

GHG mitigation is considered only in terms of CO₂. Other greenhouse gases, such as N₂O and CH₄, are not considered in the analysis. It is assumed that the manufacture of each solar module resulted in 0.155 tonnes of CO₂ emissions, which is based a PV life cycle analysis in an article by A. Stoppato (Energy vol. 33, Feb. 2008). The offset grid electricity is assigned a CO₂ value of 1.25 lb/kWh, based on the Arizona Public Service (APS) 2003 grid mix (HSU electricity provider).⁶ More recent data from APS is unavailable.

Engineering

Standard solar resource estimates for a horizontal plane for Arcata, CA from the National Solar Radiation Database are assumed to be valid. The shading of the array is based on the shading analysis that was performed, as reported in Appendix C. To account for variation in shading between locations on the roof, the average percentage of available solar energy for all locations was calculated for each month. The “K-T” method, from *Solar Engineering of Thermal Processes* (by Duffie and Beckman, 1981) was used to elevate and rotate the data from a horizontal surface to the tilt of the array (35 degrees) and azimuth (10 degrees off south). The California Energy Commission (CEC) ratings for PV performance and inverter efficiency were used to estimate the available energy from the specified array. It is assumed that that module performance will degrade at a rate of 0.5%/year, based on an approximation of the module warranty for long-term performance (80% after 25 years).

Racking Cost Assumptions

The Unirac price list (as of 2/2008) was used to estimate the cost of materials for solar array tilt-mounting on the Old Music Building roof. No information was gathered about the truss pattern or materials for the roof, which may influence future decisions on racking system specification. Our estimate is meant as a guide and starting point for design.

⁶ from PinnacleWest Capital Corporation reporting, online (3/3/08)
<http://www.pinnaclewest.com/files/EHS/2002/APSHistoric.pdf>

Table G1: Unirac racking equipment required for each 12-module row

Item	Quantity	Cost
384" Standard Rail Kit (appropriate for 12 Mitsubishi 165's)	1	\$576
Bottom Mount Clips (4 per module)	48	\$ 65
Low Profile Legs, 30"	14	\$553
7" Galvanized Standoffs w/ Flange-top	14	\$266
Galvanized Flashings w/ rubber collar	14	\$100
Misc. Ground Lugs, Clips, Ties, etc.	--	~\$150
	TOTAL	~\$1700

Appendix H: Draft RFPs for RESU Administered Parts

Draft RFP for Interpretative Signage

The following information identifies RFP criteria for the interpretative signage opportunity for HSU students, likely from the Natural Resources Planning and Interpretation (NRPI) program.

Budget for materials: \$2,500

Stipend for work: \$500

Signage requirements:

- Weatherproof
- Approximately 5' x 5' (flexible)
- Mounted safely to the side of the Old Music Building
- Aesthetically pleasing
- Easy to read
- Eye-catching
- Technically informative
- Accurate

Applicant requirements:

- Enrolled in HSU during fall 2008
- Individual or group up to 3 students

Selection/Implementation process:

RESU and Dr. Carolyn Ward will construct a flier to advertise the opportunity, which will include the information presented above. The flier will also contain basic information about the specific PV system. The advertising will begin early in fall 2008. RESU will hold an informational meeting to explain the technical aspects of the PV system to potential interpretative applicants. (Or interpretive applicants can learn about the system through a potential presentation given by PV student interns after completing the installation.) Students will submit their proposals to RESU for review. RESU will invite HEIF members to aid in the review process. The proposals will include the teams' qualifications, visual designs, and material designs. Ideally, an NRPI team will be selected by mid September and the interpretative sign will be completed by early December. Plant Operations will be involved with the interpretive signage mounting.

Draft RFP for Art Project

Renewable Energy Student Union
On behalf of
Humboldt Energy Independence Program
Request for Proposals
Deadline: September 19, 2008



Background

The campus club Renewable Energy Student Union (RESU) is designing and installing a solar PV array on the Old Music Building roof, directly west of Fulkerson Hall. Funding comes from the Humboldt Energy independence Fund (HEIF). The mission of HEIF is independence from external energy and broad student involvement congruent with university policies. The PV panels will be facing south to collect the most sun. The orientation of the building has the panels facing away from the main HSU quad. From the common area of the quad, all that will be seen is the backside of the racks and mounting.

The request is for an artist or small group of artists, composed of HSU enrolled students, who will also be enrolled next semester that can design and build an aesthetically pleasing, ecological, solar-themed art installation.

Eligibility

The team must be composed of HSU students enrolled this semester and next fall 2008 semester who will see the project through to completion. Faculty or staff may only be involved in assisting students.

Available Funds

A stipend is paid to the winning team of \$500. The total budget, including stipend allocations may not exceed \$3,500. A budget must be presented to the HEIF committee prior to the materials purchase or the start of construction.

Specifications:

(To be completed later when array size is determined)

Action Plan

Request for proposal (RFP) posted	August 29, 2008
Submission of Proposals to RESU due	September 19, 2008
Awardee designation	September 26, 2008
Completed project by	December 5, 2008

For more information

Contact: www.humboldt.edu/~heif

or James Robinson: jr71@humboldt.edu 707.407.745

Proposal Checklist: Submit an electronic and hard copy

- Submit an electronic copy to jr71@humboldt.edu
- Submit a hard copy to (Arne Jacobson's office)

containing:

Cover page

Scaled-down example of the proposed project

Proposal Narrative

Budget Breakout (use spreadsheet template provided on website)

Timeline / Outcome Table (use spreadsheet template provided on website)

Support Material with index

Signed Agreement to Grant Terms

Scaled Example of proposed project

In as much detail as possible sketch the art project design.

Proposal Narrative

In the proposal narrative state clearly:

1. a written description of the project
2. how you are going to meet the goals of HEIF
3. how students are to be involved, including quantity
4. how faculty/staff is involved
5. long-range sustainability, durability and maintenance of the design
6. what the team hopes to accomplish from this project

Project Title Old Music Photovoltaic Project

HSU / Awardee Implemented Project Budget

Alternative 2: 36 modules, 5.3 kW

Category (list major items)	Units	Cost per unit	Total cost	Amount requested from HEIF	Matching contribution to be provided by applicant or other source	Who/what is the other source?	Is the matching contribution confirmed or potential?
Durable equipment							
Mitsubishi MF165EB3	72	\$834.55	\$60,088	\$60,088			
SMA SB6000US	2	\$5,277.00	\$10,554	\$10,554			
Rack/Mounting Cost	1	\$10,200.00	\$10,200	\$10,200			
Wire / Misc. Equip Cost	1	\$2,200.00	\$2,200	\$2,200			
Sunny Portal (Web Box)	1	\$900.00	\$900	\$900			
Consumable Supplies							
Misc. Consumables	1	\$200.00	\$200	\$200			
Wages for Student Participants							
Student Worker Labor (hours)	350	\$26.50	\$9,275	\$9,275			
Stipends for Art, Interp, Admin	1	\$1,500.00	\$1,500	\$1,500			
Other							
Primary Labor (contractor hou	100	\$50.00	\$5,000	\$5,000			
Art Materials and Installation	1	\$3,000.00	\$3,000	\$3,000			
Interpretive Materials, Install	1	\$3,000.00	\$3,000	\$3,000			
Rebates / Incentives					\$18,298	Cal. Solar Init.	Potential
Taxes and Shipping Charges	10.00%	of material \$	\$8,324				
Indirect Costs	0.00%	of outlay \$	\$0				
TOTAL:			\$114,241	\$95,943	\$18,298		