UNPEPP At Ten Years

THE UNIVERSITY-NATIONAL PARK ENERGY PARTNERSHIP PROGRAM

1997- 2007: A Decade of Success

The University-National Park Energy Partnership Program (UNPEPP) is a nationwide program working to partner university students and faculty with National Park energy management personnel. Through these partnerships, parks gain assistance in addressing their energy concerns, while students obtain real-world problem-solving experience in the energy field. For more information on information found in this report, please contact:

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PURPOSE OF THIS REPORT

The National Park Service (NPS) has 388 park units, all of which have facilities that use energy, make demands on resources, and in many ways impact the quality of the environment. Given that a large part of the NPS mission is environmental stewardship and that such a strong relationship between energy use and environmental quality exists, it makes sense for the NPS to look closely at its energy management practices. The NPS should be a beacon for other agencies in demonstrating how to implement sustainable energy practices. Yet for any organization of this size—with over 20,000 employees—coordinating that scale of energy management is a daunting task.

The purpose of this report is to highlight the last 10 years of the University-National Park Energy Partnership Program (UNPEPP). This program was created through a partnership between the NPS Green Energy Parks Program and the US Department of Energy (DOE) Federal Energy Management Program to help parks meet their sustainable energy objectives. UNPEPP works by partnering universities with National Parks in order to achieve for main goals: (1) conduct energy assessments of park facilities; (2) train NPS personnel on sustainable energy practices; (3) provide hands-on learning experiences for university students, and (4) design and implement energy management plans and renewable energy systems at National Parks. Park visitors also benefit by witnessing and learning from the NPS commitment to sustainable energy use.

Below, we explore UNPEPP's program goals and objectives, highlight notable successes over the past ten the years (1997-2007), describe what some of UNPEPP's past student participants are doing now, and point the way toward even more effective UNPEPP involvement in sustainable energy management and education at the National Parks in the years ahead.

ACKNOWLEDGEMENTS

We would like to thank the many talented and resourceful people who have contributed to UNPEPP's success in the past decade. We acknowledge the students and faculty at universities nationwide who have shared their time, energy and expertise with the NPS, and the park energy managers and personnel who have worked to fulfill the NPS mission of environmental stewardship and public education through UNPEPP partnerships. We also thank the key government officials who have supported UNPEPP since 1997. In particular, we express our special thanks to: Terry Brennan (Green Energy Parks Program Coordinator), Carl Wang, Dale Wilking, and John Karish of the NPS; and Anne Sprunt-Crawley of the US Department of Energy.

This report would not have been possible without the assistance of a number of important people. Ms. Erin Green (Green and McGrath, LLC) and Mr. Joseph Torrillo (RIT) were instrumental in compiling information for the report and designing the overall report layout. Dr. David Narum (Narum and Associates), a long-time member of the UNPEPP management team, both wrote and reviewed portions of the report. Lastly, Ms. Debbie Steene (RIT) assisted in administrative tasks related to report preparation and publication.

James Winebrake, PhD., UNPEPP Director

A MESSAGE FROM...

GREEN ENERGY PARKS PROGRAM COORDINATOR, TERRY BRENNAN

With ever-tightening budgets and increasing environmental concerns, the need for sustainable energy management at our National Parks has never been more urgent than it is today. Even so, moving towards a sustainable energy future for the parks is not easy. Our park energy managers must contend with day-to-day issues, and often have little time or resources to devote to sifting through energy consumption data, or to develop plans for implementing energy efficiency or renewable energy systems.

A previously underutilized resource that park personnel have been using to further their energy management efforts—by way of the University National Park Partnership Program (UNPEPP)—is universities. Many universities have energy, environmental, engineering or architecture programs with large numbers of students interested in getting real-world experience in the energy field. Fortunately, many of these universities are located near National Parks.

UNPEPP has given National Parks an opportunity to access the many resources available in our nation's universities. By working in these partnerships, the National Park Service has cut energy costs, implemented renewable energy systems, and educated the visiting public about energy use at our parks, while students have been offered a significant opportunity to learn more about energy systems in unique and interesting environments. This is a win-win program.

UNPEPP DIRECTOR, JAMES J. WINEBRAKE PHD.

In 1997, we established an UNPEPP pilot program between James Madison University and Shenandoah National Park. Since then UNPEPP has provided mutually beneficial solutions and memorable experiences for all involved parties. UNPEPP is unique in its ability to serve both the energy needs of the parks and the educational needs of the students. We have been particularly impressed with the quality of our partnerships, and with how much students and park personnel have gained and grown over the course of their partnership experience. UNPEPP's "win-win" approach achieves multiple objectives:

- providing expert advice and training opportunities for National Park personnel on sustainable energy practices,
- providing real-world educational experiences in the National Parks for university students interested in learning more about energy efficiency and renewable energy,
- creating more sustainable National Parks, whether through improved efficiency or through the implementation of renewable energy projects, and
- creating opportunities for park visitors to learn about energy management and to witness first-hand the National Park Service's commitment to the environment.

In this report, we highlight successful UNPEPP projects from the past few years, and present the experiences of past student and faculty participants to gain an understanding of UNPEPP's impact in their lives. We hope you enjoy reading about UNPEPP!

I. UNPEPP: AN EFFECTIVE USE OF NPS FUNDS

Since 1997, the University-National Park Energy Partnership Program (UNPEPP) has leveraged close to $1.2 million for energy projects in the National Parks, spreading the wealth over all National Park Regions, at over 30 individual parks, through the development of nearly 70 projects. All told, hundreds of students and NPS personnel have taken part in the program.

Perhaps one of the least-recognized benefits of the UNPEPP program is the remarkable efficiency with which it spends NPS budget dollars. The average UNPEPP project costs $15,000—a fraction of the cost of a professional consulting team, yet the projects yield professional-quality results for the parks and help train the next generation of energy professionals.

UNPEPP applies budget dollars to such activities as:

- Training and education for park personnel
- Energy-management database and software development
- Energy auditing equipment and energy audits of park facilities
- Design and development of educational materials (i.e. signs, brochures) for NPS visitors
- Design and installation of renewable energy systems
- Exploration and implementation of alternative fuel options
- Utility-bill analyses
- Paid student work experience and small stipends for faculty advisors
- Use of university facilities (e.g., equipment, computers)
- Capitalizing on university expertise and cutting-edge technology

UNPEPP project teams produce detailed reports which are submitted to the Green Energy Parks Program Coordinator at NPS headquarters in Washington, D.C. Some partnership reports number in the hundreds of pages, offering in-depth engineering and economic analyses. Many of these reports may be obtained by request (see UNPEPP contact information).

"UNPEPP has given our National Parks an opportunity to access the many resources available in our nation's universities. By working in these partnerships, the National Park Service has cut energy costs, implemented renewable energy systems, and educated the visiting public about energy use at our parks. We have also offered a significant opportunity for students to learn more about energy systems in unique and interesting environments. This is a win-win program."

- Terry Brennan, NPS Green Energy Parks Program Coordinator

II. UNPEPP MILESTONES

Since 1997 UNPEPP has developed nearly 50 partnerships between universities and National Parks nationwide. Within these partnerships, nearly 70 separate projects have taken place, ranging from energy audits to solar power implementation to public education. In the past decade, UNPEPP partners have accomplished the following:

- *26 Energy Audits*, providing detailed recommendations for energy conservation and considerable cost savings to the NPS and taxpayers
- *19 Solar Power* projects, designing, acquiring, and/or installing solar power systems so that park facilities may produce their own energy with zero harmful emissions
- *7 Alternative Fuel* projects, to facilitate the use of clean renewable fuels in NPS vehicles
- *3 Wind Power* projects, designing or installing wind turbine systems so that parks can harness ample wind energy in the parks to generate clean power
- *Various Educational* projects have developed interpretive materials such as brochures and signage to educate the millions of NPS visitors of the benefits of alternative energy and energy efficiency.
- *Additional projects* have included hydropower, tidal power, software development, and alternative fuel vehicle design and production.

Several notable outcomes have resulted from these projects, from energy savings to environmental benefits:

- *Energy Conservation:* energy savings from energy audits and recommended energy conservation measures (ECMs) have ranged from 500 kilowatt-hours (kWh) to 212,000 kWh *per project,* with **average annual savings of 52,000 kWh** per project—enough to power an American home for nearly five years. For projects that quantified energy savings, identified ECMs would save an average of about 40% of the analyzed facilities' energy use.
- *Cost Savings:* the highlighted energy savings above led to significant cost savings for the parks and for the taxpayers who support them. The average cost savings per relevant project was **$6,000**—more than one-third of the facilities' energy expenses.
- *Environmental Benefit:* by avoiding the production of energy from polluting conventional energy sources such as diesel generators and coal power plants, UNPEPP projects have prevented the emissions of harmful pollutants into pristine parks and the nation's air. Of the projects which quantified emissions reductions the average annual reductions were: 174,000 lbs (87 tons) of carbon dioxide, 93,000 lbs (47 tons) sulfur oxides, and 1,600 lbs of nitrogen oxides.

III. UNPEPP NOTABLES—SUCCESS STORIES

The partnerships described in the following pages present a representative sample of UNPEPP partnerships experienced over the last 10 years. From the type of activities chosen to the selection of the project team to the delivery of the final product, the partnerships presented below demonstrate the UNPEPP model as a success.

UNPEPP NOTABLE PROJECT #1: DESIGN AND INSTALLATION OF A HYBRID PV SYSTEM
HUMBOLDT STATE UNIVERSITY AND REDWOOD NATIONAL AND STATE PARKS

PARTNERSHIP SUMMARY
Project Fiscal Year: 2005.
Description: Installation of hybrid solar electric system at Espa Lagoon, Redwood National and State Parks.
Outcomes: Completed installation of the system; reduction in diesel generator emissions.

The Redwood National and State Parks are the combination of several protected sections of parkland, stretching along the uppermost part of the Pacific Coast in Northern California. The protected ecosystem includes several varied features, such as coastlines, lagoons, prairies, streams and rivers, and, of course, forests of redwood trees. This UNPEPP project's goal was to design and install a hybrid solar electric system at a ranger residence on Espa Lagoon, in the Prairie Creek Redwoods State Park unit of Redwood National and State Parks.

The project team and the hybrid solar-electric system at Espa Lagoon

Two student participants, with engineers from Humboldt State University's Schatz Energy Research Center (SERC) engineers and Park staff, worked to procure equipment and coordinate the design and installation of the system. The design and site analysis was based upon recommendations made by previous UNPEPP student partners.

Much of the equipment needed to complete the installation was inherited from previous park projects, including fourteen photovoltaic (PV) modules, an inverter, a charge controller, a generator, and an automatic transfer switch. The equipment was performance tested, and an optimal placement on the site was decided upon. After construction and procurement of the balance of the system equipment, the installation went forward.

Based on performance measurements and considering the available solar energy resource (corrected for shading), the PV system output provides an l average of 2.25 kWh per day. Including efficiency and transmission losses, the PV system provides an average of 1.5 kWh per day to the ranger residence, or 38% of the measured load.

"The PV system provides an average of 1.5 kWh per day to the ranger residence, or 38% of the measured load."

UNPEPP NOTABLE PROJECT #2: INSTALLATION OF WIND TURBINE & PV ARRAY WITH WORKSHOP AND INTERPRETIVE EXHIBITS
NORTH CAROLINA STATE UNIVERSITY AND WRIGHT BROTHERS NATIONAL MEMORIAL

PARTNERSHIP SUMMARY
Project Fiscal Year: 2003.
Description: Installation of a PV array and wind turbine at Wright Brothers National Memorial and Cape Hatteras National Seashore; development and production of interpretive signs.
Outcomes: Installation of wind and solar PV systems, and developed interpretive exhibits.

2.5kW wind turbine at Coquina Beach

The North Carolina State University (NCSU) project had several objectives: installation of a wind turbine, installation of a PV array, holding a workshop for park personnel, and development of interpretive exhibits for visitor education. The project was also sponsored by the North Carolina State Energy Office, North Carolina Department of Administration, and the Department of Energy.

Under this project, students assisted with the installation of a 2.5 kW wind turbine generator at the Coquina Beach Bathhouse located on the Cape Hatteras National Seashore. The wind turbine is interconnected to the grid to allow excess power to be sold to the utility company. Annually, the turbine produces the equivalent amount of electricity used at the Coquina Beach facility.

In August 2005, a two-day workshop was held for National Park personnel. The workshop, covering wind and solar PV systems, included both classroom and hands-on instruction at the Coquina Beach site. Park personnel from three states attended the workshop, which demonstrated how renewable energy can provide electricity at park facilities and for sale to utilities and green power programs. Workshop participants assisted with the wind turbine installation. Students assisted in the turbine installation and performed a final maintenance check. By the end of the day, the turbine was successfully producing electricity. The students also assisted with the assembly of a 1 kW solar PV array at Wright Brothers Memorial.

To educate the visiting public about the renewable energy demonstration projects, two interpretive exhibits were designed and produced. UNPEPP partners developed the interpretive signs content, and worked collaboratively with subject matter experts and graphic designers to develop drafts of the signs. Guidance of NPS personnel at Cape Hatteras and at Harper's Ferry Center (the Interpretive Design Center for the NPS) was followed for the signs.

Exhibits were produced for both the wind turbine at Coquina Beach and the Solar PV system at Wright Brothers National Memorial. The Wright Brothers National Memorial exhibit is in a highly visible and accessible location, where many of the park's estimated 750,000 visitors may view it.

Wind turbine Interpretive wayside

"A two-day workshop covering wind and solar PV systems was held for NPS personnel… {Park} personnel from three states attended"

UNPEPP NOTABLE PROJECT #3:
PHOTOVOLTAIC PANEL UPGRADE AND IMPLEMENTATION
SOUTH DAKOTA STATE UNIVERSITY AND YELLOWSTONE NATIONAL PARK

PARTNERSHIP SUMMARY
Project Fiscal Year: 2004.
Description: Upgrading the Photovoltaic Power Plant at the Lamar Valley Ranger Station and Yellowstone Institute, Yellowstone National Park
Outcomes: 7.4-kW photovoltaic upgrade to existing 6.5-kW system.

The 2004 UNPEPP partnership between South Dakota State University (SDSU) and Yellowstone National Park was a highly successful follow-up from an earlier partnership in 2001. This project had the objective of upgrading an existing PV system at Yellowstone, so that more than half of the powered facility's energy would be produced sustainably by the sun.

The chosen site, the Lamar Valley Ranger Station and Yellowstone Institute, was perfect for a PV system. With the Institute's educational mission, the site would make an excellent showcase for photovoltaic technology. Further, the large increase in visitor numbers in the Lamar Valley area expected as a result of wolf reintroduction in that area might create a need for a new visitor center at Lamar. This would increase the electrical load, creating a new demand that could not be met by the existing PV system.

SDSU students and Yellowstone personnel (at right) learn about code-compliant PV installation

SDSU students proudly stand in front of the PV system that they designed and installed

The project lead—electrical engineering Professor Michael Ropp—teaches a semester PV system design course, into which he integrated the Yellowstone PV array installation. Due to the PV course being taught jointly with SDSU UNPEPP partnerships, over the years about 40 of his students have been involved in UNPEPP projects. Michael Ropp's and his students' experiences are highlighted in the following section.

After learning the basics of PV system installation on the SDSU campus, the project team of faculty and students arrived at Yellowstone. John Wiles—an expert on the National Electric Code governing PV systems—gave an all-day presentation the day prior to installation. The presentation, emphasizing PV system basics and code-compliant design, was attended by SDSU students and Yellowstone personnel.

On the day of the installation, the team constructed the module frames and assembled and inspected the PV array. The end result: a 7.4 kW upgrade to the existing 6.5 kW PV system, more power to the park, and many proud students.

"The end result: a 7.4 kW upgrade to the existing 6.5 kW PV system, more power to the park, and many proud students."

UNPEPP NOTABLE PROJECT #4:
ENERGY ASSISTANCT PROJECT
GEORGIA INSTITUTE OF TECHNOLOGY AND CHATTAHOOCHEE NATIONAL RECREATION AREA

PARTNERSHIP SUMMARY
Project Fiscal Year: 2004.
Description: Energy assistance project for facilities at the Chattahoochee National Recreation Area.
Outcomes: Conducted on-site energy assessments and developed energy savings and economic analysis of identified opportunities.

In 2005, Georgia Institute of Technology (GIT) partnered with Chattahoochee National Recreation Area with the goals of conducting on-site energy assessments, developing building energy baselines, identifying energy savings opportunities, and performing economic analysis of identified energy conservation measures (ECMs).

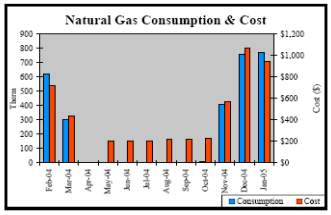
Chattahoochee Headquarters building, one of five assessed buildings

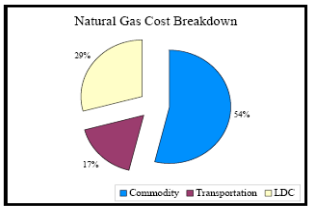
After conducting on-site assessments and collecting facilities' energy use data, the GIT team produced a 76-page report detailing Chattahoochee's existing energy use patterns and costs, and providing recommendations for cost-effective ECMs.

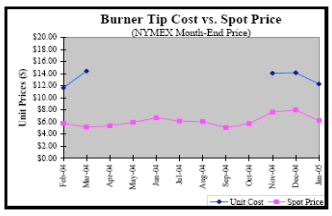
In the report, detailed monthly and annual energy consumption data—including natural gas and electricity consumption and costs, and energy use per square footage—for all of the assessed facilities were presented. The GIT partners developed tables and graphs to allow a greater understanding of energy use and costs, and to give visual indications of any strange patterns in facilities' energy usage.

The report also provided ECM opportunities, and related economic analyses. Major ECM recommendations included: improving lighting efficiency; combining electrical meters and changing metering rate; eliminating natural gas fired equipment; replacing windows; adding insulation to attic space; setting back office temperature; and, removing unused electrical accounts. Together the identified ECM opportunities would result in cost savings of approximately ***$10,500 annually*** for the analyzed facilities—36% of the buildings' utility costs—with a simple payback of only 2.7 years. Additionally, electricity and natural gas data were entered into a software program developed at Georgia Tech, which is used to track utility accounts.

Month-Year	Total Consumption (Therm)	Total Cost ($)	Burner Tip Price ($/MMBtu)	Nymex Month Close ($/MMBtu)
Feb-04	620	$ 722	$11.63	$5.775
Mar-04	303	$ 437	$14.42	$5.150
Apr-04				$5.365
May-04	0	$ 202		$5.935
Jun-04	0	$ 202		$6.680
Jul-04	0	$ 203		$6.141
Aug-04	0	$ 221		$6.048
Sep-04	0	$ 233		$5.082
Oct-04	0	$ 229		$5.723
Nov-04	406	$ 571	$14.06	$7.626
Dec-04	756	$ 1,069	$14.14	$7.976
Jan-05	769	$ 945	$12.29	$6.213
Totals	2,861	$5,024		
Unit Cost:	$1.760	/MMBtu		





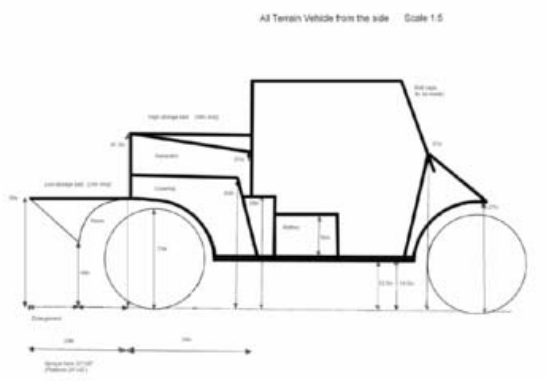


Sample analysis output: Natural gas cost and consumption for the Chattahoochee Headquarters building

"Identified energy conservation measures would result in annual savings of $10,500—36% of utility costs—with a payback of only 2.7 years."

UNPEPP NOTABLE PROJECT #5:
DESIGN AND PRODUCTION OF BIODIESEL HYBRID ATV
JAMES MADISON UNIVERSITY AND SHENANDOAH NATIONAL PARK

PARTNERSHIP SUMMARY
Project Fiscal Year: 2004/2005.
Description: Production of a hybrid biodiesel all-terrain vehicle for off-road use and demonstration by SHEN
Outcomes: A fully-functional vehicle was delivered to SHEN in spring of 2006



Biodiesel all-terrain vehicle design specifications

In 2004, James Madison University (JMU) partnered with Shenandoah National Park—continuing the partnership that began with the UNPEPP pilot project in 1997. For this partnership, JMU had the objective of designing and manufacturing a biodiesel/electric hybrid all-terrain vehicle (ATV) for use and demonstration purposes at Shenandoah.

Four JMU students were involved in the design and production of the ATV, which involved the conversion of a gasoline powered golf cart into a useful and environmentally-friendly vehicle. To ensure that the ATV would meet requirements of NPS personnel and be of use to park operations, discussions with Shenandoah maintenance and fleet management personnel were an ongoing component of the design process.

The JMU team diligently ensured excellence at every stage of the vehicle development, including final touches such as painting—for which a local business owner was recruited to assist. Once the ATV had been designed and fabricated, the JMU team worked to ensure safety and proper use of the vehicle through extensive safety checks and the development of a user manual.

Several aspects of the finalized vehicle are ideally suited for use in a National Park. First, the vehicle is fueled with biodiesel, a renewable, biodegradable, and non-toxic fuel that produces far fewer emissions than petroleum fuel.

Second, the hybrid-ATV operator can opt to power the vehicle solely on electricity when silence is desired; this way the vehicle will not disturb wildlife or ambience for visitors. Third, the ATV included two storage beds to transport tools and equipment used regularly for park operations and maintenance. As an appreciable bonus to park personnel, the vehicle can double as a portable power station, as the ATV's generator has a plug-in panel which can be used to power tools.

In early 2006, the JMU team presented and demonstrated the vehicle to Shenandoah National Park personnel. The vehicle is currently used for light-duty maintenance operations at Shenandoah.

JMU partner demonstrates hybrid biodiesel ATV to NPS personnel

"As a bonus to park personnel, the vehicle can double as a portable power station, as the ATV's generator has a plug-in panel…to power tools."

IV. THE UNPEPP STUDENT EXPERIENCE

UNPEPP has numerous benefits, from helping the National Parks reduce energy use and costs and associated environmental impacts, to developing lasting and beneficial partnerships between universities and parks. But perhaps the most valuable components of UNPEPP are the experiences the program has provided to UNPEPP student participants nationwide over the past decade. Without students, UNPEPP would simply be a program in which faculty provide consulting services to the National Parks. With the student experience, UNPEPP changes lives.

The opportunity to apply knowledge obtained in the classroom in practical, applied settings presents a true win-win situation: the UNPEPP universities and students help National Parks address and meet their energy management needs, and the students become more active participants in their broader "community." The UNPEPP experience can be likened to "service-learning," an educational model that works on the idea that learning is enhanced and solidified when it is applied.

Service learning provides students with opportunities to use their new-found skills and knowledge from the classroom in real situations, each with their own unique set of problems (unlike the more formulaic problem sets typically found in the classroom). And students are confronted not only with unique technical problems to solve, but with real people with real personalities with whom they must learn to work. As those in the "real world" already know, people skills are an integral component of a successful professional's toolkit.

Most importantly, service learning experiences like the UNPEPP program can help to instill in young people the value of *service*, not just of learning for self-fulfillment. UNPEPP helps to empower university students and instill feelings of concern, care, and commitment to their communities—local, national and global.

The Student Experience

At UNPEPP schools throughout the country, competition for participation in UNPEPP projects is intense. In a world where employers increasingly look for practical experience—and where universities are expected to provide more applied learning—the UNPEPP program stands out as a model. Not only do students apply the lessons of the classroom in the real-world, but they also have the unparalleled opportunity to work in beautiful surroundings with committed faculty and National Park staff, while helping to solve the myriad energy management issues that confront the National Park system. From energy efficiency audits to renewable energy system design, UNPEPP student participants have made significant contributions to wiser energy use at the National Parks.

Typically, the UNPEPP student experience is one where students work with a faculty member and park staff as part of a team. Students receive an hourly wage for their efforts, another valuable (if not critical) component of the UNPEPP experience. However, other UNPEPP models have been developed as well. At South Dakota State University, Professor Michael Ropp has designed an entire classroom experience around UNPEPP, in effect creating 20 or more student participants in one fell swoop. Students in Ropp's "Special Topics in Photovoltaic Systems" class study the design and installation of photovoltaic (PV) systems in the classroom, and then, with UNPEPP's assistance, work to install an operating PV system in nearby National Parks. Both Yellowstone and Wrangell-St. Elias National Parks have benefited from their association with SDSU and UNPEPP.

Student Highlights: Humboldt State University

The student experience is perhaps no better illustrated than through a closer look at UNPEPP's relationship with Humboldt State University (HSU), which has been a successful partner in the program since 2001. HSU is increasingly known as a leader in service learning, and presents many opportunities for its students to

contribute to their communities. Many HSU students, like those discussed below, go on to lead lives of service that began with their undergraduate experiences.

HSU UNPEPP intern adjusts PV rack for summer setting at Espa Lagoon.

Humboldt State University, through its affiliated Schatz Energy Research Center (SERC), has developed a valuable partnership with nearby Redwood National Park, and has completed several worthwhile projects with invaluable assistance from students. Project have included the installation of a solar water heating system at the Kuchel Visitor Center and installation of a PV system at Espa Lagoon (pictured at left).

Richard Engel, a Research Engineer at SERC and a facilitator of the UNPEPP program, notes that while many students arrive with classroom exposure to renewable energy and energy efficiency, they have little hands-on experience in the design and installation of energy systems: "The UNPEPP projects are formative experiences for these students, allowing them to take leading roles in real world projects that provide benefits to the environment and park staff and visitors."

Engel has been impressed with the successes the student participants have achieved. And while all of the students achieved their project goals at Redwood, Engel was particularly impressed by the 2003 team of Andy Sorter and Kelly Miess (Meiss's experience and perspective are highlighted below). "In twelve weeks they designed, procured equipment for, installed, and performance tested a complete solar hot water system for Redwood National Park's Kuchel Visitor Center," says Engel. "Many students have told me their work with UNPEPP committed them to a career in energy technology and/or helped them prepare them for work they're doing now," Engel notes. And Engel pointed out that UNPEPP has also benefited SERC: "Some of our UNPEPP participants have stayed on at SERC as part-time or full-time staff. The projects have helped SERC's professional staff build our skills and develop relationships in the community that have led to other opportunities and projects for the lab." Below, we highlight the experiences of two UNPEPP student participants and one UNPEPP faculty member, focusing on the impact of the UNPEPP experience on students' lives after graduation.

Lonny Grafman, Lecturer, Humboldt State University

Lonny Grafman worked on the first UNPEPP partnership between HSU and Redwood NP. Partnering with fellow student Angie Sorenson, the team worked on the redesign of a beach restroom facility and the replacement of an antiquated diesel generator with a renewable energy system.

When Grafman completed his UNPEPP experience in 2001, he expressed optimism that the experience would give him "valuable preparation for life after graduation." Grafman noted then that he hoped to work with developing countries, helping them leapfrog over polluting energy technologies to cleaner forms.

Since that time, Grafman has graduated and has become a lecturer in HSU's Environmental Resources Engineering program, where he teaches courses on Design and Appropriate Technology. Grafman also leads a work experience program (not unlike the UNPEPP model) to Mexico, where student teams apply classroom experiences to solving the real-world problems of rural Mexicans in the village of Parras de la Fuente.

Among Grafman's more interesting post-UNPEPP activities is his work with appropedia.org. Appropedia is a dynamic and open-library website (*wiki)*, focused on success in two core initiatives, reducing poverty through international development and increasing sustainability through all means, including appropriate technology. Grafman is the founder and director of appropedia.

When Grafman completed his experience, he hoped to help developing countries use cleaner energy technologies…Now he is the director of appropedia, a *wiki* focused on increasing sustainability through international development.

Michael Ropp, Electrical Engineering Professor, South Dakota State University

Dr. Ropp teaches a PV system design course at SDSU. Through UNPEPP, his students have implemented PV systems at Yellowstone National Park and Wrangell-St. Elias National Park.

My students are future electrical engineers, and UNPEPP support has enabled us to provide high-value, unique experiences. Because of the nature of electric power systems, complete design-build projects are very difficult to do in the university environment, but with UNPEPP support my students are doing exactly that—they start from a blank white sheet of paper and end up with a completed renewable energy system in a National Park. The students gain both theoretical and hands-on experience, they actually meet and work with their "customer," the end user of the power system, and they do both in an environment, namely the National Parks, that makes all of this an extremely high-impact experience that lasts a lifetime. I could not do any of this without the support I have received from UNPEPP.

I also see value to my university, and to the electrical engineering field. The value to the university is fairly obvious, but as I mentioned the ability to provide design-build experiences in electric power leads more students to consider studies in electrical engineering, because it's not so theoretical and abstract. This should have a small but positive effect on recruitment and retention into Electrical Engineering.

Approximately 40 students have participated in my UNPEPP-sponsored projects (so far). For most, the effect on their careers is measurable. The experience they gain is of value on their resumes; in fact, one student who was a recent graduate was given leave during his first month on his new job so that he could participate in one of our projects. That is an indication that employers value the experience. The students come out of the projects aware of renewable energy technology and how to use it appropriately, and several have informed me that they have had occasion to use that in their jobs. For some students, the effect is much larger; I know of six students who got their present jobs specifically because they had photovoltaic design-build experience obtained in one of our UNPEPP-sponsored projects.

UNPEPP gives tremendous "bang for the buck", is the only program of its type that I know of, is well-administered, and positively impacts American kids. It is money well spent.

Kelly Miess, UC Berkeley Engineering

Kelly Miess was part of a 2002 UNPEPP team, directed by the Schatz Energy Research Center at HSU that designed and installed a solar hot water system for Redwood National Park. She is currently a master's student in Civil and Environmental Engineering at U.C. Berkeley.

Kelly Miess and Andy Sorter install the solar thermal system at the Redwood National Park Kuchel Visitor Center.

Miess notes that she gained both personally and professionally from her UNPEPP experience: "I had the chance to work with great staff at Schatz and Redwood National Park and an opportunity to manage a project from start to finish. It was also my first paid engineering work experience and my first time collecting data and applying it to an actual design."

The solar thermal project Miess designed and installed with fellow UNPEPP student Andy Sorter makes a big contribution to better energy use at Redwood National Park. The system has a 20-year life and a 7-year payback, and provides educational opportunities for park visitors as well.

Miess has no doubt that UNPEPP helped her in achieving her academic goals. "I gained excellent work experience, and I gained great contacts at Schatz, who I still use as references. In addition, my academic advisor prompted my fellow student and me to publish an article about out work, so I also published a paper from that summer!"

CONCLUSION

For the past decade, UNPEPP projects have strengthened relationships among universities and parks, while serving as a first-rate approach for educating students, faculty, park personnel, and the general public about the value of energy efficiency and renewable energy. While educational benefits are central elements of UNPEPP, the remarkable feature of the program is that it provides educational value while also providing real and lasting energy and dollar savings.

The myriad of buildings found throughout the national parks are in varying conditions. Due to resource constraints, literally thousands of park buildings throughout the country are in need of some form of energy overhaul. This overhaul may involve the replacement of old and outdated equipment with new energy-efficient equipment, or the development of alternative forms of energy generation (e.g., solar) to replace conventional (i.e., fossil-fuel) forms. Park staff members are the first to note the countless areas where park facilities need both regular maintenance and upgrading in terms of energy use. By providing professional services to the NPS, the innovative UNPEPP formula helps the NPS meet their energy management needs in a very cost-effective way.

Since its inception in 1997, UNPEPP has provided valuable educational opportunities for students, valuable information for park personnel, and valuable energy and cost savings for the National Park Service (NPS) and the American taxpayer. The key word here is value: it would be hard to find a program that provides more return--in many different ways--for the modest cost of the program. Because the NPS will always need to address its energy use as old facilities and equipment wear out, it will always need information on the best approaches to using energy wisely. UNPEPP—while educating students, park personnel, and park visitors—provides the NPS with state-of-the-art, localized and specific information at an extremely low cost.

In the years ahead, as UNPEPP projects become more visible, it will fulfill what is perhaps its most important mission: to educate the millions of visitors to the National Parks about the value of sustainable energy use. This is in line with the goals of the Green Energy Parks Program, which is designed to turn National Parks across the nation into showcases for state-of-the-art energy efficiency and renewable energy technologies.

APPENDIX:

UNPEPP PARTNERSHIP SYNOPSES1997-2006

1997

Pilot: James Madison University - Shenandoah National Park

Partnership Activities and Outcomes: This partnership was the pilot for the UNPEPP program, pairing James Madison University with nearby Shenandoah National Park. The project team focused on three main areas in their work at the Park:

1. A Federal Energy Decision System (FEDS) analysis of several buildings at the Park.
2. Renewable energy design analyses for several potential applications within the Park.
3. Designing and populating a database system for the Park's utility bills.

1999

Utah State University - Intermountain Region National Parks

Partnership Activities and Outcomes: Utah State University paired up with Intermountain Region National Parks to gather and organize information in order to initiate utility bill tracking. A utility database was developed, leading to Energy Conservation Measure (ECM) recommendations.

The team was able to:

1. Conduct site visits to compile and audit utility billing data and to verify meter loads.
2. Assess energy usage and utility bill histories.
3. Gather information relating to facility types, square footages and utility providers.
4. Developed a database to:
    a. Identify loads that could be disconnected on a seasonal basis.
    b. Identify accounts where NPS has been overcharged.
    c. Establish baselines for evaluation of savings from energy conservation measures.
    d. Facilitate bulk procurement from utilities.
    e. Identify buildings and facilities with high energy consumption per square foot.

Georgia Institute of Technology – Kings Mountain National Military Park

Partnership Activities and Outcomes: GIT partnered with Kings Mountain Military Park to complete a full energy assessment of the park's Visitor Center and to develop recommendations for energy conservation measures in the building. The GIT project team visited the Visitor Center in May 1999 to obtain information on historical energy use patterns and to gather other building data and specifications. The

team used computer models to assess the facility and pinpoint options for energy conservation and efficiency measures.

Major identified energy conservation opportunities included:

1) Using energy efficient lamps and ballasts
2) Installing occupancy sensors in the restrooms for lights and fans
3) Insulating the ceiling
4) Insulating exterior walls in the program area
5) Removing the floor windows in lobby and hallway
6) Installing new doors with weather stripping and thresholds
7) Installing new lobby windows
8) Installing a new split system heat pump

The identified energy conservation measures would result in annual savings of nearly $5,800 from retrofits of non-HVAC (Heating, Ventilation and Air Conditioning) energy-using equipment—32% of the Visitor Center's annual utility bill. The GIT team also recommended measures to reduce the air conditioning load that would provide an additional $4,400 in savings each year. The environmental benefits of the efficiency measures include reduced emissions of harmful pollutants and greenhouse gases: 46,519 lbs/yr reduction of CO_2, 308 lbs/yr reduction of SO_x, and 173 lbs/yr reduction in NO_x emissions.

James Madison University – National Capital Region/Antietam National Battlefield

Partnership Activities and Outcomes: James Madison University's Integrated Science and Technology Program teamed up with the National Capital Region of the NPS to conduct a partnership with two primary goals: to research the feasibility of implementing PV power at several National Capital Region park facilities; and to conduct lighting audits at the Antietam National Battlefield Visitor Center.

Several areas of the National Capital Region were assessed for potential PV system implementation: the Arizona Avenue Bridge—C&O Canal, Antietam National Battlefield, and Fort Washington Park.

At Fort Washington Park, the team assessed the site for a potential PV system at the entrance booth. They developed three PV systems which could power the entire booth, the booth lighting, or the HVAC system.

At Antietam National Battlefield the team designed PV systems to power energy-efficient lighting for the Visitor center parking lot, and to power a 150-watt floodlight for a flagpole in the nearby Antietam National Cemetery.

The team also conducted a lighting audit, at the visitor center, identifying three major ECM opportunities: Reduce the number of lamps in each fixture; Install occupancy sensors in offices, copy room, and library; and, replace incandescent lamps with compact fluorescent lamps. Together these measures would increase occupant comfort while resulting in significant cost savings. For instance savings of $1400/yr—37 percent of the Visitor Center's annual electric bills—were estimated from a switch to fluorescent lighting alone.

University of Michigan – Sleeping Bear Dunes National Park

Partnership Activities and Outcomes: The University of Michigan paired up with Sleeping Bear Dunes National Park to: Design options for a PV system for South Manitou Island and to conduct an energy audit and analysis of the park's visitor center/headquarters building.

The purpose of designing options for a PV system on South Manitou Island was to reduce or eliminate the use of diesel generators, which are loud and polluting.
The University of Michigan team considered and compared three options:

1) Propane power for space and water heating, cooking and refrigeration, with a PV system meeting remaining electrical needs such as lighting and pumps.
2) PV system with a 12-hour battery, battery bank, and inverter to meet overnight energy demand
3) Complete conversion to PV power

The team recommended that both the return-to-propane option and the PV system with a correctly sized inverter ought to receive careful consideration.

The second part of the project was an energy audit and analysis targeted at the visitor center/headquarters building. Recommendations were provided for cost-effective ECMs. Using data-gathering sensors for temperature, lighting, and humidity, and sophisticated software packages, students constructed computer models of the headquarters building. Building parameters (spatial, construction, equipment, lighting, occupancy rates, and mechanical system specifications) were applied to the models, and the model output was compared to building's actual performance. The modeling process resulted in recommendations for the lighting system, the building structure, and the ducting and mechanical systems.

The primary lighting recommendation focused on the use of natural lighting through skylights. The report also recommended that lighter, reflective colors replace the darker, non-reflective tones now on the cubicles and walls, and that small fans be used to distribute the warmth in the winter and push heat through open sections of the skylights in the summer. Recommendations for the building structure generally focused on more effective use of insulation. Mechanical systems recommendations included downsizing some units to achieve higher efficiency, and redesigning the ductwork for simplicity and efficiency.

West Virginia University – New River Gorge National River

Partnership Activities and Outcomes: West Virginia University's Department of Industrial and Management Systems Engineering partnered with New River Gorge National River to conduct a comprehensive energy analysis of various buildings in the area of the National River and develop recommendations for ECMs.

The project team conducted energy analyses of 28 buildings including the National River headquarters, ranger stations, maintenance buildings, storage and support facilities, and public restrooms. The analyses included documenting the buildings' occupancy rates, costs, and operating hours, and critically considering each structure's HVAC and lighting systems.

The team reported detailed opportunities for retrofits and improvements for HVAC and lighting systems, and also included opportunities for PV power. Recommendations for ECMs ranged from a simple switch of incandescent lamps with fluorescent lamps to the complex jobs of changing a cooling layout from two large systems to three smaller forced air heat pumps with economizers.

University of Washington – Crater Lake National Park

Partnership Activities and Outcomes: The University of Washington and Crater Lake National Park partnership focused on improving energy use technology on the tour boats at Crater Lake National Park. Three project goals included: 1) Evaluating alternative fuels for the boats in Crater Lake (methane, methanol, ethanol, and bio-diesel fuels), 2) evaluating exhaust emission controls for the boats, and 3) investigating opportunities for using PV power as a supplemental power source for the boats.

After analyzing the pros and cons of the alternative fuels, the team recommended the use of biodiesel fuel, primarily for environmental reasons. Additionally, two opportunities were designed and proposed for incorporating PV power into the boat operation on Crater Lake. The first recommended option was to build a roof above the passenger section of the boats and mount PV panels on top. The engine would supply 80% of the energy and the PV systems would supply 20%. The second option was the elimination of the use of generators at the south-facing boathouse on Wizard Island by placing PV panels on the roofs of the boathouses.

In the following year (2000), additional research and analyses were conducted to determine the benefits of using fuel cell technology on tour boats. The team determined that the energy requirements/engine outputs of tour boats were approximately 125 kWh per tour. The best option found was a methanol-powered fuel cell, rated for 200kW peak performance, preferably with a methanol-to hydrogen reformer on board. The team's final recommendation was that fuel cell demonstration vehicles, such as buses, be used in the NPS before implementing their use in boats. By gaining experience with buses, the NPS would be in a good position to acquire and operate fuel cell boats.

2000

South Dakota State University – Yellowstone National Park

Partnership Activities and Outcomes: South Dakota State University teamed up with Yellowstone National Park to design and install a PV solar system on a new structure near Lewis Lake.

The team successfully designed a PV system, assembled the PV array, roof-top mounted the array, installed the battery bank, and interconnected the Integrated Power Panel, batteries, PV array and LPG-powered generator. Finally, they tested the system components and monitored the system to ensure quality and reliable power production. Ultimately, the PV system powered the new structure and the adjacent ranger residence.

Humboldt State University – Redwood National and State Parks

Partnership Activities and Outcomes: Humboldt State University partnered up with Redwood National and State Parks for the first time in 2000. However, this was the beginning of a long term relationship involving many different projects over the next few years.

In 2000, the team performed a renewable energy assessment and designed renewable energy systems for the Prairie Creek Unit of the Redwood State and National Parks. In particular, the projects major activities included: (1) conducting a load assessment and a feasibility study for a new solar PV-powered lighting and solar thermal shower system in a planned bathroom at Gold Bluffs Beach campground; and,

(2) an energy audit, electric use monitoring, and system design for a PV system to replace diesel generators at ranger residences near Espa Lagoon.

The team collected available solar energy and necessary hot water data, and designed a solar shower, solar-powered lighting system and a ranger residence hybrid-electric 2kW PV system. The HSU team developed design specifications in the form of a draft grant proposal, so that the Park may use them to seek funding for the projects in the future. The team also recommended several ECMs including: insulating the water heater; posting signs asking visitors to limit showers to 5 minutes; install a mixing valve to limit maximum water temperature; installing a beach shower w/ cold water; maintaining spring-loaded faucet control; and implementation of an indirect solar water heater.

University of Colorado-Boulder – Rocky Mountain National Park

Partnership Activities and Outcomes: The University of Colorado at Boulder teamed up with Rocky Mountain National Park to perform multiple projects. The partnership took on three projects including: 1) an energy audit at the Alpine Visitor Center, 2) identifying design problems associated with a PV system at Bear Lake Trailhead, and 3) Characterizing overall park-wide energy use and energy auditing.

For the off-grid Alpine Visitor Center, the team collected data on loads and energy needs. They recommended replacing the current generator with a more efficient generator to conserve energy.

After identifying all of the problems associated with a PV design at Bear Lake Trailhead, the team found that avoiding implementation of a PV design at that location was ultimately the best solution. Therefore, they recommended the construction of a PV array frame in a more appropriate location and increasing the array size from 14 to 24 75-W modules, thus eliminating the need for supplemental power that a smaller array would not provide.

For the general park energy audit, activities included collecting, organizing and data-basing electric utility bills, and end-use monitoring. Ultimately they performed an alternative energy feasibility study and recommended a 4.32kW array on the south roof of the Trail Ridge store.

University of Massachusetts at Lowell – Lowell National Historical Park

Partnership Activities and Outcomes: The University of Massachusetts at Lowell and the Lowell National Historical Park partnered up to investigate the feasibility of using renewable energy systems to reduce electric utility demand at the Historical Park's Maintenance shop. A feasibility study was completed and formulated into a proposal for funding the system.

A hybrid wind / photovoltaic system was designed, consisting of a 20 kW grid-tied PV system and separate wind array with minimal battery storage. The team recommended two 4-hour training sessions (Topics: O & M and safety, and power electronics) at University of Massachusetts Lowell Renewable Energy Lab for park personnel. Finally, the university partners developed a proposal with which the park could request funding for the renewable energy project in the future.

Georgia Institute of Technology – Andersonville National Historic Site and Tuskegee Institute National Historic Site

Partnership Activities and Outcomes: Georgia Institute of Technology partnered up with both Andersonville National Historic Site and Tuskegee Institute National Historic Site in 2000 to perform energy audits and recommend energy conservation measures.

At Andersonville National Historic Site, the team analyzed energy use of the visitor center and evaluated ECMs to reduce energy use of the building and reduce utility costs. The HVAC system was the primary interest of study, and was identified as the culprit for high energy expenses. The team recommended several ECMs including: Converting the HVAC system to variable air volume, using the HVAC Economizer Cycle, replacing halide lamps with high pressure sodium lamps, installing occupancy sensors, retro-fitting existing exit signs with LEDs, utilizing different electricity rates, and combining electric meters.

At Tuskegee National Historic Site, the team analyzed energy use at Carver Museum. They recommended ECMs including: improving fluorescent lighting efficiency, replacing incandescent lamps with CFLs, retro-fitting existing exit signs with LEDs, installing occupancy sensors, night setback of space temperature, installing interior storm windows and insulating the library roof.

University of Buffalo – Yosemite National Park/Theodore Roosevelt National Historic Site

Partnership Activities and Outcomes: In 2000, the State University of New York at Buffalo partnered up with both Yosemite National Park and Theodore Roosevelt National Historic Site to perform energy audits.

At Yosemite National Park the team performed an energy audit, addressed institutional implementation barriers, and modeled an effective energy policy. ECMs were recommended based on energy audit results. Identified opportunities for energy savings included: replacement of bulbs w/ CFLs; installation of motion and occupancy sensors; water conservation; insulation; reduced cooling; chiller replacement, solar water pool heating; painting the air conditioning ducts on the roof white (or insulate them); and, replacing the 85-year old single-valve boiler. The team also recommended the green design of buildings in the future, and contract language specifying green or energy efficient design. In addition, they recommended that the Park should have an Energy Officer and that conservation education for park employees should be provided.

At Theodore Roosevelt National Historic Site performed an energy audit and gathered data at the sites' century-old structure to identify energy conservation opportunities.

2001

Humboldt State University – Redwood National and State Parks

Partnership Activities and Outcomes: Humboldt State University partnered with Redwood National and State Parks again in 2001 to perform energy audits and design PV systems for the Wolf Creek Outdoor School. The HSU team conducted load assessments, and designed solar-electric powered indoor/outdoor

lighting systems for six cabins, an amphitheater and connecting paths. Solar water and space heating systems were designed to supplement or replace existing electric water and space heating.

The project recommendations included: replacement of an electric heater with a propane heater; a solar hot water system with a 1.5 gpm shower head; use of an occupancy sensor, thermostat and electric timer; fluorescent lighting in cabins; LED (light-emitting diode) lighting for trail paths; and an Energy Star washer & dryer. The team also recommended replacing HPS (high pressure sodium) outdoor lighting w/ compact florescent lighting (CFLs); the installation of a smaller, efficient ventilator for the ventilation system; a grid-tied PV system; reducing freezer energy use in the Lodge by stocking w/ thermal mass; and the use of CFLs overall.

South Dakota State University – Yellowstone National Park

Partnership Activities and Outcomes: South Dakota State University teamed up with Yellowstone National Park in 2001 to research the feasibility of demonstrating another grid-connected PV system at the North Entrance Station. The project included data collection on energy loads and solar power availability using a sophisticated instrumentation package that includes data-logging capabilities.

University of Massachusetts-Lowell – Lowell National Historic Park

Partnership Activities and Outcomes: The University of Massachusetts at Lowell and the Lowell National Historic Park partnered up again in 2001. This time they studied the use of a fuel cell system to provide electrical power for museum exhibit lighting for Lowell National Historical Park Boott Mill Museum. Project activities included the fuel cell system design and a museum load assessment.

A 200 kW fuel cell system was designed, with fuel cell heat generation considered in the analysis. Energy savings were calculated, the cost of the fuel cell system was calculated and the payback period was evaluated. The team recommended installation of the proposed fuel cell, to demonstrate to the public that renewable energy has high performance in an urban environment.

University of Colorado-Boulder – Rocky Mountain National Park

Partnership Activities and Outcomes: The University of Colorado at Boulder again partnered with Rocky Mountain National Park in 2001 for an energy audit. The Boulder team collected energy use for the entire park including electric, natural gas, and propane. They transferred paper records of energy use into a usable electronic form, and created a database to track and interpret energy use. The database includes building information, footprint square footage, location, energy use, graphical representation of energy use for each meter, and graphical representations of total monthly electric use for east and west sides of the park in kWh and BTUs. Finally, the Boulder team developed a map of park meters and tank locations and identified areas of high energy use.

The team targeted the East of the park as particularly needing energy conservation. They recommended ECMs such as: lighting and lighting control upgrades; measuring motor efficiencies as motors are replaced; considering the use of renewable energy technology when service lines need to be replaced; decreasing Natural Gas usage; in-depth audits on the highest energy consuming buildings.

James Madison University – Shenandoah National Park

Partnership Activities and Outcomes: Since the pilot partnership in 1997, James Madison University partnered up with the NPS and Shenandoah National Park again in 2001 to spark a 4 year relationship that would include a variety of projects.

In 2001, the team paired up to research alternative fuel vehicles. The work involved the design, prototype development, and testing of several electric vehicle concepts. As a result, the team developed a Park Service Electric ATV. A 2002 partnership between JMU and the NPS/Shenandoah National Park revisited this ATV. *See 2002 JMU/NPS/Shenandoah

University of Washington – North Cascades National Park

Partnership Activities and Outcomes: The University of Washington partnered with North Cascades National Park in 2001 to research the feasibility of a PV system. The project involved installation, monitoring, and evaluation of solar energy systems, as well as a comprehensive energy analysis of the Ranger Station at Marblemount.

The team conducted an energy analysis of a few representative buildings that were similar to other buildings at Marblemount, had especially large needs, or have potential for significant energy improvements. They then developed a computer model that would predict energy savings based on selected improvements and upgrades.

They found that heat pumps would have immediate and far-reaching impacts for several buildings at Marblemount. Although their initial cost is large, once installed, the heat pumps could bring a total savings of about $1,975 and 39,705 kWh annually for the four buildings that were analyzed. Caulking and weather stripping was also recommended but these upgrades were not included in the computer model. They also determined that roof insulation and window upgrades should be considered on a case-by-case basis since their benefits vary according to building.

Additionally, the team purchased a 960-Watt solar PV system for Stehekin in the fall of 2001 that they installed in 2002. They set up of a new electrical load for the PV system (a swamp cooler), which more nearly matches the summer output of the PV system.

Finally, UW partners determined the cost and system specifications of a solar hot water heating system for the Ross Lake Resort. They designed a system that would use a closed loop system with a hot water tank, pump, and controller. Plans included installation of this system in 2002.

2002

Humboldt State University – Redwood National and State Parks

Partnership Activities and Outcomes: Humboldt State University partnered up with Redwood National and State Parks from 2002 to 2003 to assess the feasibility of using a solar hot water heating system in the Redwood Information Center. The project included site analysis and a complete energy audit that included site solar availability assessment, water usage, and energy consumption data collection. It also

included used site data, research on contemporary solar water heating technologies, and an economic analysis.

The team successfully installed a system that uses two 4' by 8' collectors with backup provided by a flash heater; the system has been providing nearly all of the hot water used at the RIC. As an added educational component, The HSU team developed an interpretive sign and brochures to accompany the solar water heating system.

James Madison University – Shenandoah National Park

Partnership Activities and Outcomes: James Madison University partnered up with the NPS and Shenandoah National Park in 2002 to research, develop, and demonstrate an alternative fuel vehicle that would be useful for park personnel. The goal of the project was to produce a quiet, efficient vehicle for use in the NPS. The project had four phases: 1) collection and refinement of waste vegetable oil; 2) development of a diesel-electric hybrid vehicle; 3) development of auxiliary fueling system for the vehicle; and, 4) development of on-board fuel refining system. Students also implemented design changes and improved the performance of the Park Service Electric ATV that was developed in the previous year.

South Dakota State University – Yellowstone National Park

Partnership Activities and Outcomes: South Dakota State University teamed up with Yellowstone National Park from 2002 to 2004 to successfully install a 7.4 kW PV array at Lamar Ranger Station. Power was previously supplied by a hybrid PV-propane system. Students and Yellowstone personnel attended a presentation on PV basics and code-compliant systems design. The PV array was assembled and installed in August of 2004.

University of Delaware – Assateague Island National Seashore

Partnership Activities and Outcomes: The University of Delaware and Assateague Island National Seashore partnered up to complete a feasibility study and analysis of a PV system to power Valentine Lodge.

University of Delaware team members identified and compared alternative options for a distributed energy system at Valentine Lodge. The team prepared an audit of expected electrical end uses, and used data on insolation for the island region to extract estimates of hourly and daily outputs of a PV system.

Ultimately, the project team determined that a modest size 2.5kW PV system would meet the needs of the lodge at a comparatively lower cost than a hybrid system. In all of the analyzed scenarios of electricity demand (2, 4, 8, and 12 person occupancies w/ low, medium, or high electricity consumption) the 2.5kW PV system proved sufficient to meet energy needs.

University of Washington – North Cascades National Park

Partnership Activities and Outcomes: The University of Washington partnered with North Cascades National Park to research to perform an energy audit at Stehekin. They studied the energy options for Stehekin, Washington; a remote and isolated community not served by a major electrical grid. In addition, they explored and analyzed energy options for Stehekin that would curtail the use of diesel generators. Considering electricity use patterns, the team examined both the demand-side and the

supply-side solutions. The demand-side options included energy conservation and fuel switching. The supply-side options included central and distributed electricity storage, upgrading the existing hydro electricity plant, solar PV plant (10 kW), and wind turbines.

After performing the energy audit, the team had several recommendations. They determined that switching to propane for domestic water heating and space heating would decrease demand for electricity. They recommended central electricity storage using flow batteries, or upgrading the existing hydroelectric plant coupled with conservation and fuel switching as a long term solution.

Additional recommendations included: 1) Solving the problem of fluctuations in the frequency of electricity, 2) a more stable NPS policy on woodcutting, 3) consideration of Solar PV as part of the system, 4) and the NPS and Chelan PUD should strive to reach an agreement whereby it becomes feasible to upgrade the hydroelectric plant, increasing its efficiency from 63% to 76-79%.

University of Washington – Hawaii Volcanoes National Park

Partnership Activities and Outcomes: In 2002, the University of Washington partnered up with Hawaii Volcanoes National Park to perform a park-wide energy audit. Activities included a renewable energy systems analysis, a solar thermal conversion for domestic hot water and space heating, and analyzing the energy load and supply of the building.

The team found that if room temperature were set at 70 degrees F, the solar thermal space heating system would meet 80% of the analyzed building's annual load. At a set room temperature setting of 65 degrees F, the system would meet 92% of the annual load.

The University of Washington recommended installation of a four-panel solar thermal system with propane auxiliary. They also recommended insulation of the facilities, use of low temperature baseboard heating to meet space heating needs, and implementation of a propane boiler.

2003

Humboldt State University – Redwood National and State Parks

Partnership Activities and Outcomes: Humboldt State University partnered up with Redwood National Park from 2003-2004 to perform an energy audit and propose PV design options for the Kuchel Visitor Center. They quantified energy use and identified areas where energy consumption can be reduced. They recommended energy conservation measures and presented 3 different grid-connected PV system designs. The three proposed systems were 1): a 6 kW system mounted on the southern east-facing roof, 2) a 9 kW system mounted on the central, west facing roof and 3) a 15 kW combination of 1 & 2.

University of Pennsylvania – Independence National Historic Park

Partnership Activities and Outcomes: In 2003, The University of Pennsylvania teamed up with Independence National Historic Park to perform an energy audit at the Visitor Center.

The team performed a thermal and lighting analysis, gathering information about the building and its performance, identifying strategies for ECMs in the building, and conducting energy and lighting

simulation analysis. They also performed an evaluation of potential photovoltaic use, studying the potential use of a PV system on the existing glass roof of the building. The team selected PV modules and components, estimated system costs, and identified beneficial outcomes of PV at the park visitor center.

The University of Pennsylvania partners recommended installation of the PV array over the skylight in the visitor center, citing the following benefits: 1) Glare and excess solar gain would be reduced by shading of the array; 2) Building costs would be reduced due to lower electricity demand and a reduced cooling load; 3) Hundreds of tons of emissions and pollutants would be avoided, and 4) installation of the system will display Independence National Park's commitment to clean energy generation and visitor education.

North Carolina State University – Wright Brothers National Historic Site

Partnership Activities and Outcomes: The North Carolina State University partnered up with Cape Hatteras National Seashore and Wright Brothers National Historic Site for two different projects. At Cape Hatteras, the partnership focused on design and implementation of wind power to power the Coquina Beach bathhouse. At the Wright Brothers National Historic Site, the partnership focused on PV power and pubic education.

At Coquina Beach, a 2.5 kW grid-connected wind turbine was designed and installed. A small-wind turbine installation workshop for park personnel and other stakeholders was held at the site.

At the Wright Brothers National Historic Site, the project focused on the assembly of a PV system, and solar PV and wind power education. A kiosk on renewable energy for Wright Brothers was developed, in combination with the installation of a small wind turbine at the site. A small wind turbine, a turbine blade, and cross sections of turbine blades were donated to the project and incorporated into the exhibit.

2004

Georgia Institute of Technology – Chattahoochee National Recreation Area

Partnership Activities and Outcomes: Georgia Institute of Technology teamed up with Chattahoochee National Recreation Area to perform an energy audit. The GIT team conducted on-site energy assessments, developed a building energy baseline, and developed energy savings and economic analysis of identified ECM opportunities.

Identified ECM opportunities included improvements to lighting efficiency, combining electrical meters, eliminating natural gas fired equipment, replacing windows with more efficient windows, adding insulation to attic space, setting back office temperature, and removing unused electrical accounts.

Together, the recommended ECMs would result in annual savings of over $10,400 for the analyzed facilities, or 36% of the buildings' yearly utility costs. Additionally, electricity and natural gas data were entered into a software program developed at Georgia Tech. The program can be used to track utility accounts, providing the potential to identify additional energy savings strategies in the future.

Virginia Institute of Technology – Petersburg National Battlefield

Partnership Activities and Outcomes: Virginia Institute of Technology partnered up with Petersburg National Battlefield to conduct a park-wide energy audit. The team provided energy audits and feasibility studies for improvements in efficiency, use of renewable energy, and public energy education at Battlefield Park.

The project involved energy audits of 19 space-heated buildings in the park, and assessment of renewable energy applications in the park. Virginia Tech Partners found that significant opportunities for cost-effective energy improvements exist in the park, such as improved maintenance, lighting efficiency, insulation, and HVAC improvements.

The university team also determined that renewable systems—such as solar water heating in residential applications or photovoltaic systems in remote applications—are cost-effective and can present opportunities for public education and demonstration at Petersburg.

South Dakota State University – Yellowstone National Park

Partnership Activities and Outcomes: South Dakota State University teamed up with Yellowstone National Park in 2004 and participants revisited the previously installed Lewis Lake PV-propane system. Participants identified and corrected system problems, including improper system set points, battery charge setting, and the start feature of the generator. Participants performed a full-function test of the system, and found it to be functional.

University of Washington – Haleakala National Park

Partnership Activities and Outcomes: The University of Washington and Haleakala National Park partnered up to analyze and develop a solar PV system and a micro-hydropower system to power two districts at Kipahulu.

In the analysis and development process of the PV/micro-hydropower design were the visitor center, the parking area, the restrooms, the campground, and the small maintenance center were considered. An understanding of the electrical requirements of the Kipahulu facilities were developed, conservation and end-use efficiency was examined, and alternative systems were compared. The life cycle costs of the systems were examined and the system with the lowest life-cycle cost was to be designed.

Life-cycle cost analysis demonstrated the cost effectiveness of renewable energy by showing that a grid extension option to power the location was more than twice the cost of the renewable energy option: $857,170 compared to $414,970.

The team recommended the use of a solar PV system with a micro-hydro turbine and backup propane generator at each of two separate districts because this configuration would decrease electricity costs and increase the percentage of renewable energy generated.

University of Delaware – Assateague Island National Seashore

Partnership Activities and Outcomes: The University of Delaware and Assateague Island National Seashore partnered up again in 2004 to identify and compare alternative options for a distributed energy system for the education center. Software developed by the Center for Energy and Environmental Policy

was used to evaluate the economics, energy contributions and environmental impact of renewable energy technologies. The team found that the renewable resources at the education center were adequate for generating 10% of the building's power. Of the analyzed renewable energy systems, an array of four 300 W wind turbines was found to be the most economical. Together with efficiency measures, the wind power system has a net present value of $67,429 with a payback period of only four years; use of the system would result in lifetime emissions savings of 31.5 tons SOX, 7.7 tons NOX, and 1,996 tons of CO2.

Based on the results, the team highly recommended adopting energy efficiency improvements and renewable energy technologies, and prominently displaying them for educational purposes.

University of Pennsylvania – Independence National Historic Park

Partnership Activities and Outcomes: The University of Pennsylvania teamed up with Independence National Historic Park in 2004 to provide decision support assistance with regards to energy efficiency projects.

One of the decision support tools developed allows users to specify building features (windows) that are connected to a Knowledge Base System (KBS) and integrated with a thermal simulation engine. Based on specific goal requirements for windows such as visual transmission, energy requirements and color, the tool helps locate a set of windows from web-based vendors and/or local databases that best matches these goals. These window specifications are then sent to a thermal simulation engine. The energy consumption results of the simulation using these windows are provided to the user.

University of California-Davis – Death Valley National Park

Partnership Activities and Outcomes: The University of California at Davis partnered with Death Valley National Park to demonstrate an LED hybrid lighting system. The project plan was to provide a high-efficiency lighting system with minimal impacts on the dark sky compared to conventional lighting.

The UC-Davis team identified the sites and locations to install residential, commercial, and pathway grade light fixtures The LED Hybrid Fixture uses 5 watts of LED lighting all night long – costing only about $0.01/night – and 60 watts of incandescent lighting during "occupied" periods. The LED Hybrid has been shown to reduce energy consumption by 53% compared to a CFL, and 87% compared to a standard incandescent fixture. Results are based on 5% occupancy.

The teams' replacement of an incandescent with an LED Hybrid fixture (equipped with a 60-watt incandescent and LED) has resulted in 88% energy savings, as the 60-watt bulb is only used 35 minutes per night on average. Given that electricity at Death Valley costs 18 cents per kWh, use the LED Hybrid results in annual savings of $41.06 in energy costs per light replaced. The annual savings will continue for a decade, as the LEDs are rated to last 50,000 hours—or ten years of anticipated use. The highly-efficient hybrids will pay for themselves long before the LEDs must be replaced, as the payback period is estimated to be only 2.5 – 4 years, depending on the type of aesthetic fixture selected.

Since installation of the LED Hybrids, fixtures have been well received by most residents and rangers. The residents feel the technology is useful and innovative. Further, not only are the energy and cost savings significant, but the dark sky aspects of the hybrid models are very important to conserve the natural state of the park.

2005 - 2006

Humboldt State University – Redwood National and State Parks

Partnership Activities and Outcomes: Humboldt State University partnered up with Redwood National Park in 2005. The HSU and Redwood partnership had the objective of implementing recommendations which were proposed in the 2000 project: a) installation of a hybrid solar electric PV system with hydrogen fuel cell backup to replace an oversized, polluting diesel generator at ranger stations near Espa Lagoon, and b) the replacement of solar systems at the Gold Bluffs Beach Campground bathroom.

Project activities included updating the existing system designs, acquiring equipment, installing the energy systems and, as an additional educational component, training park personnel in the use and maintenance of the equipment. Based on performance measurements and considering the available solar energy resource (corrected for shading), the PV system is expected to produce an average of 2.25 kWh per day. After completing the project and considering efficiency and transmission losses, the PV portion of the hybrid PV/Hydrogen Fuel cell system is expected to provide an average of 1.49 kWh per day, 38% of the measured load at the facility.

South Dakota State University – Wrangell-St. Elias National Park

Partnership Activities and Outcomes: South Dakota State University partnered up with Wrangell-St. Elias National Park for the design, acquisition and installation of a hybrid PV system at the park's West McCarthy site.

As in previous SDSU projects, the project is in conjunction with a course at SDSU which teaches students to design and install a PV system. The SDSU team successfully installed the hybrid PV system in July 2006. The system includes a 8.7 kW PV array, an 8-kVA LPG-fired engine-generator set, two 4-kW inverters providing 120/240V AC output, and approximately 2.5 days worth of battery storage. Initial indications were that the system exceeded its performance expectations.

The PV system will decrease generator runtime and diesel fuel usage, benefiting the park's pristine natural environment. As an additional public educational component, the SDSU partners developed a web site describing the project and outcomes.

James Madison University – Shenandoah National Park

Partnership Activities and Outcomes: James Madison University partnered up with the NPS and Shenandoah National Park in 2005 and the projects included: 1) production, testing, and acquisition of biodiesel fuel for use in Shenandoah equipment, 2) the production of a hybrid biodiesel all-terrain vehicle, and 3) the study of the applicability of a fuel cell system for auxiliary power at Shenandoah's air quality monitoring station.

A fully functional vehicle was created that was proven to work successfully under light-duty conditions. The fuel cell project was modified to include design and development of a $1/10^{th}$ scale model fuel cell with prospects of actually implementing the fuel cell project at Shenandoah.

Georgia Institute of Technology – Jimmy Carter National Historic Site

Partnership Activities and Outcomes: GIT and Jimmy Carter partnered up in an effort to assist Jimmy Carter National Historic Site in meeting energy use and cost reduction goals.

The project activities included conducting on-site energy assessments, developing a building energy baseline, developing energy conservation measures, analyzing the economics of identified opportunities, providing an energy characterization of park facilities, and identifying energy saving opportunities.

In August 2006 the team provided site reviews for three facilities. Due to the extremely small size and small energy consumption related to two of the analyzed facilities, most of the effort was directed towards the Plains High School building—the park's meeting and welcome center. Data was collected in each of the following areas: utility billing; operating schedule; HVAC equipment; lighting; and, building construction (materials, windows and doors). The data was input into DOEs EQuest 3.6 building simulation software in order to model the baseline operations of the building and to evaluate ECM opportunities.

The recommended energy conservation measures were 1) replace incandescent bulbs with higher efficiency bulbs, 2) replace incandescent bulbs in exit signs with LED bulbs, 3) replace florescent fixtures, 4) install occupancy sensors, and 5) combine electric meters. Together these identified ECMs would save $3,626 annually, or 18% of the annual utility bill, with an average payback period of less than 2.5 years.

Rochester Institute of Technology – Women's Rights National Historic Site

Partnership Activities and Outcomes: The Rochester Institute of Technology and the Women's Rights National Historic Site partnered to conduct an energy audit of existing buildings and building envelopes. Identified energy conservation measures will be grouped to distinguish between short-, medium- and long term improvements and investments.

As additional educational components: a) the students will prepare an academic paper detailing the experiential education aspect of the project to encourage using students to assist in energy conservation projects for the public sector; and b) the results of the energy conservation measures will be tracked in future energy management and policy coursework to demonstrate the value of conservation. This project is on-going.

Rutgers University – Morristown National Historic Park

Partnership Activities and Outcomes: Rutgers University partnered with Morristown National Historic Park to perform an energy audit of park facilities.

The project objectives included energy and water audits at fifteen park structures, with a focus on pollution prevention through improving energy efficiency and water conservation. The university team interviewed park personnel, examined utility bills and blueprints, and performed multiple onsite visits to perform a comprehensive audit. Once completed, the Rutgers team prepared a feasibility study for improved energy and water efficiency and use of renewable energy, which identify opportunities for public energy conservation education.

The Rutgers came up with six primary ECM recommendations, including: 1) exit sign LED retrofits, 2) installation of occupancy sensors, 3) radiator reflectors, 4) replacement of lamps with higher efficiency equipment, 5) insulation of water pipes, 6) insulation of windows. Together, these identified ECMs would result in annual savings of 5,271 kWh, over 19 million Btu, nearly 5,000 lbs of CO_2, and $1,192, with an average payback of less than 1.5 years.

The team also provided additional recommendations, including 1) conserving water with a Dual Flush System in toilets, 2) replacing windows opportunistically, 3) finding and sealing air leaks, 4) installing attic fans and a house fans to promote air circulation, 5) water conservation tips such as fixing leaky faucets, using brooms to clean driveways instead of hoses and using shower heads with flow restrictors, 6) installing a solar PV system at Jockey Hollow visitor center, and finally 7) insulating structures.

University of Washington – Ebey's Landing National Historic Reserve

Partnership Activities and Outcomes: The University of Washington partnered up with Ebey's Landing National Historic Reserve to study opportunities for solar power at Ebey's Landing, as well as the design, acquisition and installation of a solar PV system at the Reserve. Once installed, the system will be monitored and its performance evaluated.

For the most straightforward design and installation, the team selected a grid-tied five-panel solar PV system rated at about 1 kW. The system was chosen as it is expected to be nearly maintenance free, and will permit the park to generate some of the electricity its uses, gain experience and knowledge on solar energy use for EBLA, and showcase solar PV for the farms, citizens, and visitors of Ebey's Landing.

Given the relatively low rainfall (18 inches per year), one expects fairly good sunlight and collection of solar flux on the flat panel collectors therefore making EBLA well suited for solar energy. The library at the Au Sable Institute was chosen as the site for the PV system. The PV panels were mounted on the south facing roof, with the electrical components (including a DC to AC inverter (white), DC circuit breaker, AC circuit breaker, and meter) installed on the northeast side of the building.

The system is expected to generate 1257 kWh annually, or 105 kWh monthly on average. In the first—generally overcast—month of operation, the EBLA system generated 94 kWh of electrical energy, indicating that the system is working as expected.

University of Washington – Golden Gate National Recreation Area

Partnership Activities and Outcomes: The University of Washington and Golden Gate National Recreation Area partnered up to implement an alternative energy system on Alcatraz Island. Several years ago, the ocean-floor electrical cable connecting Alcatraz Island to the mainland grid was severed. The project's main focus is to design a renewable energy based electrical generation system to replace the current system of diesel generators that Alcatraz Island has been dependent upon since the cable was severed. The team is considering a PV system, a tidal turbine system or some sort of hybrid system to replace the current system. This project is just getting started.

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