PolarPower.Org – Sharing knowledge about power systems for polar regions

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***Abstract*— Designing power systems that will function well in remote polar environments can be a complicated task. Engineers often must use creative approaches to fulfill requirements. Learning from the successes and research of others can help to avoid problems with inadequate or faulty systems.**

The US National Science Foundation (NSF) sponsors scientific research throughout the Arctic and Antarctic within the Office of Polar Programs (OPP). The OPP has taken action to facilitate the dissemination of information through the sponsorship of a Website (http://PolarPower.Org) that allows the wider polar community to establish a foundation of knowledge, share experiences, and stay current on technological developments.

PolarPower.Org offers descriptive write-ups and white papers, including an "examples" section describing systems successfully deployed, "links" to facilitate information searches, and an "events" page for announcements of upcoming meetings and exhibits. A dynamic "Wiki" section allows contributors to share their deployment experiences, alert others of new technology, or get questions answered by their peers or outside experts. It is intended to be a useful resource for the polar technology community. Contributions are solicited and welcomed.

***Index Terms*—information sharing, polar power, Website**

I. Introduction

THE US National Science Foundation (NSF) sponsors scientific research throughout the Arctic and Antarctic within the Office of Polar Programs (OPP). Research and logistical support systems must operate reliably within the harsh environment of the polar regions for this work to be successful. Most commercially available equipment has not been designed to meet these environmental extremes and past attempts to protect equipment have met with mixed levels of success.

The OPP was anxious to avoid the loss of research data due to power system failures and the costs of duplication of efforts in discovering effective methods of operation. VECO Polar Resources, as contractor for the Arctic Research Services and Logistic Support program, was tasked with developing a Website that would become a useful resource for researchers in choosing, designing, implementing, and maintaining remote power systems in polar environments. Expanding on that charter, **PolarPower.org** (http:polarpower.org) exists to afford the wider polar community, including the public, with a means to establish a foundation of knowledge, share experiences, and stay current on technological developments. Much can be gained from the empirical knowledge possessed by the residents of the polar regions and learned from commercial and government projects.

PolarPower.org contains sections devoted to specific power technologies, including descriptions of systems that have been successfully deployed in polar regions. Supporting technologies are also covered, to address other considerations in a complete system design. A section of Internet links facilitates information searches to related Websites. A calendar of events lists upcoming meetings and exhibits of potential interest. Contributions are solicited and welcomed from anyone with non-commercial information to share. Limited document formatting assistance can be provided by the the VPR support team. A less formal "Wiki" section allows contributors to share their deployment experiences, alert others of new technology, or get questions answered by their peers or outside experts. Significant knowledge can be learned from what has been unsuccessful as from what has succeeded.

II. Power Technology Areas

The Website has been launched with the six power technology areas summarized in Table I. More technologies will be added as contributions are received. These technologies, as applied to remote power systems, have sections devoted to general introductions, the applicability to small to large implementations, product reviews, and tutorial. Interactive engineering calculators will be included in the future. Icons for each technology are used uniformly throughout the Website to help the visitor to readily identify areas of potential interest. Some sections include extensive white papers that discuss the technology choices and deployment options. Results of cold temperature battery capacity testing conducted by UNAVCO are an example of contributed information that is included in the section devoted to power storage elements. A technique for the electronic control of wind turbine speed, to avoid runaway conditions in high winds, has been contributed by the British Antarctic Survey.

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TABLE I
POWER TECHNOLOGY AREAS

Symbol	Description
	Engine - Internal combustion engines are a proven technology used worldwide. A wide selection of fuels is available, depending on the application.
	Fuel Cell - A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity. The process is clean, quiet, and efficient. A byproduct of the process is water, however, which can be a problem for deployments in a polar environment. The technology is still in its infancy, but commercial products are becoming available.
	Hydroelectric - Small scale turbines can provide a source of electricity at sites where water can be found in a liquid state for at least part of the year.
	Solar Electric (Photovoltaic) - Cells made up from two or more layers of semiconductor material can produce electric power when excited by photons. The sun is a major source for such photons, but the process also works for other sources of light. Cells may be stacked into arrays to meet different voltage and power requirements.
	Storage - Primary and rechargeable batteries are often used as a site's sole source of power or in conjunction with one or more of the available power generation technologies to provide a reservoir of continuous power to the load. Flywheels and ultracapacitors are new technologies that are finding their way as a replacement for rechargeable batteries.
	Wind - Wind-powered turbines are a clean source of power. Special problems arise with a moving mechanical device in polar regions prone to ice formation and high wind velocities. Mounting structures also provide challenges for systems that may be located on ice fields well above solid ground.

III. Technology Deployment Examples

Examples of successfully deployed systems, utilizing a wide range of power technology, are available on the Website. These write-ups have been received from a broad field of international contributors, representing government research agencies, universities, and non-profit organizations. Typically limited to a single page, these write-ups contain a short description of the power system and the specific technologies employed. Some examples only utilize a primary battery as a power source. Larger systems often utilize multiple power technologies. Brand names and model numbers for system elements are encouraged to be included to provide a benchmark for anyone considering using the same or similar elements. Photographs of the system and/or its siting are included, when available, to assist in describing the site and its deployment. Links to more extensive documentation, including project Websites, are included when available. Most importantly, a point of contact for each of the systems is included to allow interested parties to correspond for additional information that may be of interest to other deployments.

An example of a deployment write-up appears in Figure 1. This describes the system deployed at Camp Raven on the ice cap of Greenland. In this case, system details of the components are not included in the description because a more detailed document can be downloaded in Adobe PDF format. The system schematic, contained in that document, appears in Figure 2.

Fig. 1. Screen capture of Camp Raven deployment example

A photograph showing the power and equipment shelter, solar array, and wind turbine installed at Ivotuk, Alaska, is presented in Figure 3. A detailed document describing this system is linked to the system's descriptive page.

IV. Supporting Technology

Technologies not directly related to power generation and energy storage are useful in the development and deployment of systems in polar environments. The **PolarPower.Org** Website contains sections for sharing knowledge about these technologies. Table II lists areas presently supported by the Website. The amount of power consumed by these support elements can be important in successful system deployments.

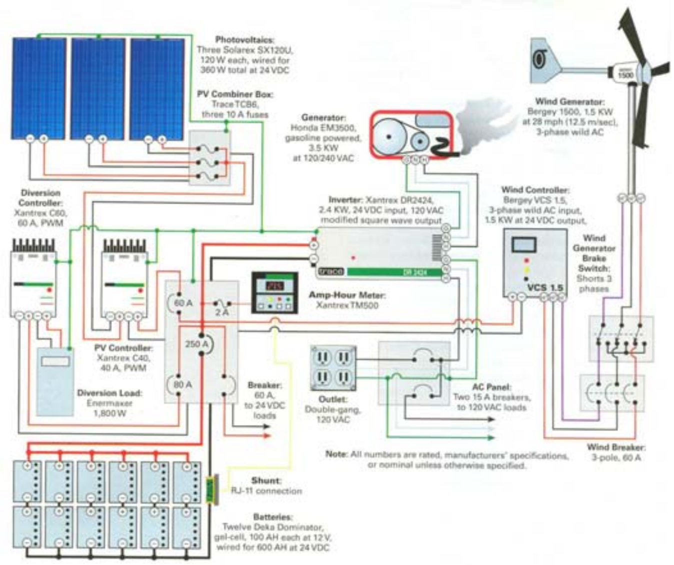

Fig. 2. Schematic diagram of Camp Raven power system

Fig. 3. Power system deployed at Ivotuk, Alaska

Communications systems can be used as a permanent part of the deployed system or just for liaison and support during field deployment or maintenance trips. In choosing a communications system, it may be possible to achieve lower total energy consumption by using a higher powered system that operates for shorter periods of time. Data showing total energy consumption to transfer typical data blocks is given for a few system examples. Examples of interconnections between data collection systems and communications equipment is also included.

Computing is important in almost every aspect of data collection in the polar regions. With more sophisticated instrumentation being deployed or the rise in need for real-time data transfers, computers with more functionality are in demand. Documentation on systems being deployed can inform others on what's been successful.

V. Reference Links

The **PolarPower.Org** Website contains a section with links to other sites that have been identified as containing potentially useful reference or product information. Three major subgroups are (1) government and non-profit organizations, (2) Industry groups and vendors, and (3) books, periodicals, and software.

TABLE II
AREAS OF SUPPORTING TECHNOLOGY

Communications – Overviews of systems that are available for voice and/or data communications in high latitudes are presented. Geostationary satellite systems can be used up to about 74° latitude. Polar orbiting satellites extend the coverage to the poles, but at a degraded throughput. Terrestrial systems can extend communications connectivity where infrastructure might exist at inhabited sites.

Computers – Permanent and transitory systems are included. Full-time dataloggers are needed for the acquisition, storage, and transfer of measurement data. Low power single board computers applicable to more complex calculations, processes, and protocols are discussed. Measurements of power consumption for selected laptop computers are presented to allow users to make informed choices in this common tool used during field trips.

Deicing – Techniques for keeping instrumentation and other components free from ice are described. Often, this includes information on electric heaters.

Enclosures & Insulation – Instrumentation and battery enclosures are critical in providing a controlled environment when ambient temperatures drop below equipment operational specifications. Information on foam and vacuum insulation systems is provided.

Ice Detectors – To conserve energy resources at remote sites, it is useful to apply deicing techniques only when icing conditions exist. Instruments for measuring icing conditions are described.

Instrumentation – The measurement of power consumption may take place in the lab or on-site. Some tools that have been found useful for measuring and logging power consumption are discussed.

Timers – Short duty cycles are often used to conserve battery power. Reliable, low power timers are needed in locations where more sophisticated dataloggers and computers aren't justified.

Towers, Anchors, & Hardware – Strong, lightweight structures are needed to support instrumentation, power sources, and antennas. Base conditions vary widely in the polar regions and approaches to hardware and anchors are shared.

Webcams – Once a day or continuous visual monitoring of a remote site can be useful in interpreting data reports. It is also of high value to pilots who use it for planning flights to these sights not normally supported by weather observations.

VI. Event Calendar

A calendar of events relating to power components and systems is kept updated for reference. The listing is international in scope and includes technical meetings, workshops, and exhibits. Links to the host sites are included.

VII. Wiki

Informal exchanges of information from the polar power community are encouraged. A Wiki section allows for registered users to post information on their work and discoveries. Little knowledge of Website formatting is required to make entries. Links to more extensive reference material can be included. A discussion of findings and decisions is possible, as a means of sharing knowledge about things that work or don't work.

VIII. Conclusion

PolarPower.Org has been established as a vehicle for the exchange of information that will contribute to more successful power system deployments in polar regions. While initiated to assist researchers deploy more reliable and survivable systems, the information content is available to the public via a Website. Much can be learned from documented cases of equipment and techniques that have worked in the past. Equally important are descriptions of what has had no or marginal success in this difficult environment. The white papers and case studies can assist developers considering new designs. Experienced system developers can serve as mentors to others through contributions to the Website.

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