Presentation Overview

- PolarPower.Org Website
- User System Survey Results
- System Deployment Categories
- Communications Options
- Design Tradeoffs
- NSF’s Arctic Logistics Support
Website on Power Systems for Polar Deployment

About the Site

PolarPower.org is hosted by Valora Sciences Foundation with the goal of providing a useful working resource for researchers in choosing, designing, implementing, and maintaining remote power systems in polar environments. The site will allow the polar research community to share knowledge, best practices, and new data relating to remote power systems.

The development of this site was a direct result of recommendations from the "999 Alternative Systems in Extreme Environments Workshop and the 2001 Renewal Energy Working Group Yearly Workshop."

Series of PDFs offering detailed discussions of available technologies, determining suitability, design and implementation considerations

- Topics such as...
  - Solar
  - Wind
  - Engine Generator
  - Electrical Fundamentals

Remote Power Technologies – Reference Papers

Components

PV Panels

PV panels tend to work much better in cold weather than in hot climates (except for amorphous silicon panels). Add a reflective snow surface and the output can sometimes exceed the rating for the panel. Array currents up to 20% greater than the specified output have been reported (1).

In general, PV materials are categorized as either crystalline or thin film, and they are judged on two basic factors: efficiency and economics. For remote installations where the actual space available for PV panels is often quite limited, the greater conversion efficiency of crystalline technology seems to have the advantage. It is also worth noting that the conversion efficiency of thin-film panels tends to drop off rather rapidly in the first few years of operation. Increases of more than 25% have been reported. This performance deterioration must be taken into account when sizing the array for a multi-year project. However, there are still applications where the lighter weight and greater flexibility of the thin-film panels may be more suitable. Which PV technology is more appropriate for a given application will need to be determined on a case-by-case basis.

Monocrystalline silicon panels should be utilized when a higher voltage is desirable. This would be in an instance where the DC power has to travel some distance before being utilized or stored in a battery bank. These panels are also the most efficient PV technology, averaging 14% to 17%. New technology charge controllers, which allow for higher array voltage than the battery bank voltage, somewhat obviate the advantages of the monocrystalline panels.

Poly-crystalline silicon panels have efficiencies of 12% to 14%. 
Case Studies as Examples

- Existing deployments as examples of the technology used
- Seeking additional write-ups
  - Systems
  - Components
    » Power Drain
    » Temperature Range
  - Lessons learned
  - Other?
Discussion Forums

- Researcher-driven discussions on remote power technologies

Polar Technology Conference         23-4 April 2005
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Verify Component Specifications

- Proven WT600 Wind Turbine
  - 600 Watts nominal
  - 700 Watts max
- 30-Amp breaker tripped during wind event in December 2004 at 38 Amps measured
  - Replaced with 50-Amp breaker in March 2005
Data Throughput vs. Average Power

October 2002 Survey Results
Data Throughput vs. Average Power (Power Class)
Data Throughput vs. Average Power (Satellite Comms)

![Graph showing data throughput vs. average power for satellite communications, with two regions labeled LEO and Geostationary.]

- **Data Throughput (kB/Day)**: Ranges from $10^0$ to $10^7$.
- **Average Power (Watts)**: Ranges from $10^{-2}$ to $10^5$. 

The graph compares data throughput to average power for LEO and Geostationary satellite communications.
**Small System**

- Single tower deployment

- Battery bank as primary power source
  - < 3 Watts average power
  - Photovoltaic array or wind turbine as secondary source

- Low data throughput requirement
  - Daily data & status report

- LEO satellite communications service
  - Iridium
  - Argos
  - Orbcomm

- Geostationary satellites
  - GOES
**Medium System**

- **Generator in shelter**
  - 3 to 300 Watts average power
  - Some thermal management
  - Fuel storage

- **Moderate data throughput**
  - Updates hourly or more often
  - Remote monitoring and system control

- **Geostationary satellite communications system**

- **Need smaller system for easier deployment**
  - Modular elements to increase capacity
Large System

- Permanent Camps
  - Summit Camp
  - Toolik Lake

- > 300 Watts Average Power
  - Multiple generator systems
  - Major refueling logistics

- Large data communications needs
  - Data transfers
  - E-mail
  - Weather
  - Logistics planning

- Geostationary satellite Internet access or scheduled polar-orbit satellite service

- WLAN within camp
Iridium Satellite Service

- Low Earth Orbiting (LEO)
  - 66 active satellites

- Global coverage
  - Always in view
  - Concentration at the poles

- Voice and data
  - 2400 bps
  - Full duplex

- Service cost (commercial)
  - $30.60 / month plus
  - $1.02 / minute
Iridium Satellite Service (cont’d)

- Rugged (voice and) data transceiver
  - $1,200 transceiver
  - $260 omnidirectional antenna & cable
  - $150 AC power supply
- 3 Watts transmit power consumption
  - Datalogger can switch power to unit for power conservation
- Serial data interface to instrumentation
  - Simple subset of a Data Transport Network
  - Short Burst Data
- Techniques for enhanced data handling
  - Bonding for higher data rate
  - DoD unlimited access SIMs (20 MB/day)
Iridium Communications Parameters

- ISU to ISU connection; Master and Slave co-located
- Variable ZIP file size to 70 KB; protocol overhead added
- Transfers every 5 minutes
- Dialing time is significant to connection time, affecting throughput
Iridium Communications Parameters (Cont’d)

- Dial-up connection time significantly impacts datarate
- "Flattening" at about 35 KB
StarBand Satellite Service

- Geostationary
  - Telstar 7 (129° W)
  - AMC 4 (101° W)

- No service above 72° Latitude
  - Large dish required in Alaska
  - Low look angles
  - Susceptible to icing

- High on-demand data rates
  - 500 kbps downlink
  - 80 kbps uplink
StarBand Satellite Service (cont’d)

- **Commercial service**
  - $150 / month (2 year contract)
  - Always on service
  - 500 MB / week upload limit
    » 6.6 kbps average limit for “good neighbor”

- **Commercial hardware**
  - $600 modem
  - $200 – 1000 dish (1.2 – 1.8 m)
  - Certified dish installer required
  - 0° to +50° C operating range

- **Model 360**
  - *Required a PC w/ Windows OS*
    » Virus and Worm attacks
  - 27 Watts + PC power

- **Model 480Pro**
  - *Built-in 4-port router*
    » Controlled communications interface
  - 20 Watts
StarBand Data Transfer Rates

- **Downlink:** 390 kbps
- **Uplink:** 74.5 kbps
StarBand Network Parameters

- **Channel Capacity**
  - Diurnal and Weekly load variations
Terrestrial Packet Radio Network

- Traditional relay network (i.e., packet forwarding)
- Initial deployment costs
- Routine maintenance as a recurring cost
- Star network topology is common
FreeWave ISM Band Transceivers

- **ISM Band Spread Spectrum**
  - 902 – 928 MHz
  - 7 hopping bands

- **Data Rate**
  - 38.4 or 115.2 kbps
  - RS-232/422/485 or Ethernet interface

- **Programmable Power Consumption**
  - 0.1 to 1 W transmitter power
  - 6 W maximum while transmitting
  - 72 mW in sleep mode
  - 6 to 30 VDC input range

- **Environmental**
  - Temperature: - 40 to + 75°C
  - Ruggedized
  - Waterproof version available

- **Cost**
  - ~ $800
WERC’s Upper Kuparuk Network

- Network of monitoring stations
  - Predefined relay topology

- Relay site on Slope Mountain
  - 27 km link

- StarBand gateway at Sag River
  DOT Maintenance Station
Network Topology Extension

- Topography dictates whether links might succeed
- Earth curvature is significant on long links
- Lower frequencies will propagate better
- Range is inversely proportional to data rate
Peer-to-Peer Packet Radio Network

- Mobile Ad-Hoc Network (MANET) protocols
  - Alternate routing for reliability and load sharing
  - Self-reconstituting for dynamic conditions
- Mostly practical in dense, mobile network
StarDot Technologies Netcam

- Rugged design
- Internal Web & FTP servers
- Standard: 640 x 480 max
  Megapixel: 1280 x 960 max
StarDot Technologies Netcam (Cont’d)

- Robust sensor resists burning with direct view of the sun
  - Any polar deployment will view the sun during some part of the year
  - Gradual burning of red solar arcs
- Internal Boa Web server hangs on StarBand (long delay) links
- Slow exposure adaptation
Netcam MP Problems

- Internal DC/DC converters will lock to others causing power supply ripple that is visible in the image
  - MP CCD is very susceptible to noise on negative supply
  - Requires addition of additional capacitors (1000 µF)
  - “Only happens at remote locations”
- Red blooming in bright sun
Slow Scan Webcam Test on StarBand Model 484

- Sony SNC-RZ25N Network Camera
  - MPEG-4 compression for streaming video
  - 12 W static; 6 W more during PTZ operations
- Approximate frame rate:
  - 3 fps for 640 x 480 image size
  - 6 fps for 320 x 240 image size
- Needs NAT buffer on long delay StarBand link
Rugged, Flexible Processor Systems

- Control & Data Acquisition
  - Sensor system
  - Power system
  - Communications system
  - Thermal control

- Single Board Computers
  - Rugged
  - Low power
  - Powerful as laptop
Ethernet Interfaces Becoming Common

- Common bus with wide IP address range
- Interfaces to other buses
  - Serial
  - Web
- Caution with power requirements
  - Intended for high speed data transfers

Newport iServer

Lantronix XPort
USB Bus Data Acquisition

- Simple Data Acquisition Systems
**NSF’s Arctic Logistics Support through VPR**

**Who Qualifies?**

- Primarily Arctic Program, but support given to other OPP, non-Polar directorates within NSF, and even non-NSF agencies
- 2004 support (over 100 projects)
  - NSF/OPP - 63%
  - Other NSF – 18%
  - Other US gov’t (mostly NASA) – 8%
  - Foreign Funding Agencies – 9%

**NSF’s Arctic Logistics Contractor:**
VECO Polar Resources

- Collaborative effort
  - **VECO, USA** – Contract lead & management, construction, engineering
  - **Polar Field Services** – Project planning, field management and logistics
  - **SRI International** – Communications
- Funded through NSF’s Arctic Research Support and Logistics Program
Areas of Support
- Field Camps & Gear
- Air & Ground Transport
- Cargo Movement
- Safety & Remote Medical
- Polar Technologies
  - Construction & Engineering
  - Communications
  - Power Systems

Locations
- Alaska
- Greenland
- Canada
- Russia
- Arctic Ocean
- Northern Europe

How to get support?
- Contact VPR (www.vecopolar.com)
- Obtain support letter/logistics estimate to include in your NSF proposal
- Non-NSF support determined with Simon Stephenson, NSF Arctic Research Support and Logistics Program Manager, on a case-by-case basis and may include interagency funds transfer or cost-reimbursable support