USAP Proof of Concept Projects
Dick Armstrong, PE
John H. Rand

• LED Greenhouse Lighting
• LED Cold Location Lighting
• Solar Garage
• Capacitor Batteries
• Solar Voltaic
• Solar Thermal
• Plyboo Furniture
• South Pole Solar Camp
South Pole Food Growth Chamber

• Parameters controlled:
  – 14 hours high PAR **lighting**
  – 1,000 PPM **CO2**
  – 60% **RH**
  – 23-25 Deg C daytime
  – 22-24 Deg C evening
  – **PH** 6.3 water
  – **Nutrient** levels
South Pole Test Layout
## Comparing Light Sources

<table>
<thead>
<tr>
<th>Light Source</th>
<th>LER</th>
<th>Lm/W</th>
<th>K factor</th>
<th>Delivered µmol/W</th>
<th>Lamp Life (hrs)</th>
<th>Estimated Total Energy used</th>
<th>Estimated Energy Savings</th>
<th>Estimated gallon of fuel saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS (400W)</td>
<td>67%</td>
<td>130</td>
<td>0.012</td>
<td>0.65</td>
<td>16,000</td>
<td>13 kW</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>LSGC Grow (50W*)</td>
<td>88%</td>
<td>50</td>
<td>0.024</td>
<td>1.25</td>
<td>50,000</td>
<td>6.8 kW</td>
<td>6.2 kW</td>
<td>1,967</td>
</tr>
</tbody>
</table>

*Can be scaled up to any wattage with similar efficiency.*
## Comparison

<table>
<thead>
<tr>
<th>Input Wattage</th>
<th>66</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR [µmol]</td>
<td>92.71</td>
<td>66.25</td>
<td>70.51</td>
</tr>
<tr>
<td>PAR/W [µmol/W]</td>
<td>1.4</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>YPF [µmol]</td>
<td>72.05</td>
<td>49.72</td>
<td>61.20</td>
</tr>
<tr>
<td>YPF/W [µmol/W]</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Color Temp. (CCT)</td>
<td>1,509</td>
<td>3,050</td>
<td>3,826</td>
</tr>
<tr>
<td>CRI</td>
<td>-181</td>
<td>69</td>
<td>74</td>
</tr>
</tbody>
</table>
Cold Space (-60F) LED Lighting

- Changed all incandescent to Lighting Science Group Inc (LSGI) LED in Storage Arch
- Changing snow tunnel lights to LED
  - Some brands pulsed on and off till warm
  - Found one brand that did not pulse
  - Operate and start with -60F ambient
- Reduced energy 130 W to 18 W per lamp
- One year savings at Storage Arch:
  - 4.2 kW demand
  - 2,812 Gallon/year generator fuel
  - $58,389/year saved
Solar Garage

- Under test at Fairbanks, Alaska
- Cost under $25,000
- Various sizes available
- Modular sizing approach
- Translucent fabric structure
- Investigating new material for low temperature handling, fire resistance, insulation quality (R-8)
- Aluminum tubular frame
- Outer fabric would be clear UV resistant
- Inner heater fabric would be black
- Utilizes convective, conductive, and radiant heat transfer
- Black rubber matting on floor absorbs heat and radiates up
- Twelve inch thick SIP panel insulates floor
Advantages

• Install in <1 hour with 3-4 people
• Fabric and frame weighs less than 100 lbs ea
• Two packages carry entire structure
• No electricity needed
• No tools needed
• Can accept external heater if needed
• Summer time application with sun only
• Insulated floor
Applications

• Equipment storage garage
• Shelter for equipment inspection/repair
• Temporary storage (C-130 engines)
• Emergency garage for traverse/equipment repairs
• Science staging shelter
  – McMurdoo science staging
  – WISSARD equipment staging
• Construction sub assembly and staging
• Temporary office
Install Fabric over Frame
Connect two halves of fabric
Stitch two halves together
Two halves assembled
Fairbanks Test Build Unit
Garage with Radiant Heaters
Garage with radiant panels
Fairbanks Plotted Data

Temperature (degrees F)

-60 -40 -20 0 20 40 60 80 100 120 140

2-Mar-12 7-Mar-12 12-Mar-12 17-Mar-12 22-Mar-12 27-Mar-12 1-Apr-12

75 Deg F Rise Observed at +12’
50 Deg F Rise Observed at Floor

Floor
Alarm
12ft
Ambient
Capacitor Batteries

- Cycle life > .5 million vs <1,000 for lead acid
- No problems with cold temperatures (-40F)
- Much lighter (1/5 as heavy as lead acid)
- Recharge time 0.5 minutes vs. 8 hours
- Shelf life unlimited
- Very low self discharge rate
- High Power / short term
- Excellent potential hybrid system with battery
Capacitor Battery
Hybrid Installation

- Capacitor with lead acid battery hybrid
- Produce 1200 Amp at very low temperatures
Potential Applications

• Grid stabilization
• Start up assist with electric vehicles
• Start up booster for large engines
• Lightweight, portable booster battery
• Aviation starter battery
• Emergency battery/power source
Solar Voltaic

175 Watt Sharp Panels at South Pole 2-year daylight stats:
- North: 9.68 kWh/week
- South: 10.38 kWh/week
- East: 10.45 kWh/week
- West: 8.69 kWh/week
- Horizontal: 9.28 kWh/wk
Solar Thermal at Pole Summer Camp

• Installed 4 panels
• Application will work
• POC had not been commissioned:
  – Control problems
  – Dumping heat down water well
  – Plumbing issues
Plyboo Furniture

- Sustainable Bamboo materials
- Steam pressed to form plyboo plywood
- No or very low VOCs
South Pole Solar Camp POC

- Seven single status bedrooms
- Connected to grid
- Generates more power than used
- Slab heat system
- Solar thermal heating
- Solar voltaic power generation
- Passive solar lighting
- On skids, towable