Solar Thermal Radiant Heating at Pohakuloa Training Area

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Technology Transition – Supporting DoD Readiness, Sustainability, and the Warfighter
# Solar Thermal Radiant Heating at Pohakuloa Training Area

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Energy Situation in Hawaii

- Electricity rates for Pohakuloa Training Area were $0.26/kWh in 2009 and $0.35/kWh in 2008.

- In remote locations such as Hawaii, fossil fuel must be imported, resulting in:
  - High utility prices
  - Security risk for transportation.

- Hawaii Electric Light Company (HELCO) imports oil as majority fuel source:

<table>
<thead>
<tr>
<th>Fuel Sources</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>68.0%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>18.8%</td>
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<tr>
<td>Hydro</td>
<td>2.9%</td>
</tr>
<tr>
<td>Wind</td>
<td>10.3%</td>
</tr>
</tbody>
</table>
Pohakuloa Training Area

• Pohakuloa Training Area (PTA) is a military training complex for soldiers and marines.
  – Hosts up to 2,000 +/- at one time
  – Can host up to 75,000 +/- personnel in a year
  – Largest DoD Live Fire Training installation in Hawaii

• Located in a rural area between two volcanic mountains.
  – Near the center of the island of Hawaii
  – Approximately 6,800 ft elevation (PTA Base Camp)
  – Temperatures can drop below freezing at night

Photo caption: A 25th CAB CH-47D Chinook helicopter lifts one of 28 “EOD-T” targets for placement at one of several ranges at PTA for live-fire training.
PTA Billet Buildings

• Newly constructed Billet Buildings sleep 60 people each:
  – Each building is 2,000 square feet
  – Heating and cooling is provided with electric heat pump
  – No water; latrines are provided in nearby separate building.

• Solar thermal radiant heat flooring project will combine solar thermal hot water system with in-floor radiant heating.
  – Flooring heat only; no domestic water.
  – Flat plate collectors combined with water storage tank will collect and store the sun’s energy during the day.
  – System will provide heat to Billet Building 227C at night.

PTA Billet Buildings 227A, B, and C
What IS a solar thermal radiant heat flooring system?

- Main components are solar collectors, a storage tank, radiant heat emitter (flooring system), circulation pumps, thermostat, electronic controls, and a heat dissipator.
- This system could be modified to include domestic water heating.
System Design Approach

• Step 1: Determine the peak hourly load for the building in BTU/hr.
  – Based on expected lowest outside temperature.

• Step 2: Determine the thermal storage required for the highest calculated daily load in BTU/day.
  – Use local weather data and energy modeling software.
  – Peak hourly load is summed over 24 hours.

• Step 3: Size the solar collector array.
  – Use BTU/day calculated in Step 2.
  – Use solar collector rating output in BTU per day.
  – Determine number of collector panels necessary.

• Step 4: Choose the system type.
  – Options include open loop, closed loop, drainback, etc.
System Design Approach (continued)

• Step 5: Plan the array layout.
  – Options vary depending on system type (closed loop, etc.).
  – Layout determines plumbing configuration.
• Step 6: Size the storage tank and heat exchangers.
  – Amount of fluid and storage tank size can be calculated.
  – Heat exchanger only required for domestic water heating.
• Step 7: Size and select the floor heating system.
  – Using peak hourly heat load, determine circuiting of heated water tubing and floor panels (loop layout).
• Step 8: Size the pump skid and ancillary equipment.
  – Calculate head losses and flow rate to size pump(s).
  – Select expansion tank, relief valves, check valves, heat dissipation equipment, etc.
Daily Thermal Storage Calculations

• To determine the daily thermal storage for heating systems (Step 2), need to use energy simulation model such as Trane TRACE™.
  – TRACE is a design/analysis tool for HVAC professionals used to calculate peak cooling and heating loads, evaluate energy savings, and optimize the design of HVAC systems.

• Model requires local weather information files.
  – Called TMY2 files, these are data sets of hourly values of solar radiation, temperature, humidity, and cloud cover for a 1-year period.
  – Produced and published free by National Renewable Energy Laboratory (NREL).
  – TMY2 files are often applicable for a large area.
PTA TMY2 Data File

• Hawaii Island has 12 distinct climate zones, but no TMY2 data file for PTA.
• Because there is no TMY2 data file applicable for the micro-climate at PTA, a unique TMY2 data set had to be created.
• TMY2 data compiled from two sources:
  – Solar radiation data came from a State University of New York (SUNY) model for nearby Bradshaw Army Airfield at PTA.
  – Weather data came from one of four small weather stations on PTA grounds monitored by PTA firemen.
      ➢ PTA Range 17 station is closest to site location and elevation.
      ➢ Data only recorded for one year at time; most TMY2 data files are averaged over multiple years.
PTA TMY2 Data File (continued)

PTA Solar Data

• Using the SUNY data mean estimate for each hour gives average solar radiation = 481 cal/cm²/day.

PTA Weather Data

• PTA Range 17 data was compiled and minor data gaps were filled in by interpolation.
• A pivot table was created to summarize the 8,760 hours of data into monthly “Design Days”.
• Next, data was formatted and SUNY solar radiation data was added.
• MS Excel file was turned into text file, then converted to TMY2 file for input into TRACE.
PTA Heating System Design

• Data loggers are currently in place at PTA to record indoor and outside temperatures and relative humidity.
  – More data loggers will be added, including solar radiation measurement.
  – Additional data will be used to validate PTA TMY2 data file.
  – If successful, we may be able to publish this TMY2 data file.

• After creating TMY2 file, TRACE output for coldest month showed a daily heating load of 256,000 BTU/day.
  – First calculations for thermal storage were based on a 75 °F space set point and an average low temperature of 32.4 °F.
  – Revised calculations are based on a 70 °F space set point and an adjusted low temperature of 23 °F.
  – The peak design load for this space set point temperature is 35,908 BTU/h.
PTA Heating System Design (continued)

- Performed market analysis to compile information for various components of system
  - Radiant heat flooring panels
  - PEX tubing
  - Solar collector panels.
- Sizing the array: Using thermal storage of 256,000 BTU/day and 4' x 10' flat panel collectors with output of 35,600 BTU/day, seven (7) collectors are necessary for 227C bldg.
- Selected closed loop system with heat transfer fluid.
- Solar collector plates will be arranged side-by-side on the south-facing pitch of roof.
  - Racked at 30° angle to maximize winter sun.
PTA Heating System Design (continued)

- Flow rate for system will be approximately 8 gallons/minute.
- Based on flow rate and number of collectors, the storage tank should be approximately 585 gallons.
  - Selected vertical orientation for smaller footprint and better stratification.
- Selected retro-fit flooring panels to be installed over existing concrete floor.
  - One inch thick floor panels with channels cut for tubing.
- Consulted with Roth Industries to complete a Radiant Heating Design Summary.
  - Piping length will be approximately 3,780 feet for Bldg 227C.

Roth flooring panel
Rebates and Grants

• A variety of tax credits, rebates, and grants were explored, but only one option is available for this project.

• Hawaii Electric Company’s (HECO’s) Hawaii Energy Efficiency Program.
  – This project falls under the Customized Business Incentive Rebate Program.
  – For customers under commercial rate schedules that are not covered by other utility incentive programs.

• To qualify, the Customized Incentive Application and the Worksheet must be submitted to HECO.
  – Include supporting information such as layouts, drawings, technical attachments, and/or vendor literature.

• Program approval is required prior to the start of work.
Rebates and Grants (continued)

- Application is being prepared for submittal to HECO.
- The rebate levels for the Customized Incentive Program are as follows:

<table>
<thead>
<tr>
<th>Rebate Levels</th>
<th>Existing Facilities</th>
<th>New Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year Energy Savings</td>
<td>$0.05 per kWh saved</td>
<td>$0.06 per kWh saved</td>
</tr>
<tr>
<td>On-Peak Utility Demand Reduction</td>
<td>$125 per kW reduced</td>
<td>$125 per kW reduced</td>
</tr>
</tbody>
</table>

- Still unsure how rebate is paid out.
PTA Project Status

- System design is complete.
- Structural analysis to evaluate potential wind load is being performed.
- Request for Proposals submitted to General Contractors.
- Bids turned in and being evaluated.
  - Contract will be awarded soon to selected GC
- HECO Custom Rebate application is being prepared for submittal.
- Installation scheduled to begin September 1, 2010.
  - Installation to be complete by October 15, 2010.
Path Forward

• Following installation, system will be monitored for one year as part of demonstration/validation (dem/val).
• Following dem/val, a life cycle cost and performance evaluation of the system will be completed.
• Stay tuned for further development…
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