National Defense Center for Energy and Environment

Solar Thermal Radiant Heating at Pohakuloa Training Area

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DoD Executive Agent

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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:

HELCO's 2008 Fuel Mix	
Fuel Sources	Percentage
Oil	68.0%
Geothermal	18.8%
Hydro	2.9%
Wind	10.3%

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

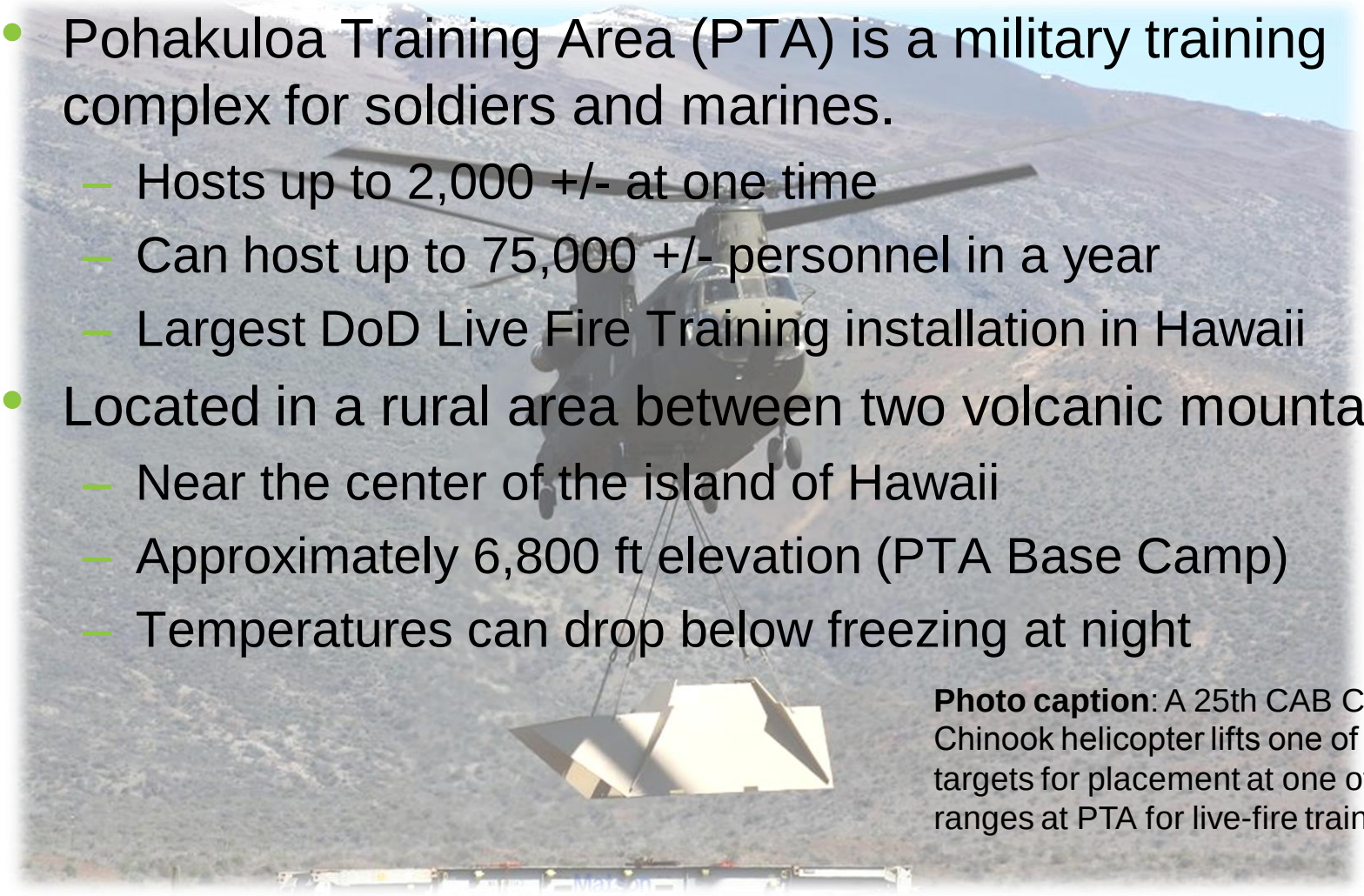


Photo caption: A 25th CAB CH-47D Chinook helicopter lifts one of 28 “EOD-T” targets for placement at one of several ranges at PTA for live-fire training.

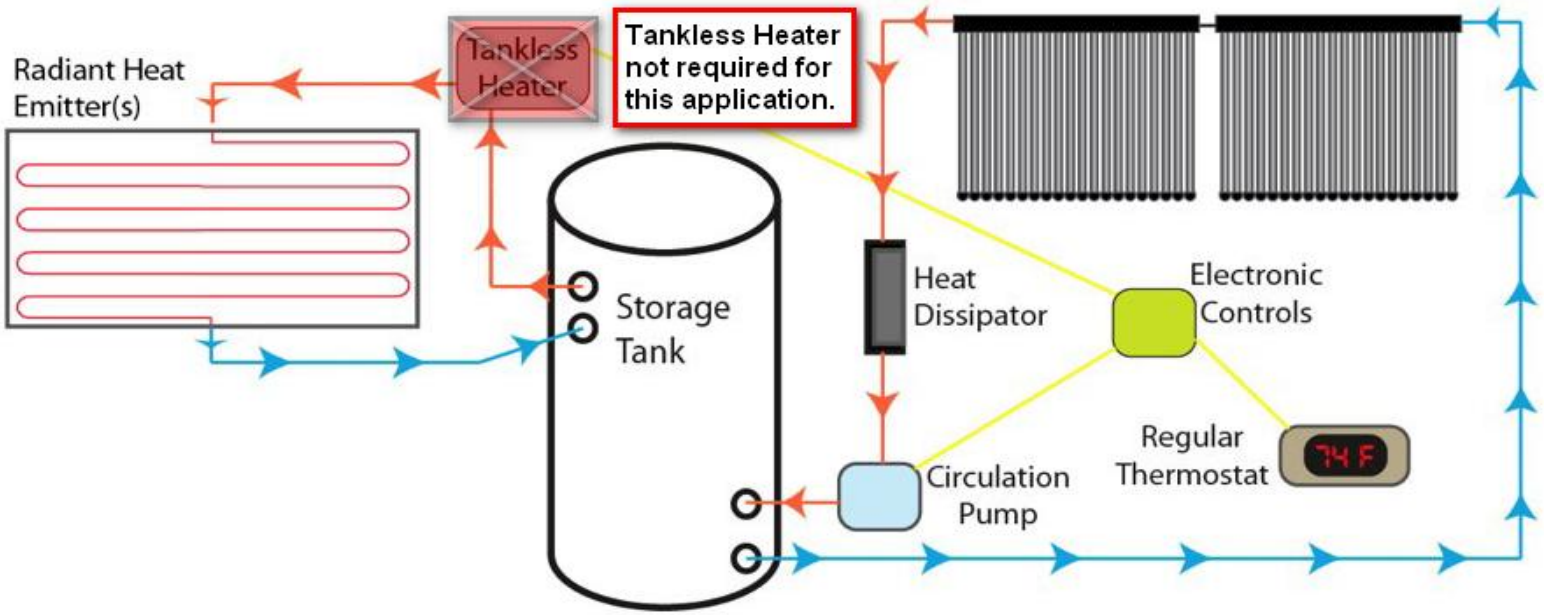
PTA Billet Buildings

- 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.

PTA Billet Buildings 227A, B, and C

- 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.

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.

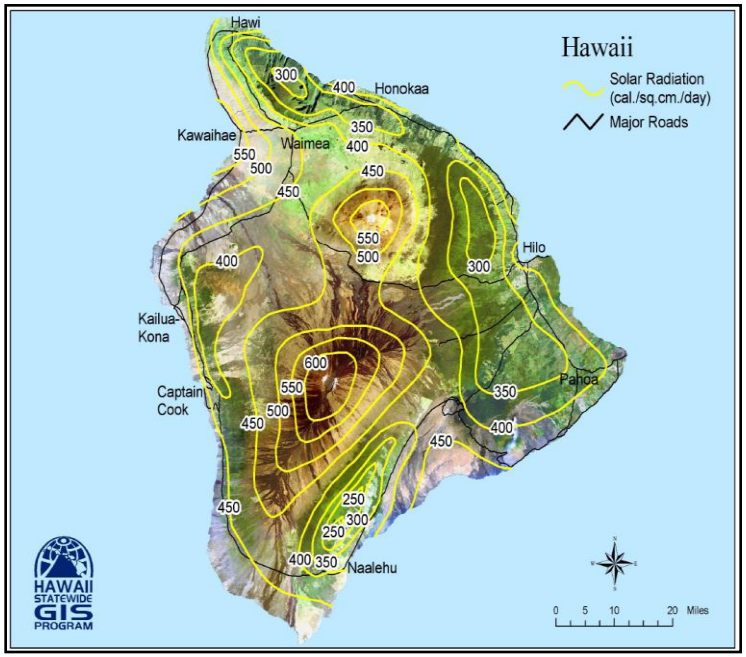
PTA TMY2 Data File

- 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/cm^2/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 BTUh.

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.

Flat plate solar collectors

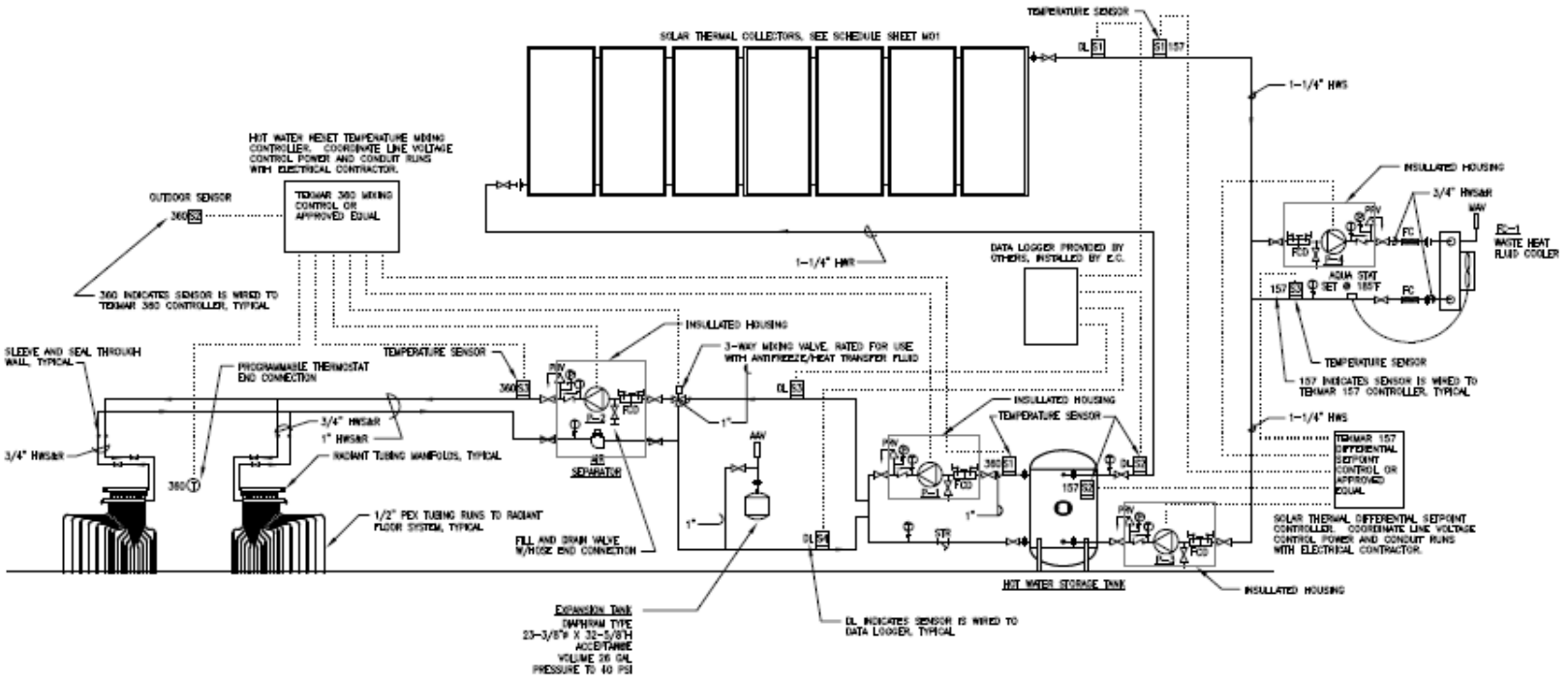
PTA Heating System Design (continued)

- 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.

Roth flooring panel

- Consulted with Roth Industries to complete a Radiant Heating Design Summary.
  - Piping length will be approximately 3,780 feet for Bldg 227C.

PTA System Design Schematic



MECHANICAL – PIPING SCHEMATIC

SCALE: NTS

GENERAL NOTES:

1. ALL PIPING SHOWN IS 3/4" COPPER UNLESS NOTED OTHERWISE.
2. PROVIDE PIPE REDUCERS AND UNIONS AS REQUIRED BY MANUFACTURER.
3. PROVIDE FILL STATION FOR PROPYLENE GLYCOL SOLUTION.
4. REFER TO SHEET M01 FOR SYMBOLS, ABBREVIATIONS, DETAILS AND NOTES.
5. SLOPE PIPING TO ALLOW DRAINING OF SYSTEM.

NOTE:
ALL EQUIPMENT AND PIPING IS NEW UNLESS NOTED OTHERWISE

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:

Rebate Levels	Existing Facilities	New Construction
First Year Energy Savings	$0.05 per kWh saved	$0.06 per kWh saved
On-Peak Utility Demand Reduction	$125 per kW reduced	$125 per kW reduced

- 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…

National Defense Center for Energy and Environment

DoD Executive Agent

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