Fort Polk Joint Readiness Training Center, Leesville Louisiana

The world's largest geothermal heat pump project (utilizing over 700 miles of buried pipe). Earned Vice President Gore's "Golden Hammer Award".

The Fort Polk Joint Readiness Training Center is located in west-central Louisiana just outside of Leesville. The 200,000 acre facility contains military offices, training centers, equipment and storage warehouses, a hospital, and housing for service members and their families. Approximately 12,000 people live in on-post family housing in two distinct areas called North Fort and South Fort. The family housing stock consists of 4,003 living units in 1,292 buildings which were constructed in nine phases between 1972 and 1988. Units range in size from 1,073 to 2,746 square feet, with an average area of 1,393 square feet.

Prior to 1994, most of the units were served by air source heat pumps and electric water heaters, while the remaining units had central air, conditioners, natural gas forced-air furnaces, and natural gas-fired water heaters.

In January 1994, the U.S. Army awarded a 20-year energy-savings performance contract (ESPC) of the shared savings type to an energy-savings contractor (ESCO). Under the terms of the contract, the ESCO replaced the space conditioning systems in all of Ft. Polk's family housing with geothermal heat pumps (GHPs).

The total capacity of GHPs is 6,593 tons, installed in heat pump nominal capacities of 1.5, 2, and 2.5 tons, with one heat pump per living unit. This corresponds to an incredible 686 miles of buried pipe used for heat rejection and heat absorption for the heat pumps– making it the largest geothermal heat pump project in the world.

Additional energy conservation measures included low-flow shower heads, desuperheaters to make hot water from the waste heat from the GHPs, compact fluorescent lighting, and attic insulation installed as needed.

It is well-known that predictions of savings from energy conservation programs are often optimistic, especially in the case of residential retrofits. Factors which influence the sometimes large discrepancies between actual and predicted savings include changes in occupancy, take-back effects (in which more efficient system operation leads occupants to choose higher levels of comfort), and changes in base energy use (e.g. through purchase of additional appliances such as washing machines and clothes dryers). An even larger factor, perhaps, is the inaccuracy inherent in the engineering models (E-Quest, DOE-2, etc.) commonly used to estimate building energy consumption, if these models are not first calibrated to site-monitored data. For example, prior estimates of base-wide savings from the Fort Polk ESPC were on the order of 40% of pre-retrofit electrical use; an analysis by Oak Ridge National Laboratory (ORNL) has shown the true savings for the entire project (which includes 16 separate electrical feeders) to be about 32 % .

In the course of evaluating the ESPC at Fort Polk, Louisiana, ORNL collected energy use data - both at the electrical feeder level and at the level of individual residences - which allowed us to develop calibrated engineering models which accurately predict pre-retrofit energy consumption. We believe that such calibrated models could be used to provide much more accurate estimates of energy savings in retrofit projects, particularly in cases where the energy consumption of large populations of housing can be captured on one or several meters.

In order to determine how a calibrated model would predict energy consumption at the electric feeder level, we chose a feeder located on the North Fort which serves 200 apartments located in 46 separate buildings. Of the 46 buildings, there are three unique types, and among these types the only difference is compass orientation – allowing us to significantly reduce the modeling effort.

Electrical energy on the feeder can be categorized into four end-uses: space conditioning (i.e. heating and cooling), water heating, residential lighting and other electrical appliances, and streetlights. Given the floor plan, construction details, and compass orientation of each of 46 buildings, as well as the average 15-minute hot water draw and appliance electrical loads derived from the detailed measured data, we were able to begin modeling the feeder.
A dynamic TRNSYS-based model of pre-retrofit energy use was then developed for all housing and non-housing loads on the selected electrical feeder at Fort Polk. The model included the heat transfer characteristics of the buildings, the pre-retrofit air source heat pumps, a hot water consumption model and a profile for electrical use by lights and other appliances. Energy consumption for all 200 apartments was then totaled, and by adjusting thermostat set-points and outdoor air infiltration parameters, the results from the models were matched to field-collected energy consumption data for the entire feeder.

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As the purpose of this exercise was to demonstrate that calibrated pre-retrofit models can and should be used to predict the impacts of energy efficiency retrofits, Oak Ridge National Laboratory withheld the post-retrofit energy consumption from us – only providing us with details on the retrofits (kind, size, etc.)

The energy conservation measures were then implemented in our calibrated models: the air source heat pumps were replaced by geothermal heat pumps equipped with desuperheaters; hot water loads were reduced to account for the low-flow shower heads; lighting loads were reduced to account for fixture de-lamping and replacement with compact fluorescent lights (CFLs); and attic insulation upgrades were modeled where appropriate.

The ORNL analysis of pre- and post-retrofit measured data indicated that the retrofits saved 30.3 % of pre-retrofit electrical energy consumption on the feeder modeled for this project. Using the method outlined, we were able to predict this savings within 0.1 % of its measured value, using only pre-construction energy consumption data, as-built drawings and equipment specifications and data from one pilot test site. Plots of the pre and post-retrofit measured data, the TRNSYS calibrated pre-retrofit model and the predicted TRNSYS post-retrofit results have been included to show the benefits of this approach on future retrofit projects.