U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Oak Ridge City Center Technology Demonstration Project

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David Thrash, Principal Investigator

Oak Ridge City Center, LLC

Track Name

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Mandatory Overview Slide

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Timeline:	Estimate a late spring 2010 project start date; Feb. 1, 2010 project end date; Zero percent complete
Budget:	Total project funding: $13,206,633 DOE share: $5,000,000 Awardee share: $8,206,633 Est. funding for FY10: $7,200,000
Barriers:	Lack of comprehensive technical/technological resource data; Lack of valid cost and performance data; Lack of information on lifecycle/breakeven costs; High up-front costs for investor-owned properties; Coordination of required tenant approvals concerning construction/ integration activities for the existing occupied retail properties.
Partners	Oak Ridge National Lab - CEEB CDH Energy

Relevance/Impact of Research

Project Objectives

To broaden market understanding of large-scale GSHP technology, and the design considerations that will impact front-end costs, ongoing maintenance costs, future energy savings, and system breakeven/lifecycle cost.

Front costs will be reduced by installing a hybrid GSHP system. Utilizing one or more dry fluid coolers, a dispersed GHX field and a GHP loop design that maximizes benefits to be derived from temperature diversity among buildings (balancing loads) will reduce the ground heat exchanger requirement.

•Performance will be optimized by running loops at depths of 650 feet which place more heat exchange pipe in bedrock where conductivity is greatest and groundwater is present to aid in borehole temperature recovery, by designing the geothermal field geometry to enable efficient movement of thermal energy throughout the year, and by utilizing sub-fields for efficient energy transfer between the buildings and the earth.

•Performance will be maximized by incorporating single- and variable-speed pumps, two-stage heat pumps with variable-speed fans and control boards for multi-stage operation.

Relevance/Impact of Research

•Market understanding will be enhanced by designing a data acquisition system and through the gathering, analysis and reporting of performance benefits and system costs, and by experienced partners automating the transfer of the performance dataset to the National Geothermal Data System.

Market acceptance will derive from the collection, analysis and reporting of data pertaining to system costs, performance benefits, installation techniques, commissioning and optimization methodologies, and system breakeven and lifecycle costs. Installed cost savings should be 20% to 30% over non-hybrid, vertical-bore GSHP systems, and energy cost savings should equal or exceed 40% over conventional commercial HVAC equipment energy costs.

•Market adoption will benefit due to design application validation. ASHRAE-developed GSHP system design software will be utilized in designing this large-scale GSHP system, and field data collected will be used to validate and calibrate it. This will convert a simulation research tool into a field-validated, non-proprietary, publicly-available design tool that can be used with confidence by large-scale GSHP system designers.

•Market penetration will increase as a result of the preparation and distribution

Relevance/Impact of Research

of comparative reports (GSHP versus conventional), educational materials and marketing outreach strategies to the commercial property and investor-owned property markets, exhibiting how to differentiate commercial projects in a competitive environment while providing savings to third-party tenants.

Scientific/Technical Approach

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- Scientific/Technical Approach Summary
  - Perform soil conductivity tests
  - Perform simulation modeling and feasibility study
  - Perform annual energy analysis study
  - Complete the Hybrid GSHP system design
  - Determine data set to be collected
  - Design Data collection and monitoring system
  - Commence data gathering
  - Produce annual report based on data gathering and the final report
- Highlights
  - Soil conductivity tests have been successfully completed.
  - Examine underground layer conditions to determine best drilling technology for the site.
  - Use of existing design/simulation software to establish baseline for calibration of a large-scale hybrid GSHP project.

Scientific/Technical Approach

- Highlights (cont.)
  - Perform research on options for additional heat rejects to determine cost/benefit of each and choose optimum heat reject for this project.
  - Modeling of the as-built detailed hourly building simulation, and calibrating the model using available measured data (energy units).
  - Based on the as-built calibrated simulation, borehole size and depth, and efficiency of heat reject will be determined.
  - Using that data, the pre-retrofit hourly building energy simulation will be performed to estimate peak demand, annual energy consumption/cost.
  - Calculation of energy savings and resultant pollution reductions of as-built versus hybrid GSHP system.
  - Calculation of cost/benefit of hybrid GSHP vs. conventional GSHP system, and of economic feasibility through simple payback method.
  - Upon system installation, data set collection and analysis will begin and a feedback loop established for reporting system operation and sensor problems and for re-calibrating the pre-retrofit simulation.

- Project Design and Technical Innovation centers on the following:

  Temperature Diversity

  – The use of a central, shared GHX system takes advantage of energy and temperature diversity between buildings to increase efficiency. Heating and cooling different buildings simultaneously and differences in run hours and peak loads create efficiencies in GHX performance. The GHX can be right-sized for this diversity, and will result in reductions in GHX size and build cost.

  Hybrid Geothermal-Based System

  – Sizing the GHX field to +/-70% of peak tonnage, and integrating a dry fluid cooler connected in series with the GHX to handle peak loads. This lowers operating and maintenance costs over that of a typical evaporative cooling tower or water-based cooler, reduces front costs and life-cycle cost through decreasing the GHX field's size, optimizes the cost/benefit ratio, and produces the lowest lifecycle cost.

Hybrid Geothermal-Based System (cont.)

- The integration of controls to optimize dry fluid cooler operation with the GHX field in order to maximize heat pump efficiency, thereby increasing energy savings during daily as well as seasonal temperature extremes;
- The incorporation/integration of variable- and single-speed pumps into system design to maximize energy savings during periods wherein the heating or cooling load is lower than system design loads.
- The deployment of dual-stage, dual-circuit heat pumps incorporating auto-shutoff valves on the secondary circuits to realize savings on pumping energy during low-load periods.

Scientific/Technical Approach

- Planned 2010 milestones:
  - Determine the Baseline Load
  - Economic benefit analysis of the cost of installing cool roofs against potential savings from GHX field size reduction
  - Determine number, size and design configuration of heat pumps for each individual building
  - Design the loop configuration and system control strategies
  - Integrate new units into air-handling systems of existing stores
  - Finalize project financing vehicle
  - Rerun economic analysis for Go/No Go decision

  If Go:
  - Complete design/engineering for GSHP system installation, building construction/redevelopment
  - Obtain regulatory and environmental permitting
  - Demolish mall and commence redevelopment

Scientific/Technical Approach

The 2010 Go/No-Go Decision

This decision point follows analysis of the existing load to develop the baseline case, loop design and configuration, integration design for retrofit rooftop GSHP, and determination of the financing vehicle.

The nature of this project, a large commercial real estate redevelopment, requires that once it commences (demolition, GHX and loop installed), the project is seen through to completion.

Accomplishments, Expected Outcomes and Progress

- Planned outcomes
  - Successful coordination with project partners and GSHP-industry participants to deploy leading-edge GSHP system design and technology combined with development of advanced monitoring and reporting systems to achieve technology demonstration project goals.
  - Demonstrate to the commercial real estate industry a hybrid GSHP design that lowers front costs at least 30% over non-hybrid vertical bore systems, and that provides energy savings of at least 40% over baseline energy usage.
  - Recruit two to three retailers from the Retail Energy Alliance, CREEA or EPA Energy Star partners to locate their retail stores in the project and to participate in the research project.
  - Foster broader commercial real estate market participants' understanding and adoption of hybrid GSHP technology and design by developing and disseminating project reports, analytical papers and other publications on all aspects of the project.
  - Achieve project-specific LEED or LEED Silver certification.

Accomplishments, Expected Outcomes and Progress

- Accomplishments
  - Completed the soil thermal conductivity test indicating limestone at 135 feet and conductivity levels in the 1.4 to 1.6 range.
- Planned outcomes
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Accomplishments, Expected Outcomes and Progress

- Planned Outcomes (cont.)
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- Team Qualifications:
  - Oak Ridge National Lab (ORNL) and CDH Energy will perform data gathering and reporting. The ORNL team will be led by John Shonder, with guidance from Patrick Hughes, and implemented primarily by Shonder and other researchers at ORNL. Hughes and Shonder have collaborated on GSHP research, market transformation, and deployment for the last 10 years. They are responsible for the successful FEMP program that increased cumulative federal sector GSHP project investment from $6 million in 1995 to over $300 million by 2007.

- Team Qualifications (cont.):

  John Shonder, a senior ORNL research staff member, has more than 20 years of experience in the design, implementation, and evaluation of energy conservation projects, and more than a decade of experience with GSHPs. Shonder has published more than 30 technical papers and reports involving all aspects of the technology. Shonder is an active member of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). He is the chair of TC 9.4, Applied Heat Pump Technology, and research chair of TC 6.8, Geothermal Energy Utilization. Shonder holds B.S. and M.S. degrees in engineering from the University of Illinois at Urbana-Champaign.

  – Patrick Hughes has been involved with research, lab characterization, and field trials of GSHP systems since the late 1970s, including being recognized with a U.S. DOE Award for Energy Innovation in 1987 for a distinguished contribution to our nation's energy efficiency for leading an upstate New York GSHP research program from 1982-87 sponsored by Niagara Mohawk Power Corporation, New York State

Accomplishments, Expected Outcomes and Progress

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- Team Qualifications (cont.):

  Energy Research and Development Authority, and Rochester Gas and Electric Corporation.

  – Melissa Lapsa will lead ORNL's team providing educational materials and marketing outreach strategies for specific target markets. Lapsa received her M.B.A. from Western Illinois University and her B.A. from St. Mary's University. Ms. Lapsa leads ORNL's Sustainable Campus

  – Initiative and is Group Leader of the Whole-Building and Community Integration (WBCI) research group for ORNL's Building Technologies Research and Integration Center. Ms. Lapsa has supported the International Energy Agency's Implementing Agreement on Heat Pumping Technologies for the past fifteen years, including coordinating the successful activities of the U.S. National Team (www.ornl.gov/estd/usiea).

  – CDH Energy Corp. is an energy consulting firm specializing in the evaluation of energy technologies through field monitoring and energy

- <u>Team Qualifications (cont.):</u>

simulations. CDH has substantial experience field monitoring a wide range of building technologies including air conditioners and geothermal heat pumps. In the late 1990s, CDH collected detailed field monitored data on nearly two dozen commercial GSHP systems for the Geothermal Heat Pump Consortium (GSHPC), EPRI, and various electric utilities across the US (see Appendix A). Hugh Henderson, Jr., Principal, will lead this project and will be the main

point of contact for administrative and technical matters, directing all monitoring and data collection activities as well as the web site reporting, data presentation and analysis. He has authored several technical papers related to geothermal heat pump technology. He active in ASHRAE and holds a M.S. degree in Agricultural Engineering from Cornell University. Steve Carlson, Principal, will provide technical leadership for the field monitoring effort. Mr. Carlson holds a M.S. degree in Mechanical Engineering from the University of Wisconsin, Madison. Adam Walburger, Principal, will oversee CDH staff responsible for web site operation and development of automated

- Team Qualifications (cont.):

reporting. Mr. Walburger has significant experience measuring the field performance of geothermal heat pump test projects, including evaluations of novel technologies such as direct-expansion ground loops, new refrigerants and hydronic heating. He also developed many of CDH’s web-based data systems and automated data handling procedures. Mr. Walburger holds a B.S. in Mechanical Engineering from Syracuse University.

Project Management

Phase 1: GSHP contractor and ORNL will collaborate during the feasibility study phase. For the design phase, CDH Energy will join the working group to develop the data collection system, define the data set to be collected to met project goals, and ensure monitoring hardware is properly incorporated into the total system design. The budget will be refined, and financial models re-run, influencing the go/go decision.

Phase 2: If go, Team will coordinate permitting activities, mall demolition, and GHX field installation. The GSHP contractor will manage loop equipment acquisition, balancing cost-effectiveness with best-in-class technology. CDH Energy and GSHP contractor will collaborate on installation of necessary monitoring instruments and controls. GSHP and building contractors will collaborate on installing GSHP interfaces for existing tenants and the system replacements in the least-disruptive manner. System commissioning will be performed by GSHP contractor and heat pump manufacturer, with ORNL and CDH's participation. Building contractor will manage the reconstruction activities for the existing buildings and for new building construction activities on an as-leased basis.

Project Management

Phase 2 (cont.): Upon completion of the existing anchor tenant retrofits, ORNL will coordinate with applicant, CDH Energy, the GHP manufacturer and the Oak Ridge Utility Department to implement the data collection plan. ORNL and CDH will perform the validation and re-calibration of the simulation model and design program as required for ASHRAE's GSHP design software. ORNL and CDH Energy will collaborate to perform data analysis and prepare reports as required.

Application of resources and leveraged funds/budget/spend plan

The project plan was developed with input from researchers from ORNL, CDH Energy's principal and with major project vendors including the building contractor and the GSHP system contractor. The project budget requires the Awardee to invest $1.64 for every ARRA grant dollar received. The project already includes two members of the DOE's Retail Energy Alliance (JC Penney and Belk) as tenants, and the Awardee has contacted other retailers

Project Management/Coordination

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Application of resources and leveraged funds/budget/spend plan (cont.)

members of the DOE and EPA alliances to determine their interest in joining the project and leveraging research being performed across their building portfolios.

Based on the budget and spending plan, 55% of the project budget will be spent in budget year 1, and almost 90% by the end of budget year two.

- National Geothermal Data System

CDH will develop and maintain the project website providing access to historic data and a daily update for the project's duration. CDH Energy will ensure the data collection automatically transfers data to the National Geothermal Data System as required by DOE.

Future Directions

- Future Research, Development, Deployment
  - The final report will discuss how the design, technology and experience on ORCC project can be transferred to other commercial sites, and make recommendations on improving the next project.
  - The project's complete dataset will be provided to the National Geothermal Data System to support outreach goals for hybrid GSHP system and to be utilized in future research.
  - As the overall redevelopment of the Oak Ridge City Center project will extend beyond the life of this outlive this research, technologies not currently available could be deployed as additional buildings are added to the center.
  - Future research opportunities may present in the form of joint-venture research with Retail Energy Alliance, CREEA or EPA partners including hotels and office users.

Mandatory Summary Slide

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The ORCC project's desired result is to

- Design and install a large-scale GSHP system that demonstrates to the investor-owned commercial property market the replicability and economic feasibility of, benefits derived from, and long-term savings generated by, such an investment.
- Design a monitoring and data-collection system to collect, analyze and report on energy use and system performance that validates the investment decision, and uplink the dataset to the National Geothermal Data System.
- Produce educational materials and marketing outreach strategies targeting specific markets - including commercial property investors -that broaden market understanding and acceptance of hybrid GSHP systems and technology.
- Calibrate ASHRAE-developed non-proprietary GSHP design software by comparing measured site data against the performance parameters predicted by the software. Calibration of this tool with field-collected data will inspire GSHP designer confidence in the software and result in wider acceptance of hybrid GSHP systems and technology.
- Leverage project research by attracting members of the Retail Energy Alliance as tenants in the project to share in research activities which will benefit their store at ORCC and may produce benefits across their real estate portfolios.
- Create jobs.