PMC-EF2a

(2.04.02)

U.S. DEPARTMENT OF ENERGY
EERE PROJECT MANAGEMENT CENTER
NEPA DETERMINATION

RECIPIENT: Oklahoma State University **STATE:** OK

PROJECT TITLE : Improved Design Tools for Surface Water and Standing Column Well Heat Pump Systems

Funding Opportunity Announcement Number	Procurement Instrument Number	NEPA Control Number	CID Number
DE-FOA-0000116	DE-EE0002961	GFO-10-187	GO2961

Based on my review of the information concerning the proposed action, as NEPA Compliance Officer (authorized under DOE Order 451.1A), I have made the following determination:

CX, EA, EIS APPENDIX AND NUMBER:
Description:

A9 Information gathering (including, but not limited to, literature surveys, inventories, audits), data analysis (including computer modeling), document preparation (such as conceptual design or feasibility studies, analytical energy supply and demand studies), and dissemination (including, but not limited to, document mailings, publication, and distribution; and classroom training and informational programs), but not including site characterization or environmental monitoring.

Rational for determination:

Oklahoma State University (OSU) would develop a modeling system for heat pump systems that utilize surface water or sanding column wells (SCW) as a heat source and sink. The project would produce a computer model, which could be used in the planning and design of stimulation techniques to create engineered heat pump systems. The work would take place at the existing Building and Environmental Thermal Systems Research Group at Oklahoma State University in Stillwater, Oklahoma. The project would be divided into two phases with multiple tasks:
PHASE 1
Task 1.0 (SCW Track) Enhancement of Existing Standing Column Well Model

Subtask 1.1 Develop and validate the SCW model with separate bleed control
The expected outcome is a revised model with the bleed control implemented separately. Previously obtained experimental data would be used for validation and research. The milestones for this subtask are a report describing the revised model and validation of the revised model.

Subtask 1.2 Testing of model with various bleed control strategies
The revised model would be tested with these strategies as well as a constant bleed strategy and a strategy where domestic water consumption provides the bleed. In addition, the bleed rate would be varied. The study would serve both to investigate bleed control strategies and serve to test the robustness of the model. The milestone would be a report on the results of the parametric study.

Task 2.0 (SW Track) Enhancement of Existing Pond Model
The existing pond model previously developed by the research team and currently implemented in EnergyPlus is suitable for shallow ponds (without stratification) and for cooling use, as formation of ice either on the submerged coil or at the pond surface is not modeled. The outcome of this task would be a model that does account for these phenomena, and is therefore suitable for general use with surface water heat pump systems.

Subtask 2.1 Modeling of Stratification
Stratification of pond or lake water can be important to the performance of the heat pump and especially important in direct cooling systems. For simulation purposes, a model of stratification is important for predicting the day-by-day changes in water temperature that, in turn, control the entering fluid temperatures to the heat pumps. This is further complicated by the heat rejection and extraction from the heat pumps, which can have a minor effect on water temperatures in some cases. A range of models would be investigated. The most detailed would be similar to the models based on an eddy diffusivity formulation of the one-dimensional advection-diffusion equation. The model applies a full energy balance at the top surface, accounting for evaporation, convection, solar radiation, and thermal radiation. Inflows, outflows, and conduction to/from the lake bottom are also accounted for. Simpler models would also

be investigated. The best candidate would be added to the existing EnergyPlus shallow pond model. The milestone for this subtask would be delivery of source code and a report detailing the methodology.

Subtask 2.2 Modeling of Ice-on-Coil
For use with heat pumps that provide both heating and cooling, freezing of water around the coil submerged in the pond is a possibility for most systems, and highly probable for systems in cold climates. While some freezing on a diurnal cycle or for periods of several days is acceptable, continued operation with increasing ice would be detrimental to heat pump performance. Therefore, a model of ice-on-coil is necessary to evaluate system performance and size the pond coils sufficiently large to avoid long-duration icing. This model would keep track of the ice formation and melting around the coil. A first-principles model or a thermal network model would be implemented in EnergyPlus and then tested by comparing to data in the literature. The milestone for this subtask would be delivery of source code and a report detailing the methodology.

Subtask 2.3 Modeling of Ice-on-Surface
For surface water heat pump systems in cold climates, ice and snow accumulation at the surface of the pond can have a significant effect on the temperature profile in the pond, and hence on the heat pump performance. Therefore, a model which accounts for formation of ice on the surface of the pond and accumulation of snow is needed. A detailed deterministic submodel is a more desirable solution might be to utilize the regression-based equations. A model would be selected that gives the best combination of accuracy and computational speed, then implemented in EnergyPlus and tested against data published in the literature. The milestone for this subtask would be delivery of source code and a report detailing the methodology.

PHASE 2
Task 3.0 (SCW Track) Implementation of Enhanced SCW Model

Subtask 3.1 Implementation of Enhanced SCW Model in EnergyPlus
The enhanced SCW model developed in Phase 1 would be implemented as a plant loop component model in EnergyPlus. The implementation would be tested against experimental data. Documentation, including one or more examples, would be developed. The milestones for this subtask are the EnergyPlus source code, documentation, and a report covering validation of the revised model.

Subtask 3.2 Implementation of Enhanced SCW Model in Design Tool
The enhanced SCW model developed in Phase 1 would be implemented as part of an existing design tool for ground heat exchangers (GLHEPRO). Additional user interface would be developed to support description of the SCW. The milestone for this subtask is a report containing documentation and example usage of the design tool.

Subtask 3.3 Technology Transfer
One or more technical papers covering the SCW track would be prepared and submitted to journals. The results would also be presented in conferences, and meetings. The milestone for this subtask would be a report containing a copy of the submitted paper.

Task 4.0 (SW Track) Enhancement, Implementation and Validation of Enhanced Pond Model
The existing pond model was developed for a single, Slinky-type heat exchanger. Additional closed-loop pond heat exchangers, such as coiled copper heat exchangers would be implemented. The enhanced pond model developed and implemented in EnergyPlus in Phases 1 and 2 would be made fully ready for distribution by developing documentation and examples. It would also be implemented as part of an existing design tool for ground heat exchangers (GLHEPRO).

Subtask 4.1 Modeling of Alternate Pond Heat Exchanger Types
In practice, there are several different types of pond heat exchangers including loose-bundled coils, Slinky-type coils, bundled coils with controlled spacing, and flat plate heat exchangers. Experimental data collected as part of another project would be used to develop convection coefficients and/or correlations suitable for the different types of heat exchangers, which would allow modeling of alternate pond heat exchanger types. The milestone for this subtask would be a report documenting the algorithms and EnergyPlus documentation and examples.

Subtask 4.2 Documentation of Enhanced Pond Model in EnergyPlus
The enhanced pond model developed and implemented in EnergyPlus in Phase 1 would be fully documented and examples of usage would be prepared. The milestone would be a report containing the documentation and examples.

Subtask 4.3 Implementation of Enhanced Pond Model in Design Tool
The enhanced pond model developed in Phase 1 would be implemented as part of an existing design tool for ground heat exchangers (GLHEPRO). Additional user interface would be added to support specification of the pond heat exchanger design parameters and inclusion of climatic data. The milestone for this subtask is a report containing documentation and example usage of the design tool.

Subtask 4.4 Validation of Pond Model

The enhanced pond model implemented in EnergyPlus would be validated against experimental data collected in a research pond. The undisturbed pond temperature profile would be measured near the test heat exchanger. A variety of test heat exchangers would be operated for relatively short periods.

Subtask 4.5 Technology Transfer
One or more technical papers covering the SW track would be prepared and submitted to journals. The results would also be presented in conferences and meetings. The milestone for this subtask would be a report containing a copy of the submitted paper.

Task 5.0 Project Management and Reporting
Reports and other deliverables would be provided in accordance with the Federal Assistance Reporting Checklist following the instructions included therein. They also would be provided to the National Geothermal Data System (NGDS).

This proposed action includes gathering, analysis, and dissemination of data via reports, publications, and the development of computer software. This proposal comprises conventional laboratory operations, data analysis, and actions to promote the research and development of more efficient geothermal technologies; therefore this project is categorized as CX A9.

NEPA PROVISION

DOE has made a final NEPA determination for this award

Insert the following language in the award:

Note to Specialist :

None Given.

SIGNATURE OF THIS MEMORANDUM CONSTITUTES A RECORD OF THIS DECISION.

NEPA Compliance Officer Signature: [signature] Date: 2/24/10
NEPA Compliance Officer

FIELD OFFICE MANAGER DETERMINATION

☐ Field Office Manager review required

NCO REQUESTS THE FIELD OFFICE MANAGER REVIEW FOR THE FOLLOWING REASON:

☐ Proposed action fits within a categorical exclusion but involves a high profile or controversial issue that warrants Field Office Manager's attention.
☐ Proposed action falls within an EA or EIS category and therefore requires Field Office Manager's review and determination.

BASED ON MY REVIEW I CONCUR WITH THE DETERMINATION OF THE NCO :

Field Office Manager's Signature: ______________________ Date: __________
Field Office Manager