The Mechanical Engineer's Role

Lisa Meline, PE

Energy Management

The mechanical engineering professional is an important player on the custom home design team. Mechanical engineering is at the crossroads of all engineering disciplines, with formal education in topics also covered by electrical, civil, and structural engineering programs. Many mechanical engineers also have had basic courses in controls, acoustics, and environmental topics.

The core of the mechanical engineer's value on a custom home design team is his or her role in managing energy: solar, electricity, petroleum-based products, and sometimes wind. The mechanical engineer must be familiar with the standard building codes in the state in which he or she is licensed. For example, I am licensed in California and must be familiar with California's Building Energy Efficiency Standards, which were recently updated to be more restrictive, especially in the residential arena. By code, the mechanical engineer is one of several design professionals required to specify the energy efficiency of the home building materials, lighting, and mechanical systems. He or she must also maintain the aesthetics required of the custom home designer and the comfort desired by the owner.

The innovation and technology in the custom home industry has become more complex. There are new building materials that must be modeled for their heat transfer characteristics. Because homes are built "tighter" than in the past, this introduces a new challenge in mechanical system design, which is to provide the necessary ventilation of fresh air. Good ventilation improves indoor air quality and can mitigate issues with mold.

Many of the high-end homes are moving toward total home control or smart home controls, as is the case with the first Optimum Performance Home™ at The Sea Ranch. This type of system can control anything from the security system and lighting to the volume of built-in sound and video systems, inside and out.

All of these design elements need to be coordinated with the mechanical engineer. On the design team, the mechanical engineer is usually responsible for the plumbing system design; heating, ventilation, and air-conditioning (HVAC) design, sequence of operation for the control system design; and, in most cases, the energy calculations, which show compliance with the Building Energy Efficiency Standards (often called, in California, Title 24 documents). The mechanical engineer creates his or her system design with input from other specialty professionals on the custom home design team, such as the home theatre designer, humidor and wine cellar consultants, kitchen designers, and pool and spa builders. The mechanical engineer also coordinates the mechanical equipment requirements with the electrical engineer to make sure that the electric service to the home is of the proper size. The dividing line between the civil engineer and the mechanical engineer relative to the plumbing design is usually drawn at a five-foot perimeter around the house. The mechanical engineer determines the sewer, water, and gas (if applicable) requirements of the home and coordinates this with the civil engineer to ensure that the proper size and capacity of the utilities are brought on site and the proper connections are provided for the home. Because of the open space of some custom home designs and often the home's geographic location in anticipated seismic activity zones, piping and plumbing within a custom home can often be a challenge to the integration of a duct distribution system.

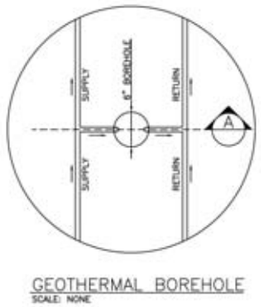
Geothermal Energy Use In The Optimum Performance Home™

For this particular design of the Optimum Performance Home at The Sea Ranch, a geoexchange system manufactured by WaterFurnace International, Inc. was chosen as the means for heating and air conditioning. The system (also commonly referred to as a ground-source heat pump system or geothermal heat pump system) consists of three main components—the heat pump, which is the foundation of the system (manufactured by WaterFurnace International); a closed-loop vertical "well" system, which is drilled into the constant temperature earth on site; and water, which is circulated between the ground loop and the heat pump in high-density polyethylene pipe. The ground-loop portion of the geoexchange system uses the constant temperature of the earth as a heat source instead of natural gas or propane for increasing the efficiency of an electric ground-coupled heat pump. A heat pump can provide both heating and cooling, and it operates on the

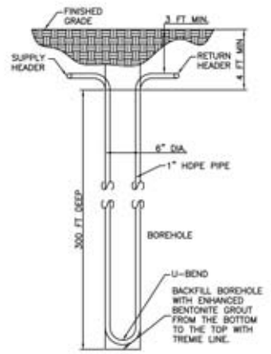
Shown is a typical water-to-water heat pump installation for a radiant floor system. The hot water heater to the left is used as a buffer tank for the radiant floor system.

same type of refrigeration cycles as conventional HVAC equipment. The difference is that the ground-coupled heat pump can take 1 kilowatt (kW) of electricity and turn it into 3 to 4 kW of heating energy for the home. This rating is called the coefficient of performance (COP), and for geoexchange systems, the performance is usually between 3 and 4 COP. On the Optimum Performance Home project, the water-to-water ground-coupled heat pumps will be making hot water to be distributed through the home in a radiant floor distribution system manufactured by Uponor. All of the rooms except the home theatre and the projection room will have radiant floor heating. The home theatre and the projection room will be heated and cooled with a two-zone water-to-air ground-coupled heat pump. This type of system was selected for the home theatre and projection room because it is expected that more continuous cooling will be required to offset the heat created by the home theatre projection and audio equipment. Both of these heat pumps will be connected to a single ground-loop system. The ground-loop system will allow the heat pumps to operate in heating and cooling modes simultaneously.

The mechanical engineer will be responsible for selecting the mechanical equipment, designing the radiant floor and duct distribution systems, and providing basic control sequences for the builder. The mechanical engineer is also responsible for sizing the ground loop. The ground-loop piping will be buried between 3- and 4-feet below finished grade in the guest parking area. It will be a series of vertical 1-inch diameter high-density polyethylene tubing drilled down into the earth to 250- to 300-feet deep placed at roughly 10- to 15-foot centers. Water will be circulated within this 1-inch diameter high-density polyethylene closed-loop pipe to transfer heat from the earth to the heat pumps in the house. In cooling mode, the water will be circulated between the heat pumps in the house and the earth, to reject heat back into the earth. If both units are operating simultaneously, the heat rejected from the water-to-air heat pump in the home theatre (cooling) will be transferred directly to the water-to-air heat pump, making hot water for the radiant floor.



GEOTHERMAL BOREHOLE
SCALE: NONE



A GEOTHERMAL BOREHOLE SECTION
SCALE: NONE

In addition to being energy efficient, the ground-loop portion of the geoexchange system is all below ground and out-of-sight. Essentially, the ground loop replaces the "outdoor unit" of a conventional air-to-air heat pump. There is no noisy equipment outside the home to detract from the beautiful Sea Ranch setting of this Optimum Performance Home.

The geoexchange system will also be used as a backup-heating source for the domestic hot water system. The solar thermal system designed by TrendSetter Industries, Inc. will be heating water and storing it in a large tank buried outside the home beneath the courtyard. On days where the energy from the sun cannot be used, the geoexchange system will be engaged to maintain the hot water temperature in the solar hot water storage tank. This ensures that when additional energy is required to heat the hot water it will operate at a COP of about 3 rather than a COP of 1, which is the efficiency of an electric resistance hot water heater.

The challenges of integrating this system into the Optimum Performance Home will lay mainly in interfacing with other trades on the project. The installation of the ground-loop system will need to be coordinated with the site development work. A drilling permit is usually required in addition to a construction permit for the ground loop portion of the geoexchange system. The spoils resulting from the drilling process will need to be contained and, in some cases, hauled off the project site.

Since the geoexchange system is essentially a "central plant" system, there will need to be integration with many of the systems in the home. Careful coordination will be required between the contractors providing the radiant floor system, sheet metal and under-slab ductwork, plumbing, controls, and solar system.

Because of the high level of coordination and unfamiliarity of many trades with the geoexchange system, a contractor certified by the International Ground Source Heat Pump Association (IGSHPA) will install the system at the Optimum Performance Home site. The entire system will be commissioned by the engineer of record. It is very important that the system performance be verified to ensure its energy efficiency in accordance with California Title 24 documents. UHD

The Authors

Gary Reber is the President of Ultimate Home Design, Inc. and the founding Editor-In-Chief and Publisher of *Ultimate Home Design* magazine. His diverse background in several fields includes an undergraduate, graduate, and postgraduate university education in architecture, community planning, and economic development planning. For years he was a consultant on community and economic development planning. For the past 15 years he has been an editor and publisher of magazines in the consumer electronics field. Gary can be reached at 951 676 4914 or gary@ultimatehome design.com.

Lisa Meline, P.E., is the principal engineer and owner of Meline Engineering. She has 17 years of mechanical engineering experience and over 22 years of experience in the construction industry. Ms. Meline has a strong background in project and construction management and design engineering. She has prepared HVAC and plumbing designs for commercial, educational, industrial, residential, and government buildings throughout California, Nevada, and Colorado. Ms. Meline is a LEED Accredited Professional and a Certified Geoexchange Designer by the Association of Energy Engineers. She is a voting member of ASHRAE TC6.8, the Technical Committee on Geothermal Energy Utilization and holds memberships with ASME, ASHRAE, AEE, GHPC and IGSHPA. Ms. Meline is the Chair of the Industry Advisory Council for California State University Sacramento and is a recipient of ASME's Distinguished Service Award. More recently, Meline Engineering was nominated and was a finalist for the Sacramento Workplace Excellence Leadership Award (SWEL) in the Small For-Profit category .Meline Engineering is located at 9216 Kiefer Boulevard, Suite 6, Sacramento, CA 95826. Lisa can be reached at 916 366 3458 or lisa@meline.com.

Acknowledgements

Ed Rose is a residential architectural designer. His company is Rosebud Studios based in Monte Rio, California. Ed has been designing homes and remodels on The Sea Ranch and surrounding areas since the late 1980s. His skill in listening to and understanding his client's architectural program and then translating that into a workable and pleasing design acceptable to the rigorous philosophy of The Sea Ranch Design Committee is responsible for the final successful approval of the First Optimum Performance Home™ at The Sea Ranch. This included the fairly new design concepts of universal access and aging-in-place, use of "green" materials, and meeting the exacting guidelines for a residential LEED® designation. It wasn't until Ed joined our team that we began to make progress with the Design Committee in this challenging process. Ed provided all of the images of the site plan, floor plans, elevations, and isometric perspectives for the magazine. His extensive education and experience span numerous disciplines from architecture to industrial and graphic design to technical illustration, photography, and painting. Ed can be reached at 707 865 1146 or 707 785 9180 or rosebud@thegrid.net.

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Scott Simpson is a pilot and aerial photographer. His company is West Of One, based in Gualala, California. Scott resides at The Sea Ranch and provided the aerial photos depicted in this article. Samples of his work can be viewed at www.westofone.com. Scott can be reached at 707 785 9445 or scott@westofone.com.

Product Information

- Aquacore by Aquest, Inc., 604 East North Street, Elburn, Illinois 60119, 630 365 2525, www.aquacore.com
- Broan-NuTone, 926 West State Street, Hartford, Wisconsin 53027, 800 548 0790, www.broan.com
- GridPoint, Inc., 2020 K Street NW, Suite 550, Washington, DC 20006, 202 903 2100, www.gridpoint.com
- Kyocera Solar, Inc., 7812 East Acoma Drive, Scottsdale, Arizona, 85260, 480 948 8003, www.kyocerasolar.com
- Panasonic Home & Entertainment Company, One Panasonic Way, Secaucus, New Jersey 07094, 866 292 7292, www.us.panasonic.com
- Spunstrand Incorporated, 620 North Post Street, Post Falls, Idaho 83854, 208 665 7444, www.spunstrand.com
- Sylvan Source, 285 North Wolfe Road, Suite 103, Sunnyvale, California 94085, 408 736 7186, www.sylvansource.com
- Takagi Tankless Water Heaters, 5 Whatney, Irvine, California 92618, 888 882 5244, 949 770 7171, www.takagi.com
- TrendSetter Industries, 1385 8th Street, Arcata, California 95521, 800 492 9276, www.trendsetterindustries.com
- Uponor North America, 5925 148th Street West, Apple Valley, Minnesota 55124, 2 997 5329, www.uponor-usa.com
- Wardflex® by Ward Manufacturing, Inc., P.O. Box 9, Blossburg, Pennsylvania 16912, 800 248 1027. 570 638 2131, www.wardflex.com
- WaterFurnance International, Inc., 9000 Conservation Way, Fort Wayne, Indiana 46809, 800 222 5667, www.waterfurnace.com

Mechanical Equipment Installers

- WaterFurnace Equipment—Air Connection, 395 Irwin Lane, Santa Rosa, California 95401, 707 571 8384, www.acconnections.com
- Uponor Radiant Floors & AQUAPEX Plumbing—Tom's Plumbing, Inc., P.O. Box 92, Gualala, California 95445, 707 884 3818, tpinc@mcn.org