national ground water association®

Phone/ Toll-free 800 551.7379/ 614 898.7791 Fax/ 614 898.7786
Web/ www.ngwa.org and www.wellowner.org
Address/ 601 Dempsey Road/ Westerville, Ohio 43081-8978 U.S.A.

National Ground Water Association Response to U.S. Department of Energy Quadrennial Technology Review

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Groundwater supplies and energy production

Most states across the country are either experiencing groundwater shortages now or predict shortages in the next 20 years, according to a series of National Ground Water Association (NGWA) sponsored surveys of private and public sector groundwater professionals. The surveys showed that there is no one cause of shortages or expected shortages, but rather a combination of quality and quantity related causes. These are critical issues because energy production requires water and water movement requires energy.

Energy-water nexus – two sides of the coin:

1. It takes energy to pump, treat, store and distribute water to meet water supply needs. If the nation moves to more wastewater recycling and desalination the level of treatment required increases. "Energy use for the water sector could double from 3 percent of total energy use to 7-8 percent of total energy use. Depending on the mix of technologies, the water sector's energy use could go as high as 10 percent of the total energy need, making the water sector one of the biggest energy-using sectors.[1]" That is just for treatment, add in pumping and transportation and it would be a higher percentage.

   Concurrently, for example, the production of biofuels and the extraction of oil from shales have the potential to increase water used for energy production.[2] Actions to consider include:

   a. Research and deployment of more energy efficient technology in the water sector, e.g. solar powered pumps.
   b. Tools to encourage integrated planning between the water and energy sectors to understand the full implications of decisions made.
   c. Research in industrial scale membrane and micro filtration technology to make large scale water recycling more economical

2. As the nation moves to address its energy needs and greenhouse gases emitted from these energy generating sources, the potential exists for impacts to the nation's groundwater

[1] Personal communication, Michael Hightower, Sandia National Laboratory, July 2008.

[2] Report to Congress at http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf

resources. The following are specific topics identified as warranting research related to the geologic sequestration of CO_2 into the subsurface:

a. Chemical interactions between ambient groundwater and injected constituents.
b. The adequacy of current and the development of future tools and methods to undertake initial and ongoing geologic characterization, containment, monitoring, mitigation, and performance assessments to ensure the protection of the groundwater resource, the public and air quality.

Professional and business impacts:

1. Ensuring an adequately trained work force that can assist in meeting the nation's water supply needs, including for energy production and distribution, requires we address:

    a. Barriers to the recruitment and retention of employees for existing occupations.
    b. Training and education to provide technical or scientific skills for new or emerging fields, e.g. geologic carbon sequestration, geothermal heat pump drilling and business practices, hydrothermal drilling and dry hot rock reservoir stimulation,.
    c. Assisting the profession address its carbon footprint – small contracting firms are facing or are concerned they will face in the future significant costs to replace or retrofit existing transportation and stationary equipment used in their work. Steps that may assist these firms remain viable include:
        - Research to identify cost-effective options to upgrade existing equipment to address air quality concerns.
        - Financial assistance to replace or retrofit existing equipment.
        - Research to quantify that changes provide a net benefit, e.g. some of our members indicate that the new technology to address air emissions results in a loss of fuel efficiency and the burning of additional diesel fuel.

In the face of the current and expected future water supply challenges, NGWA offers the following as research, technology development, education and technology transfer needs – all of which have either a direct or indirect impact on energy technologies.

1. The nation lacks the fundamental data necessary to adequately understand the nation's groundwater resources and make informed decisions regarding its use and management. <u>Groundwater professionals identified the need for additional federal funding for cooperative groundwater quantity and quality data collection as the most useful federal action</u>.

    a. Support is needed for the federal Advisory Committee on Water Information's Subcommittee on Ground Water (SOGW), which includes federal, state and private sector organizations, as they work cooperatively to develop and encourage implementation of a nationwide, long-term groundwater quantity and quality monitoring framework that would provide information to help answer questions such as:

i. What are current water-levels or pressures in the nation's aquifers?
ii. How is groundwater quality changing in the nation's aquifers?
iii. How is groundwater availability changing in the nation's aquifers?

Collecting groundwater data is costly, given its widespread location and variability. While specific data gaps and priorities may vary around the country, collaboration will help optimize data-gathering efforts.

Geothermal Energy

NGWA is disappointed by the absence of references to geothermal heat pump (GHP)[3] technology in the *Quadrennial Technology Review*. The *Quadrennial Technology Review* suggests insufficient understanding of the current and potential utilization of GHPs, especially for the HVAC sector, which according to pages 28 to 30, accounts for 32 percent of building energy use (plus an additional nine percent for water heating), which in turn accounts for 72 percent of primary stationary energy demand. While high temperature geothermal *is* mentioned only in passing in the document, there is no real mention of the utilization of the Earth as a heat source and heat sink with low temperature geothermal heat pump systems.

NGWA is compelled to comment on the Department's *Quadrennial Technology Review* because it is our conviction GHP technology remains under deployed, too often resulting from weak understanding of geologic and hydrogeologic conditions during system design, installation, and operation. Ground source or groundwater heat pumps (GHPs) use the only renewable energy resource that is available at every building's point of use, on-demand, that cannot be depleted (assuming proper design), and is potentially affordable in all 50 states.[i]

Heat pumps exchange energy with the Earth to heat and cool homes, businesses, and public facilities at substantially less cost while using fewer natural resources than conventional alternatives. GHPs do and will play an integral part in reducing our country's energy consumption. One could just take a look at federal building projects to notice how big of a difference GHPs make in a building's energy use.[4]

GHPs are sometimes confused with high-temperature geothermal systems that generate electricity from steam. Instead, GHPs replace conventional heating and cooling systems for domestic and commercial applications. GHPs can also be configured to heat some or all of a building's domestic hot water. Because they simply move heat to and from the Earth, instead of burning a fuel to generate heat, properly designed GHP systems can provide decades of inexpensive renewable energy.

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[3] Ground-coupled heat pumps that use the Earth itself as a heat source and heat sink and are coupled to the ground by means of a closed loop heat exchanger installed horizontally or vertically underground; sometimes known as ground-source, or groundwater-source heat pumps; sometimes known as "geoexchange" heat pumps.

[4] Department of Energy. *Geothermal Heat Pumps for Federal Buildings*. August 1999. Retrieved April 7, 2011 at http://www.nrel.gov/docs/fy99osti/26275.pdf

GHP systems are comprised of three major components: the Earth connection, a heat pump, and a heating and cooling distribution system. The Earth connection can be an "open loop" that supplies well water to the heat pump, or a "closed loop" that circulates an eco-friendly anti-freeze/water solution through a closed loop of piping buried in the ground or submerged in a pond or lake. The heat pump's refrigeration cycle uses the Earth connection to move heat from the Earth to the building during winter, and to move heat from the building to the Earth during summer. Ductwork or hydronic piping then distributes the heating or cooling throughout the building.

Although industry estimates place closed loop systems at ninety (90) percent or more of the systems installed, there are at least nine (9) different configurations of geothermal heat pump technology. They include:

1) Open loop – single well for water withdrawal, water returned to a surface source
2) Open loop – single well for water withdrawal, water returned to a second well
3) Standing column – single well for water withdrawal and water return
4) Closed loop – vertical boreholes
5) Closed loop – subsurface trenched, or other configuration, but not vertical boreholes
6) Closed loop – surface water body emplacement
7) Direct exchange (DX) – vertical boreholes
8) Direct exchange (DX) – subsurface trenched, or other configuration, but not vertical boreholes
9) Concentric pipe systems (heat exchange fluid flows to the bottom of the hole through a small diameter inner pipe)

GHPs are among the most efficient and comfortable heating and cooling technologies currently available, according to the U.S. EPA's Energy Star Program. GHPs, properly installed by qualified professionals, can reduce energy consumption up to 44 percent compared to air-source heat pumps and up to 72 percent compared to electric resistance heating, with standard air-conditioning equipment.[5]

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[5] U.S. Environmental Protection Agency. *Space Conditioning: The Next Frontier* (Office of Air and Radiation, 430-R-93-004), Retrieved April 8, 2011 at http://nepis.epa.gov/Exe/ZyNET.exe/9100NXOW.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=430R93004&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=pubnumber percent5E percent22430R93004 percent22&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=pubnumber&IntQFieldOp=1&ExtQFieldOp=1&XmlQuery=&File=D percent3A percent5Czyfiles percent5CIndex percent20Data percent5C91thru94 percent5CTxt percent5C00000024 percent5C9100NXOW.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h percent7C-&MaximumDocuments=10&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p percent7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results percent20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL. Page ES-5

A Department of Energy, Oak Ridge National Laboratory report concludes that the aggressive deployment of GHPs in buildings could avoid the need to build up to 48 percent of the new electric generation capacity projected to be needed nationwide by 2030, also saving up to $38 billion annually in reduced consumer utility bills. GHPs can also help to heat domestic hot water at no cost during the summer and reduce winter water heating costs by as much as 50 percent.[6]

A 2008 report looking at federal research and development needs for buildings points out that energy-efficiency and renewable energy technologies, such as GHPs, still have enormous potential for energy savings at lower cost than acquiring supplies from non-renewable or renewable power sources. The enhanced use of ground energy sources and heat sinks at the building or community level is highlighted as a promising option.[7]

Our perspectives are driven by two philosophical anchors:

- Protection of groundwater is NGWA's **first** concern.
- Well-functioning geothermal heat pump systems are NGWA's **second** concern so as to protect the future of this business diversification opportunity for our members and industry by way of quality loop well drilling and construction.

Since DOE realizes HVAC dominates building energy use, NGWA reminds the Department low-temperature geothermal (associated with GHPs) provides:

- A source of clean energy that does not generate CO_2 emissions
- Is a nationally secure source that is fully formed within (below) the country (therefore can significantly reduce the importation of energy at the current cost of $1 billion per day)
- Low temperature geothermal is available everywhere in the country, not just a few localities. As such the need to transport this energy is non-existent, thereby saving even more energy in the transportation sector. Every building, whether residential, commercial or industrial can tap into this energy source on site
- Low temperature geothermal installations and their design are flexible and can easily be modified to accommodate and take advantage of local on-site conditions. In essence, low temperature heat exchange systems are using stored solar energy by way capitalizing on the near constant temperature of the shallow subsurface, as its temperature is determined by the mean average air temperature—which is ultimately determined by incoming solar radiation.

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[6] Hughes, Patrick. Oakridge National Laboratory. *Geothermal (Ground-Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers*. December 2008. Retrieved March 28, 2011 at http://www.ornl.gov/sci/ees/etsd/btric/pdfs/geothermal_report_12-08.pdf. Page 1.

[7] Executive Office of the President's National Science and Technology Council. 2008. *Federal R&D agenda for net-zero energy, high-performance green buildings. Retrieved April 8, 2011 at http://www.bfrl.nist.gov/buildingtechnology/documents/FederalRDAgendaforNetZeroEnergyHighPerformanceGreenBuildings.pdf* Page 26.

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- Low temperature geothermal systems can deal with storage issues, either daily or seasonal, and can easily be designed to store solar energy in the subsurface. The current framing document (page 34 section 6.2.2.3, Energy Storage) only discusses storage in terms of electricity, which is not very efficient, and the four sources of information that DOE will rely on are all dealing with electricity. There is nothing to deal with storage of other types of energy or any form of clean energy
- By using low-temperature geothermal it is possible to significantly reduce electricity consumption and therefore the need to generate additional electrical supplies. (above it was pointed out the document (pages 28 and 29) says 72 percent of U.S. primary electrical energy goes to building energy use and that HVAC needs are the largest part of this.

Geothermal (hydrothermal) ranks almost last in the Department's Figure 1, providing only 0.37 percent of the energy and 0.32 percent is electrical power generation (high temperature). The low temperature installations total 0.05 percent. High temperature geothermal also gets a quick mention at the very end of the document (page 40) under the final heading of "Other Clean Electricity Supply Technologies" where in the one paragraph dedicated to this section the authors say that geothermal and marine face "uncertainties that exceed those of other clean power technologies."

NGWA disagrees with those who contend GHPs are a mature technology and therefore do not warrant further dollars toward scientific and technical research projects. GHP technology will greatly benefit from verification through research. The importance of research verification is establishing credibility for the technology and the associated industry. Policy makers are strongly influenced by formal research, the domain of academics or those appropriately degreed. The GHP industry has real world experience, but if this experience is not verified by formal research conclusions, policy makers will be reluctant to responsibly act.

NGWA representatives recently participated in a March 2011 "green" buildings symposium in Beijing, China. One of the presentations during the symposium featured a map of China indicating the probable success of a GHP system functioning effectively in the various locales. The U.S. GHP industry may state these systems will efficiently and effectively function effectively in every state, but when a system fails to perform as marketed it remains a challenge to determine if the underperformance is due to improper installation or improper design specifications that also account for the geologic and hydrogeologic conditions. NGWA supports one or more of the national energy laboratories, such as Oak Ridge National Laboratory, establishing a GHP success probability map for the United States. Data currently being compiled by the state geological surveys though DOE funding could provide the input needed to generate accurate probability maps based on geology, overburden cover, and related thermal conductivities.

Also in Beijing, GHP presentations focused on large-scale installations identified sources of heat source and heat sink water as groundwater, surface water, sea water, and gray water. It was shared some researchers prefer groundwater-sources systems because the initial cost of installation is the lowest, but due to the high groundwater demand volumes – 3,000 gpm to 4,000 gpm per city block - the feasibility that an aquifer can sustain the pumping volume is extremely

low. The concept of using the Earth (groundwater) as a heat source is an energy savings approach. But taking a concept to reality requires that the real world be able to perform to the specifications – again, identifying the need for further appropriate scientific and technical research.

Researchers are developing simulation software for predicting GHP system performance across numerous parameters. For instance, the understanding of the construction of the loop well is generally minimal, at best, to the observation of NGWA member professionals. And yet, the importance of a competent drilling professional will be numerically supported by demonstrating the impact on projected system performance from loop well parameters. Simulation software will assist the loop well contractor in evaluating if the design parameters will succeed in the particular installation's geologic setting.

Energy Saving Performance Contracts (ESPC) demonstrate the value of the GHP system in actual energy dollars saved, and are worthy of further qualified investigation.

Also, there is only one known aquifer thermal energy storage (ATES) project in the United States (Richard Stockton Community College, New Jersey), compared to several throughout the rest of the world, particularly within the European Union. The same is true of borehole thermal energy storage (BTES). These two technologies, while utilized elsewhere in the world are largely absent from U.S. implementation. Perhaps this is due to a lack of DOE recognition of these technologies?

The Association has been a long-term participant in the GHP sector.

- We have been a long-term player in research and technology transfer projects, including for the Department of Energy and the U.S. Environmental Protection Agency.

- NGWA created Guidelines for the *Construction of Vertical Boreholes for Closed Loop Heat Pump Systems* in 1997 and have updated its guidance twice, the most recent being in 2010.

- The Association was an active participant in an International Energy Agency effort to develop an annex, or standard, for both Aquifer Thermal Energy Storage (ATES) and Borehole Thermal Energy Storage (BTES) technologies.

- NGWA is a significant provider of professional development education and training related to GHPs.

- The Association has developed financial analysis tools to help industry professionals better understand the costs associated with GHP installations.

- Through our consumer-oriented Web site, www.wellowner.org, we are a major provider of sound information to the general public about GHP technology.

- We are an active participant in GHP-related public policy discussions at the local, state, and federal level. The Association has been represented on the National Renewable Energy Laboratory geothermal heat pump road map project, currently is represented on a DOE geothermal heat pump grant project advisory team, and has participated with other related efforts.

- A NGWA-developed body of knowledge related to borehole construction contributes to sound GHP installation practices. NGWA's members -- groundwater scientists and engineers, as well as drilling and well construction professionals -- are resources for advancing GHP technology and its performance.

Geologic Sequestration of Carbon Dioxide

NGWA understands and values the need to deal with excessive volumes of carbon dioxide, portions of which are associated with energy production.

As expressed on several occasions, our concerns are that aquifers be protected from unacceptable degradation during every phase of a CCS project through hydrologic and hydrogeochemical characterization.

Potential water supplies, today seen as not viable for drinking water or other high uses, should not be "written off" due to a defined "high level" of total dissolved solids. Technology continues to improve that will treat those waters to levels useful for drinking water supplies and other critical uses.

What is the National Ground Water Association?

The National Ground Water Association is the global organization for anyone affiliated with the groundwater industry. A nonprofit organization, NGWA is comprised of more than 12,000 U.S. and international groundwater professionals — contractors, scientists and engineers, equipment manufacturers, and suppliers from all 50 states and more than 60 nations.

Our purpose is to provide guidance to members, government representatives, and the public for sound scientific, economic, and beneficial development, protection, and management of the world's groundwater resources.

Submitted: April 12, 2011
Submitted on behalf of: National Ground Water Association
Submitted by: Kevin McCray, CAE – Executive Director
601 Dempsey Road
Westerville, Ohio 43081
Ph/ 614 898-7791
www.ngwa.org
kmccray@ngwa.org

[i] Hughes, Patrick. Oakridge National Laboratory. Geothermal (Ground-Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers. December 2008. Retrieved March 28, 2011 at http://www.ornl.gov/sci/ees/etsd/btric/pdfs/geothermal_report_12-08.pdf. page 34.