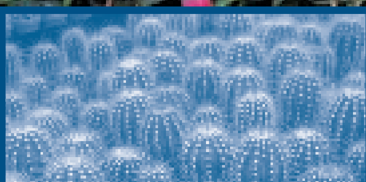
U.S. Department of Energy

**Energy Efficiency and Renewable Energy**

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

# Geothermal Technologies Program



## Direct Use

As charged by Secretary Abraham, the Office of Energy Efficiency and Renewable Energy provides national leadership to revolutionize energy efficiency and renewable energy technologies, to leapfrog the status quo, and to pursue dramatic environmental benefits.

The Geothermal Technologies Program, a critical part of our overall effort, is making great strides toward increasing the viability and deployment of geothermal heat and power. The peer reviewed, focused R&D and supporting outreach activities conducted by this program will enable broad expansion of the use of geothermal resources throughout the western United States. Through federal leadership and partnership with states, communities, industry, and universities, we will ensure that geothermal energy is established as an economically competitive contributor to the U.S. energy supply. Our program's success will mean a stronger economy, a cleaner environment, and a more secure energy future for our nation.

**David K. Garman**
**Assistant Secretary**
**Energy Efficiency and Renewable Energy**

# Direct Use Equals Smart Use

PIX13000 NREL, Robb Williamson

***Many communities and businesses in the western United States are showing the way, saving large sums of energy and money while using "direct-use" geothermal resources.***

## Heat that Comes Directly from the Earth

Low-temperature geothermal resources exist throughout the western U.S., and there is tremendous potential for new direct-use applications. A recent survey of 16 western states identified almost 12,000 thermal wells and springs, more than 1,000 low- to moderate-temperature (68° to 302°F, or 20° to 150°C) geothermal resource areas, and hundreds of direct-use sites.

Direct use of geothermal resources is the use of underground hot water to heat buildings, grow plants in greenhouses, dehydrate onions and garlic, heat water for fish farming, pasteurize milk, and for many other applications. Some cities pipe the hot water under roads and sidewalks to melt snow. District heating applications use networks of piped hot water to heat buildings in whole communities.

Directly using geothermal energy in homes and commercial operations is much less expensive than using traditional fuels. **Savings can be as much as 80 percent over fossil fuels.** It is also very clean, producing only a small percentage (and in many cases none) of the air pollutants emitted by burning fossil fuels.

Idaho Department of Water Resources

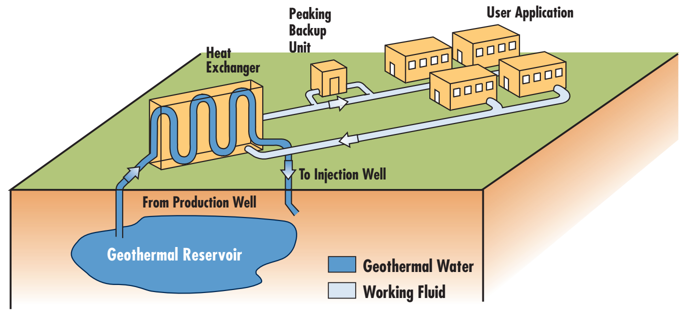
*The Idaho State Capitol Building (Boise) uses the city geothermal district-heating system.*

Direct-use systems are typically composed of three components:

- A production facility – usually a well – to bring the hot water to the surface;
- A mechanical system – piping, heat exchanger, controls – to deliver the heat to the space or process; and
- A disposal system – injection well, storage pond, or river – to receive the cooled geothermal fluid.

According to the Oregon Institute of Technology's Geo-Heat Center (DOE-funded), there are nearly 2,500 potentially productive geothermal wells located within five miles of towns and medium-sized cities throughout 16 western states. If these "collocated" resources were used only to heat buildings, the cities have the potential to displace 18 million barrels of oil per year!

Historically, most of the communities that were identified have experienced some development of their geothermal resources. However, depending on the characteristics of the resource, the potential




***Graphical representation of a geothermal district-heating system.***

exists for increased geothermal development for applications such as space and district heating, resort/spa facilities, aquaculture, industrial and greenhouse operations, and possible electrical generation in some areas.

Use of heat pumps with low-temperature geothermal resources can be very cost-effective, and can really extend the usefulness of the resource. For example, the College of Southern Idaho (CSI) uses two 36-ton heat pumps to provide supplemental space heating in a building that houses CSI's Health and Human Services Program. These two heat pumps have performed so well that an additional sixteen 36-ton heat pumps have been installed in another facility to extract more useful energy from the school's geothermal resource.

PIX13092 NREL

***Two 36-ton heat pumps being used for space heating at the College of Southern Idaho.***

## District and Space Heating

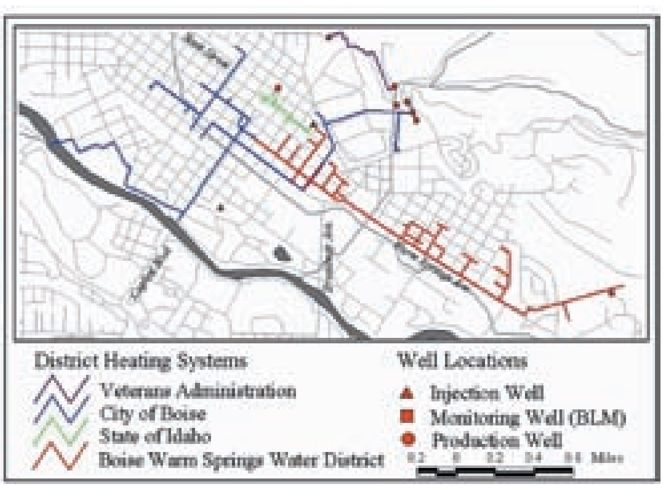
A growing and attractive use of low-temperature geothermal resources is in district and space heating. District heating systems distribute hydrothermal water from one or more geothermal wells through a series of pipes to numerous individual houses and buildings, or blocks of buildings. Space heating typically uses one well per structure, but can use more than one well. In both district and space heating systems, the geothermal production well and

PIX08827 Geo-Heat Center

***In Klamath Falls, Oregon, a geothermal district-heating system keeps the sidewalks clear and dry at the Basin Transit station after a snowfall.***

distribution piping replace the fossil fuel–burning heat source of the traditional heating system.

Savings are achieved not only by eliminating the need for conventional heating energy, but also through elimination of the need for equipment (e.g., boilers and gas vents) and interior space for this equipment. Most district systems also provide chilled water for building cooling (using conventional, but high-efficiency, modular equipment), and these savings can be substantially greater than heating bill savings because of the greater cost of electricity compared to heating fuels.




***Boise geothermal district-heating system map.***

**Boise District Heating, Idaho**

In 1892, two companies competed furiously for Boise's water system contract. One company, the Boise Water Works, sweetened its proposal by declaring the preposterous idea that it would distribute both cold and hot water. They got the contract, and Boise has used its geothermal resources ever since.

Today, that system is one of four geothermal district heating systems in Boise: the Boise Warm Springs, Water District System (the original), the Boise City System, the Veterans Administration Hospital System, and the State of Idaho Capitol Mall System (all three installed in the 1980s). Three hundred and sixty-six buildings are heated by these four geothermal systems. That's 4,426,000 square feet (411,189 square meters) – equal to about 1,770 houses. Boise has the only state capitol building in the U.S. that is heated by geothermal water.

In 1998, the city of Boise signed a Cooperative Agreement with DOE that provided $870,000 for the construction of an injection well for the city's geothermal heating system. The goals of the project are to reduce discharge into the Boise river and hydraulically replenish the geothermal aquifer the city shares with the Boise Warm Springs Water District, the Veterans Administration hospital, and the state of Idaho Capital Mall buildings. Since 1999, water levels in a nearby monitoring well have risen significantly, thus addressing one of the project goals.

PIX03694 Geo-Heat Center, Oregon Institute of Technology

***Heat exchangers and circulation pumps for the geothermal district-heating system in Klamath Falls, Oregon.***

PIX03706 Geo-Heat Center, OR Institute of Technology

***Geothermal energy is ideal for dehydration operations (onions and garlic), as seen in Empire, Nevada.***

The people of Idaho also use geothermal resources for other direct uses (see *Idaho's Buried Treasure*). In 1930, Idaho's first commercial greenhouse use of geothermal energy was undertaken. The system still uses a 1,000-foot (305-meter) well drilled in 1926. At least 14 other greenhouses now operate in Idaho. Geothermal aquaculture is also popular. Nine fish farms raise tilapia, catfish, alligators, and other fauna. "Using geothermal resources makes sense because they are clean, less expensive than other sources, and renewable," says Ken Neely of the Idaho Department of Water Resources, "Geothermal resources could become even more important in Idaho as demands for energy increase."

### Klamath Falls District Heating, Oregon

The city of Klamath Falls, Oregon, geothermal district-heating system was constructed in 1981 to initially serve 14 government buildings, with planned expansion to serve additional buildings along the route. The original and continuing municipal purpose of the district heating system is to serve building space heating requirements.
The City of Klamath Falls, with assistance from DOE, upgraded their district heating system in 2003 and 2004 to a thermal capacity of 36 million Btu/hr, allowing more customers to use the system.

PIX04133 Jeff Hulen

***Developing geothermal resources in the United States translates to more jobs at home, and a more robust economy.***

The district heating system was originally designed for a thermal capacity of 20 million Btu/hr (5.9 MW thermal). At peak heating, the original buildings on the system utilized only about 20 percent of the system thermal capacity, and revenue from heating those buildings was inadequate to sustain system operation. This led the city to begin a marketing effort in 1992 to add more customers to the system. Since 1992, the customer base has increased substantially, with the district heating system serving several additional buildings.

Geothermally heated sidewalks and crosswalks have been incorporated into a downtown redevelopment project along Main Street, starting with the 800 block in 1995. That same snowmelt system has been extended to cover nine blocks of sidewalks and crosswalks. The heated sidewalk and crosswalk area currently served by the city snowmelt system is over 60,000 square feet (18,288 square meters).

### Reno and Elko, Nevada

Nevada is also a hotbed of geothermal development, with applications growing rapidly in this resource-rich geothermal state. Modern geothermal energy use in Nevada began in 1940 with the first residential space-heating project in Reno. Today, almost 400 homes


use geothermal energy for heat or hot water in Warren Estates and Manzanita Estates. These two housing developments, located in southwest Reno, Nevada, comprise the largest residential geothermal space-heating district in Nevada.

Production well depths range from 700 to 800 feet (213 to 244 meters) with temperatures in excess of 200°F (98˚C). Geothermal water is pumped at a rate of 250 to 350 gallons-per-minute (gpm) (1,137 to 1,591 liters-per-minute) from one of two production wells to flat-plate heat exchangers at the surface. Hot water at about 180°F (82°C) is circulated from the heat exchangers to the subdivisions via underground pipes. All geothermal water is injected back into the reservoir through a well located on the premises.

Elko is another Nevada community with a long-standing history using geothermal heating. In 1978, the first geothermal food-processing plant was opened in Brady Hot Springs. More than 25 million pounds (11.3 million kilograms) of dehydrated onion and garlic are being processed annually.

Elko Heat Company has been operating a geothermal district heating system in Elko, Nevada, since December 1982. The Elko Heat Company project was funded by DOE in the late-1970s, and continues to operate successfully today. This system serves 17 customers, and distributes approximately 80 million gallons (364 million liters) of 178°F (81°C) geothermal water annually. Customers are primarily using the geothermal water for space heating and domestic hot water heating. Two customers are using their return water for wintertime snow and ice melting on walkways, and one is using a heat pump system.

***Cactus production at the Southwest Technology Development Institute (SWTDI), Las Cruces, New Mexico.***

## Aquaculture and Horticulture

Greenhouses and aquaculture (e.g., fish farming) are the two primary uses of geothermal energy in the agribusiness industry. Most greenhouse operators estimate that using geothermal resources instead of traditional energy sources saves about 80 percent of fuel costs – about 5 to 8 percent of total operating costs. The relatively rural location of most geothermal resources also offers advantages, including clean air, few disease problems, clean water, a skilled and available workforce, and, often, low taxes.

New Mexico is appealing to the greenhouse industry for several reasons, including a good climate, inexpensive land, a skilled agricultural labor force, and the availability of relatively inexpensive geothermal heat. New Mexico has taken the nation's lead in geothermal greenhouse acreage with more than half of the state's acreage now heated by geothermal resources. And there are also many successful, thriving geothermal direct-use greenhouses in other western states (see Geo-Heat Center website at: ***geoheat.oit.edu/***).

New Mexico has the nation's two largest geothermal greenhouses and a total of 50 acres (20.2 hectares) of greenhouses that are heated with geothermal energy. This represents a payroll of more than $5.6 million and sales of $20.6 million. Nearly all of the greenhouse sales are to out-of-state buyers. In addition, the largest geothermal greenhouse pays royalties to the state for geothermal production, and the smallest geothermal greenhouse pays Federal royalties for geothermal heat.

Altogether, the projected new greenhouse acreage and business startups by 1997 represented a capital investment of more than $21.5 million, with sales of nearly $26.1 million. Nearly 500 new jobs are the result. Annual energy savings to the greenhouse operators, using geothermal energy, approaches $1 million.

The largest geothermal greenhouse in the nation is the Burgett Geothermal Greenhouse near Animas in southwestern New Mexico. This 32-acre (13-hectare) facility produces high-quality cut roses that are marketed widely, contributing substantially to county tax receipts, and creating local jobs.

*This is an example of a geothermal "direct-use" application in horticulture in Idaho (Mountain States Plants, Flint Greenhouses).*

PIX13097 NREL


NREL, Rob Williamson

**AmeriCulture Fish Farm**

AmeriCulture Inc., located in Animas in southwest New Mexico, is among the largest domestic suppliers of tilapia fingerlings and is able to produce between four and seven million fingerlings annually. AmeriCulture markets and sells a disease-free tilapia fry to growers and researchers nationwide for grow-out to full size. Tilapia is a fish that is growing in popularity for its taste. AmeriCulture ships male tilapia fingerlings by UPS throughout the country. In recent years, local Red Lobster™ seafood restaurants have added tilapia from AmeriCulture to the menu.


PIX13027 NREL, Rob Williamson

*Tilapia is growing in popularity for its mild taste.*

Geothermal offers several advantages for fish culture. For example, AmeriCulture facilities are heated at much lower costs, compared to fossil fuels like propane, with a downhole heat exchanger installed in a 400-foot (122-meter) depth well. Many species have accelerated growth rates in warm water, adding to energy-saving advantages.

**Masson Radium Springs Farm**

The Masson Radium Springs Farm geothermal greenhouses are located on private land in southern New Mexico 15 miles (24 kilometers) north of Las Cruces. The operation started in 1987 with four acres of geothermally heated greenhouses. Masson selected New Mexico and the Radium Springs area to take advantage of the sunshine, ease of climate control because of the dry desert air, a willing and trainable work force, and geothermal heat. Today, the greenhouses employ 110 people, and cover 16 acres (6.5 hectares) in two major modules, each with shipping and warehousing buildings attached. The Masson Radium Springs Farm geothermal greenhouses produce more than 30 groups of potted plant products, including seasonal products such as poinsettias and carnations.

***Masson Radium Springs Farm greenhouse in New Mexico.*** NREL, Rob Williamson

The greenhouse space is heated by geothermal energy from three wells that are located on private land. Two are shallow wells less than 350-foot (107-meter) depth, and produce 165°F (74°C) water. The third well was drilled about two years ago to 800-foot (244-meter) depth, and produces water at 199°F (93°C). The water is stored in a newly constructed 167,000-gallon (760,000-liter) storage tank used mainly for nighttime heating. After use, the geothermal water is injected back into three shallow (less than 250-foot/76-meter depth) injection wells.

**Mountain States Plants**

Flint Greenhouses, owned and operated by Mountain States Plants, and located in the Hagerman Valley of southern Idaho, uses geothermal fluid ranging in temperature from 98° to 110°F (37° to 43°C) for greenhouse heating. The two-acre (0.8-hectare) greenhouse facility achieves an estimated annual savings of about $100,000 over propane gas, representing a significant competitive advantage on operating costs. Compared to Mountain States Plant's other two greenhouse operations (not geothermally heated), the Flint Greenhouses delivers the best cost-per-square-foot operating performance. About 20 permanent employees and 10 to 15 seasonal employees work at the Flint Greenhouses raising potted plants.

## DOE Support and Assistance

Through its support of the Geo-Heat Center (website at ***geoheat.oit.edu/***) at the Oregon Institute of Technology in Klamath Falls, Oregon, DOE conducts research, provides technical assistance, and distributes general information on a wide range of geothermal direct-use applications. The center is the primary source of data and information about all types of direct-use operations. Those interested are encouraged to contact this organization by the Internet or by phone (541-885-1750) for technical assistance and consumer information. ■

# Idaho's Buried Treasure – Geothermal Energy

*Homegrown, abundant, secure energy right beneath the ground.*

Idaho holds enormous reserves – among the largest in the United States – of this clean, reliable form of energy that to date have barely been tapped. According to U.S. Geological Survey estimates, Idaho ranks seventh among the 50 states in geothermal energy potential. **These resources could provide up to 20 percent of Idaho's heat and power needs.**

Idaho State Historical Society (73-2.52)

***The Natatorium was a landmark in Boise.***

***Geothermal resource map of Idaho, showing areas in pink with potential for direct-use applications (mostly lower half of State).***

Idaho's history of geothermal use begins with Native Americans who congregated at hot springs, as indicated by artifacts and petroglyphs on nearby rocks. Settlers, miners, and trappers also used hot springs by the mid 1800s. In 1892, the nation's first district heating system was birthed in Boise (see *Direct Use Equals Smart Use*). Geothermal water was put to use along Warm Springs Road to heat over 200 buildings including homes, businesses, and the Boise Natatorium, a 65 by 125-foot (20 by 38-meter) swimming pool.

The district heating system is still in operation and has been joined by three more district heating systems in the Boise area. The current city system is used to heat about 2.7 million square feet (250,838 square meters) including the City Hall, the new Ada County Courthouse, and over 40 businesses. The water is extracted from several wells that range in depth from 880 to 1,900 feet (268 to 580 meters). Water production temperature is about 175°F (80°C). Most of the used geothermal water is re-injected about a mile to the southwest of the wellfield.

In 1930, Edward's Greenhouses became the first commercial greenhouse operation in the United States to use geothermal water for a heat source to grow plants. The facility still exists and prospers today. Several other greenhouse businesses were developed throughout southern Idaho in the next half-decade to take advantage of the natural hot water available in many places.

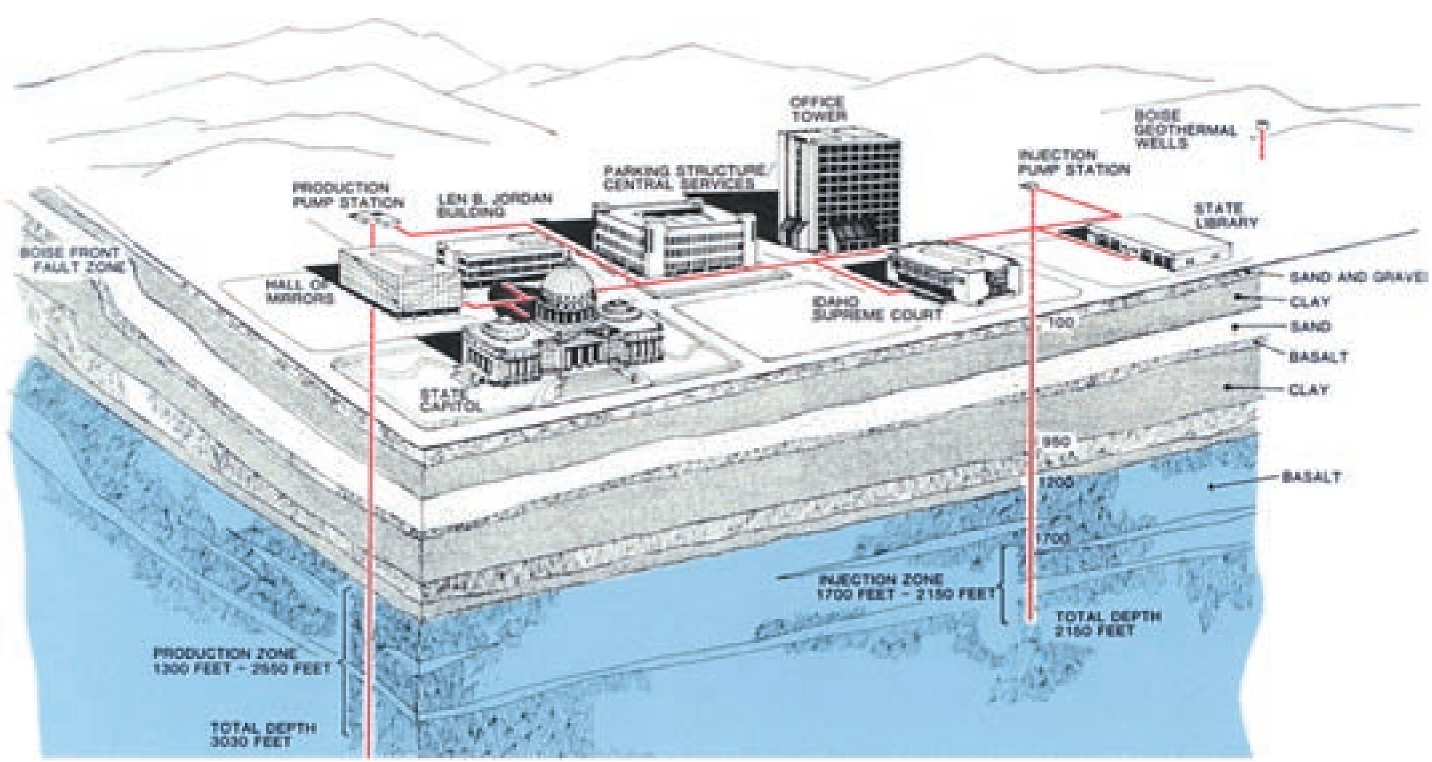
In 1979, the College of Southern Idaho (CSI) drilled the first geothermal well on its campus in Twin Falls. During the 1980s, district heating operations were put in place in Twin Falls and Ada counties.

*The Ada County Courthouse in Boise, Idaho, uses the city geothermal district-heating system.* PIX13078 NREL

*The Idaho State Capitol Building in Boise is heated by the city geothermal district-heating system.* PIX13100 NREL

CSI drilled a second geothermal well in 1981. Throughout the 1980s, CSI converted their existing heating system into a geothermal heating system by laying the underground supply and return lines, retrofitting the existing buildings, and installing heating systems in the new buildings. The heating system serves 12 buildings and 4 greenhouses, with over 440,000 square feet (40,877 square meters) of facilities kept warm by geothermal energy. About 35,000 square feet (3,252 square meters) of this area is conditioned with two 36-ton heat pumps using geothermal fluid. Water temperature from the two production wells is about 101°F (38°C). The system currently produces about 209 million gallons (950 million liters) per year. The spent water is discharged over the south rim of the Snake River Canyon.

In the early 1980s, the State of Idaho drilled two wells in the vicinity of the Capitol Building. By 1982, the State of Idaho geothermal system was supplying heat to nine buildings in the Capitol Mall complex, including the State Capitol. Currently, the system is used to heat about 4,426,000 square feet (411,189 square meters).




*The Capitol Mall geothermal district-heating system, Boise, Idaho.*


***Geothermal production well at the College of Southern Idaho, Twin Falls. This district-heating system now heats nearly half a million square feet (46,450 square meters), with more area reached by this winter with 16 heat-pump units.***

Geothermal interest has grown in Idaho since the early 1990s. In the mid 1990s, a computer modeling study was conducted for the Boise geothermal system in an effort to predict how different production scenarios might affect water levels and temperatures. In 1999, the City of Boise began re-injecting its used geothermal water into the aquifer through a newly completed (cost-shared with DOE) injection well. Since 1999, water levels in a nearby monitoring well have risen significantly and in a manner similar to modeling predictions.

## *These resources could provide up to 20 percent of Idaho's heat and power needs!*

Although there has been a great deal of development of geothermal energy in Idaho, considering its small population and large land mass, the potential for further use of this resource is great. Development of geothermal energy resources for various applications has proven to be a positive economic impact for Idaho. ■

# Fish Breeders of Idaho

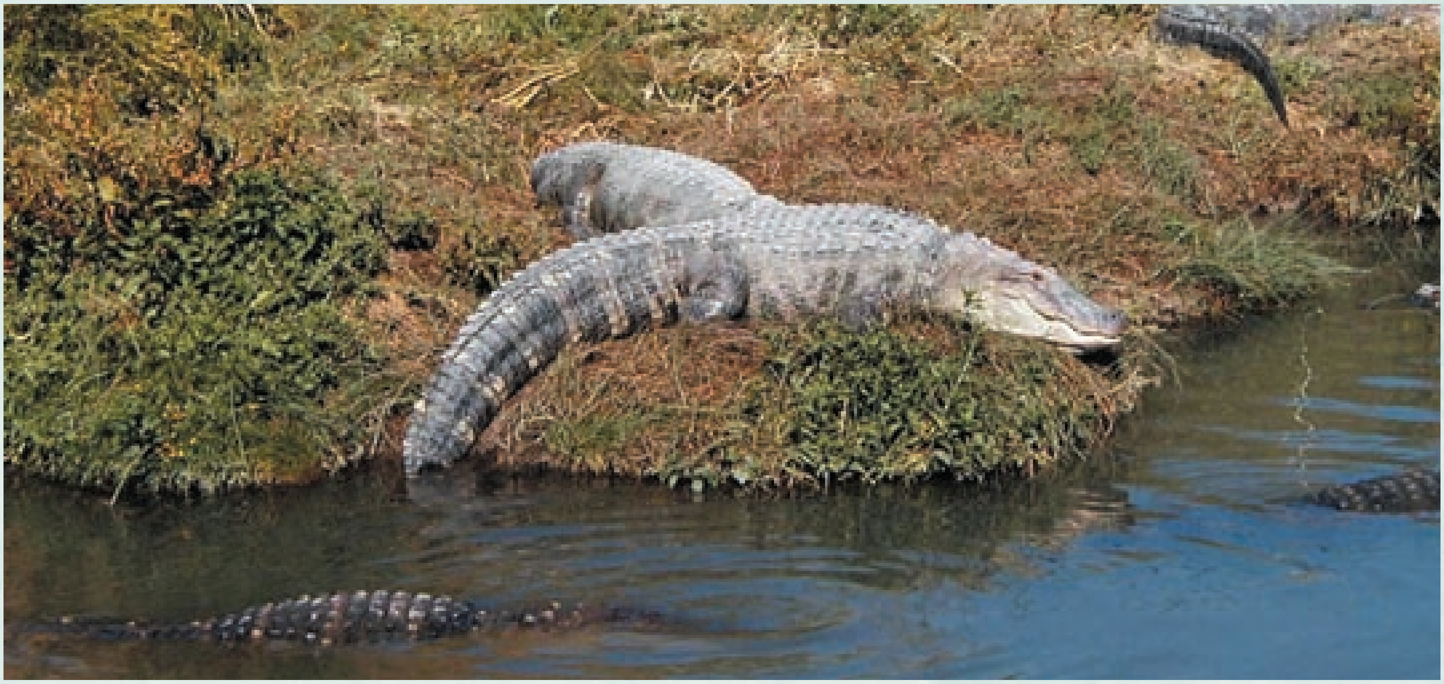
In 1973, Leo Ray became the first person to use geothermal water to raise catfish in the Hagerman Valley near Buhl, located in the Snake River Valley in southern Idaho. In fact, Mr. Ray may have been the first person in Idaho to put geothermal resources to work for fish farming, raising tilapia, sturgeon, blue-channel catfish, and rainbow trout.

Mr. Ray's site has hot artesian wells that produce abundant quantities of 95°F (35°C) water. Mixing this hot water with crystal-clear cold springwater produces the ideal temperature for growing these fish. The climate is too cold and the growing season too short to grow these aquatic species without hot water. Geothermal water changes a non-commercial area into a 365-day optimum growing season.

After processing onsite, the fish are shipped daily to supermarkets and restaurants throughout the United States and Canada. Mr. Ray also raises alligators with geothermal water – 2000 alligators! Some of the alligator hides are even sold to Gucci™ for women's purses. (For more details, see GATORS IN THE SAGE, *geoheat.oit.edu/bullletin/bull23-2/art2.pdf*, Geo-Heat Center Quarterly Bulletin, Vol. 23 #2.)

*Leo Ray in front of geothermally heated cascading fish raceways. Geothermally heated water accelerates fish growth.*

*Tilapia fingerlings being raised in Idaho with the aid of geothermal energy.*



*Mature alligators at Fish Breeders of Idaho – without geothermal heat, they could not survive in Idaho.*

## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

* Conserve energy in the residential, commercial, industrial, government, and transportation sectors
* Increase and diversify energy supply, with a focus on renewable domestic sources
* Upgrade our national energy infrastructure
* Facilitate the emergence of hydrogen technologies as vital new "energy carriers."

## The Opportunities

**Biomass Program**
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

**Building Technologies Program**
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

**Distributed Energy & Electric Reliability Program**
A more reliable energy infrastructure and reduced need for new power plants

**Federal Energy Management Program**
Leading by example, saving energy and taxpayer dollars in federal facilities

**FreedomCAR & Vehicle Technologies Program**
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

**Geothermal Technologies Program**
Tapping the Earth's energy to meet our heat and power needs

**Hydrogen, Fuel Cells & Infrastructure Technologies Program**
Paving the way toward a hydrogen economy and net-zero carbon energy future

**Industrial Technologies Program**
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

**Solar Energy Technology Program**
Utilizing the sun's natural energy to generate electricity and provide water and space heating

**Weatherization & Intergovernmental Program**
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and businesses

**Wind & Hydropower Technologies Program**
Harnessing America's abundant natural resources for clean power generation

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