VINEYARD CONSERVATION SOCIETY'S

Conservation Almanac

ENERGY: GEOTHERMAL

Geothermal energy the gift that keeps on giving!

Brian Nelson and his partner David Sprague are both driven by a passion to reduce their carbon foot print and make their children proud! Nelson Mechanical Design, Inc is housed in Brian's basement in Vineyard Haven, which is alive with hoses, gauges, valves and panels of digitally driven information about their 4 year old business, geothermal energy, as well as the display of the onsite functioning geothermal heating and cooling system which services Brian's house.

Both men are master plumbers with years of experience, which they have found extremely useful for research and development of geothermal technology as well as the installation of geothermal units. Their infectious enthusiasm for this solar solution coupled with other renewable energy sources such as wind, is a powerful solution and welcome relief to ward off the woes of global warming.

It is important to note that this renewable resource, in the form of a geothermal heating and cooling unit, qualifies as an Energy Star product and therefore the homeowner is eligible for State rebates and low interest homeowner loans.

"Education is a big piece of what we do," Brian noted, and we are determined to inform the architects and builders as well as the public about this remarkable ever present energy source." Judging from their current projects and networking it is safe to say these two men are well on their way to being an important part of the solution to our dependency on fossil fuels.

Following is a thoroughly presented paper by Brian Nelson, on the workings of geothermal technology and why its use is so important for the Vineyard and beyond.

To see a functioning unit and find out much contact Brian at brian@nmdgreen.com or call 508-696-3120.

View of the Energy Present and Future of Martha's Vineyard
Geothermal Energy and Technology

By Brian Nelson, from Nelson Mechanical Design Inc.

In this paper we will describe the components of our energy present and future here on Martha's Vineyard and what Nelson Mechanical Design is and will be doing to move us towards a self-sufficient carbon neutral island. We see a tremendous awakening across the island (and the nation) and an intense interest in global warming, energy efficiency, and self-sufficiency. One of our paramount goals is to be part of the solution in the fight against global warming – through education, design, installation, and example.

We see three main components of our energy present and future on the Vineyard – each of which is essential for the success of the other two. They are the solar resource, the solar delivery, and the solar storage. The Sun is doing a great job in providing us with a dependable and amazing solar resource. We have several exciting new and improved solar delivery and storage techniques that are now mature enough to be used on an island-wide basis.

To maximize the value of the solar input, we must improve our buildings and their energy efficiency. The end result can be the net-zero energy building with no carbon footprint. This is doable – we have the technology and the local capability to make this happen now.

Solar Resource: Direct Sunshine – Stored Solar Energy - Wind

In 10 seconds enough sunshine hits the surface of the Earth to power the entire world for a day. Stated another way, every year we get 500 times more energy from the Sun than mankind uses. We have no shortage of energy available – the issue at hand is how do we collect it, store it, and deliver it?

The sun gives us several potential sources of energy: direct sunshine, stored solar energy in the Earth, and wind. All of our energy needs can be met with these sources using technology available now.

Solar Resource: Stored Solar Energy in the Earth – Geothermal Energy

There are two main types of geothermal energy – hot rock geothermal energy and solar geothermal energy.

Hot rock geothermal energy involves the use of the heat from the molten rock and natural radioactive decay in the core of the Earth (ranging up to 10,000 F) to heat steam for space heating and electricity generation. Old Faithful and Iceland are

prime examples of hot rock geothermal. Hot rock geothermal essentially starts at 1000' underground and continues to the core of the Earth.

Solar geothermal energy involves the upper crust and surface of the Earth. The Sun dumps an amazing amount of energy every minute in the form of low grade heat into the Earth, oceans, lakes, rivers, and ponds of our planet. As mentioned above, there is an immense amount of energy available – more than enough for all of our needs. The only issue at hand is how to collect this stored solar energy and move it into our buildings for heating and domestic hot water. The geothermal process we will discuss (and the only type applicable to the Vineyard) is the solar geothermal system.

Solar Resource: Wind Power – Electricity from the Sun

We have an amazing wind resource here on the Vineyard – this resource will be the solution of our energy needs for the future. Because wind power produces electricity for direct use and to run geothermal heat pumps for heating and cooling we will have a direct replacement for our fossil fuel using systems. The installed cost of wind power is currently about half the price of solar photovoltaic panels.

Currently we have a very small wind turbine presence. We predict tremendous changes in the Vineyard landscape in the next few years as the land based wind resource here is developed. Our plans for the very near future are outlined in more detail in our overview of upcoming projects.

Solar Delivery: Heating and Cooling Our Buildings using the Sun

The heating of buildings is responsible for 50% of the global warming problem. After the necessary implementation of better insulation, less infiltration, and better passive solar design, we will still need to heat, cool, and ventilate our buildings.

Geothermal systems use geothermal energy (in the form of stored solar energy) to heat and cool buildings. They are the essential solution to this situation – through the use of wind or solar photovoltaic panel generated electricity, the carbon footprint is zero or negative, no carbon dioxide is created, and the island and its buildings can approach self-sufficiency.

Attempts in the past to use direct sunshine to heat and cool buildings have been plagued with storage problems – to meet the heating demand in the middle of winter with direct solar energy, the storage requirements (perhaps a large holding tank of solar heated water) become expensive and cumbersome.

Passive solar design is very important but is not reliable as the sole source of heat throughout the winter, especially with commercial buildings that need fresh outside air in the winter that must be heated (such as schools)

Geothermal Systems – Why They Are So Important:

The geothermal process involves a heat pump which is amazingly effective at cheaply moving and concentrating stored solar energy.

As we progress toward an all electric island, the only effective way to use electricity for heating of buildings is through a geothermal system.

This is because for every unit of energy we put into the geothermal system, we receive 3 to 5 units of energy from the system – the extra amount comes to us free from the Sun! This means that it is between 300% and 500% efficient – an essential requirement if we are to use electricity in a cost-effective way to heat or cool our buildings.

It has consistently proven to cost HALF of the operating cost of a 100% efficient fossil fuel system (because the Sun is giving the stored solar energy for free).

Because it is not a combustion process, no carbon dioxide is created, making it an essential component in our fight against global warming and reducing our carbon footprint.

The life span of geothermal systems across the globe is over 30 years. The connection to the earth has a life expectancy of between 100 and 200 years and the heat pumps at least 30 years. There is no required maintenance and only one moving part (in the compressor).

Geothermal Systems – How They Work:

If you have ever used a paint spray can, you know that as the nozzle is depressed, the can gets cold. This is a phase change of liquid paint in the can into vaporized paint outside of the can. As the pressure of the paint drops (the pressure is high in the can as a liquid and low outside the can as it changes from liquid to vapor) the temperature drops as well. The same process is used by the heat pump to capture the stored solar energy in the Earth. There are many ways a geothermal system can connect to the Earth or water but the heat exchange process is the same.

Let's use the copper loop connection as an example to illustrate the "geothermal magic"

Two copper pipes are installed in a 100' borehole in the Earth – they are connected together at the bottom of the hole and up in the house at the geothermal heat pump.

Liquid high pressure refrigerant (50 F and 200 pounds per square inch) goes from the heat pump down the pipe into the earth. The average year round earth temperature is 50F. At the bottom of the hole the copper pipe going down is connected to the copper pipe coming up.

This connection has an orifice – just like a can of spray paint. The same phase change occurs between the two copper pipes at the bottom of the hole - the high pressure liquid is now changed to a low pressure vapor at about 40 pounds per square inch in the pipe - and the temperature plummets to 10F!

This makes the copper pipe going back up very cold and very attractive to all the free stored solar energy in the earth. The refrigerant vapor in the pipe going up soaks up a lot of this heat and takes it to the geothermal heat pump in the building.

The vapor reaches about 50F during its journey upward through the earth – once it enters the geothermal heat pump it is compressed to 200 pounds per square inch. This compression drives the temperature up to 190F! – this is a very hot and highly compressed vapor.

This means that the compressor in the heat pump has very cheaply and effectively <u>concentrated</u> the stored solar energy in the earth trapped in the vapor – now it can be used to heat buildings and domestic hot water. (if we run it backwards we get cooling from the same system).

By pulling the heat out of the vapor to heat our building we have changed it from a vapor back to a liquid – still at 200 pounds per square inch. It is now around 50 F and ready to repeat the cycle – it will get sent by the heat pump back down the copper pipe to start the process over. This heat moving "conveyor belt" is what moves the stored solar energy so easily into the building.

Across the globe, the millions of these systems have consistently averaged over 300% efficiency – for every kilowatt of electricity put in we can move 3 to 4 kilowatts of free stored solar energy – this means that the operating cost of a geothermal system is consistently half of the cost to operate a 100% efficient fossil fuel system! It is much cheaper to move heat than it is to make it. This savings is what allows us to project a 5 to 7 year payback on the geothermal system installation.

<u>Geothermal Systems</u>: <u>Earth Connections</u>

We can connect to the Earth using the following methods:

plastic HDPE tubing (using propylene glycol as a working fluid – called a closed loop system)

copper tubing (using refrigerant as a working fluid – called a direct exchange system)

well water (with a supply well and discharge well – essentially the Sun heats the Earth, the Earth heats the ground water, we remove some stored solar energy from the water, and return the water to the ground unharmed – called an open loop system)

municipal water (similar to an open loop system – there is a school in Oklahoma that uses town water as the stored solar energy source, removes a few degrees, and sends the drinking water back to the town water supply!)

standing column well (with a very deep single well with a smaller inner return line – this is the system in place at the Woods Hole Research Center – like an open loop system, the Sun heats the Earth, the Earth heats the ground water, we remove some stored solar energy from the water, and return the water to the ground unharmed.)

Geothermal Systems: Ocean and Pond Connections - Ocean Front Geothermal

We are surrounded by a practically infinite source of stored solar energy – the Atlantic Ocean and Vineyard Sound.

We can connect to this resource using a plate heat exchanger – this is a titanium or stainless steel sandwich about ½ inch thick, 4 by 8 feet in height and width, that is suspended below a pier or on a skid on the bottom. It weighs about 100 pounds.

The Sun heats the Atlantic and the Sound and this stored solar energy is captured by this suspended heat exchanger. Even in the middle of winter, with slush and ice on the ocean's surface, the water below is above 30F – according to the daily temperature data at the South Beach ocean monitoring center the lowest recorded temperature was 33 F. New heat pumps are now available with extended ranges down to 30 F which makes their use in these systems economical and practical.

Martha's Vineyard: Ocean Front Geothermal Systems on a Municipal Level!

If we think about our geothermal resource of stored solar energy in the waters surrounding the Vineyard, it is an astonishing amount of energy!

We can easily gang these heat exchangers together to provide heating and cooling for any size building – from single family homes to restaurants to the hospital to an entire town!

All at a 50% reduction in yearly operating cost.

And this approach to geothermal has the lowest first cost because the heat exchangers are fairly inexpensive and have an expected service life of over 100 years.

Thinking of a town wide system, it would be very easy and cost effective to install plastic (HDPE) pipes to and from the ocean based heat exchanger suspended under existing piers and run them under the streets as another utility – a geothermal energy utility.

Then each town could meter geothermal energy use from each building – if one building is cooling and another building next door is making hot water the energy would merely flow from one building to another, and the town would meter it in either direction. This is a reality now – the heat exchangers are extremely robust and compact, we have plenty of piers, and pipes could be buried throughout towns as roads are resurfaced.

Solar Storage:

Solar Storage: Stored Solar Energy - Earth, Oceans, Lakes, and Ponds

The Sun is constantly storing energy an immense reservoir of free heat in the Earth's surface and its waters – more than enough for all of our heating and cooling needs. This is a much more effective way of storing solar energy than via hot water or pebble bed storage systems but is at a lower temperature – we must use geothermal systems to concentrate this heat into a usable form.

Solar Storage: Electricity Storage - Batteries or Hydrogen or Ammonia

Sunshine converted into electricity by solar photovoltaic panels or wind turbines can be stored for later use in batteries, in hydrogen, or ammonia. The advances in hydrogen technology are very exciting – especially since many of them use water, electrolyzers, and renewably generated electricity to generate hydrogen. We foresee an explosion in hydrogen storage applications as soon as our installed capacity of wind power becomes more significant.

Net-Zero Energy Buildings:

All of the above energy components are essential – but equally important is the efficient building shell. We must make widespread the work of modern builders

here on the Vineyard (notably South Mountain) by adopting their greatly increased wall insulation, window glazing, and shell infiltration reduction.

Fortunately there has been great progress on the architect and design front to begin to incorporate these developments. We are seeing more and more projects including these elements – this allows us to shrink our mechanical systems and reduce energy use to meet the reduced heat loss.

This increased awareness is a nice complement to our energy and heat loss software which quantifies savings from improvements in both energy and dollars.