Renewable Geothermal – A Path to Reduced Carbon Emissions and Increased Reliability

August 2017

Overview

This white paper is intended for industry leaders and business owners to consider an energy system alternative with the potential to disrupt the current legacy grid and provide a 24 / 7 zero carbon power.

Executive summary

Virtually all involved in the energy and power sectors understand the need to promote renewable resources. Renewables can reduce the consumption of fossil fuels at the utility power stations, thereby improving energy security and the environment simultaneously.

This paper describes a new system design that combines solar energy and geothermal storage to create non-depletable, continuous carbon free electrical generation.

About the Author

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Mark is a chemical engineering graduate from the University of Kansas where is studied the use of CO_2 injection in the Permian Oil Basin as part of tertiary oil recovery. He has been a registered professional engineer since 1986 and is licensed in six western states. Mark is the president of Technical Designs, an engineering consulting firm, based in Reno, NV and managing partner of UC-Won, an intellectual property development collective with core patents in clean energy and sustainable markets. Since 2013, Technical Designs has been recognized as a member of the EPA's CHP Clean Power Partnership and has successfully completed CHP projects in urban areas. Mark is certified by the US Green Building Council and Technical Designs has worked to LEED certify approximately 3 million square feet of built environment. For the past three years, Mark has been the energy chair for Western Nevada Development District, working with energy related infrastructure challenges in nine rural Nevada counties.

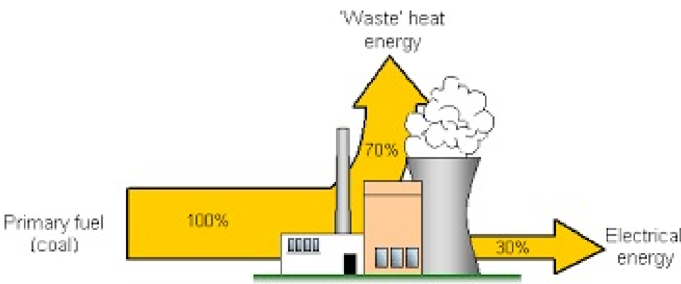
Technical Designs is currently working with Homestretch Geothermal, the oldest geothermal plant in Nevada, to monitor and improve the efficiency of their 5.6 MW binary cycle generation equipment.

The current legacy electrical grid is not sustainable

Background

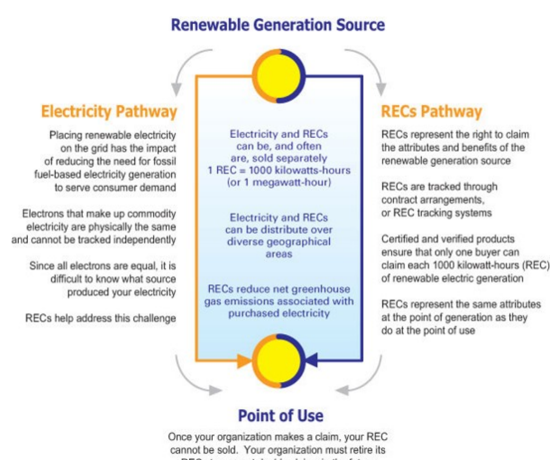
Today, messages about energy are mostly negative ones. As anthropogenic carbon emissions continue to escalate and the effects of climate change become increasingly evident, the need to address the effects has never been more urgent than now. We are forced to look for ways to use less energy, even though life in the 21st century requires increasing consumption of energy and the resulting increase of carbon emissions. The recent message from the Pope, the Clean Power Plan, and global summit meetings on the environment are all aimed at reducing greenhouse gas emissions and the resulting long-term effects of climate change. Whether the US agrees or disagrees with the terms of the Paris Agreement, the profound shift in thinking has been made around the world: CO_2 emissions are pollutants, harmful to sustainable life on planet earth, and steps need to be taken to aggressively manage all sources.

The electricity delivered to your door comes from many different sources. Some very efficient and some not so efficient. It may surprise you to learn that from an energy standpoint, most electricity delivered to you is less than 50% efficient. This means that two units of greenhouse gas are created for every unit of electricity you consume. We all know that when we consume electricity, that in some remote location, the last major smoke stack industry is pumping out uncontrolled amounts of CO_2, or carbon emissions. That's how it works: burning fossil fuels creates heat, carbon dioxide, and water, along with a few other noxious compounds as the byproduct. Following the electricity from the power plant to the legacy grid, there are additional losses and inefficiencies that further multiply the problem of increased carbon emissions. These problems can be directly attributed to a system, invented over 100 years ago, of inefficient, antiquated electrical generation concepts tied to a US unplanned patchwork of over 160,000 miles of complex interconnecting wires. Due to the costs involved and inherent political drag to upgrading an outdated infrastructure, most countries and industries are unwilling to take, or are incapable of taking the necessary action. There is a growing consensus that we can no longer wait for governments or industries to act, rather solutions, using new technologies need to be developed and deployed.



An attempt at change

We should all be able to agree that power plants that use fossil fuels generate higher levels of air pollution and their emissions have been linked to acid rain and climate change. In response to an increasing demand for "green" energy, many countries have adopted legislation requiring, and providing incentives for, electric utilities to sell electricity generated from renewable energy sources. In the United States, approximately 40 states have adopted renewable portfolio standards (RPS), or similar laws requiring or encouraging electric utilities in such states to generate or buy a certain percentage of their electricity from renewable energy sources. The tracking mechanism for renewable energy is the REC, or renewable energy credit.

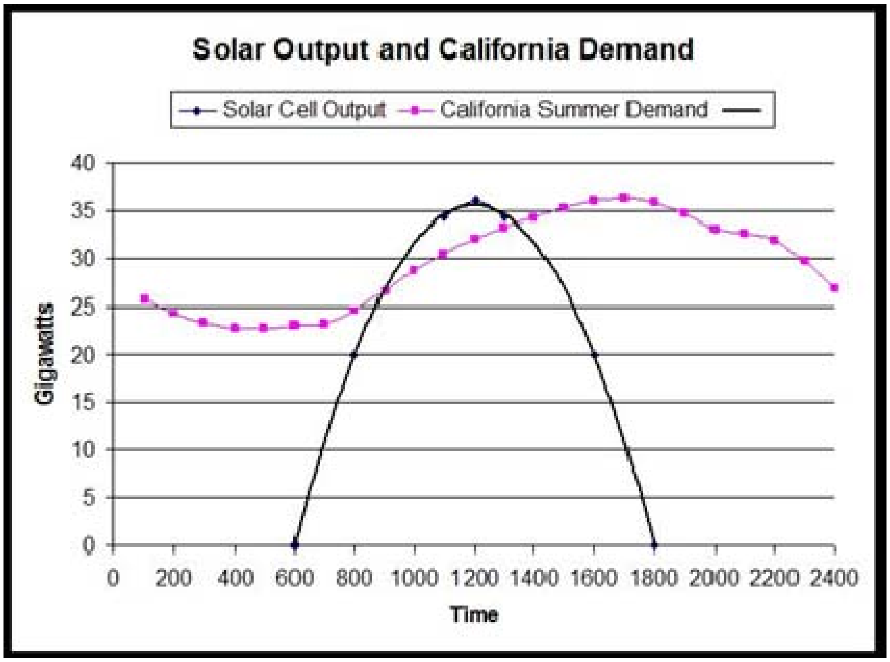


Per DOE *"All grid-tied renewable-based electricity generators produce two distinct products: 1) Physical electricity; and 2) RECs: As renewable generators produce electricity, they create one REC for every 1000 kilowatt-hours (or 1 megawatt-hour) of electricity placed on the grid. The REC product is what conveys the attributes and benefits of the renewable electricity, not the electricity itself."*

Because of these programs, most regulated markets have invested in solar photovoltaic (PV) and wind as being the "least upfront installed cost" in the evaluation of long term avoided costs. But the obvious flaw in this approach is wind is available on an intermittent basis and solar, under the best conditions, is only available 8 hours a day. The long term unintended consequences of investment in wind and solar PV is the increasing reliance on fossil fuels and severe grid balancing problems as these resources turn on and off during the course of the day.

The Duck Curve and the argument against solar PV and wind

If you study the graph below of the California grid performance, you will see the problem with reliance on solar PV. At a time when the demand for electrical power continues to climb, the amount of available solar drops off and creates a large imbalance in the electrical grid. For each megawatt of solar, you need a matching spinning reserve of batteries, standby peaking power plants, neighboring power plants, or a combination of all three. To maintain reserves and balance the grid is both costly and complicated. None of these costs are currently evaluated into the low-cost decision to use solar PV. California is on an aggressive path to 50% renewable energy by 2030 and you must ask if this can be achieved with solar PV as a viable alternative.



Electricity from wind power can be produced at night when solar is not available but is susceptible to the changing weather and seasonal patterns and requires the same sort of redundancy as solar PV that is backed up by burning fossil fuels.

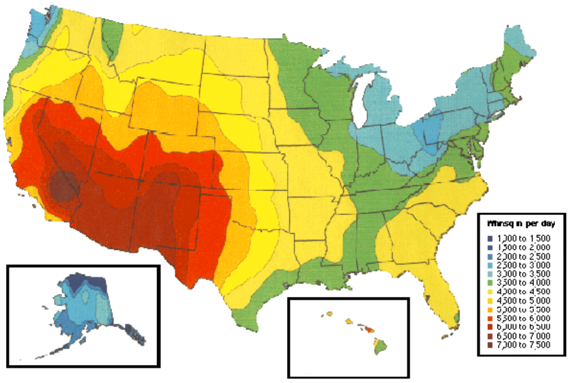
Data Centers now create more carbon emissions than all air travel combined and are now generating not only demand for fossil fuel generation at night, when solar PV is not available. Consider a future where the largest growth in electrical demand will be data centers and electrical vehicles charging, both with high nighttime demands from the legacy grid. The problem is clear to see: the unintended consequences and the resulting environmental injustice of generating more fossil fuel emissions. Additionally, more grid instability is created as you transition daily from solar PV / wind to burning fossil fuels.

We can see the disingenuous behavior of using REC's created during the day from solar photovoltaic to cover loads at night, but in defense of the market, REC's were the only tool available to barter in the world of "green" energy. Google has been one of few leaders in the marketplace to address this problem by reconciling both renewable energy and carbon emissions. "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond", published in December 2016 discussed a pathway for Google data centers to reach carbon free goals. This confirms the need for a power source that is both carbon free and available continuously.

Solar Storage

We know that the sun places enough energy on our planet in one hour to handle all our electrical needs for a year. The real challenge is to find ways to capture and store this energy to use it at our convenience.

If we consider batteries (added to solar PV) that store electricity, using lithium technology as the most efficient choice, there is not enough world reserves of lithium to handle a grid storage demand scenario. Greentech Media estimates there is just under 17 years of production from known lithium reserves with a resounding "No" to the question of whether lithium technology can scale to meet the demands of the grid and electrical vehicles.



Therefore, batteries using lithium technology would never scale and the cost for battery storage would be enormous.

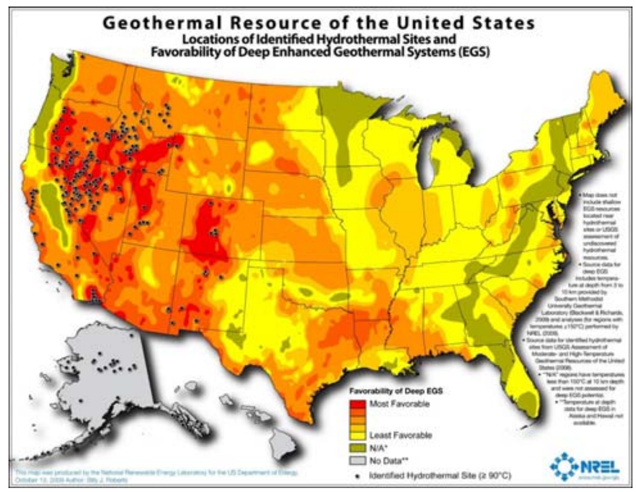
However, storage of solar is possible if you consider harvesting and storing thermal energy. Most of the Southwestern US has the highest average daily solar radiation which identifies where to harvest solar in abundance.

The next step is to decide how to store this energy. We will focus on known underground resources that have been mapped and logged: abandoned geothermal wells and abandoned oil or gas wells.

EGS Geothermal

Most of the history of geothermal exploration and development in the US has been built around finding easily assessible (close to the surface) high temperature resources. Most of the time, exploration holes were drilled and many wells were abandoned because they failed to produce enough heat in a consistent manner that could create a commercially viable electric generation project. In response to these "dry" holes, the industry began the process of developing Enhanced Geothermal Systems (EGS). EGS is defined by the DOE as:

"A naturally occurring geothermal system, known as a hydrothermal system, is defined by three key elements: heat, fluid, and permeability at depth. An Enhanced Geothermal System (EGS) is a man-made reservoir, created where there is hot rock but insufficient or little natural permeability or fluid saturation."



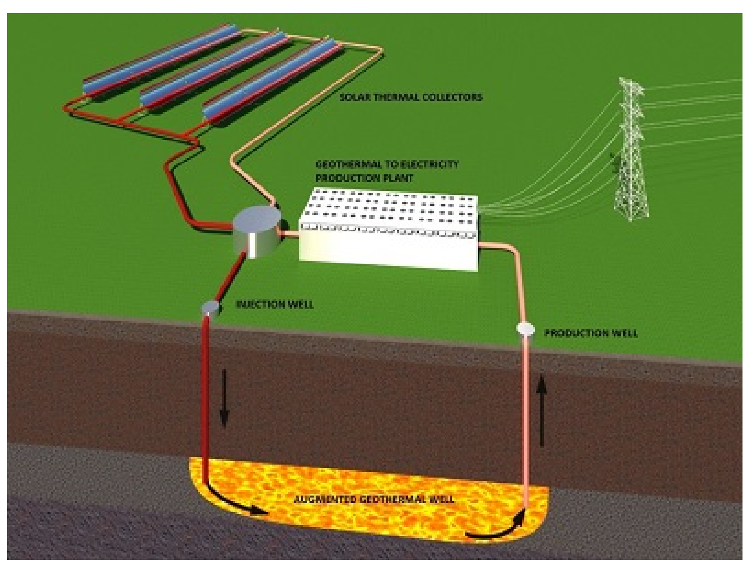
In an EGS, fluid is injected into the subsurface under carefully controlled conditions, which cause pre-existing fractures to re-open, creating permeability.

The DOE has a long history in funding research into the area of Hot Dry Rock (HDR) as published in "**A TECHNOLOGY ROADMAP FOR STRATEGIC DEVELOPMENT OF ENHANCED GEOTHERMAL SYSTEMS"**, by John Ziagos, et al., Stanford University, 2013.

In simple terms, EGS is about finding a hot pan in the earth and "priming the pump". What we propose can use these same wells and resource points, but rather than hope the flow between two wells can create enough heat, we propose a new approach that enhances the outcome substantially.

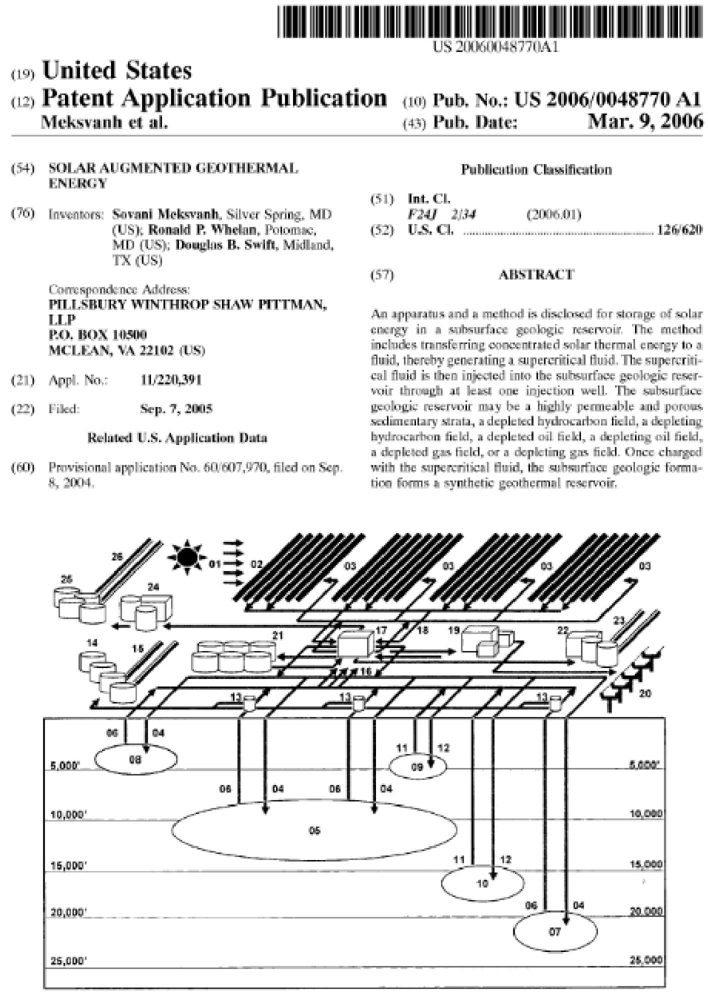
Renewable Geothermal is born

Renewable Geothermal (RenewGeo™) is simply the idea of harvesting solar energy in the form of heat and injecting it into the ground to create a synthetic geothermal resource. The amount of solar heat injected in 8 hours is adequate to replenish the resource to allow for 24 hours of electrical power generation with no depletion to the reserve.



We know from EGS research (Petty), that a volume of one cubic kilometer of subsurface rock has the potential to store enough thermal energy to produce 1,360,000 MWh of electricity. We would need just a fraction of this volume of storage to power a small city.

The renewable geothermal approach will use what we have learned in EGS trials regarding storage but removes the gamble that the ground will naturally heat fluid to the temperature needed by actively heating the synthetic geothermal resource. Any heat added by nature will be taken as further improvement to the thermal to electricity conversion process.



US 20060048770A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0048770 A1**
Meksvanh et al. (43) **Pub. Date: Mar. 9, 2006**

(54) **SOLAR AUGMENTED GEOTHERMAL ENERGY**

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(21) Appl. No.: **11/220,391**

(22) Filed: **Sep. 7, 2005**

Related U.S. Application Data

(60) Provisional application No. 60/607,970, filed on Sep. 8, 2004.

Publication Classification

(51) **Int. Cl.**
F24J 2/34 (2006.01)
(52) **U.S. Cl.** **126/620**

(57) **ABSTRACT**

An apparatus and a method is disclosed for storage of solar energy in a subsurface geologic reservoir. The method includes transferring concentrated solar thermal energy to a fluid, thereby generating a supercritical fluid. The supercritical fluid is then injected into the subsurface geologic reservoir through at least one injection well. The subsurface geologic reservoir may be a highly permeable and porous sedimentary strata, a depleted hydrocarbon field, a depleting hydrocarbon field, a depleted oil field, a depleting oil field, a depleted gas field, or a depleting gas field. Once charged with the supercritical fluid, the subsurface geologic formation forms a synthetic geothermal reservoir.

Connecting the dots

Today's energy problem is less about sources and more about storage; it is known that geothermal is a 24 / 7 carbon free renewable energy. We combined our knowledge of how CO_2 was injected in the Permian Oil fields and used to control flow underground from injection to production wells as a method of enhanced oil recovery. One of the patents most aligned with this approach is Patent US20060048770A1, "Solar Augmented Geothermal Energy". This patent, along with other intellectual property, creates a new technology architecture with a clear market advantage to creating a new non-depletable form of geothermal, RenewGeo™.

Risks and Rewards

As much knowledge as we have about pumping water into the ground and retrieving that water with heat added from nature, we know very little about the injection and retrieval of solar heated water. There are modeling challenges to predict the flow from injection / extraction points, but using the same injection / production techniques that the oil industry has developed, it should be possible to control the reservoir temperature and flow to create useable thermal storage. Recognize that much of the cost of geothermal is in drilling wells and this cost could be avoided as part of the upfront capital costs if reusing existing wells.

The installed cost of solar geothermal is higher than conventional geothermal plants, but keep in mind that you are buying solar storage along with geothermal. We also see an opportunity to bring new ideas and technology to an industry that has limited and antiquated approaches. The improvements in performance and efficiency can bring revenue up to offset these additional costs. Capital costs for geothermal projects have seen a 30% investment tax credit in the past, but it is hard to know if these will continue under the current administration.

Sadly, the risk to our planet is great. Because if the message of disingenuous behavior (8-hour solar PV backed up with burning fossil fuels vs. 24 / 7 geothermal as a superior renewable energy source) is not understood and corrected, we may end up where we cannot reverse the environmental damage.

Conclusion

As a disrupter, RenewGeo™ can become the Amazon of renewable energy. No other technology can easily incorporate solar storage and scale to a utility level development. Once the technology is deployed, the next step would be to incorporate data centers directly on site to avoid the costs and time for traditional legacy grid infrastructure and create built in levels of redundancy (these costs are currently additive to the data center capital costs).