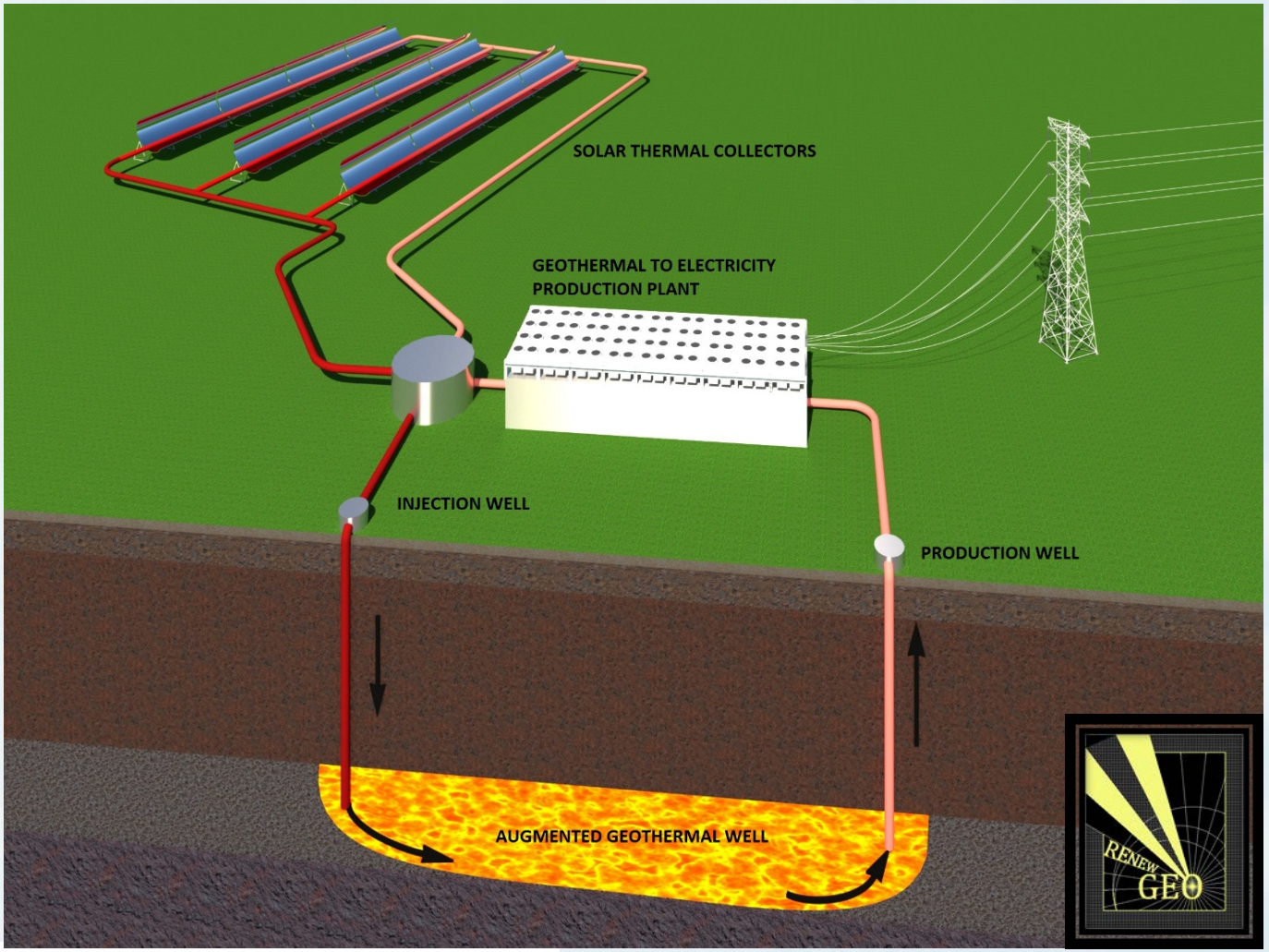
Mark Hauenstein, P.E.
UC-Won

Abstract: The sun places enough energy on our planet in one hour, that if converted efficienctly, could handle all our electrical needs for a year. So, the real challenge to today's electrical grid is to find ways to capture and store this energy to use it at our convenience. What if there was a way to store solar heat and create electricity without carbon emissions from a renewable geothermal resource? Let's look at what we have learned from CO2 injection used to control flow and enhance recovery with knowledge gained from ESG to create new synthetic geothermal resources using existing wells and infrastructure.

SMU POWER PLAYS CONFERENCE 2018
GEOTHERMAL STORAGE APPLICATIONS



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♦ JANUARY 2018 ♦

Mark Hauenstein, P.E., Managing Partner
UC Won, LLC
1150 Selmi Drive, Suite 505, Reno, NV 89505
markh@uc-won.com

A GLASS OF WATER – AN ENGINEERS PERSPECTIVE

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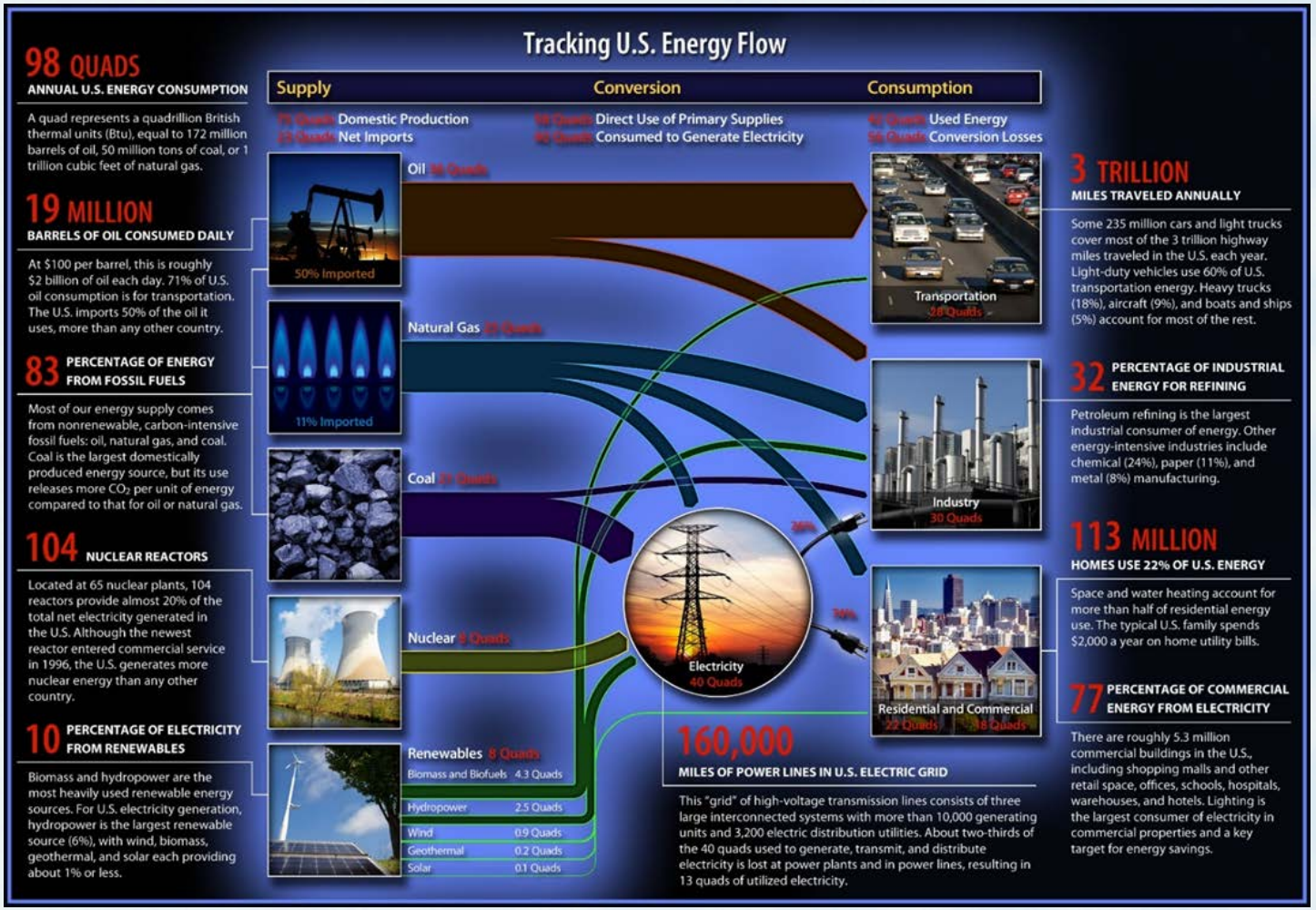
ENERGY TRACKING ON A NATIONAL SCALE



Out of the 98 apples a year; 42 apples are consumed and 56 apples are thrown away!

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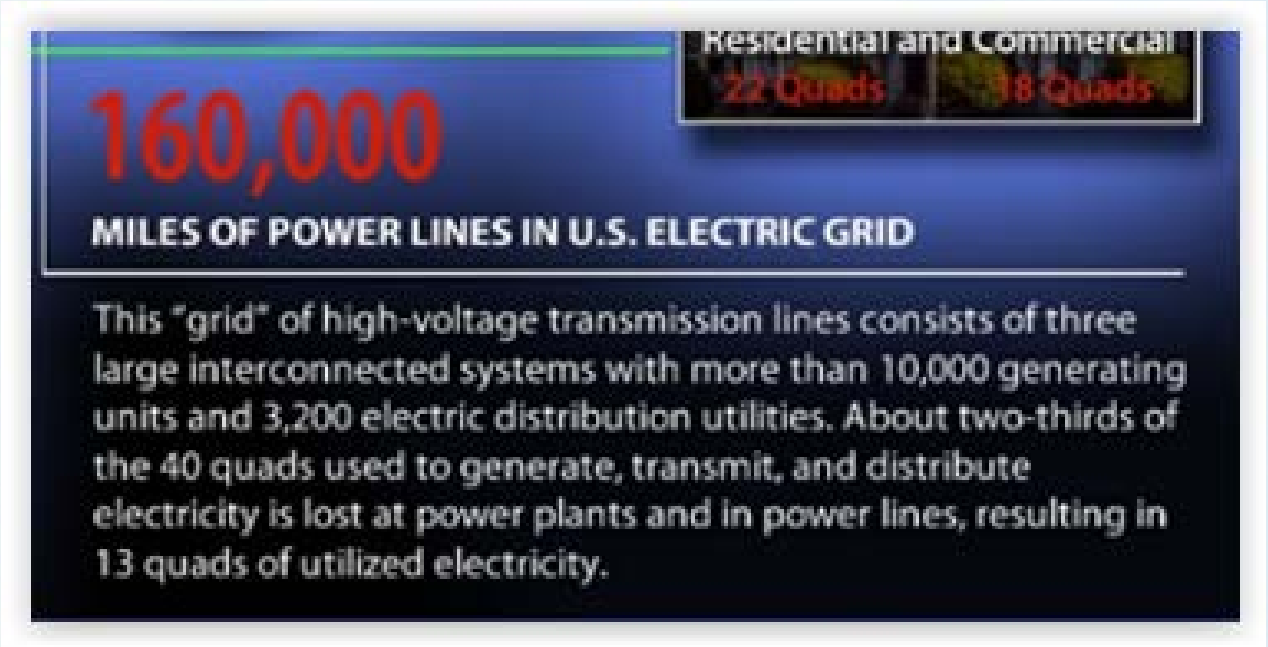
ENERGY TRACKING ON A NATIONAL SCALE



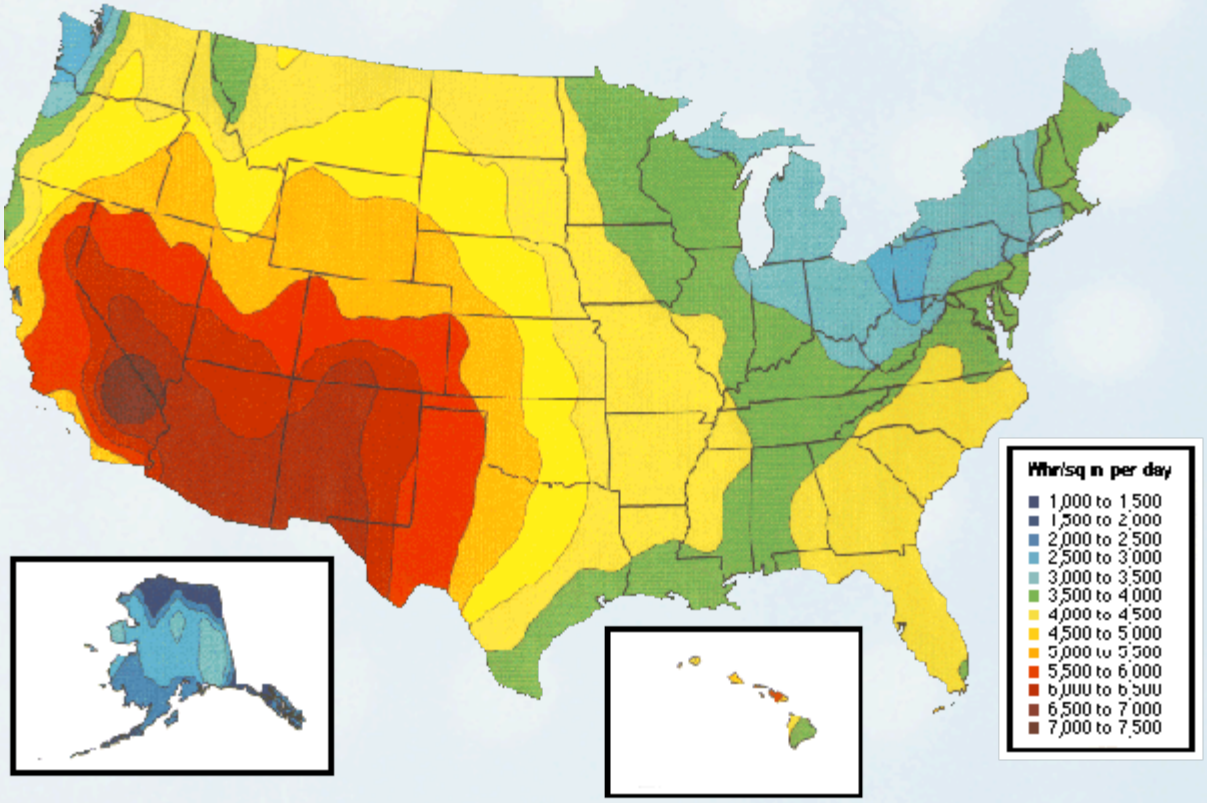
From the 98 apples consumed annually, 40 of the apples are set aside to make apple sauce (electricity).

Out of the 40 apples, two thirds (27 apples) are wasted and 13 apples are delivered and sold. (Wait, the 40 apples and all the emissions were consumed to sell 13 apples.)

Note: 235 million vehicles travel 3 trillion miles on just 28 apples.

ENERGY TRACKING ON A NATIONAL SCALE

We know that the sun places enough energy on our planet in 1 hour to handle all our electrical needs for 1 year.



And solar PV has been the first choice to de-carbon the grid because of the cheap first cost and easy to deploy.

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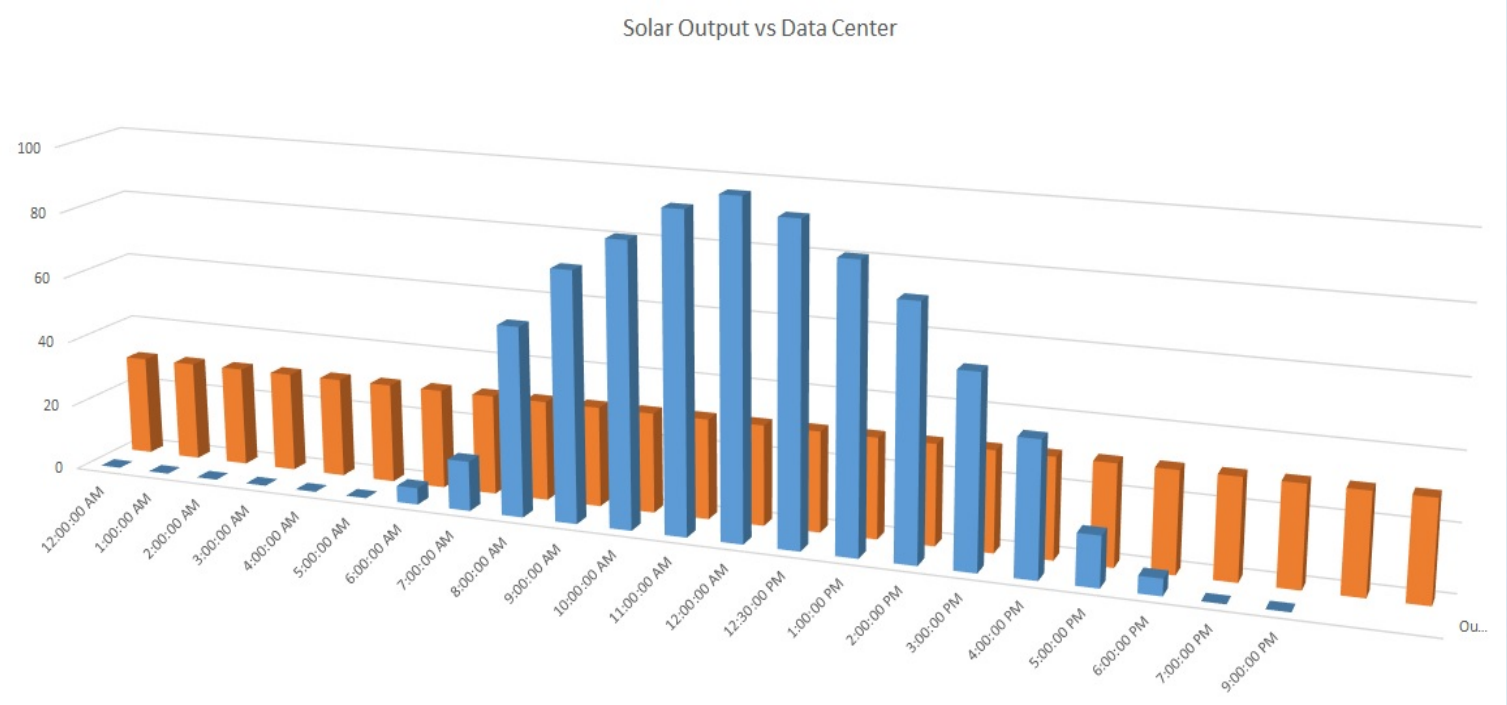
ENERGY TRACKING ON A NATIONAL SCALE

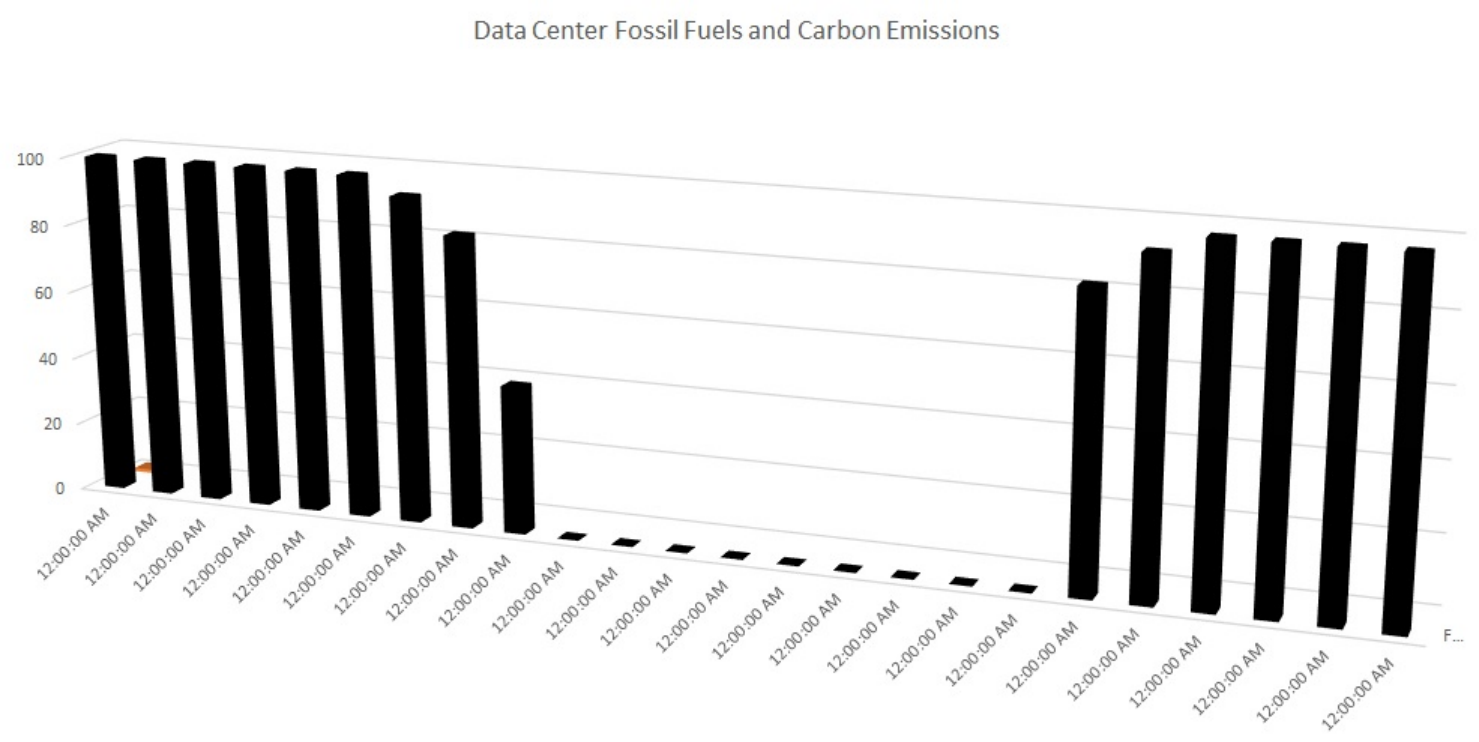
But electricity created from solar PV has the limitation of being available roughly 8 hours a day.



The long term unintended consequences of investment in 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.

ENERGY TRACKING ON A NATIONAL SCALE

…and increased carbon emissions.



So, today's renewable energy problem is less about cheap sources and more about storage. Most electrical grid storage projects today are centered on batteries with cost and scale limitations.

GEOTHERMAL STORAGE APPLICATIONS

THE SOLAR CHARGED GEOTHERMAL TECHNOLOGY

What if there was a way to store solar heat and create electricity without carbon emissions from a renewable geothermal resource?

And what if this technology could be deployed using existing resources and infrastructure?

The oil industry and geothermal have much to share with each other.

THE HISTORY OF SOLAR GEOTHERMAL FROM AN OIL PRODUCTION PERSPECTIVE

1907
Thermal Injection

Thermal injection, which involves the introduction of heat, is one form of enhanced oil recovery (EOR) and dates back to the early 1900's. Themal injection today accounts for 40 percent of EOR production in the United States, with most of it occurring in California.

1957
Solar Thermal is Born

Solar thermal has been used for EOR, dating back to 1957, when Atlantic Richfield tried an experimental facility in California.

2005
Production Scale Thermal Assist

The world's first full field Thermally Assisted Gas Oil Gravity Drainage (TAGOGD) development has been successfully implemented in Oman at Qarn Alam Fractured Carbonate Reservoir. The concept of TAGOGD was invented by Shell in 1992 and the first successful pilot was developed in the Qarn Alam field from 1995 to 2005, during which 1.3 million tons of steam were injected. The benefit was clearly demonstrated by the fact that this recovery process increased the recovery factor tenfold from 3% to over 30%. This is exceptional for any EOR project.

2005
Solar Augmented Geothermal Energy (SAGE)

In the early 2000s, Doug Swift and Ron Whelan traveled to Oman to offer assistance and expertise on solar energy systems for EOR for the Qarn Alam project. At the time, the project was looking for an alternate to burning natural gas for the thermal energy source. Doug and Ron developed a solar powered solution and their unique proposal was adopted. Sovani Meksvanh, Doug Swift, and Ron Whelan filed application for a patent entitled, "Solar Augmented Geothermal Energy" in 2005, and this application was granted a patent (2006/0048770) in March 2006.

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THE HISTORY OF SOLAR GEOTHERMAL FROM AN OIL PRODUCTION PERSPECTIVE

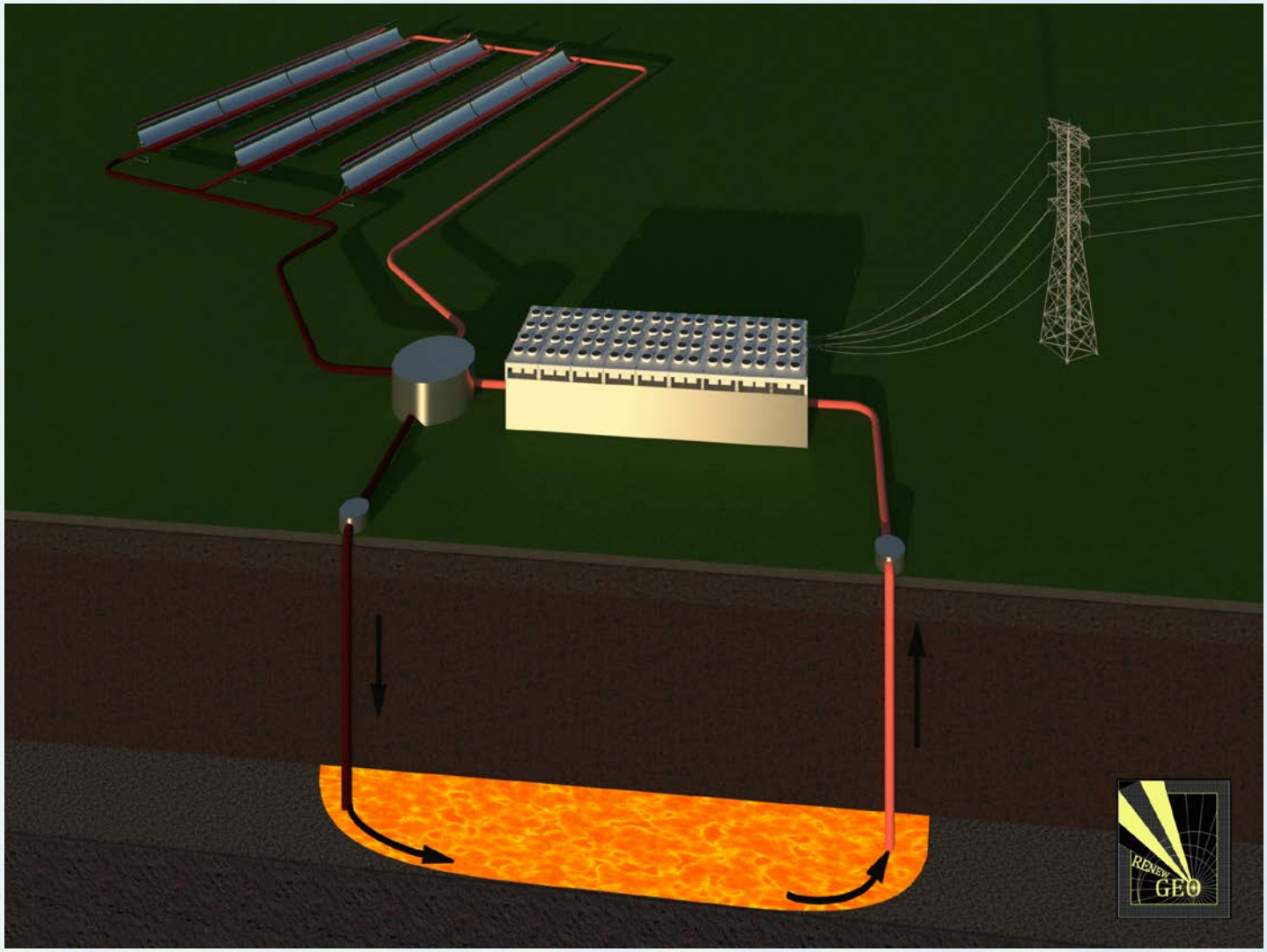
2015
Solar Thermal Expansion

In July 2015, Petroleum Development Oman and GlassPoint Solar announced that they signed a $600 million agreement to build a 1 GWth solar field on the Amal oilfield. The project, named Miraah, will be the world's largest solar field measured by peak thermal capacity.

2017
Renew Geothermal is born.

Mark Hauenstein with UC-Won, in working with the original inventors, was granted a license for the patent 2006/0048770 for solar augmented geothermal process. Together with other patents filed by UC-Won, an architecture and team emerges that brings together the technology and expertise to create large scale 24/7 carbon free electricity from a solar augmented charged geothermal resource.

GEOTHERMAL STORAGE APPLICATIONS



Solar Augmented Geothermal

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THE HISTORY OF SOLAR GEOTHERMAL FROM A GEOTHERMAL PERSPECTIVE

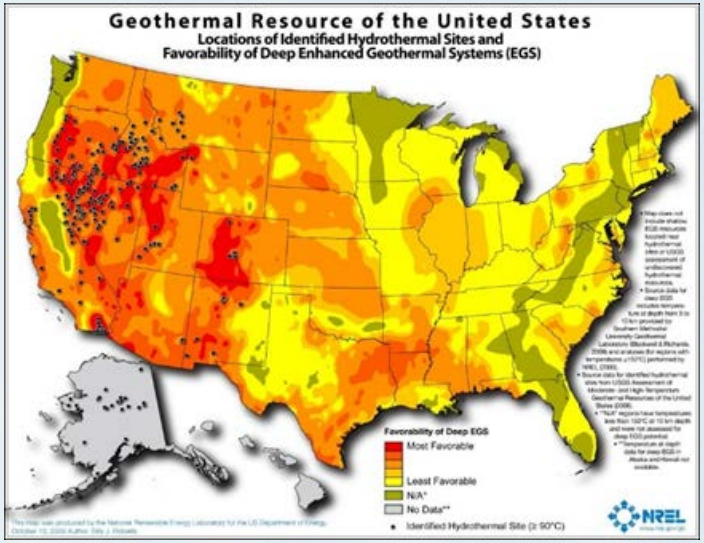
Most of the history of geothermal exploration and development in the US has been built around finding easily assessible high temperature resources.

NOT A FIX TO WELL ISSUES

Solar Geothermal as presented here is not about adding solar heat to compensate for poor well performance conditions. The result is improved plant performance only during solar hours.

THIS IS NOT EGS

"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."



RENEWGEO IS BASED ON NEW CONDITIONS

By creating a synthetic resource, there is one degree of complexity removed from the evaluation of potential sites. Because this technology needs only certain geological conditions and an abundance of solar, this technology can be deployed in many more locations than traditional geothermal.

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GEOTHERMAL STORAGE APPLICATIONS

THE SOLAR CHARGED GEOTHERMAL TECHNOLOGY

Combining our knowledge from EOR and EGS to advance new ways of creating geothermal resources.

CONNECTING THE DOTS

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.

LOOKING AT EXISING RESOURCES WITH NEW EYES

- **Marginal or abandoned oil or gas fields that have demonstrated good permeability and porosity.**
  Texas, Oklahoma, New Mexico, California
- **Geothermal wells that showed great flows but less than adequate recharge rates.**
  Nevada, California, Eastern Oregon and Washington
- **Any existing formation with certain geological conditions and an abundance of solar.**
  Colorado, Arizona, New Mexico

INCIDENTAL BENEFITS

- **Use of existing wells for new cash benefits (carbon reduction)**
- **In oil fields you eliminate parasitic loads and back feed grid**
- **Enhanced oil recovery**
- **Heat from mother nature**

THE SOLAR CHARGED GEOTHERMAL TECHNOLOGY

Moving forward, what does this look like.

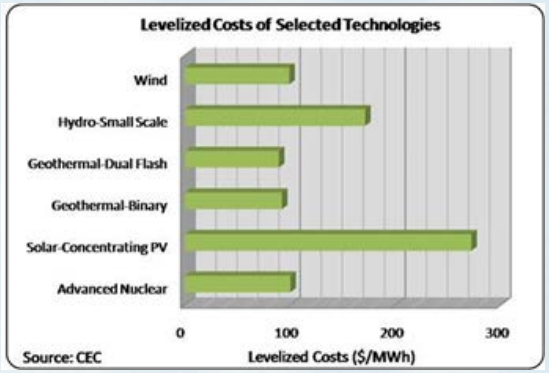
CAREFUL TESTING AND PLACEMENT

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.

COSTING

The levelized cost of this technology is between conventional geothermal and solar concentrated salt (Crescent Dunes). Throw out disingenuous solar PV and it's cost point and problems, solar renewable geothermal has much promise.

Keep in mind this is not just power generation, but power generation with storage that is carbon free renewable. And unlike conventional geothermal is not limited to what mother nature can provide.



OTHER THOUGHTS

- **Small footprint - 5 MW with good solar conditions require 40 acres.**
- **Since site selection is open to un-traditional locations, this should be deployed more in a microgrid fashion in the 1- 10 MW range.**
- **Onsite generation for data centers. (easier to connect fiber, reduced reliance on PPA's)**
- **Begins to look like direct use geothermal (and all of its possible applications)**

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Questions

Mark Hauenstein, P.E., Managing Partner
UC Won, LLC
1150 Selmi Drive, Suite 505, Reno, NV 89505
markh@uc-won.com