Subject: Abstract for 2018 SMU Power Plays Conference, 10-11 January 2018

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Organization: Good Earth Mechanics, LLC

Title: Converting Geopressured-Geothermal Reservoirs into Renewable Energy Systems

Format: Prefer oral presentation

Presenter:

George Nitschke has 23 years' experience in the aerospace industry and 12 years' experience drilling oil, gas, and geothermal wells in the U.S. and abroad. Nitschke holds patents in Geopressured-Geothermal (GPGT) systems and was a principal contributor to the U.S. Department of Energy's GPGT consortium. Nitschke formed Good Earth Mechanics in 2007 to promote the optimal conversion of the GPGT resource into Salinity Gradient Solar Pond (SGSP) systems to help solve the integrated water and energy challenges in the U.S and abroad.

Abstract:

Geopressured-Geothermal (GPGT) brine reservoirs have an immense energy potential: heat exchange, gas and pressure recovery are available from the hot, high-pressure, gas-cut brine waters. According to U.S. Geological Survey estimates, there are 5,700 quads of recoverable gas and 11,000 quads of available thermal energy in the Gulf Coast GPGT basin alone; for comparison, the U.S. *total annual energy consumption* is ~100 quads. Disposal of the spent GPGT brine water, after energy recovery, is a limitation to high-rate production and recovery of the GPGT energy resource. Good Earth Mechanics, LLC (GEM) is developing a solution to this limitation: utilizing the GPGT end-brine for large-scale construction of Salinity Gradient Solar Ponds (SGSP) versus, for example, down-hole reinjection. The SGSP systems produce fully dispatchable, cost-competitive energy in perpetuity, effectively converting the GPGT resource into a true renewable energy solution. The talk will review GEM's GPGT-SGSP conversion technology and provide a progress-update on the efforts to commercialize that technology.

Good Earth Mechanics

Converting Geopressured-Geothermal Brine Reservoirs into Fully-Dispatchable Renewable Energy Systems

2018 SMU Power Plays Conference

11 January 2018

Overview

Presentation Outline

- Geopressured-Geothermal (GPGT) Brine Reservoirs
- GEM GPGT Conversion Systems
- GEM Salinity Gradient Solar Pond (SGSP) Technology
- GEM SGSP Applications for Texas
- Summary

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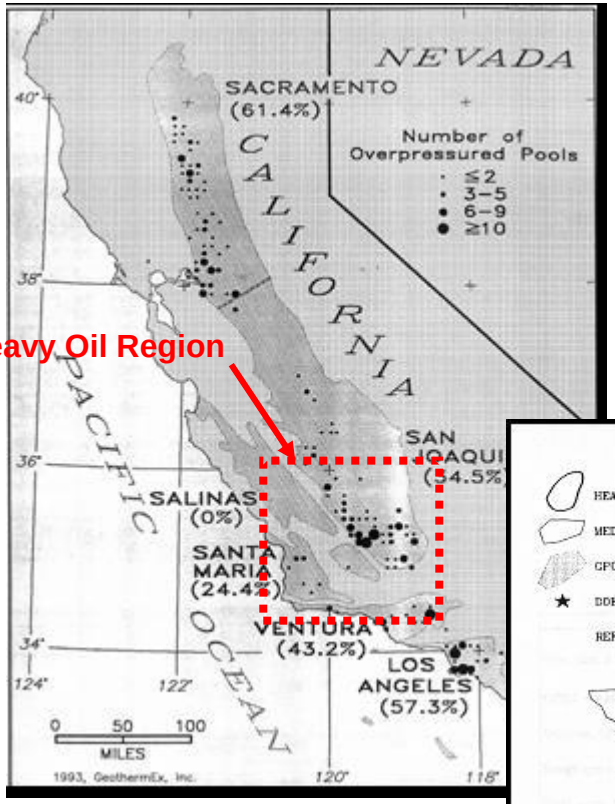
The GPGT Resource

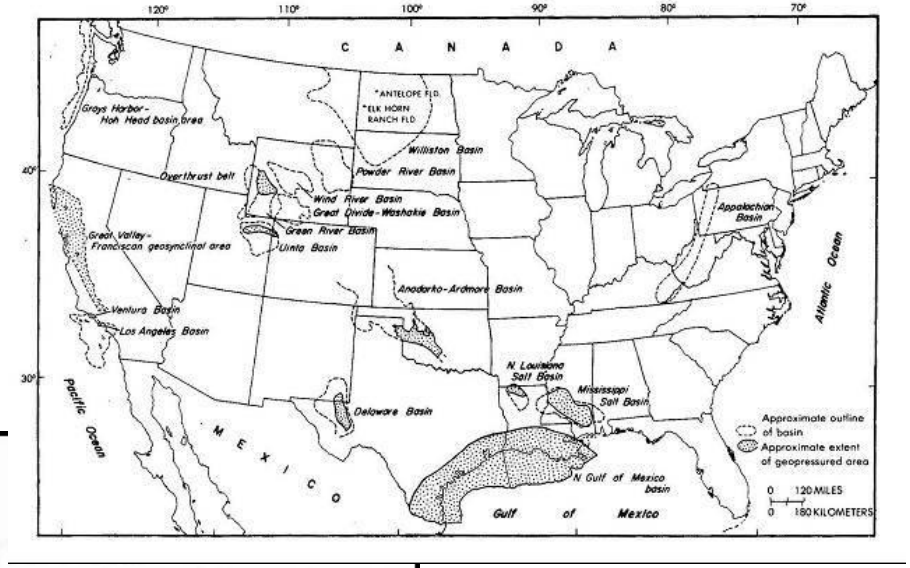
Geopressured-Geothermal (GPGT) energy is an immense energy resource that remains virtually untapped throughout the world

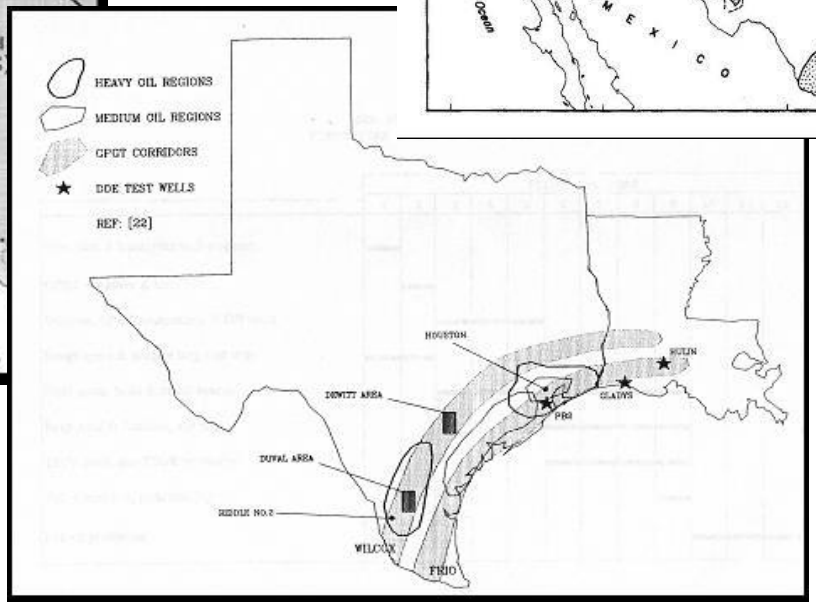
- **High pressure, high temperature, gas cut, brine reservoirs**
  - wellhead pressure: 1000–4000 psi
  - brine temperature: 250-400°F
  - GPGT brines contain 20-100 scf/bbl natural gas
  - normally found at depths greater than 10,000 feet
  - can be produced at high flow rates: 20,000-40,000 bbl/day (*vertical bore-hole*)
  - outstanding flow longevity (Dept. of Energy flow tests, Gulf Coast region)
  - GPGT brines contain 15,000-200,000 ppm dissolved solids, typically 85% NaCl
  - USGS: 5,700 quads of gas and 11,000 quads of thermal energy in the Gulf Coast GPGT
- **The recoverable GPGT energies are**
  - thermal (heat exchange with brine)
  - mechanical (flowing pressure at wellhead)
  - natural gas

Not to be confused with "*hot-rock*" geothermal energy

The GPGT Resource

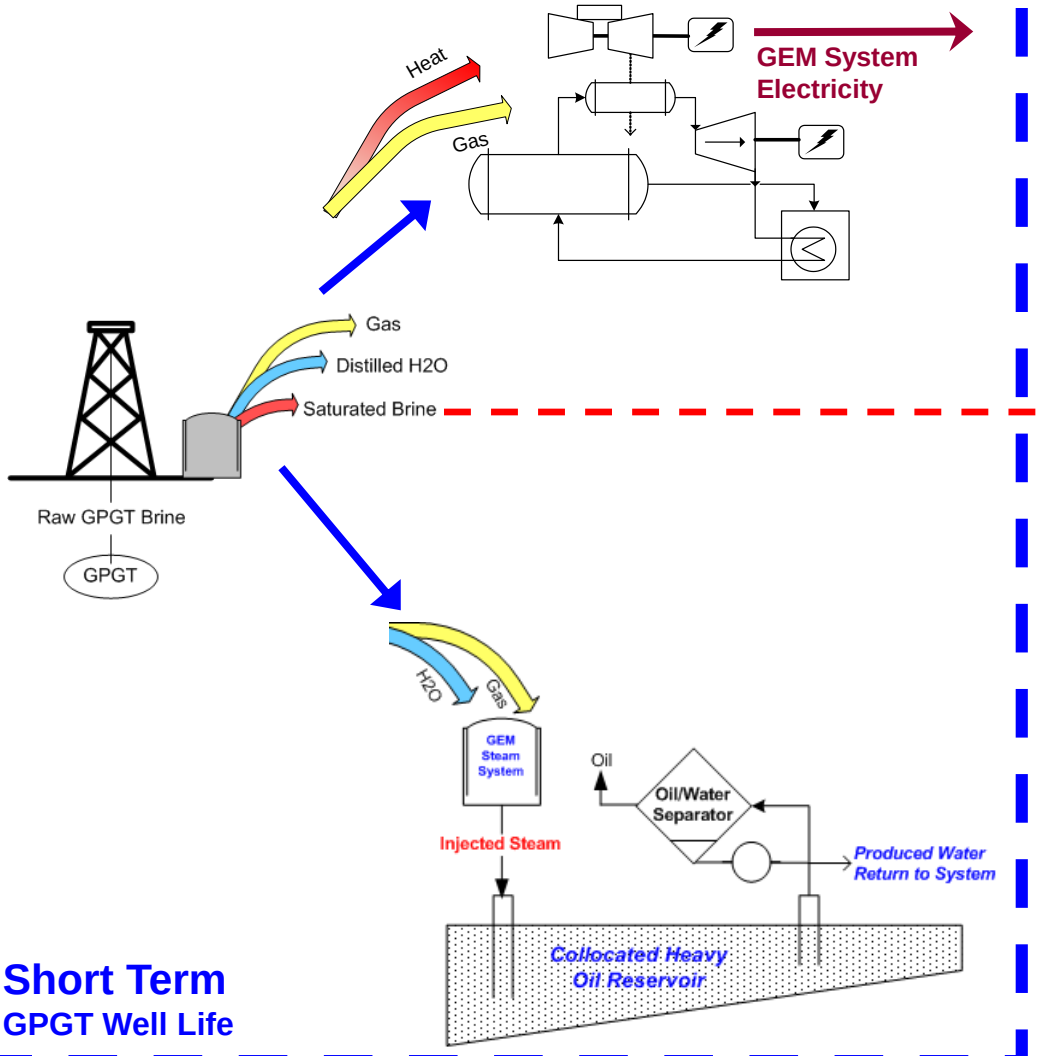


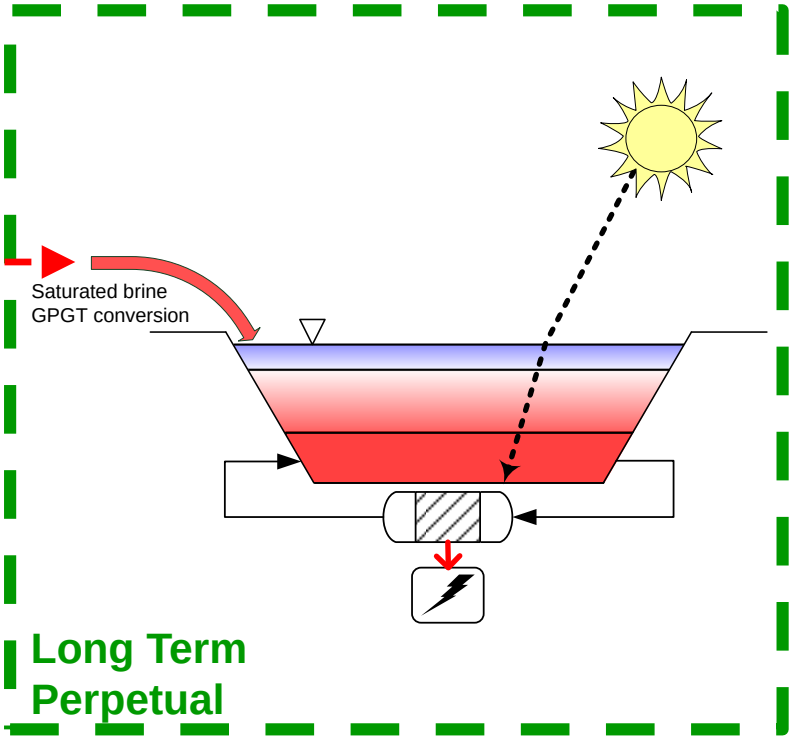




U.S. GPGT and Heavy Oil Collocational Aspects

Overall GEM GPGT Conversion





Two Patents pending, U.S. and Foreign

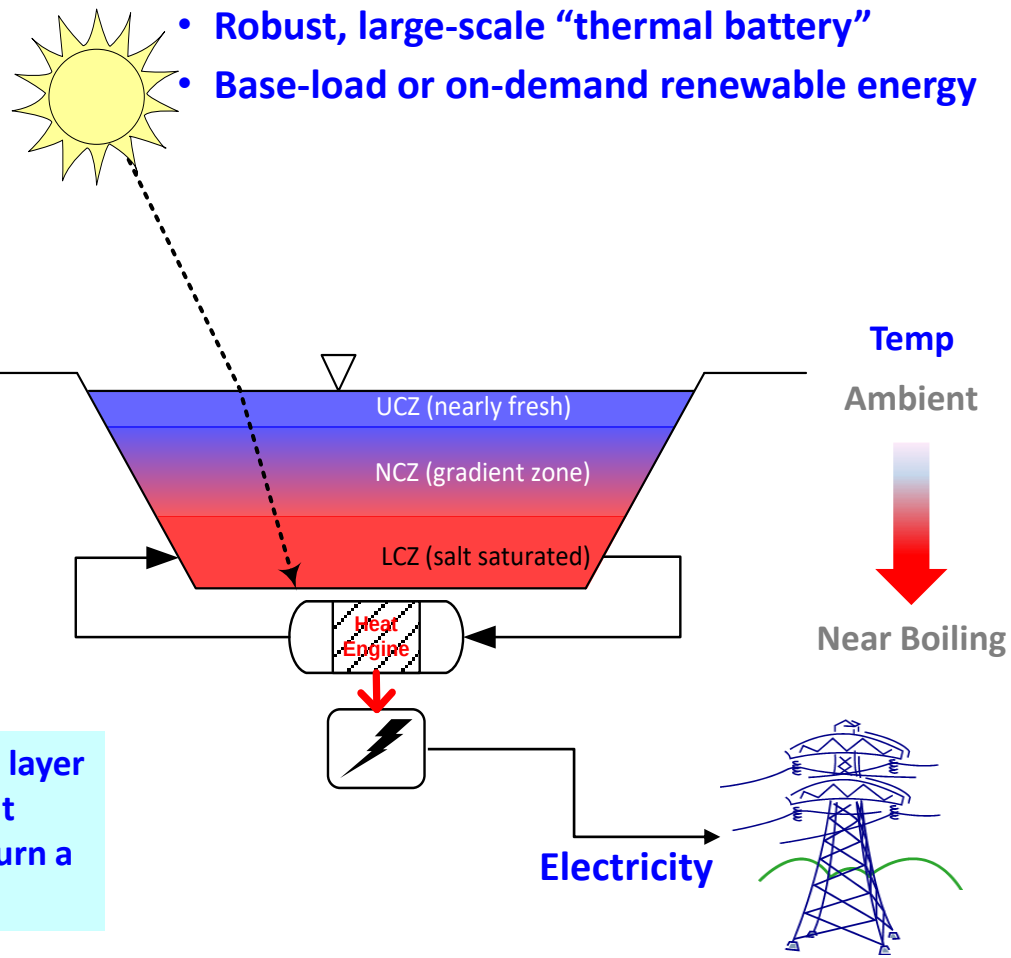
U.S. Patents *7,845,406 B2* and *8,707,697 B2*

Salinity Gradient Solar Ponds: Discovered Natural Phenomena

Engineered to Maximize Heat Collection & Storage

Solar energy is absorbed at the pond bottom, heating the adjacent fluid, which is prevented from buoying to the surface and releasing the heat to the ambient due to density stratification

- Collector / storage / delivery all in one
- Robust, large-scale "thermal battery"
- Base-load or on-demand renewable energy



UCZ Upper Convective Zone
NCZ Non-Convective Zone
LCZ Lower Convective Zone

The near-boiling hot brine of the bottom layer is circulated through an off-the-shelf heat engine that uses the thermal energy to turn a turbine-generator to produce electricity

The GEM Salinity Gradient Solar Pond Team:
World Recognized SGSP Leadership

George Nitschke
President & Founder

Peter Gross
Business Development

Dennis Duke
Field Operations

Huanmin Lu
Chief SGSP Scientist

John Walton
SGSP Environmental

Andrew Swift
SGSP & Wind Energy

Herbert Hein, Jr.
SGSP Project Mngmnt

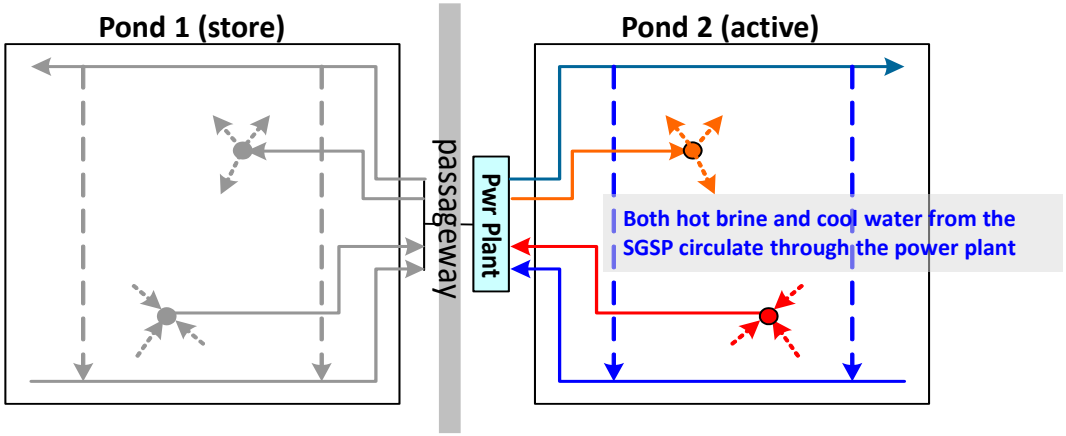
- 16+ years SGSP development at the *University of Texas El Paso (UTEP)*
- Engineering data & models
- Proprietary practices & processes
- Patent pending methods & components
- Key vendor relationships
- Evaluated by NREL Commercialization Assistance Program – favorable review

Summary paper of Team's SGSP UTEP work:
http://www.goodearthmechanics.com/pdfs/JSEE%20Paper%20Lu%20SP.pdf

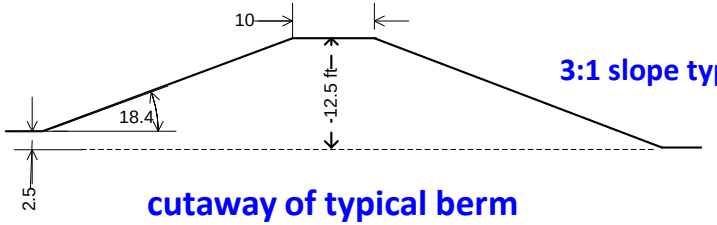
GEM's Commercial SGSP Module

Designed for Optimal Performance

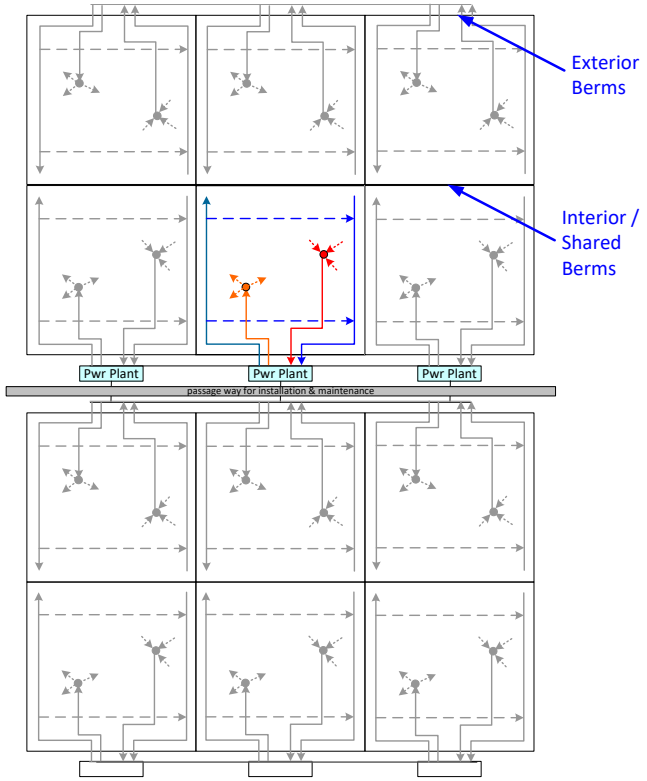
Top Down View



GEM's 250kW Commercial "Module"
sized to deliver 250kW 24x7 year-around



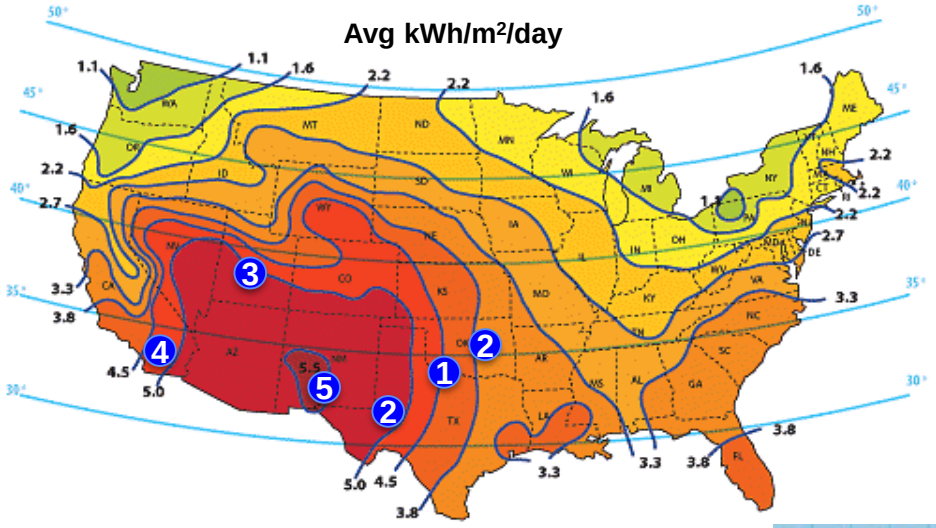
cutaway of typical berm
lined ponds, minimum depth below grade



add modules to scale-up
to desired system size

GEM's patent-pending SGSP modularity

Large Global Potential for SGSP

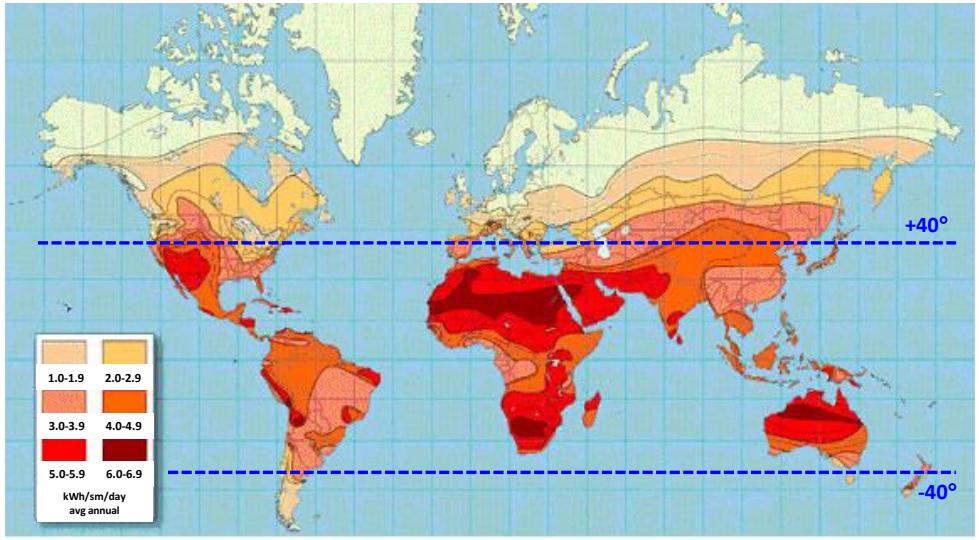


GEM U.S. SGSP Project Launch Sites

1. **TX/OK River Basins**
2. **TX/OK E&P Recycling**
3. **Delta, UT**
4. **Salton Sea, CA**
5. **White Sands, NM**

Govt-sponsored engineering analyses support SGSP for all these regions

Good SGSP Conditions	
General Location	+/- 40° latitude
Solar Insolation	>3.3 kWh/sm/day
Landprint	60-90 acres/MW (base-load)
Salt	Readily available
Water	Seawater/Brackish OK

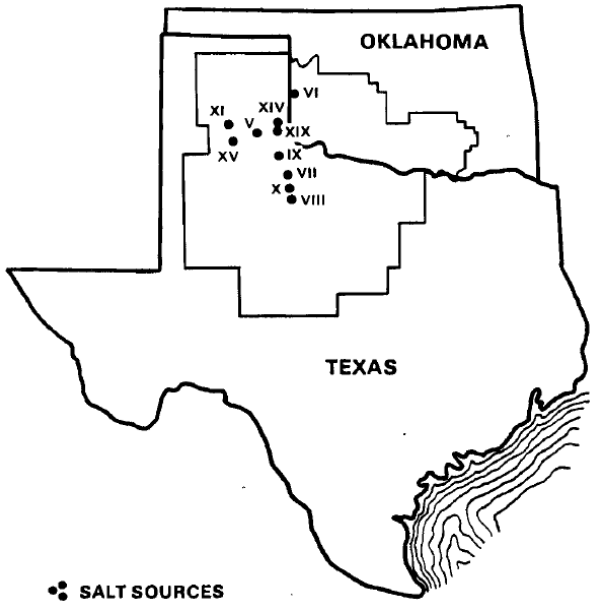


Chloride Control on the Red & Brazos Rivers

Regional Deployment in TX & OK

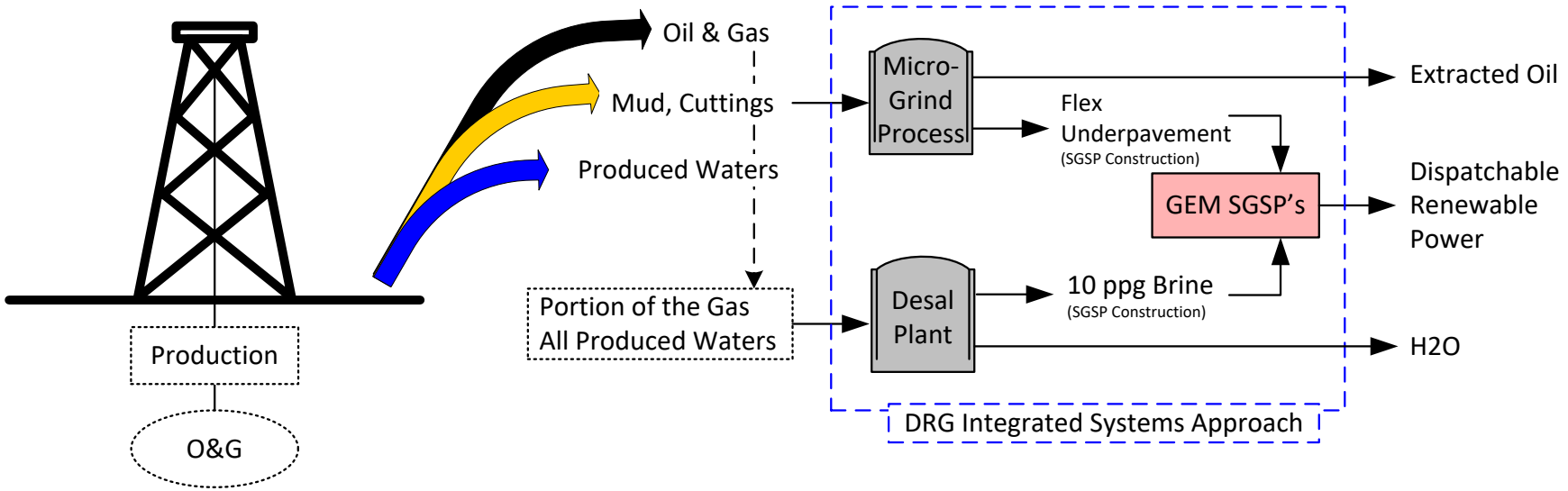
GEM's deployment of SGSP systems will provide a commercial solution to the region's salt-contamination problem (Brazos & Red River Basins)

- US Corps of Engs. estimates 1.6M tons/year natural salt flows to the Red River Basin
- Other studies estimate 2.4M tons/year natural salt flows to the Brazos River Basin
- GEM SGSP systems require approximately 170,000 tons/MW to build in this region



- Regionally deploy SGSP systems to utilize the salt for profitable renewable power production
- Install ~24 MW per year (Red & Brazos River Basins) to match natural inflows, or faster if desired
- Use extraction wells to sequester the salt before it enters the rivers via springs for regional remediation
- Integrate/piggyback into existing grid to help balance intermittent wind-energy
- **Add jobs & capital development to the region**

Deep River Group Integrated Approach:
E&P Waste Recycle



- **Utilize all E&P waste streams**
- **Negate induced seismicity**
- **Distributed power for E&P**
- **Long-term solution**
- **Representative example →**

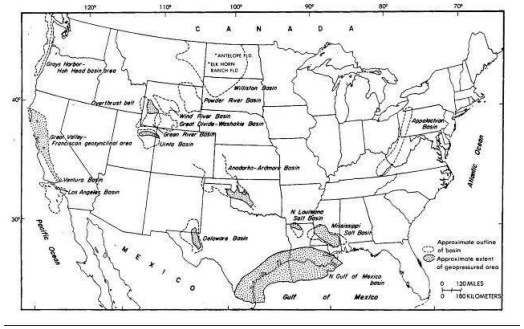
Produced Water Flow Rate	150,000	bpd
Produced Water TDS	120,000	ppm
Concentration Ratio (for 10 ppg brine)	2.49	
Recovered H2O	89,759	bpd
Required Wellhead Gas	3,129	Mcf/day

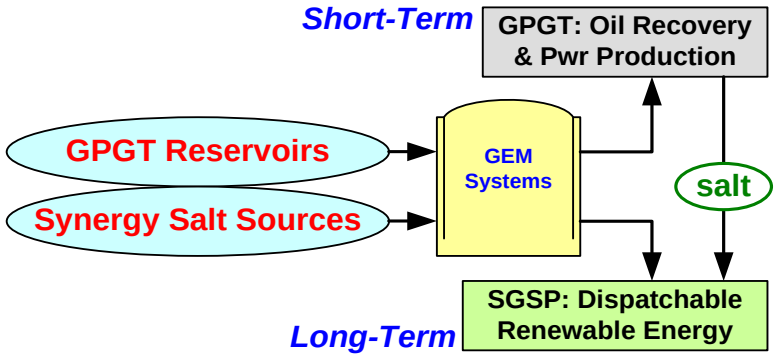
SGSP MW Build Rate (base-load equiv.)	6.40	MW/yr
SGSP Land Requirement (per MW)	90	acres/MW
SGSP Land Requirement (per yr)	576	acres/yr

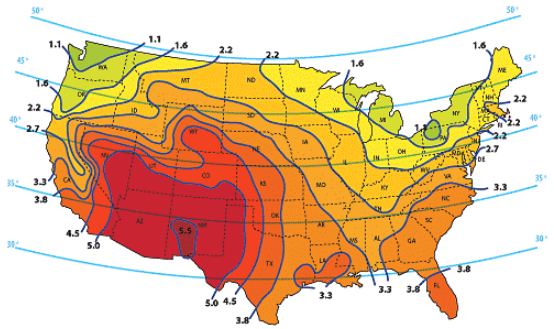
Deep River Group: http://www.deeprivergrp.com/

Summary: GEM Renewable Technologies

GPGT Conversion & SGSP Systems







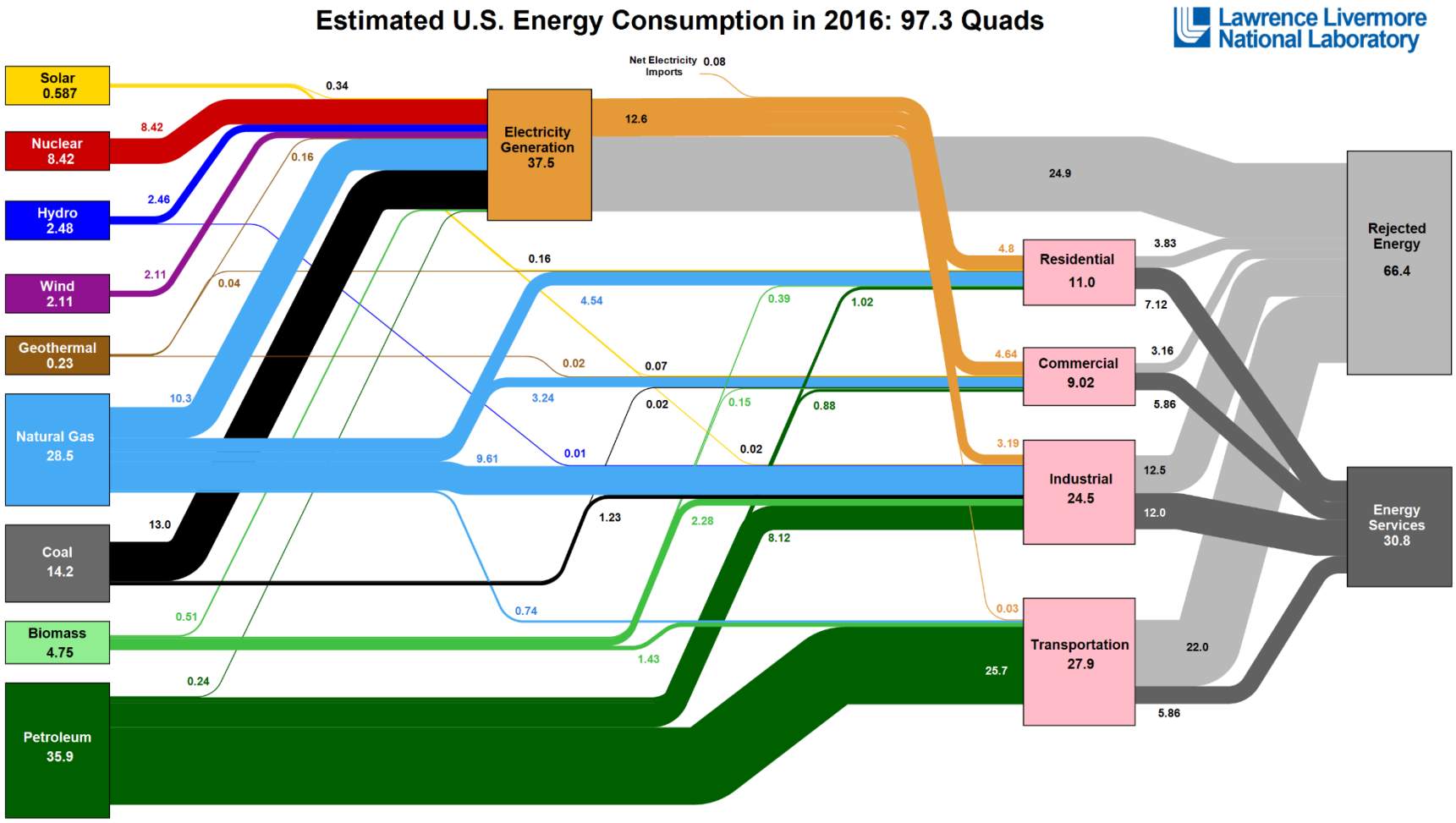
Zero-discharge GPGT production by using the waste brine to build SGSP systems

1. Steam for enhanced oil recovery
   a. half the costs of steam generators
   b. compliant with GHG laws
2. Cost-effective geothermal power
   a. save ~$1M/yr costs per 5MW system
   b. recovers H2O from brine
3. SGSP dispatchable renewable energy

GEM in early commercialization of its patented/patent-pending technologies

U.S. Energy Flow in Quadrillion BTUs

(thanks to Lawrence Livermore)



Source: LLNL March, 2017. Data is based on DOE/EIA MER (2016). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration's analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector, and 49% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527