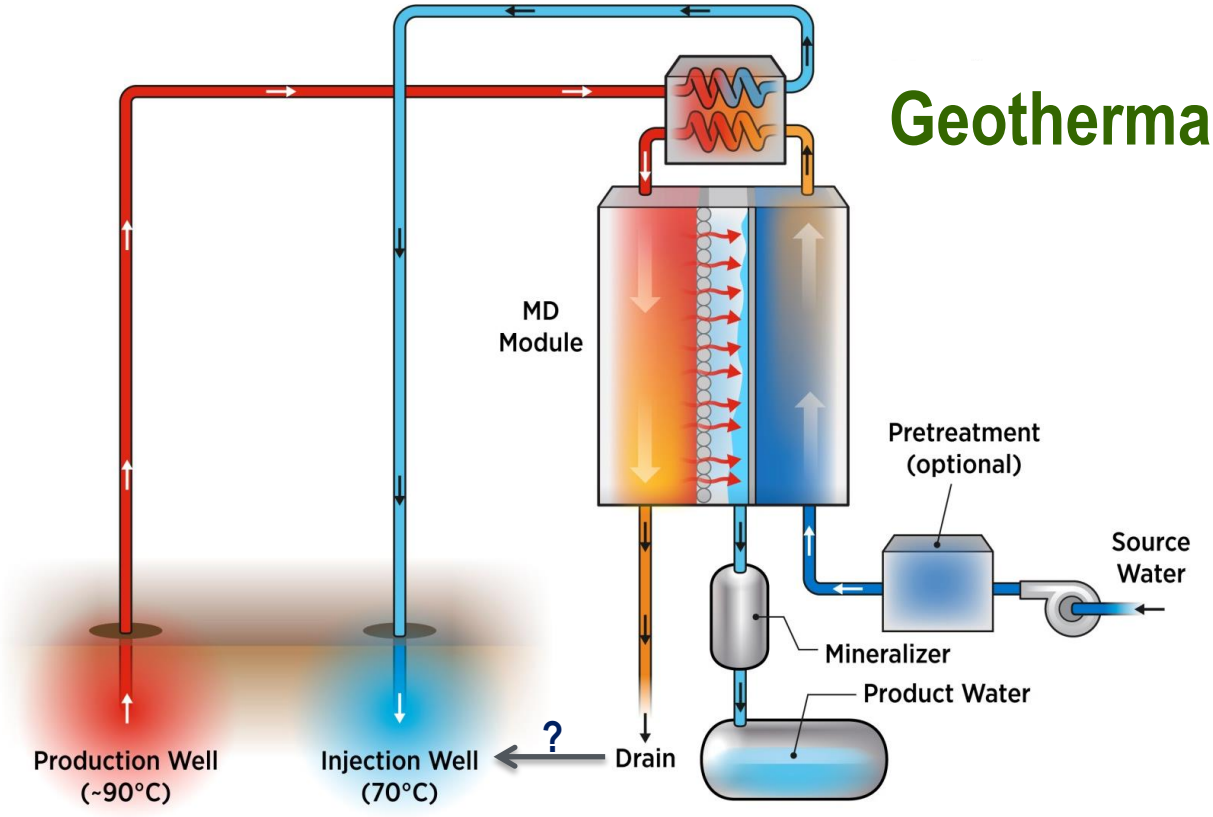


Geothermal Desalination

Low-Enthalpy Geothermal Desalination

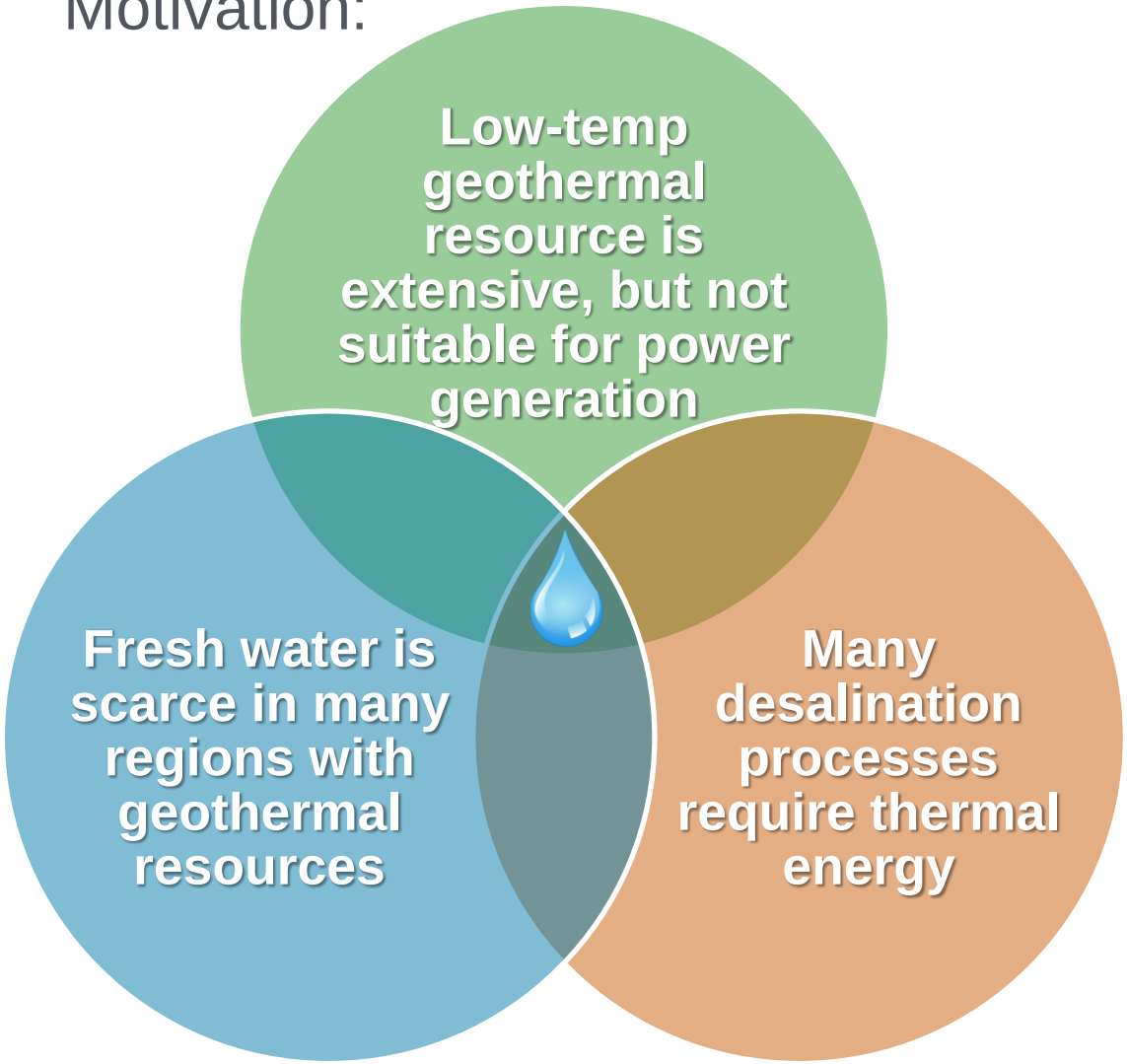
Project Officer: Holly Thomas
Total Project Funding: $265,000
May 11, 2015

Craig Turchi
NREL

Low Temperature

Relevance/Impact of Research

Motivation:

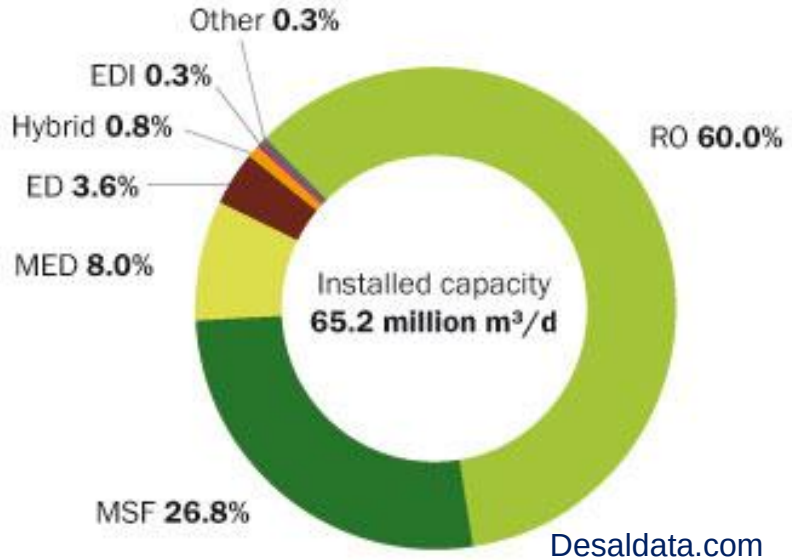


Objectives:

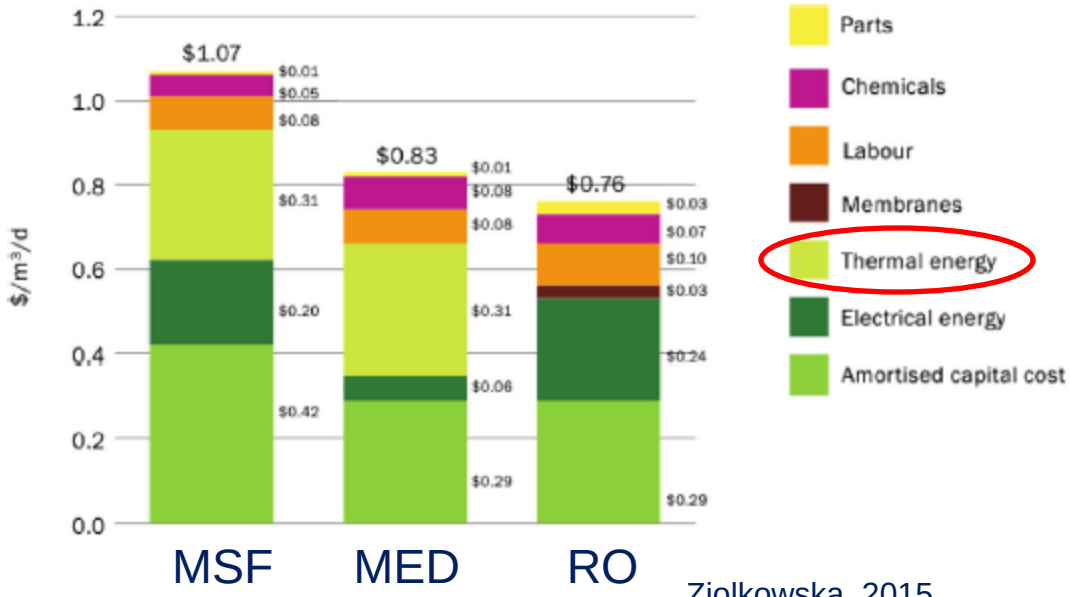
- Identify promising options for using geothermal energy to desalinate water and characterize the technology performance, cost, and commercialization gaps.
- Expand direct use of low-enthalpy geothermal resources

Desalination Technologies

- Electric
  - Reverse Osmosis (RO)
  - Electrodialysis (ED)
- Thermal
  - Multistage Flash (MSF)
  - Multi-effect Distillation (MED)



Desaldata.com



Ziolkowska, 2015

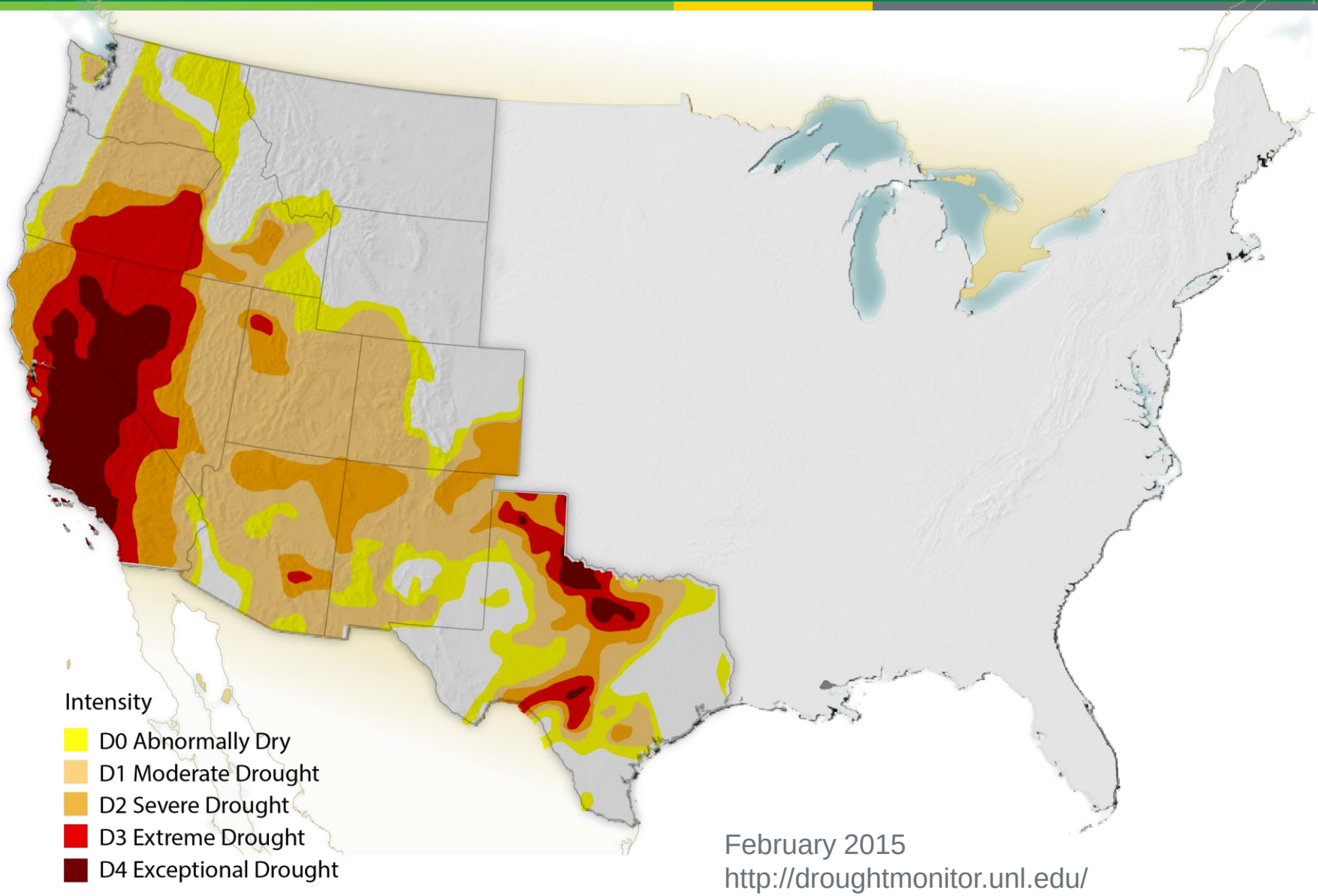
Thermal energy can account for 30%-50% of desalination cost

Scientific/Technical Approach

- Identify regions of collocated water scarcity, impaired water sources and low-temperature geothermal resources.
- Modify Colorado School of Mines spreadsheet tool that recommends equipment trains for water treatment and desalination.
  - Originally developed for coal-bed methane water
  - Geothermal variant known as “GDsalt”
- Assess best integration of geothermal energy and desalination technologies.
- Determine economic case for geo-desal; if compelling, pursue a field test.

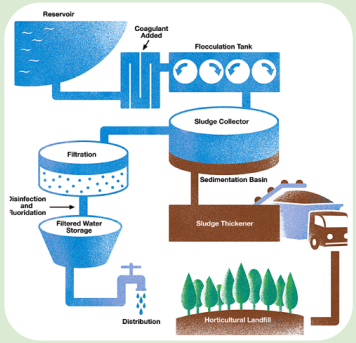
COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

Water Stress in the Western U.S.



February 2015
http://droughtmonitor.unl.edu/

GDsalt Decision Support Tool



Inputs

Source-water composition

Geothermal resource

Product-water targets

Treatment Selection Module

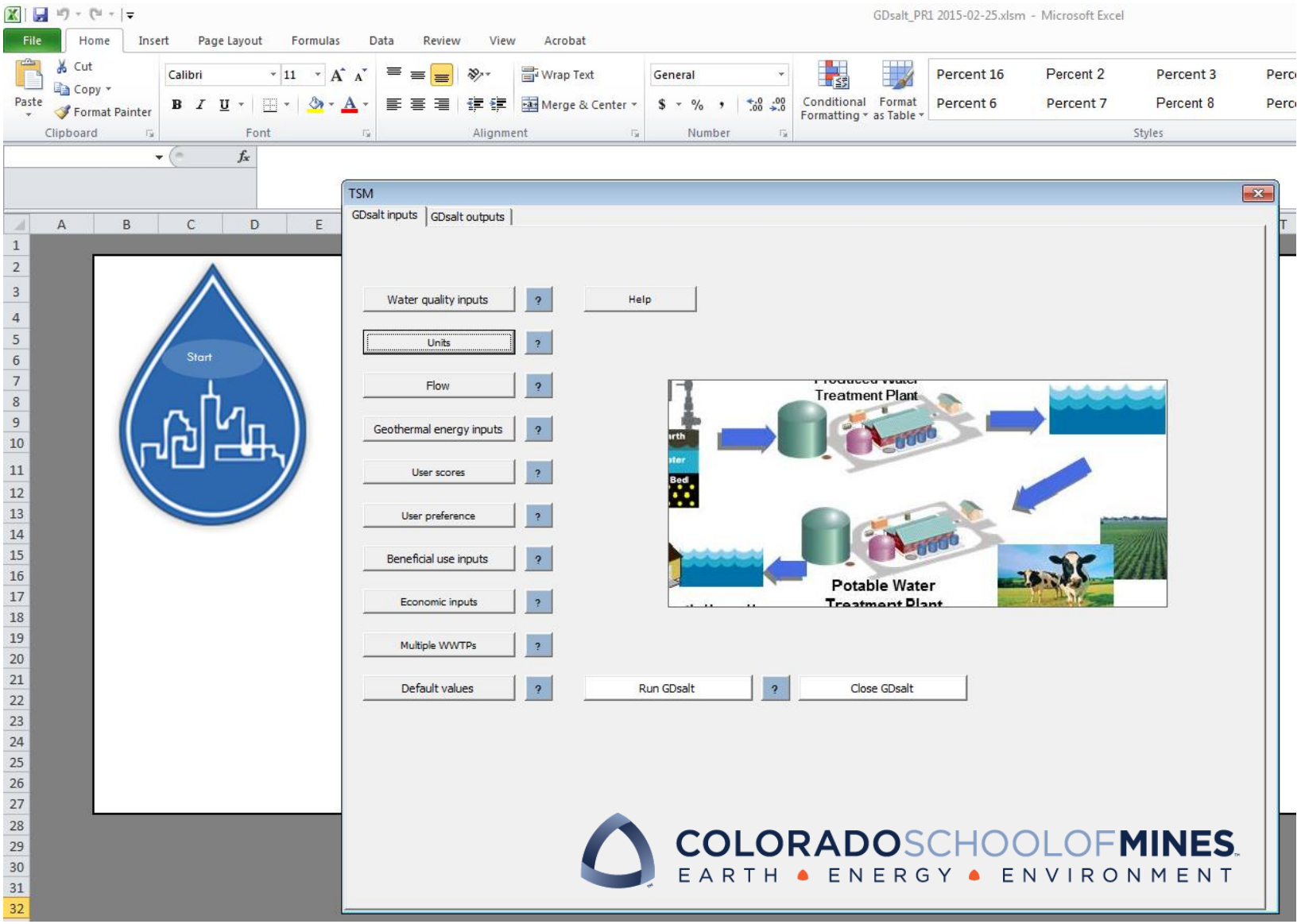
Beneficial Use Screening Module

Beneficial Use Economic Module

Outputs

Conceptual design of suitable treatment train(s) with energy demand and estimated cost

GDsalt Input Screen



Accomplishments, Results and Progress

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

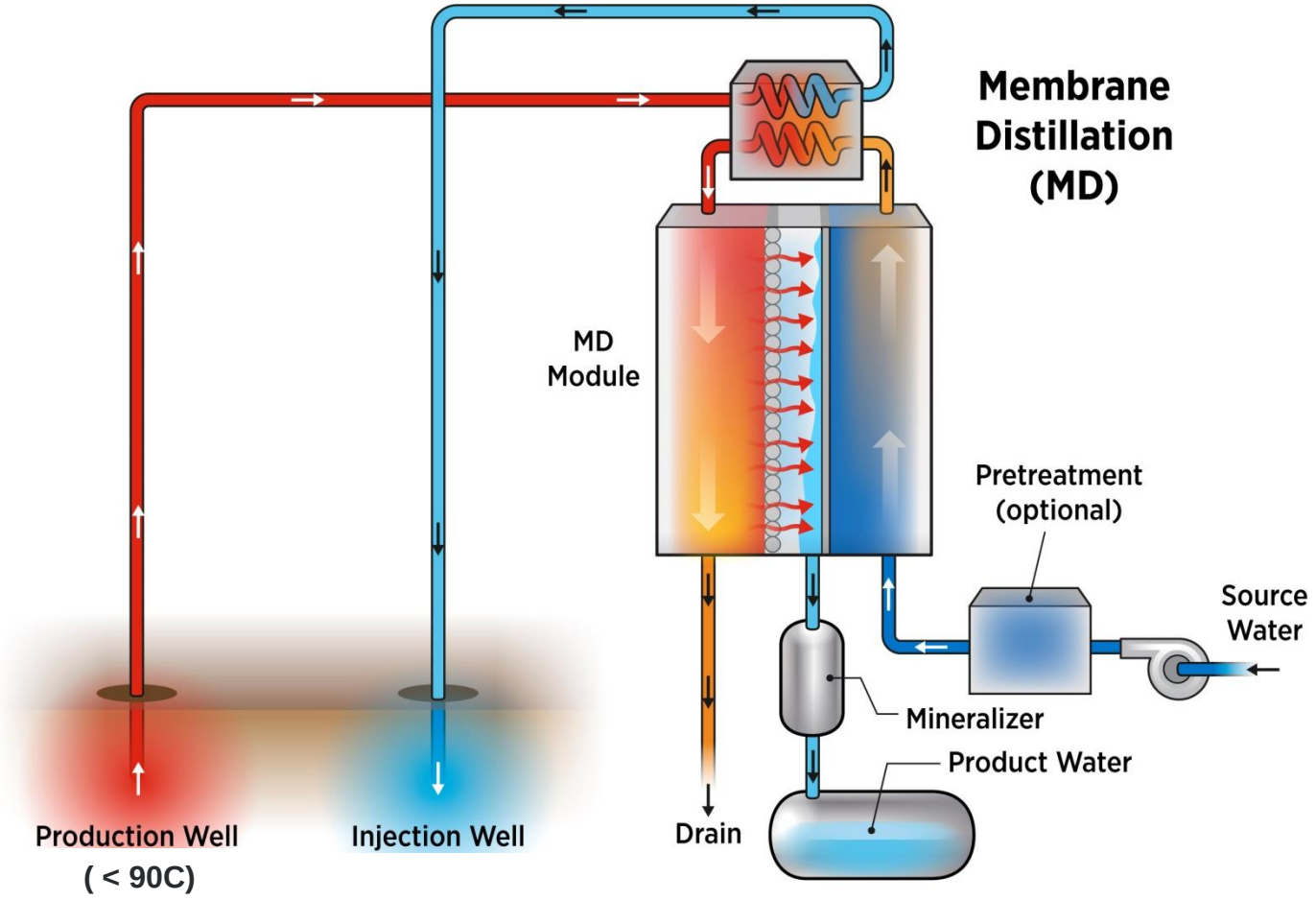
Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date
Identify geothermal use scenarios that have promise of being more cost effective than the best FY14 systems evaluated.	• Outlined regions of interest • Developed initial version of GDsalt • Identified suitable desalination technologies	11/24/2014
Complete evaluation of additional geothermal use scenarios.	• Revised/debugged GDsalt • Highlighted best applications • Developed senior-design case study to beta-test GDsalt	02/27/2015

- Commercial desalination methods that were deemed unsuitable for integration with geothermal energy:
  - Reverse Osmosis (RO) and other high-pressure (electrical) methods. Low-enthalpy geothermal is inefficient for electricity production.
  - Multi-stage Flash (MSF) requires a high-temperature thermal input.

Geothermal Desalination

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

One Approach: Membrane distillation with heat exchanger

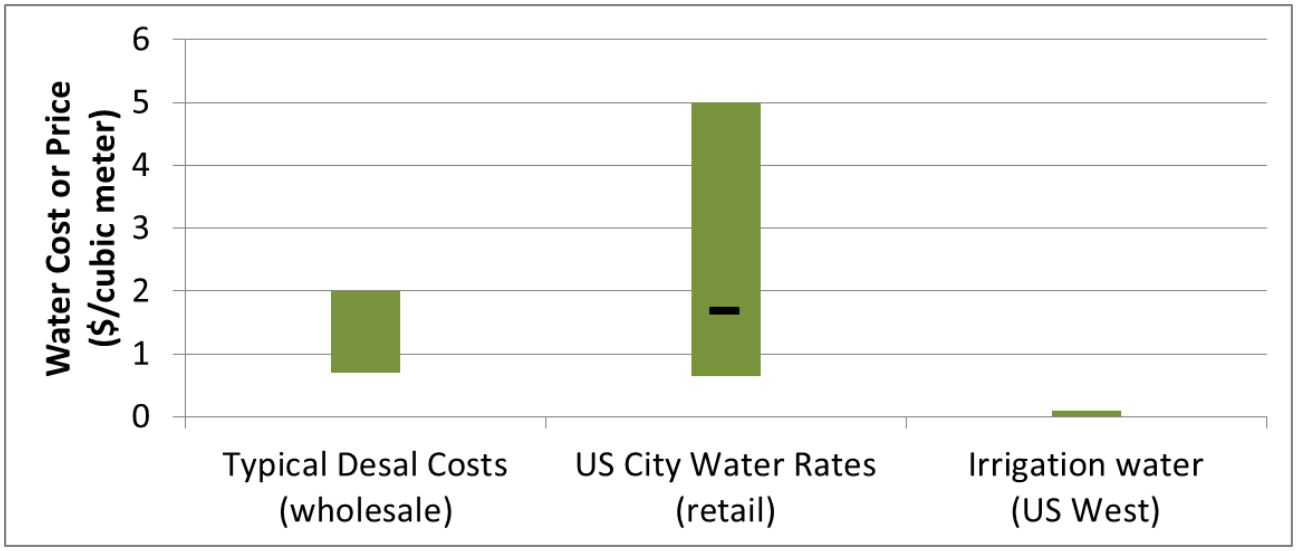


Opportunities

- Use low-cost geothermal energy to drive down the cost of thermal desalination
  - Energy is 30-50% of the cost of thermal-desal methods
- Unlike RO, thermal-desal methods are relatively insensitive to source water quality, therefore, preferred applications are for highly contaminated water, such as:
  - RO reject water for zero-discharge systems
  - Disposing of reject brine can be difficult and costly
  - Co-produced water disposal can cost several dollars per m3
  - Treat geothermal brine directly

Challenges

- Desalination is generally the option of last resort, *where there is an alternative*
  - Water for industrial and agricultural users is often highly subsidized, for example agricultural water rates in CA's Imperial Valley are ~$0.02/m^3
- Reverse Osmosis (all electric) is the leading and lowest cost desalination approach



Future Directions

- Membrane Distillation is an emerging thermal-desal method with advantages for renewable energy integration:
  - Uses low-temp (< 90ºC) thermal energy
  - Compatible with sensible heat transfer
  - Amenable to small-scale units
  - Potentially low-cost membranes
  - Suitable for high-salinity, poor-quality source water
- Seeking pilot-scale test sites with geothermal resource
- Coordinating with forward-osmosis project at Idaho National Laboratory; potential for shared test site.

Milestone or Go/No-Go	Status & Expected Completion Date
Beta version of GDsalt completed and initial user testing begins	Due 05/30/2015
Conceptual design shows technical feasibility and the economic potential to use low-enthalpy geothermal energy to desalinate impaired waters and reduce costs of water treatment on a $/gallon basis by 5% or more relative to conventional technology.	Due 09/30/2015

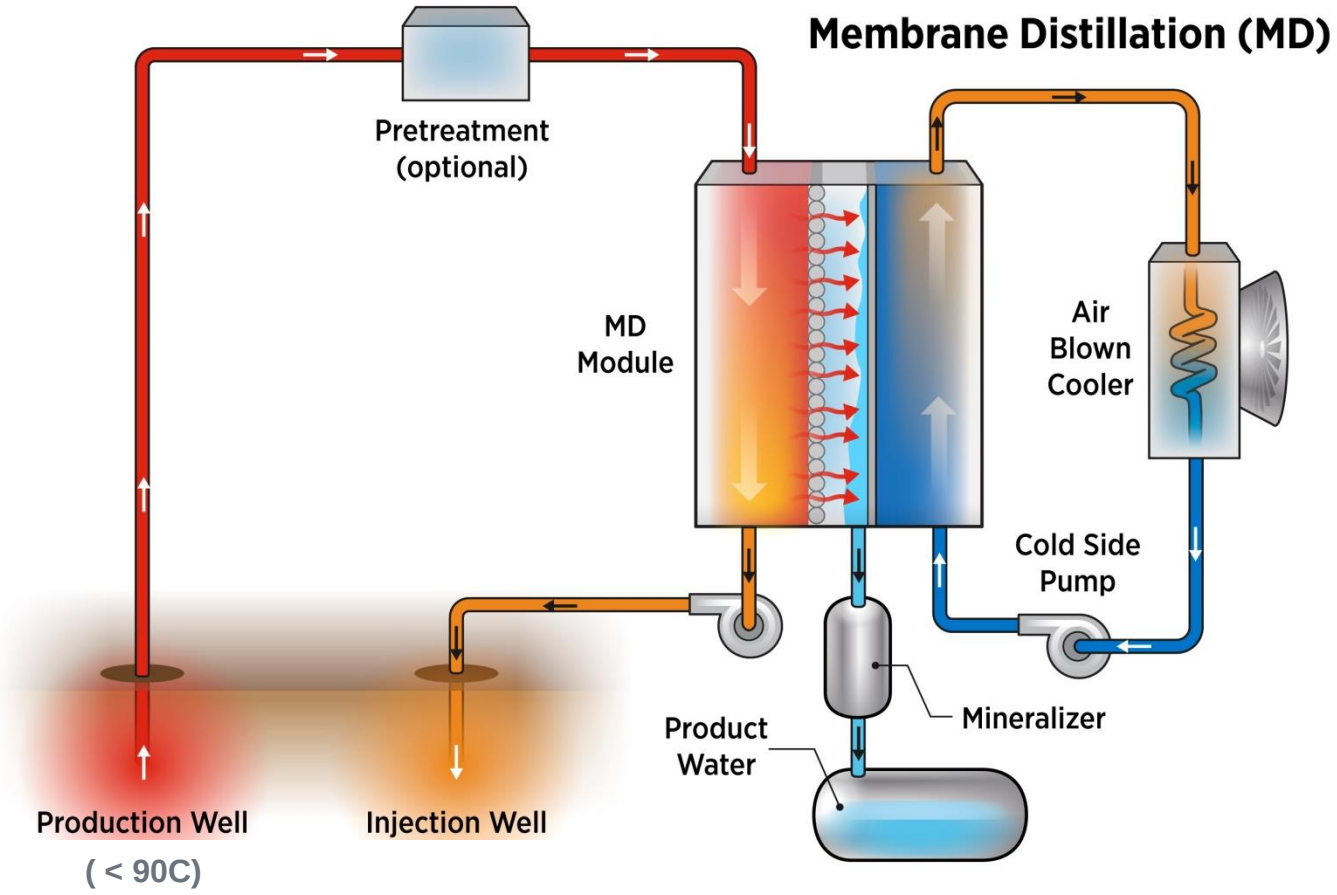
Summary Slide

- Low-enthalpy geothermal energy (< 90ºC) is well suited for use with thermal desalination technologies
  - Energy can account for 30% to 50% of thermal-desal cost, offering an avenue for cost reduction with geothermal sources
  - Membrane Distillation is a good match for geothermal
- GDsalt allows users to screen geo-desal applications
- Cost for desalinated water typically exceeds that for alternative water sources if alternatives exist
  - Project is seeking locations where fresh-water scarcity, impaired-water sources, and geothermal resource coincide to present a case study for geo-desalination

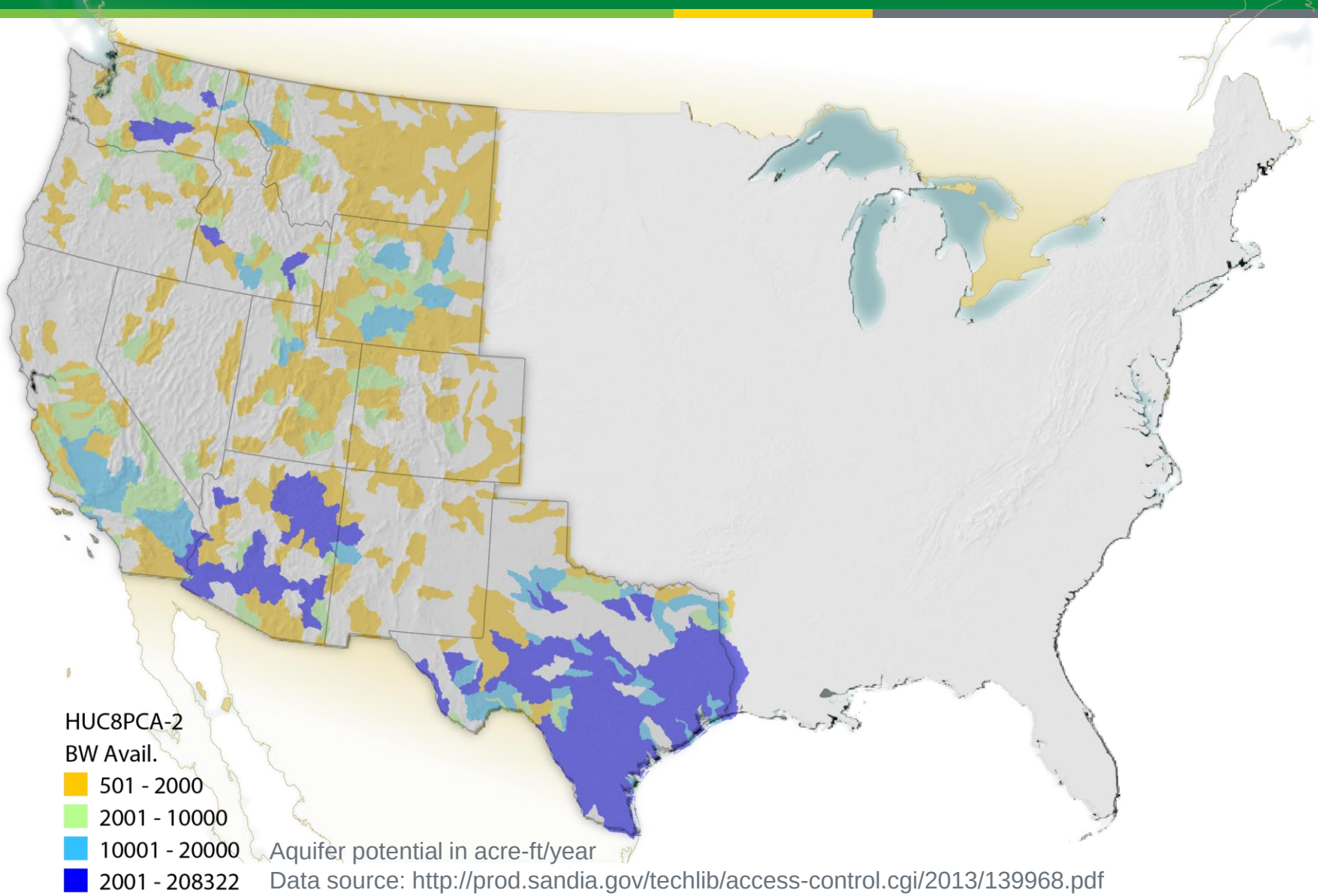
    …current best lead is in south Texas

Desalination of Geo-brine

Membrane distillation with direct heating and use of the geothermal brine



Brackish Water Aquifers

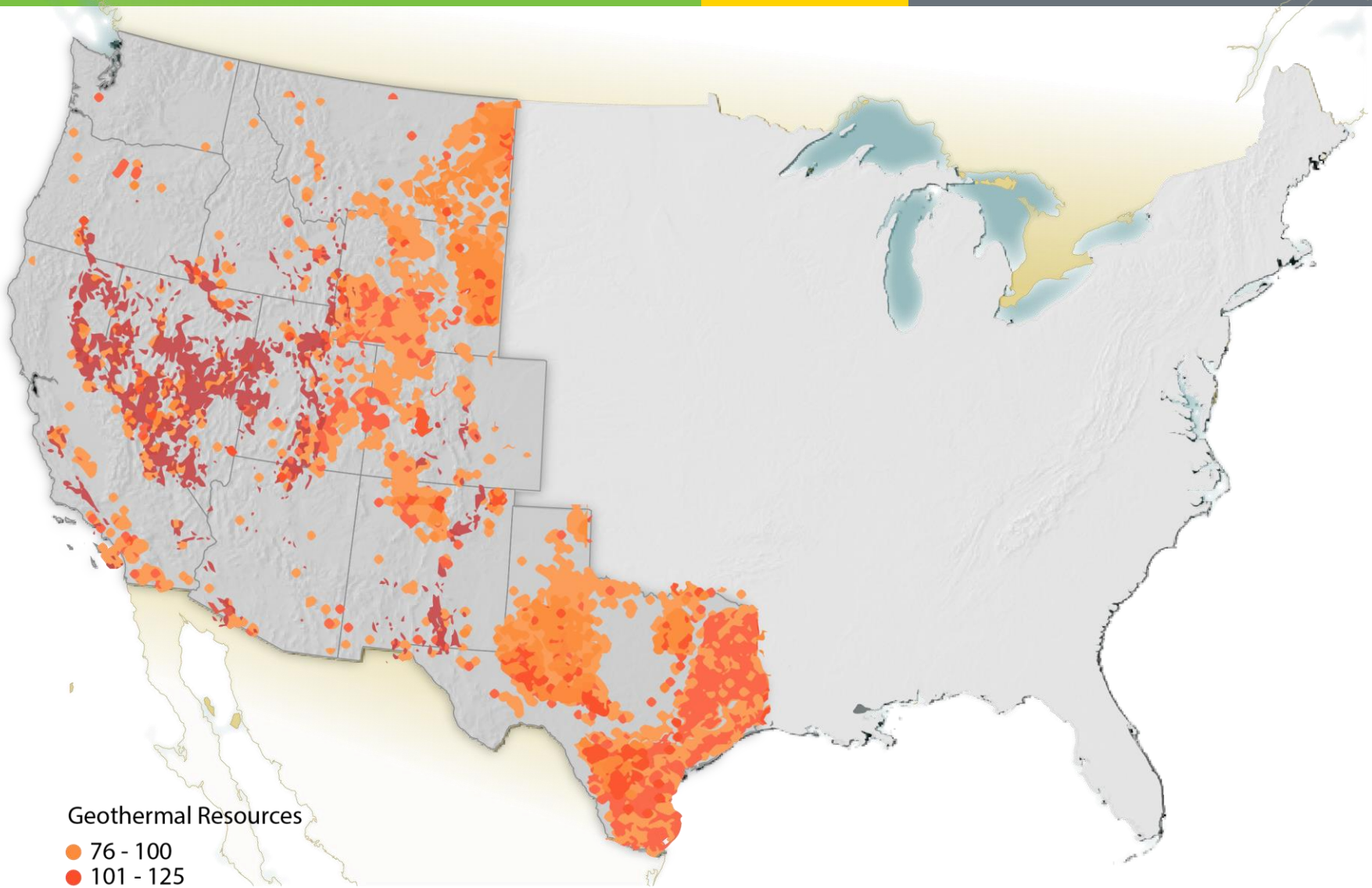


Aquifer potential in acre-ft/year

Data source: http://prod.sandia.gov/techlib/access-control.cgi/2013/139968.pdf

Low-Temp Geothermal Resources

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Well temps (ºC) from SMU and AASG databases accessed via Geothermal Prospector at http://maps.nrel.gov/