

# Geothermal Desalination



Craig Turchi, NREL

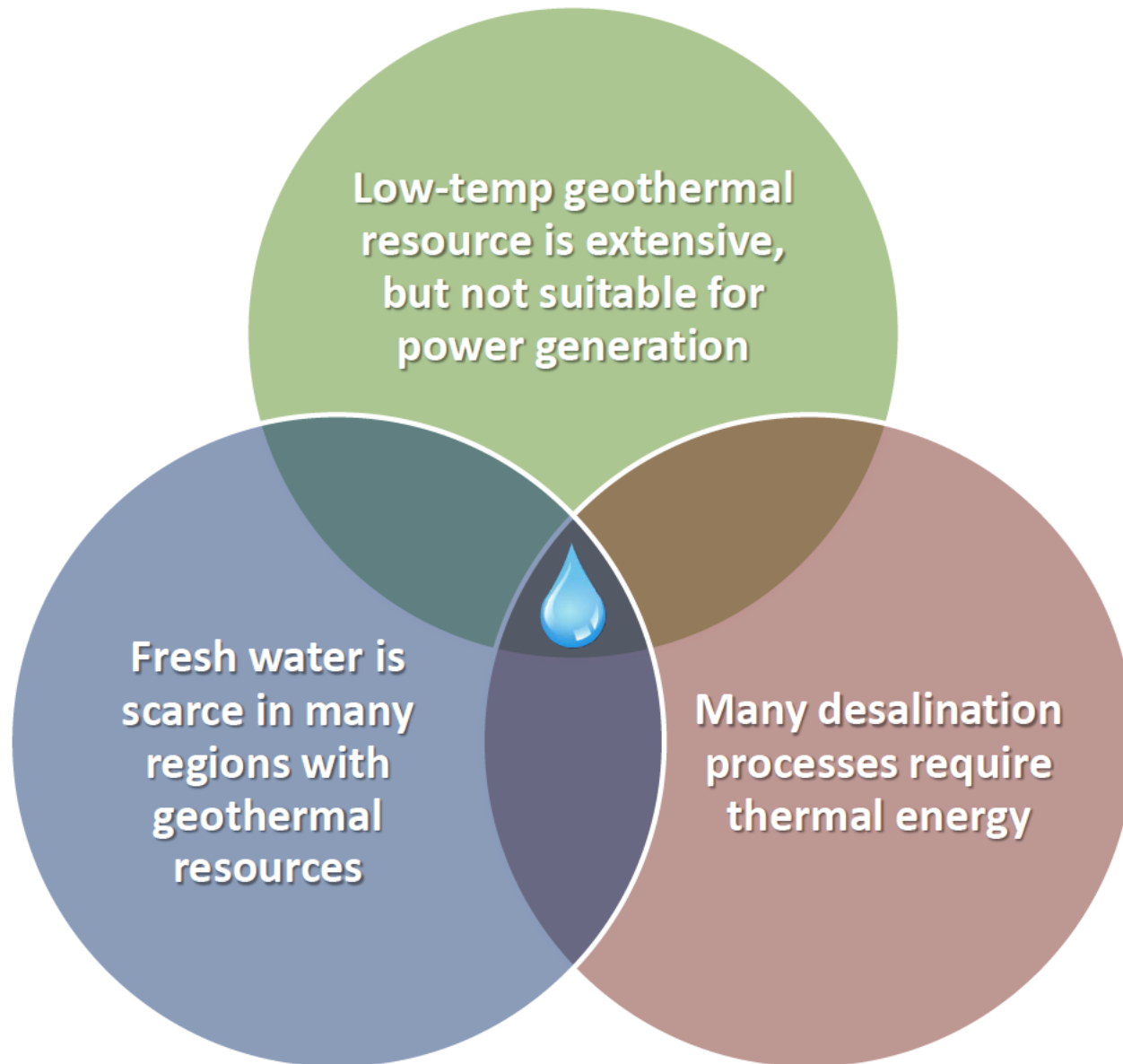
Tzahi Cath, Colorado School of Mines

*Workshop on Advances in Geothermal Direct Use*

*Matching Low-Temperature Geothermal Resources to End-Use Demand*

*Colorado School of Mines, March 18, 2015*

# Motivation

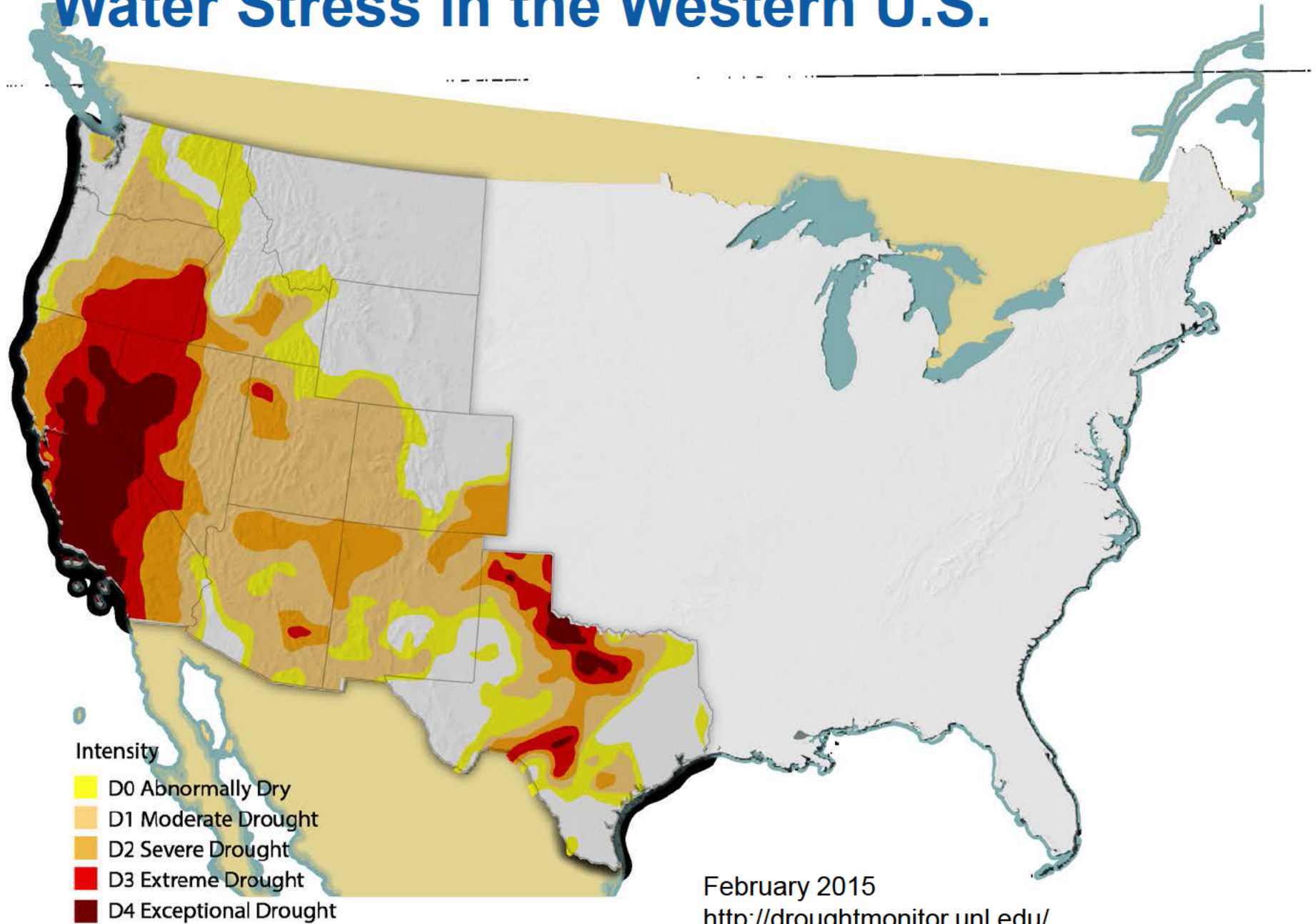


# Outline

- Water scarcity and resources in the US
- Desalination technologies
- “GDsalt” decision support tool
- Project status and conclusions to date
- Future plans

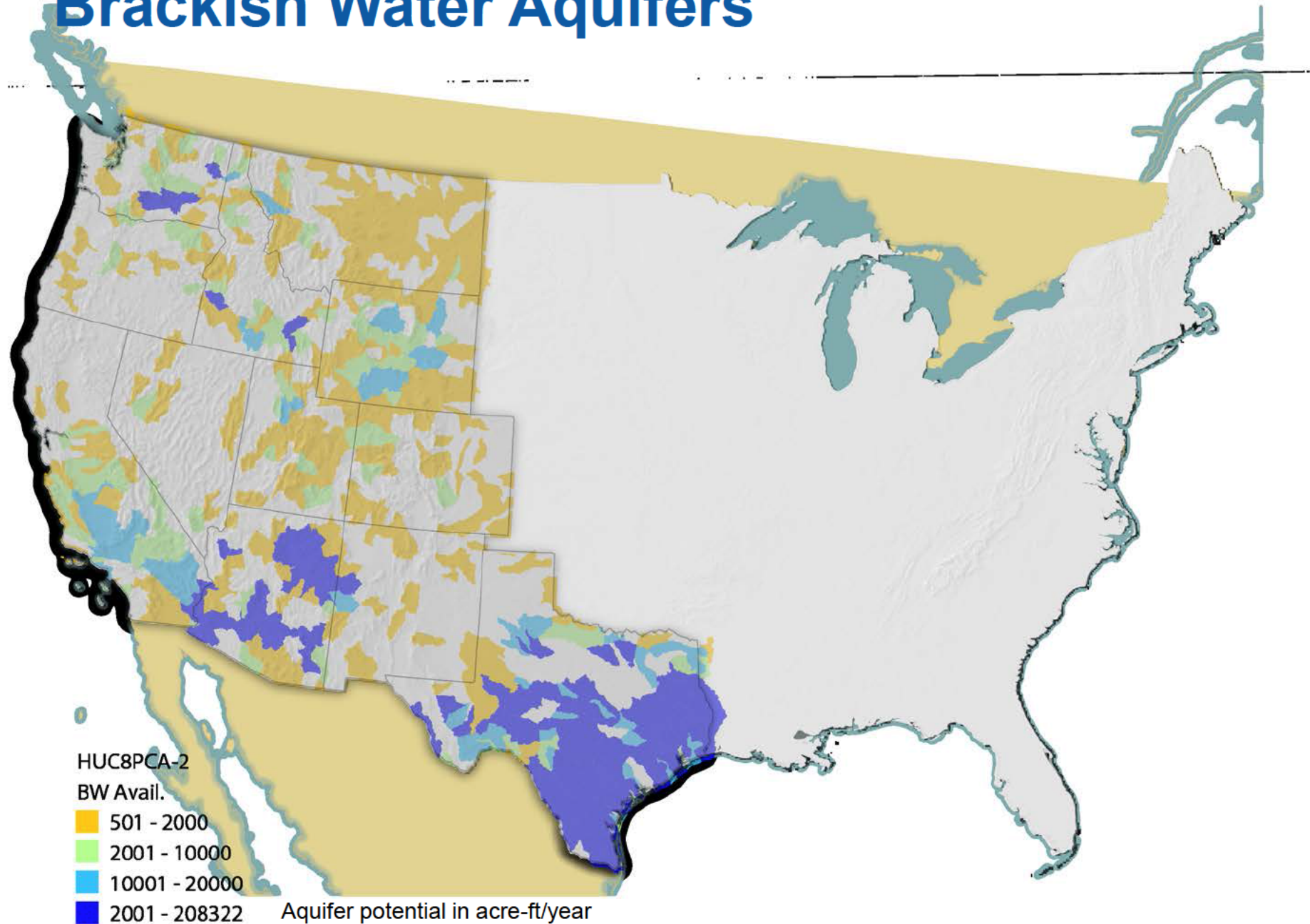


# Water Stress in the Western U.S.

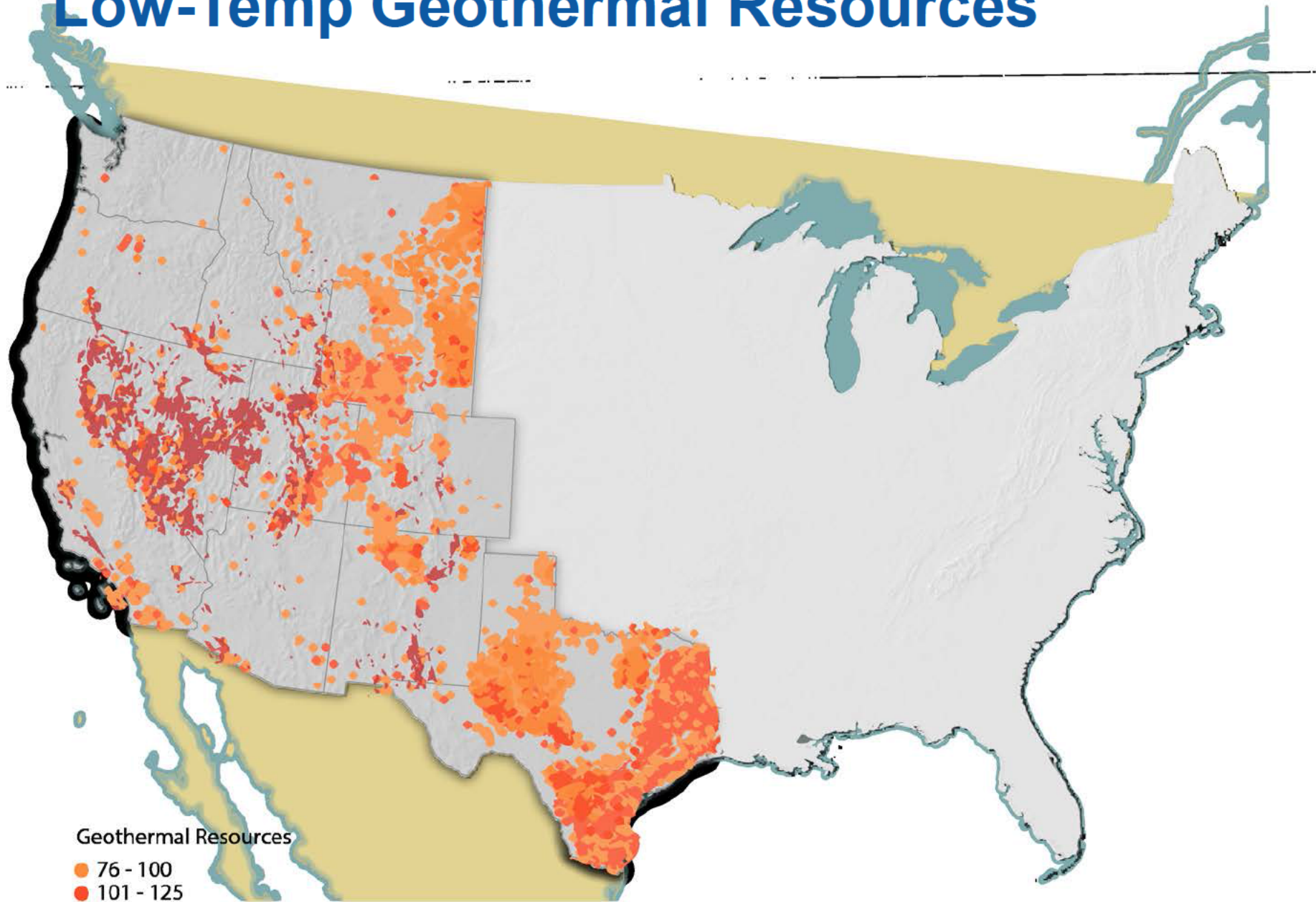




# Brackish Water Aquifers



# Low-Temp Geothermal Resources



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

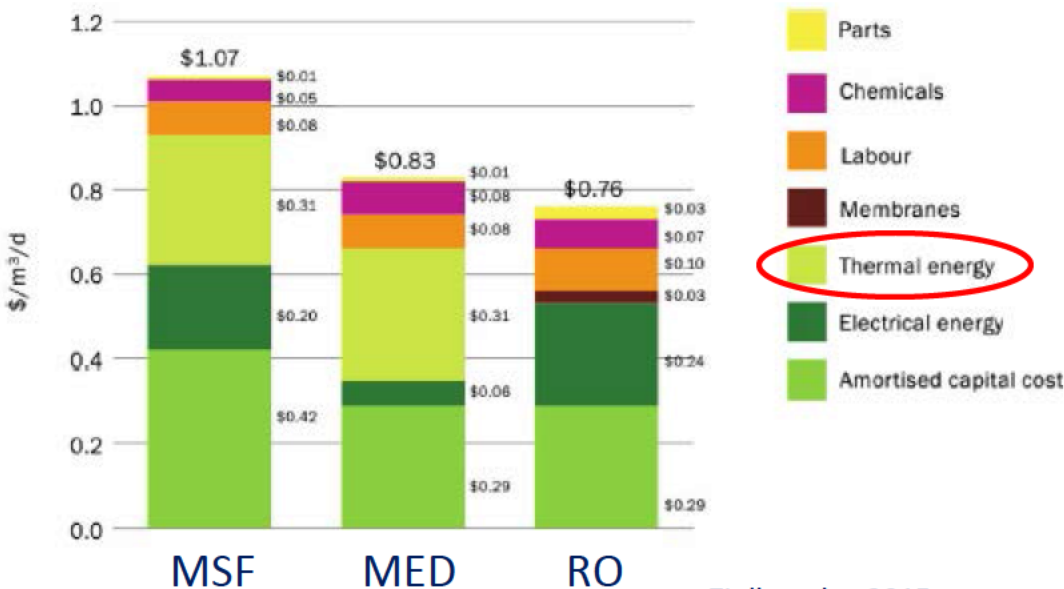
# Desalination Technologies

## Electric

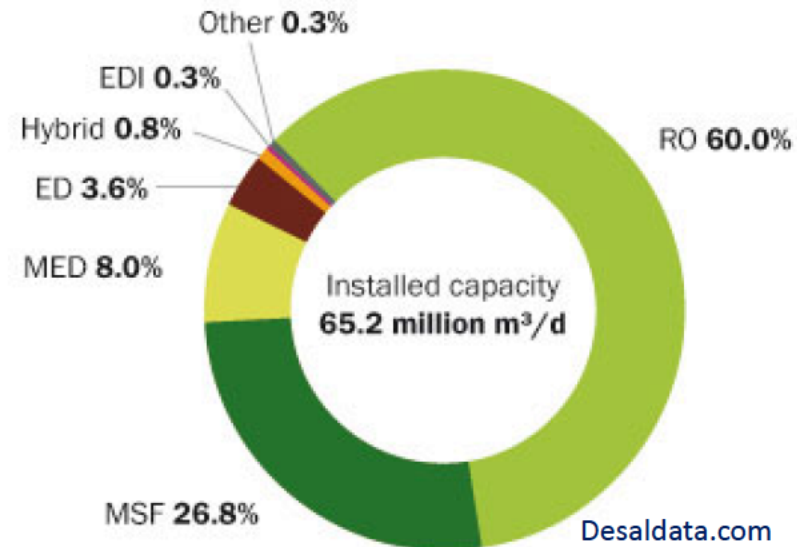
- Reverse Osmosis (RO)
- Electrodialysis (ED)

## Thermal

- Multistage Flash (MSF)
- Multi-effect Distillation (MED)



Ziolkowska, 2015



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

# NREL / Mines Partnership

## Project Objective:

*Identify promising options for using geothermal energy to desalinate water and characterize the technology performance, cost, and commercialization gaps.*

## NREL Team

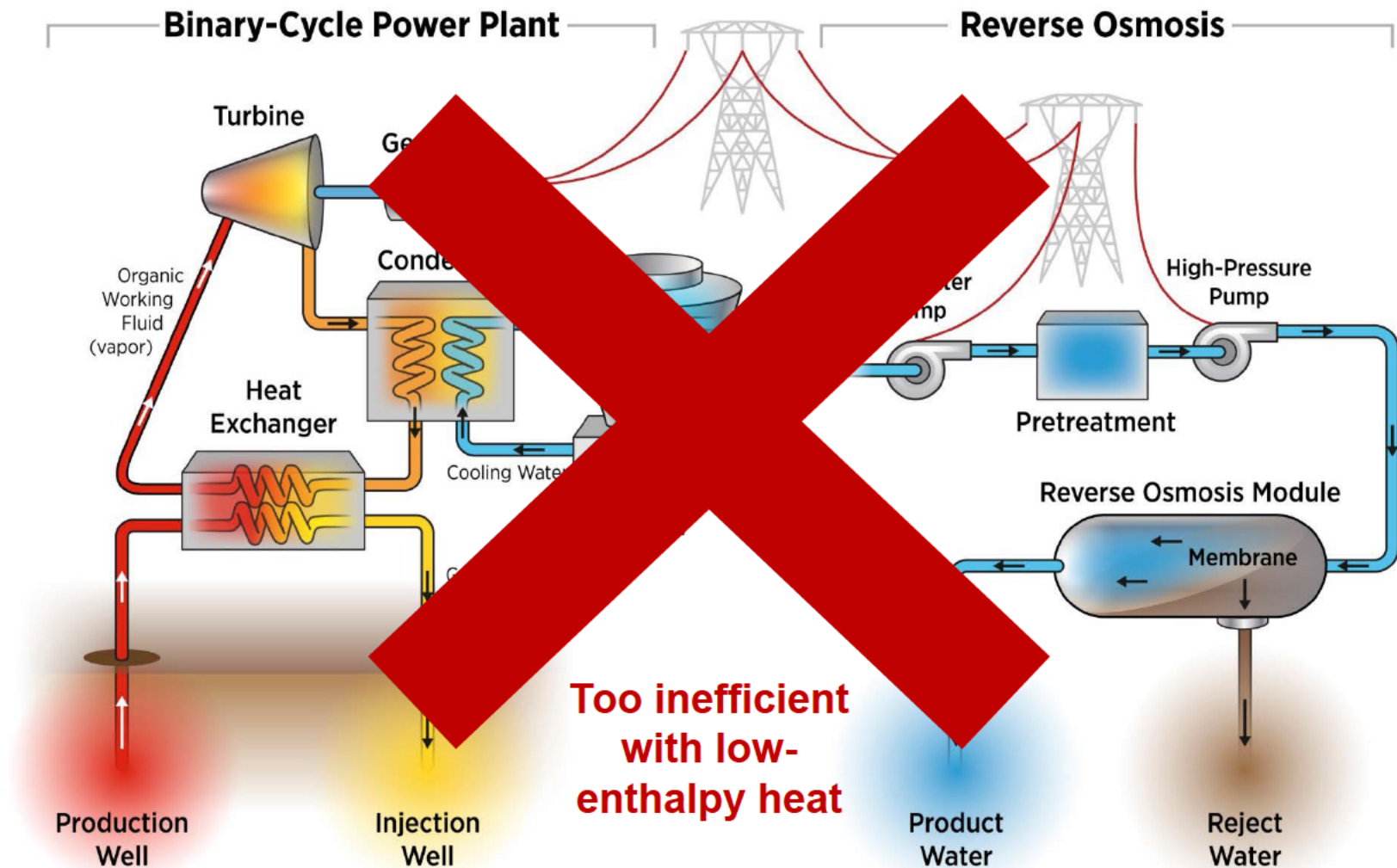
- Craig Turchi and Michael Hillesheim

## CSM Team

- Dr. Tzahi Cath, Civil & Environmental Engineering
  - Dr. Mengistu Geza, Research Assistant Professor
  - Dr. Johan Vanneste, Postdoctoral Associate
  - Bethany Grace Yaffe, Research Assistant
- Dr. John Persichetti, Chemical & Biological Engineering
  - Oversees senior-design course case study on geothermal desalination



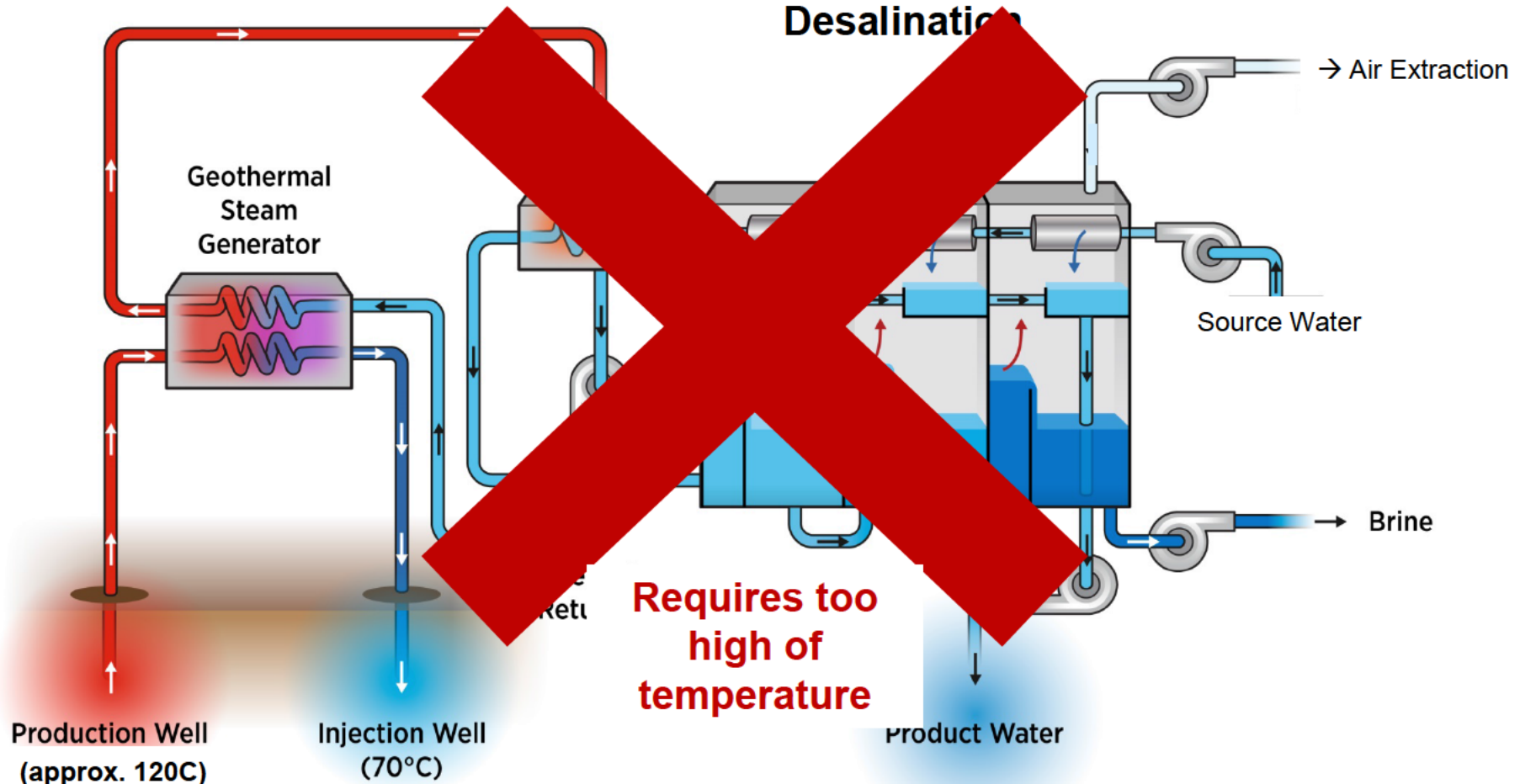
# Geothermal Electricity for Desalination





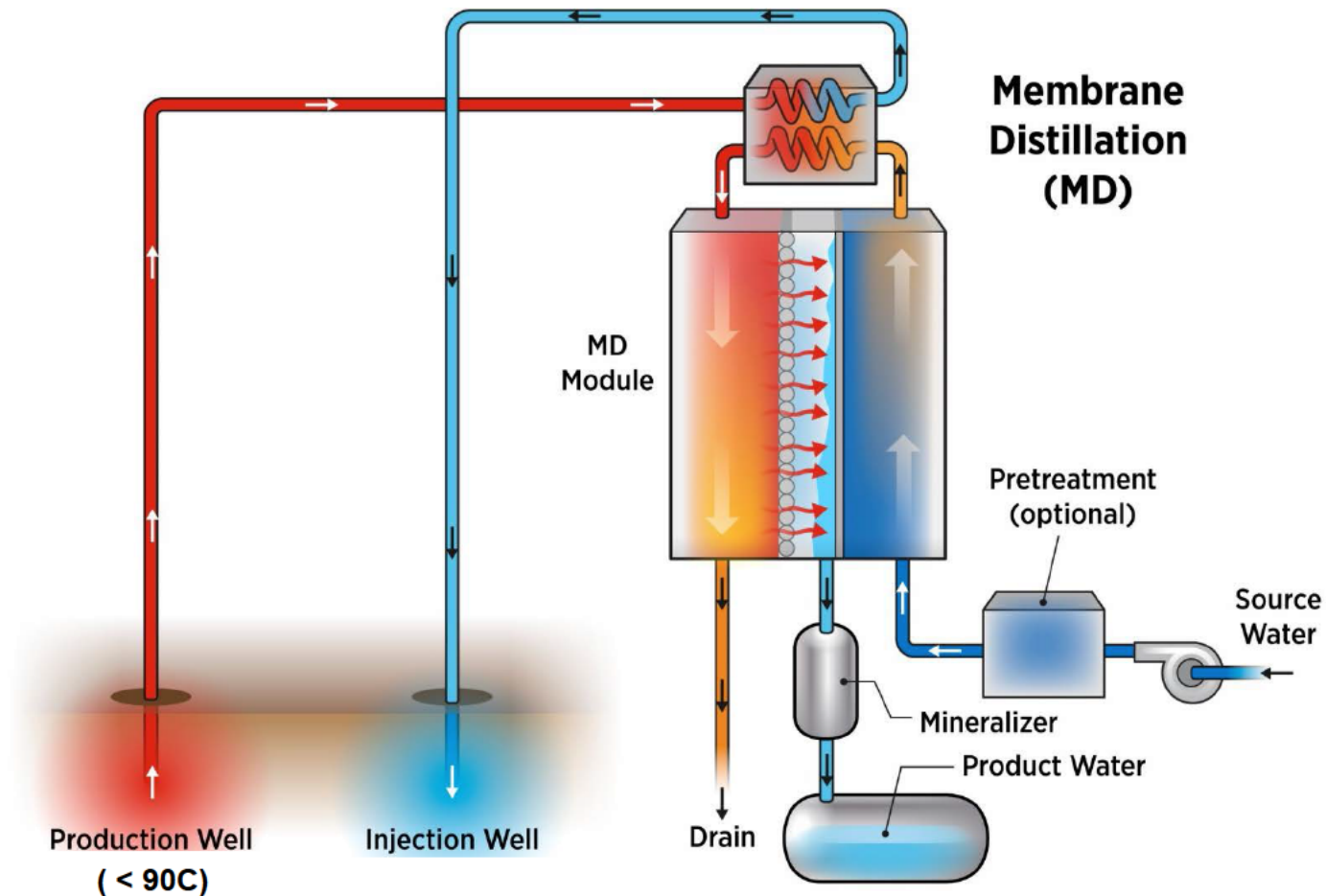
# Geothermal Desalination

## Multistage Flash (MSF) Desalination

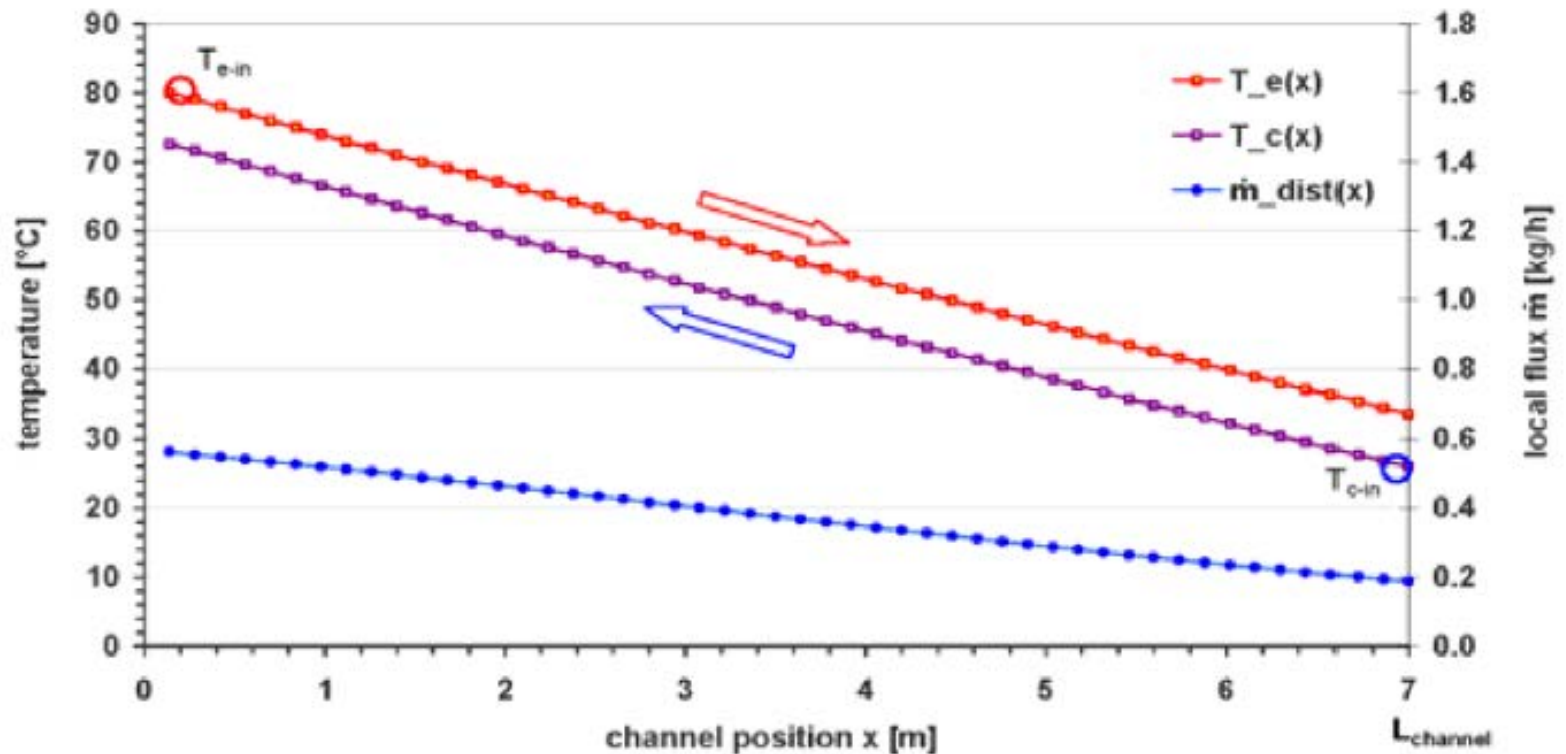


# Geothermal Desalination

One Approach: Membrane distillation with heat exchanger



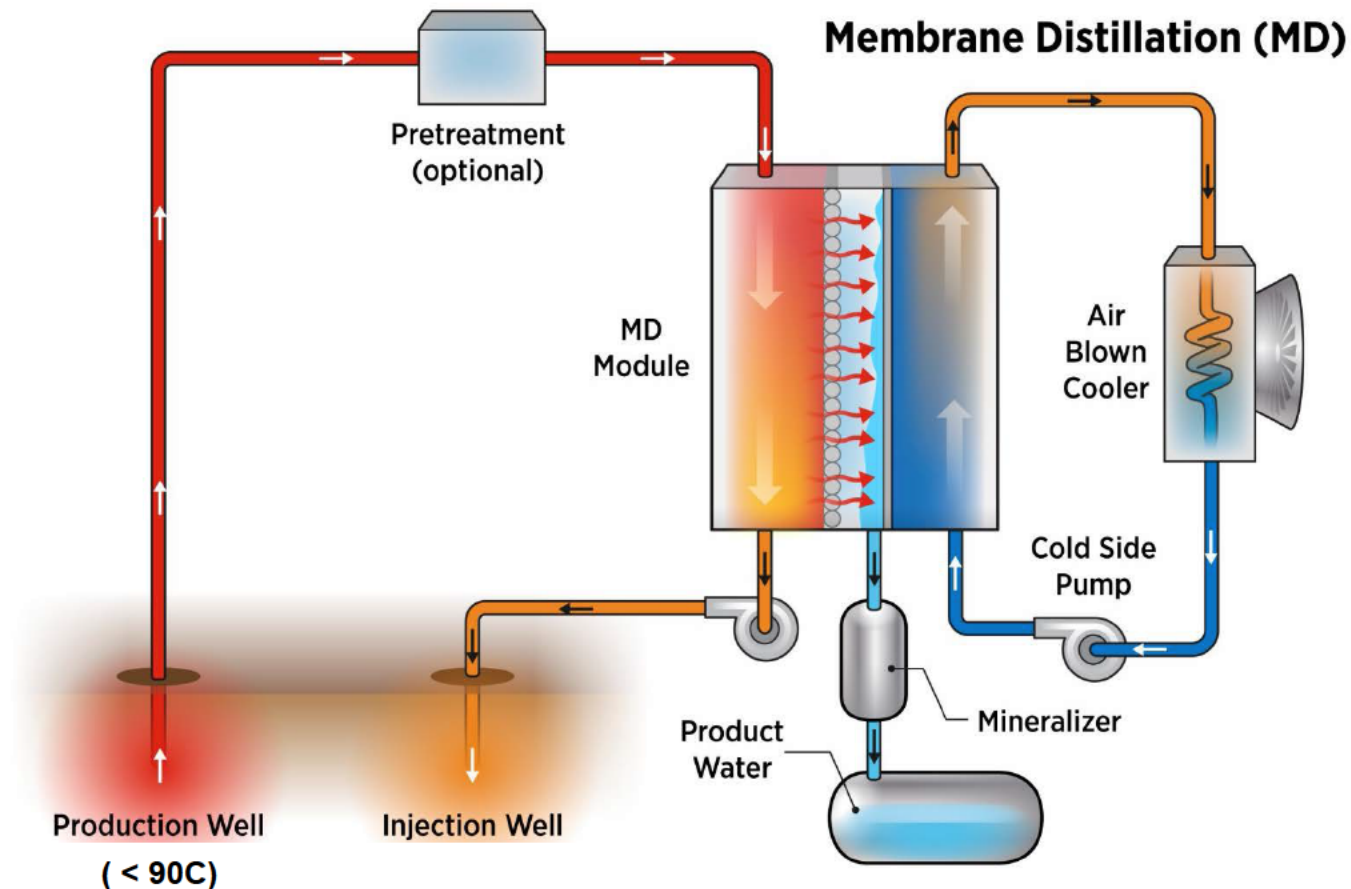
# Membrane Flux vs. Temperature



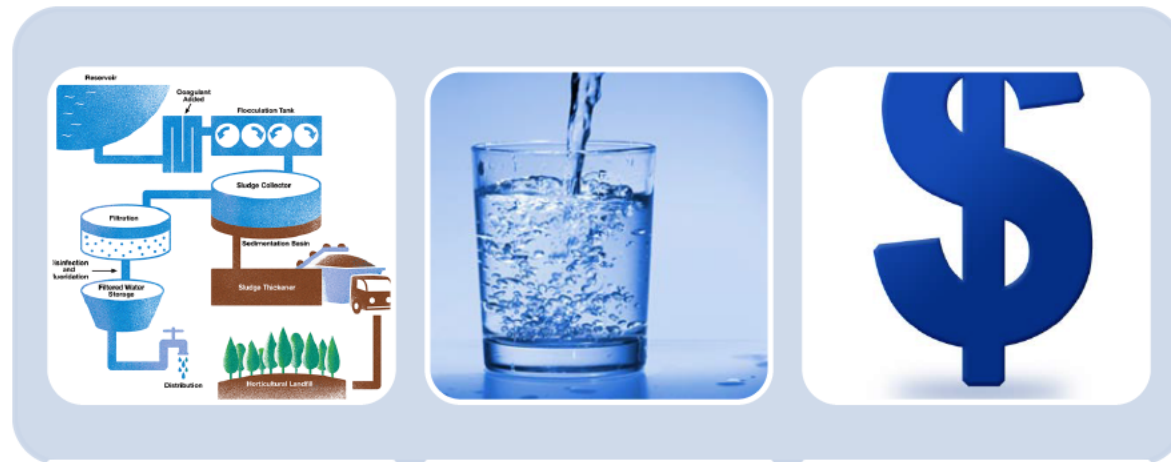
Koschikowski, 2015 (webinar)

# Geothermal Desalination

Membrane distillation with direct heating and use of the geothermal brine



# Geothermal-Desal 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” Example – inputs page

GDsalt\_PR1 2015-02-25.xlsm - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Acrobat

Paste Cut Copy Format Painter Clipboard Font Alignment Number Conditional Formatting Format as Table Styles

Percent 16 Percent 2 Percent 3 Perc  
Percent 6 Percent 7 Percent 8 Perc

TSM

GDsalt inputs | GDsalt outputs

Water quality inputs ? Help

Units ?

Flow ?

Geothermal energy inputs ?

User scores ?

User preference ?

Beneficial use inputs ?

Economic inputs ?

Multiple WWTPs ?

Default values ?

Run GDsalt ? Close GDsalt

Start

Produced Water Treatment Plant

Potable Water Treatment Plant

The screenshot shows a Microsoft Excel spreadsheet titled "GDsalt\_PR1 2015-02-25.xlsm". The ribbon includes File, Home, Insert, Page Layout, Formulas, Data, Review, View, and Acrobat. The Home tab is active, showing options for Paste, Cut, Copy, Format Painter, Clipboard, Font, Alignment, Number, Conditional Formatting, Format as Table, and Styles. The Styles section shows a table with percentages: Percent 16, Percent 2, Percent 3, Perc, Percent 6, Percent 7, Percent 8, and Perc. A "TSM" window is open, displaying the "GDsalt inputs" tab. This window contains a list of input categories, each with a question mark icon for help: Water quality inputs, Units, Flow, Geothermal energy inputs, User scores, User preference, Beneficial use inputs, Economic inputs, Multiple WWTPs, and Default values. At the bottom of the window are buttons for "Run GDsalt" and "Close GDsalt". To the left of the window, a large blue water drop icon contains the word "Start" and a city skyline. To the right, a diagram illustrates the water treatment process, showing "Produced Water Treatment Plant" and "Potable Water Treatment Plant" with arrows indicating the flow of water between them and to various sources like "Earth", "Water", and "Bed".

# Challenges

---

- Desalination is generally the option of last resort, *where there is an alternative*
  - Cost of desalinated water ranges from \$0.7/m<sup>3</sup> to \$2/m<sup>3</sup>
  - Retail water cost in major US cities is \$0.6/m<sup>3</sup> to \$5/m<sup>3</sup>
  - Water for industrial and agricultural users is often highly subsidized, for example agricultural water rates in CA's Imperial Valley are ~\$0.02/m<sup>3</sup>
- Reverse Osmosis (all electric) is the leading and lowest cost desalination approach

# 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
- Treat RO reject water
  - Disposing of reject brine can be difficult and costly
  - Zero-discharge requirements are becoming more common
- Treat highly contaminated water
  - Co-produced water disposal can cost several dollars per m<sup>3</sup>
  - Treat geothermal brine directly

# Project Status

---

- Refining and debugging GDsalt
- Assisting CSM senior-design projects on geothermal desalination
- Assessing thermal-desalination technologies for combination with geothermal energy
- Mapping collocated geothermal resources and brackish/impaired source waters
- Seeking candidate technology demonstration sites

# Contact information

Dr. Craig Turchi

[craig.turchi@nrel.gov](mailto:craig.turchi@nrel.gov)

303-384-7565

Dr. Tzahi Cath

[tcath@mines.edu](mailto:tcath@mines.edu)

303-273-3402

