

U.S. Department of Energy Geothermal Technologies Office Desalination Projects

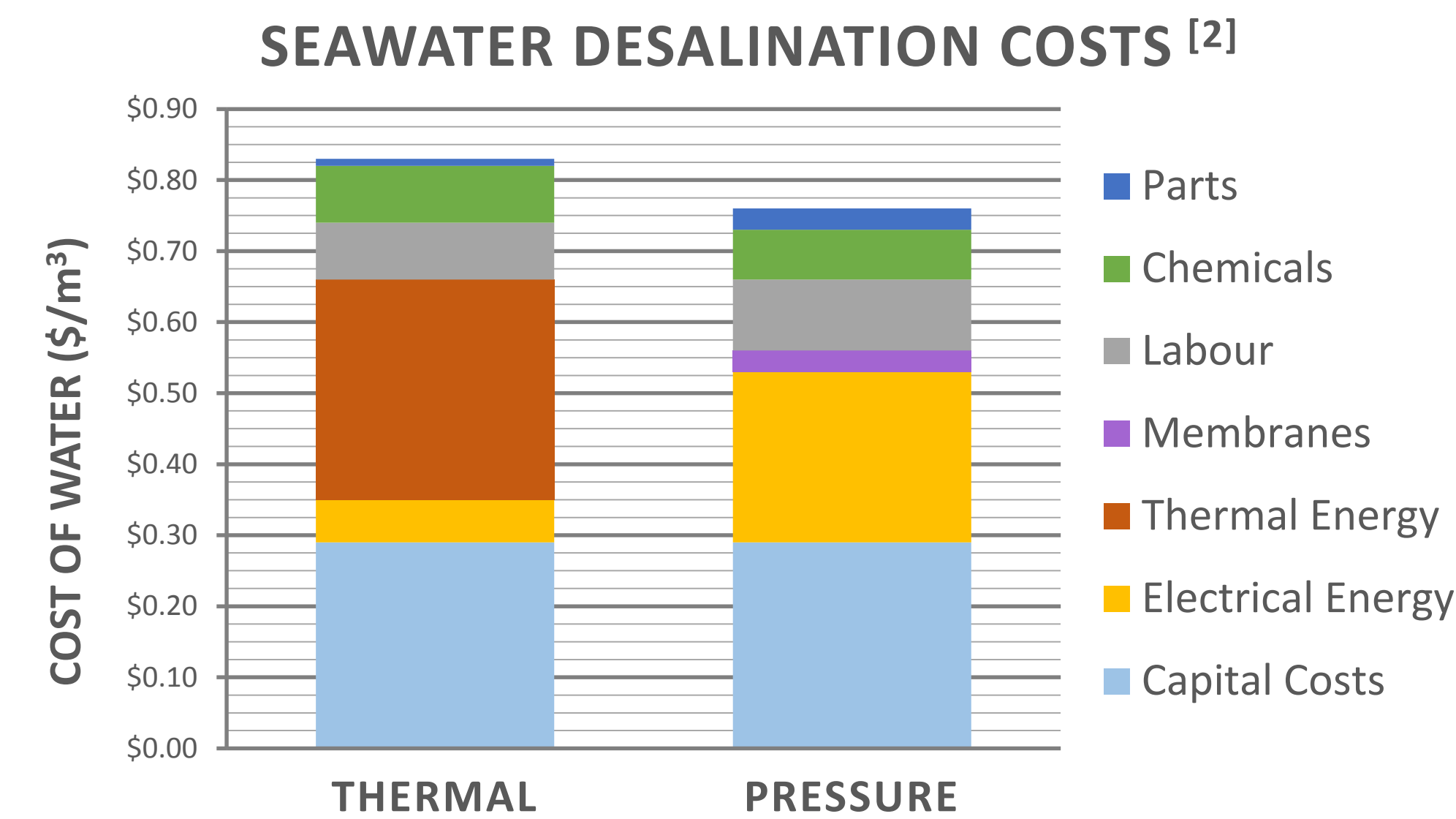
NEED:

Water resources are increasingly becoming more scarce, variable, and uncertain both domestically and internationally. Desalination technologies can assure water availability, but this solution is not yet cost competitive. The industry standard for desalination is Reverse Osmosis which is a pressure driven technology that has a large energy demand. Energy production requires water resources creating an interdependency called the Energy-Water Nexus.^[1]

Thermal desalination technologies can use low-grade or waste heat reducing the energy requirements. Coupling renewable energy with desalination can address the Energy-Water Nexus and help to reduce carbon emission. Using intermittent renewables like wind or solar introduces the problems of energy storage or running at reduced capacity both of which increase costs. Using geothermal resources for desalination can address all of these concerns.

OPPORTUNITY:

The chart below shows an estimate of the cost of water for two technologies assuming a large seawater desalination plant. The capital costs for each are similar and aside from the energy requirements the operating costs for a thermal plant is lower. There is an opportunity to reduce the energy costs of desalinating produced waters by using co-produced geothermal resource.



BENEFITS:

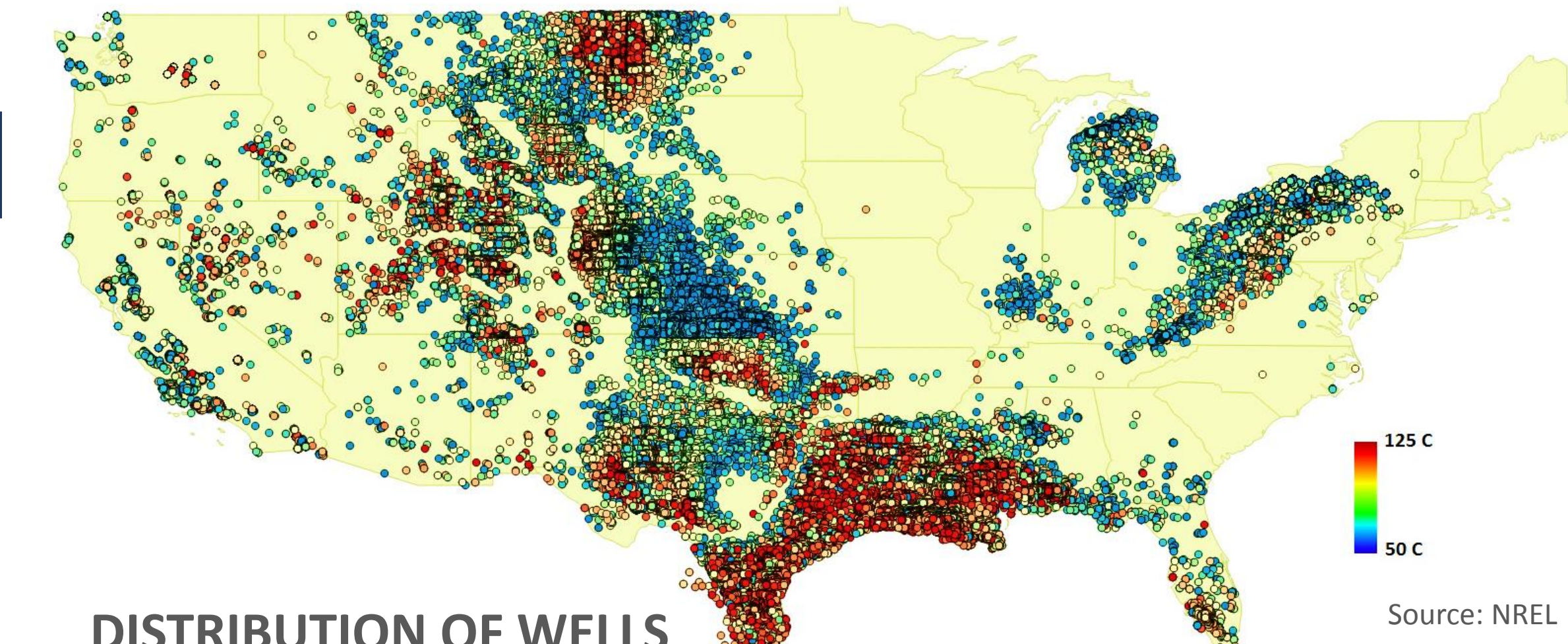
- **OFFSET DISPOSAL COSTS**
- **REDUCE ADVERSE ENVIRONMENTAL EFFECTS:**
 - **INDUCED SEISMICITY**
 - **CARBON EMISSIONS**
- **ADDRESS WATER NEEDS**

IMPROVEMENT:

In addition to these benefits, thermal desalination has the potential to treat waters that have higher Total Dissolved Solids and to recover a larger percentage of water. For example, Idaho National Laboratory's Forward Osmosis has the ability to recover up to 95% of the water from a brine, where Reverse Osmosis typically recovers only 75%. This five-fold reduction in concentrated brine volume can drastically reduce the cost of disposal.

POTENTIAL:

The initial market for geothermal desalination is the treatment of produced waters from oil and gas operations. As shown in the map below, many of these operations have co-produced geothermal resources that are currently untapped.



DISTRIBUTION OF WELLS HAVING TEMPERATURES BETWEEN 50°C AND 125°C
Source: NREL

Geothermal desalination of produced waters has many benefits. In addition to offsetting carbon dioxide emissions through the beneficial use of geothermal energy, it also has the ability to reduce the cost of disposal of produced waters and mitigate the induced seismicity caused by reinjection. The biggest potential benefit is changing these waters from a waste stream to a resource to help address water stress.

PROGRESS:

Beginning in 2012, the Geothermal Technologies Office started investing in research and development of thermal desalination technologies that could use low enthalpy geothermal resources. Since then both projects have made substantial progress.

- **Idaho National Laboratory** has identified Switchable Polarity Solvents as an ideal draw solute for Forward Osmosis.
- **National Renewable Energy Laboratory** investigated many thermal desalination technologies and identified Membrane Distillation as the most promising.

During 2015, both of these projects increased their scope from proof of concept to prototype development with plans for field testing at a geothermal site beginning in 2017 or 2018.

REFERENCES:

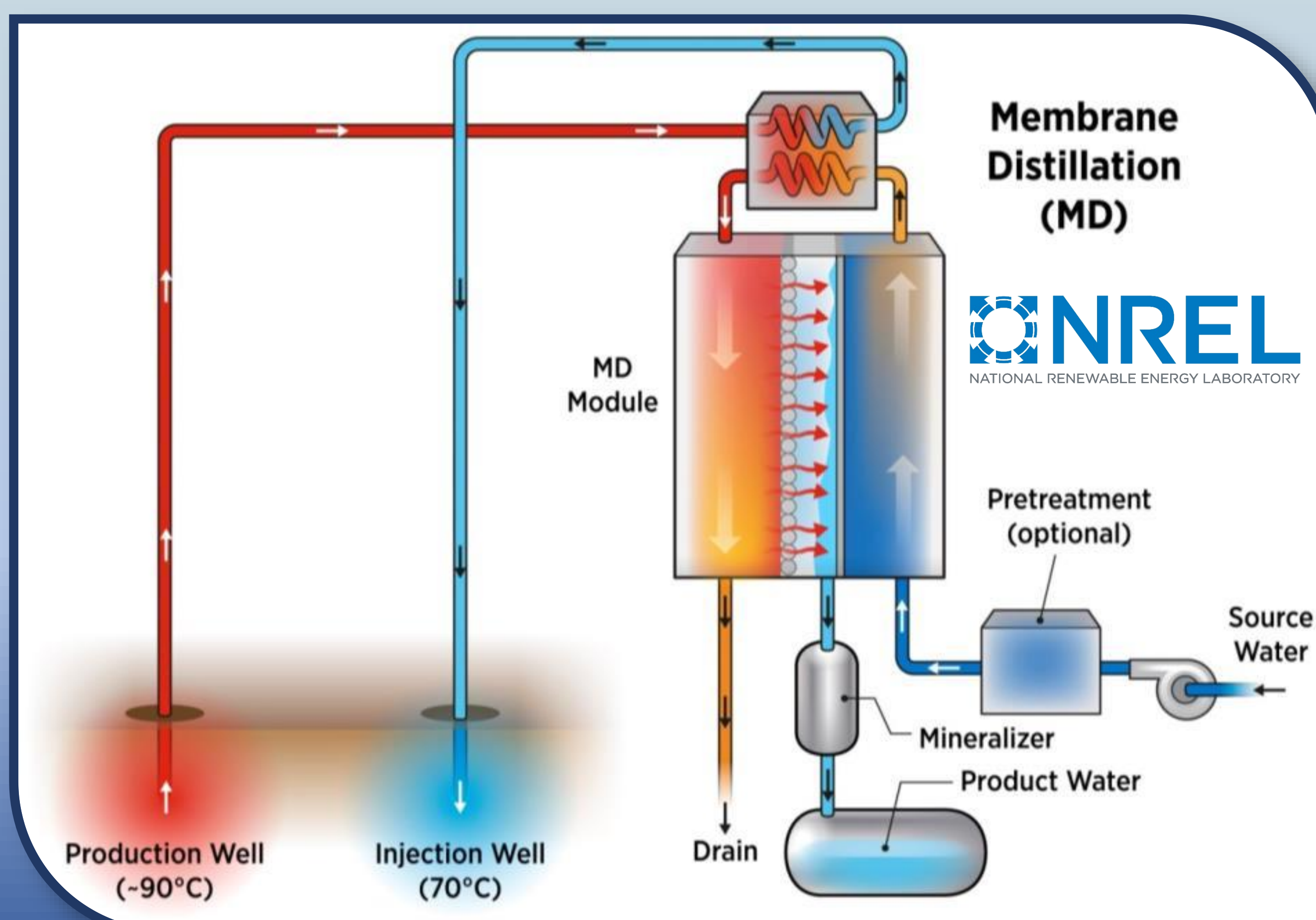
- [1] U.S. Department of Energy Report, "The Water-Energy Nexus: Challenges and Opportunities", June 2014
 [2] J. Ziolkowska, "Is Desalination Affordable?—Regional Cost," Water Resource Management, vol. 29, pp. 1385-1397, 2015.

SOLUTIONS:

The Department of Energy, Geothermal Technologies Office is currently funding research and development of thermal desalination technologies in two projects being led by the National Laboratories.

MEMBRANE DISTILLATION

A project led by the National Renewable Energy Laboratory has the goal of demonstrating the efficacy and quantifying the cost of using low-temperature geothermal resources in a Membrane Distillation system to produce high-quality water. The technology benefits will be quantified by the combination of avoided treatment / disposal cost of the source water and the value of the product water.



SWITCHABLE POLARITY SOLVENT – FORWARD OSMOSIS

An Idaho National Laboratory led project will demonstrate the technical viability and assess the economic feasibility of utilizing low-temperature geothermal resources to provide the energy necessary for Forward Osmosis water treatment. Specific project goals include using < 100°C geothermal fluids to provide all the thermal energy necessary for the treatment, while recovering more water from the feed stream than Reverse Osmosis.

Both of these projects currently have lab scale and prototype testing ongoing to validate the technology and feasibility. In the coming years they are planning on partnering with industry for field testing.

