

Together, **WELL** Ahead

Moving the geothermal
industry forward

NALCO Water: Your Partner on the Journey to a Cleaner Planet

Sustainability is the core to NALCO Water's purpose. Today, CO₂ reduction, water conservation, and energy savings are no longer considered "nice to have": They are imperatives. With increasing energy demand and carbon emissions, geothermal is playing a greater role as a clean alternative to support global energy.

Using our technologies smartly to reduce our environmental footprint while delivering sustainable growth is a key driver of NALCO Water's significant investment in helping the geothermal industry move forward.



Meeting Your Operational Needs, Wherever You Are

The geothermal power industry is continuously striving to maximize the utilization of their resources, increase power generation and reduce the Total Cost of Operation (TCO). NALCO Water's comprehensive offerings for the geothermal power industry can help the industry achieve these goals. NALCO Water invests heavily in Research & Development to continuously develop a range of innovative technologies, field expertise, patented chemistries, field and global testing, and laboratory services focused on the needs of the geothermal power industry. NALCO Water is committed to partnering with geothermal power plants worldwide to move this industry forward. Together, well ahead.

Your goals are our goals

NALCO Water partners with geothermal energy producers worldwide to develop reliable, cost-effective and safe solutions. Our ultimate goal is to deliver a measurable economic advantage and exponential return on investment.

PROVIDING CLEANER WATER & AIR: TODAY AND TOMORROW



ENHANCED RELIABILITY

- Maximize plant availability
- Minimize unscheduled shutdown
- Maximize the life of cooling tower
- Maximize the life of flash/binary plant
- Maximize well flow and performance
- On-line removal of build-up



WATER SAVING

- Limit blowdown loss by maximizing cooling tower cycles of concentration



IMPROVED AIR QUALITY

- H₂S abatement (non-condensable gases & condensate)



REDUCED TOTAL COST OF OPERATION

- Maximize wells production
- Maximize power (mWh) production
- Reduce maintenance cost by minimizing corrosion, scaling, and fouling
- Improve heat exchange efficiency



INCREASED ENERGY SAVING

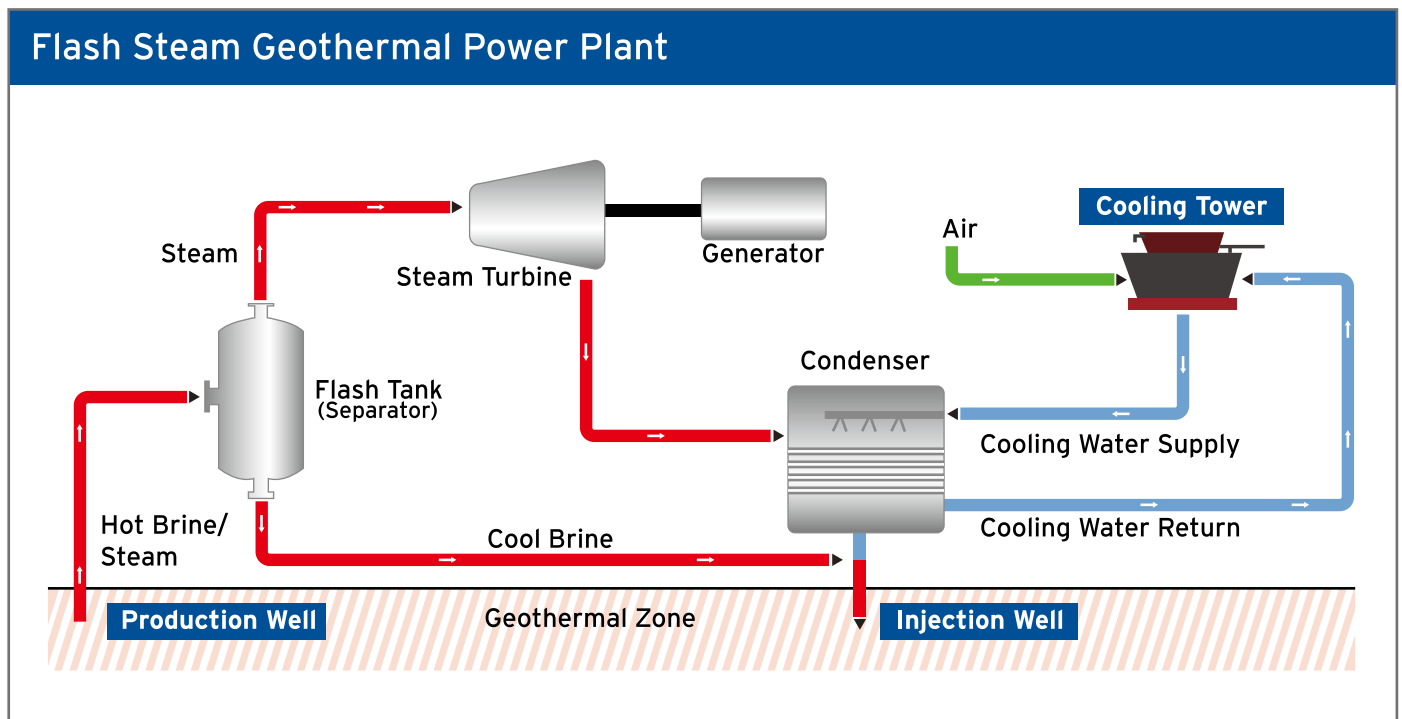
- Optimize performance of cooling tower through sulfur deposit inhibition and microbial control
- Maximize mWh output by limiting scale formation in production wells, process equipment, and injection wells



ENVIRONMENTAL COMPLIANCE

- Enable brine discharge to injection wells by controlling scale and corrosion
- Enable cooling tower blowdown to injection wells with scale and corrosion inhibitors

Complete solutions to your challenges



Production Well

Challenges:

- Ensuring maximum brine flow to the process for power generation by preventing scaling, corrosion, and fouling in production wells and downstream process equipment.
- Minimizing well down-time (lost production, costs of re-drilling and chemical cleaning)

NALCO Water Solutions:

- Geomizer™ modeling software
- Laboratory simulation and product screening
- Complete range of scale and corrosion inhibition chemistries

Benefits:

- Prevent loss of power generation
- Minimize the number of unscheduled shutdowns
- Minimize acidizing and/or reaming of production well
- Reduce maintenance cost

Injection Well

Challenges:

- Maintain maximum flow back to resource by minimizing deposit
- Maximize the life of well casings

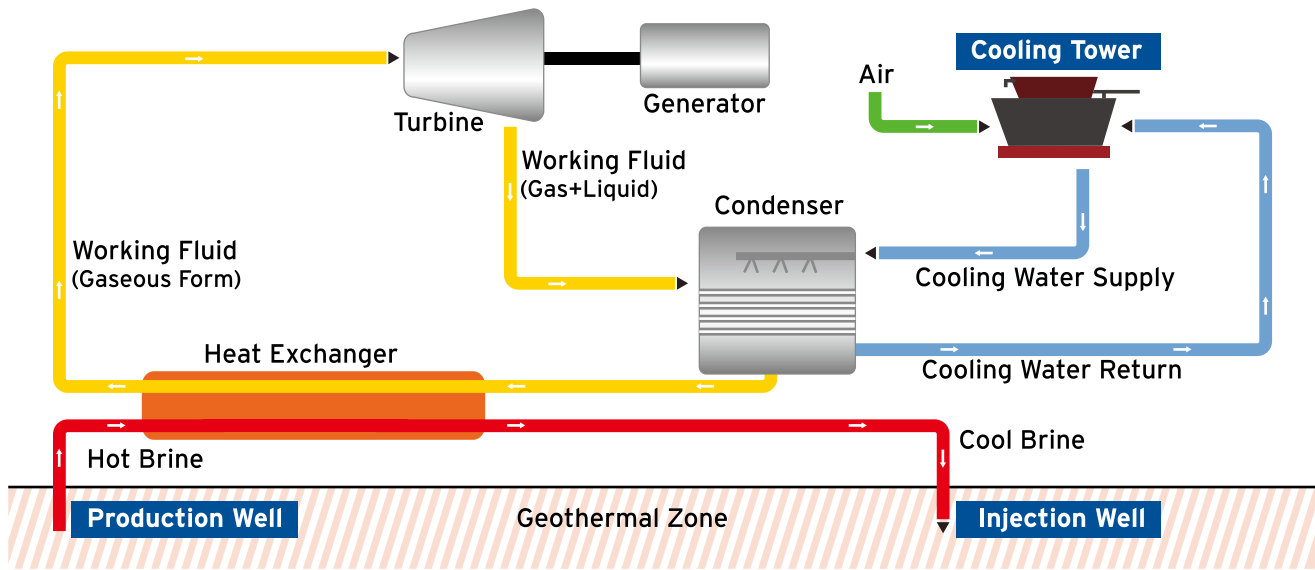
NALCO Water Solutions:

- Geomizer modeling software
- Laboratory simulation and product screening
- Complete range of scale and corrosion inhibition chemistries
- On-line chemical cleaning solution to remove brine flow restrictions caused by deposit build-up

Benefits:

- Maximize injection well flow and performance
- Reduce maintenance cost

Binary Cycle Geothermal Power Plant



Surface Equipment / Binary Plant

Challenges:

- Maintain efficiencies in critical exchangers (e.g. process or binary exchangers and vaporizers)
- Reduce downtime for hazardous chemical cleaning
- Improve enthalpy extraction for greater economic returns.

NALCO Water Solutions:

- Geomizer software for modeling and maximizing new plant design parameters
- Laboratory simulation and product screening
- Complete range of scale inhibition chemistries

Benefits:

- Maximize ROI of plant capital
- Reduce maintenance cost

Cooling Water System

Challenges:

- Maintain cooling tower efficiency through minimizing deposits and controlling microbial growth
- Minimize H₂S emission

NALCO Water Solutions:

- 3D TRASAR™ Technology to optimize deposit and microbial control treatments
- H₂S abatement program through conversion to sulfate
- Microbiological monitoring and control program
- Fill fouling clean-up and prevention program

Benefits:

- Optimize cooling tower performance
- Reduce energy consumption
- Achieve environmental compliance due to reduced H₂S discharge

Innovative Technologies

Geomizer

Geomizer is a web-based tool designed to:

- Provide advanced modeling in a simple and effective user interface
- Identify scale-forming minerals that commonly affect geothermal power plants including calcite, anhydrite, silica and fluorite
- Rapidly identify potential issues from production well through reinjection well
- Recommend cost-effective solutions to mitigate scaling and silica issues



Key Features

- Capable of modeling scaling potential from the source (production wells) through brine disposal (injection well) and determine the effect of applying various stabilization treatment programs
- Optimize chemistry selection and dosage
- Analyze different silica control strategies including temperature control and silica inhibitors
- Incorporate NALCO Water's industry experience and best practices

Functionality

- Flexibility to virtually model any plant configuration including binary, flash separator, single versus multiple stage flash, or combined binary and flash plants
- Ability to model variable blending of multiple brine sources
- Predict appropriate scale inhibitor and dose rates to prevent scale for the indicated conditions

3D TRASAR Cooling Water Technology

Patented Actives-Based Control

3D TRASAR Technology for Cooling Water utilizes unique real-time monitoring, patented actives-based control technology, proprietary stress-resistant chemistry and 24/7 information management capabilities to detect, determine and deliver improved scale, corrosion and microbiological performance in cooling systems.



Scale Inhibitor:

Superior Scaling Control

NALCO Water has a complete range of scale inhibitors for controlling the calcite, anhydrite, silica & silicate, stibnite and other types of scale to cater to various geothermal processes. Our proprietary silica inhibitor is proven to be very effective against silica scale - the most commonly found and most difficult scale to handle.



Corrosion Inhibitor:

Down-hole Asset Management

Whether it is due to acidic production wells or an acidic environment in the reinjection system (i.e. silica control), NALCO Water's comprehensive range of corrosion inhibitors is specifically designed to effectively control corrosion in high-stress geothermal fluid conditions to ensure the system is well protected.





Geomizer Identifies Effective Treatment Program to Reduce Total Cost of Operation

Region:

- Asia Pacific

Background:

A major geothermal power plant in New Zealand faced a calcite scaling issue with one of its production wells. This issue has caused the reduction of steam production and the customer has to carry out well reaming on a yearly basis due to calcite deposition, which was a significant cost. The customer was looking for a solution to overcome the large maintenance cost and improve process efficiency.

Solutions:

- Geomizer modeling software
- NALCO Water high-purity polymeric dispersant for scale control

eROI Benefits:

- Reduced maintenance cost by US \$600,000 per year
- Minimized unscheduled shutdown
- Consistent steam flow from the production well



NALCO Water's New Silica Inhibitor Increases Generating Output

Region:

- North America

Background:

One of the largest geothermal operators in the world was struggling with silica deposits fouling their binary OEC units (Ormat Energy Converter) at a combined flash and binary plant in the United States. The silica deposits formed in the headers and heat exchanger tubes in the injection wells. This problem caused decreased electrical output, high maintenance costs and risks associated with acid cleaning of the equipment. The client was searching for an effective silica inhibitor that would help prevent deposits at a cost-effective dosage.

Solutions:

- NALCO Water proprietary silica inhibitor - GEO 980

eROI Benefits:

- No new accumulation of silica scale or any other deposits
- Increased generation output worth over US \$525,000 per year
- Avoided mechanical or chemical cleaning of the heat exchangers, saving US \$175,000 per year
- Reduced maintenance cost caused by acid cleaning of the injection wells, saving US \$100,000 per year
- Lower risk of being designated a "degraded resource", which could decrease the annual bonus US \$1 million for maintaining operation at 80% capacity factor



Geomizer Simulation Tool Identifies Scale Potential and Helps to Avoid Production Loss

Region:

- Asia Pacific

Background:

A major geothermal power producer in New Zealand faces severe silica scaling issue in their binary plant. With silica deposited on the heat exchangers, less energy was recovered from the brine. This caused performance drop in the plant by approximately 2mWh, which was a huge revenue loss to the customer.

Solutions:

- Geomizer modeling software
- NALCO Water new proprietary silica inhibitor - GEO 980

eROI Benefits:

- Identified solution to avoid production loss by estimated US \$900,000 per year
- Reduced chemical usage for acid cleaning and disposal, saving US \$240,000
- Improved heat exchanger efficiency
- Reduce maintenance cost by reducing acidizing frequency of injection well



NALCO Water Scale Control Program Reduces Operation Cost and Environmental Impact

Region:

- Central America

Background:

A geothermal field in Central America had production wells that were prone to calcite scale formation, limiting power generation capacity. This condition demanded the use of a scale inhibitor to avoid the reduction of steam production and generation losses, in addition to the high cost associated with the cleaning and maintenance of the well. The customer requested a solution to optimize operation and production of the production wells without affecting operating costs.

Solutions:

- NALCO Water high-purity polymeric dispersant for scale control

eROI Benefits:

- Reduced electricity consumption by 21 mWh per year
- Avoided production loss and reduced electricity consumption, saving US \$11.900 million per year
- Reduced CO₂ by 114,055 ton per year, equivalent to 5,232 million trees
- Reduced hazardous chemical usage and cleaning cost by US \$500,000 per year for each well



Moving the Geothermal Industry Forward: Together WELL Ahead

NALCO Water, an Ecolab company is a trusted partner at more than one million customer locations in more than 170 countries around the world.

With an 80-year-plus track record, NALCO Water is the world's leading process and water treatment solutions provider. Our innovative solutions are carefully designed to help you achieve environmental, social and economic sustainability goals.

Nalco Water, an Ecolab Company

North America: 1601 West Diehl Road • Naperville, Illinois 60563 • USA

Europe: Richtistrasse 7 • 8304 Wallisellen • Switzerland

Asia Pacific: 2 International Business Park • #02-20 The Strategy Tower 2 • Singapore 609930

Greater China: 18G • Lane 168 • Da Du He Road • Shanghai China • 200062

Latin America: Av. Francisco Matarazzo • nº 1350 • Sao Paulo – SP Brazil • CEP: 05001-100

ecolab.com/nalco-water

eROI, 3D TRASAR, Geomizer, Ecolab, Nalco Water and the logos are Trademarks of Ecolab USA Inc.
©2014, 2016, 2017 Ecolab USA Inc. All Rights Reserved 09/17 B-1361

NALCO  **Water**
An Ecolab Company