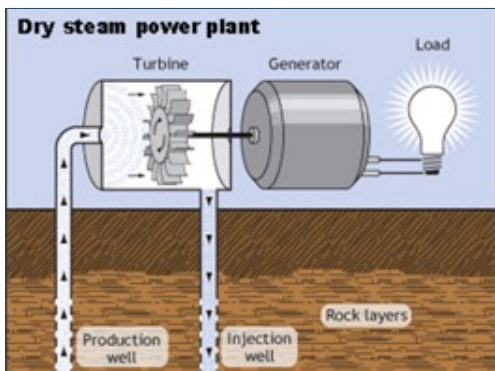




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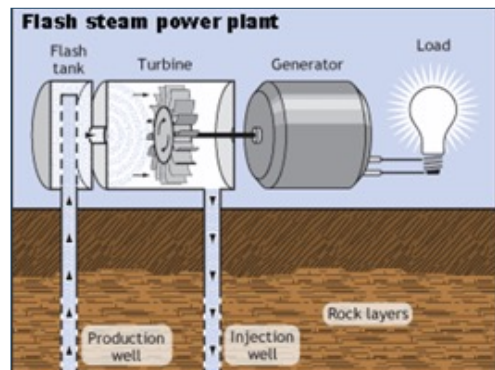
Geothermal Power Plant Impact of Scale and Corrosion



According to an April 2021 report by Global Industry Analysts, the global geothermal energy market is expected to reach US \$8.9 billion by 2027, up from US \$4.7 billion in 2020, with the US market estimated at US \$1.4 billion in 2020.^[1]

Geothermal energy systems fall into three categories, as outlined by the US Energy Information Administration:^[2]

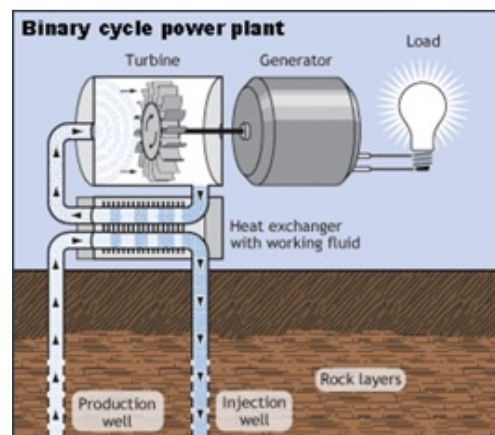
- Direct use and district heating systems
- Geothermal power plants
- Geothermal heat pumps



This paper is focused on corrosion and scale control in the geothermal power generation market.

Geothermal power plants are categorized as the following:^[3]

- Dry Steam - harnesses steam produced naturally in the geothermal reservoir
 - Simplest and oldest
- Flash Steam - converts high-pressure hot groundwater to steam
 - Most common
- Binary - uses geothermal hot water as the heat source to turn a secondary liquid to steam
 - Most recent design



The market for dry steam plants is estimated to grow by 8.4% CAGR to US \$2.4 billion by year's end 2027. Binary plants will have a projected 8.8% CAGR. The flash steam segment is expected to see a 10.6% CAGR propelled by growth in the USA, Canada, Japan, China, and Europe, developing from an estimated US \$2.1 billion regional market share in 2020 to US \$4.3 billion in 2027, with China growing at the fastest rate. Asia-Pacific leaders for the flash steam sector will include Australia, India, and South Korea (US \$1 billion regional forecast for 2027).^[1]

Image Source: U.S. Department of Energy

Cortec® Corporation is the global leader in innovative, environmentally responsible VpCI® and MCI® corrosion control technologies for the Packaging, Metalworking, Construction, Electronics, Water Treatment, Oil & Gas, and other industries. Headquartered in St. Paul, Minnesota, Cortec® manufactures over 400 products distributed worldwide. ISO 9001, ISO 14001, and ISO 17025 Certified.





At the end of 2020 there were 522 geothermal plants operating worldwide.^[4] As of 2019 there were 43 operating geothermal plants in California with the highest percentage in the Geysers complex north of San Francisco.^[5] California has two proposed sites: Hell’s Kitchen (2023) and Casa Diablo IV (2021).^[6] After California, Nevada is the second largest geothermal producing state in the U.S.

The table below shows the top ten nations for installed geothermal power generation in 2020.^[7]

Country	MWe Installed in 2020
1. USA	3,700.00
2. Indonesia	2,289.00
3. Philippines	1,918.00
4. Turkey	1,549.00
5. Kenya	1,193.00
6. Mexico	1,005.80
7. New Zealand	1,064.00
8. Italy	916.00
9. Japan	550.00
10. Iceland	755.00



Top States in the United States for Geothermal Power Generation^[8]

State	Installed MW Capacity
1. California	2,792
2. Nevada	805
3. Utah	84
4. Hawaii	51
5. Oregon	37
6. New Mexico	19
7. Idaho	18



ThinkGeoEnergy's Global Geothermal Power Plant Map^[9]



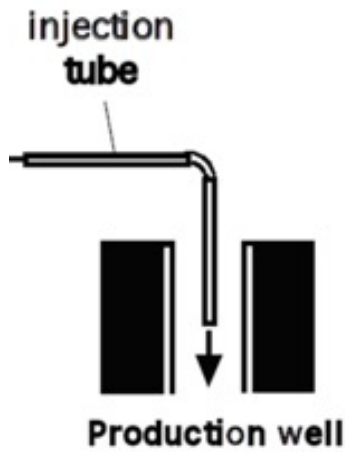
A Transparency Market Research (TMR) report indicates a promising decade ahead for geothermal power, thanks to changes in attitudes about fossil fuels and an increasing focus on renewable energy, even among governments. The quest to reduce carbon footprints has become an encouragement for companies to fall back on geothermal energy. Despite the challenges to attracting investors due to high initial investments and delayed ROI, TMR expects the value of geothermal power equipment to steadily grow to approximately US \$32 billion by year's end 2027.^[10]

The steam and/or hot water from geothermal wells are high in corrosive elements such as chlorine, hydrogen sulfide, sulfuric acid, carbonic acid, and ammonia. The presence of these elements leads to the following types of corrosion within a plant: uniform corrosion, pitting corrosion, stress corrosion cracking, and sulphur stress corrosion cracking. Hydrogen bubbling and scale formation can also occur. Common types of scale in a geothermal system are calcium carbonate, heavy metal sulphides, and silica or metal-silicates. Corrosive elements in the steam and/or hot water attack the surfaces of the production and injection well casings, steam turbine flow path, and heat exchangers for binary systems. The corrosive gases emitting from the steam/hot water attack the infrastructure (steel and concrete), the external surfaces of machinery, and the electrical control systems (e.g., control panels, junction boxes, motor control centers, and motors). The following materials and methods are suggested to minimize the impact of these harsh geothermal conditions.



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Prevention of Scale and Corrosion in Well and Turbine

- Inject scale and corrosion inhibitor into the production well
- Inject scale and corrosion inhibitor into the discharge from the steam turbine
- Coat turbine blades and casing internals with VpCI®-396 Carbide
- Use S-15

Protection of Operational Systems

- Lubrication systems
 - Add M-528, M-530, M-531 at 2%-5% by weight
- Electronics/electricals
 - Install Emitters
 - VpCI®-101 Device, VpCI®-105 Emitter, VpCI®-111 Emitter, VpCI®-308 Pouch
 - Apply ElectriCorr™ VpCI®-239
- Threaded assemblies such as valve stems and packing body bolts
 - Apply VpCI® Super Penetrant
- Exposed machined surfaces
 - Coat with VpCI®-391 or EcoShield® 386 Clear
- External painted surfaces – choose from the following coatings:
 - VpCI®-386 HT for turbines and other equipment that reach 750 °F (399 °C)
 - VpCI®-371 for surfaces that reach 1250 °F (677 °C)
 - VpCI®-386, VpCI®-387, VpCI®-384, VpCI®-375 for non-submerged external surfaces below 350 °F (177 °C)
 - To optimize coating selection, it is recommended that a sample of any fluid that will be in contact with the surface be sent to Cortec® lab for analysis
- Under insulation
 - Apply VpCI®-658, VpCI®-619
- Transformer oil
 - Add M-236



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- Generators
 - Place VpCI®-308 Pouch inside generator housing
- Steam system
 - Inject Corrosorber® liquid into the production steam at the wellhead
 - Dose rate to be calculated by Cortec® lab based on CO₂ and H₂S content
- Cooling water system
 - Inject Corrosorber® liquid and VpCI®-647 into the condenser hotwell.
 - Dose rate to be calculated by Cortec® lab based on CO₂ and H₂S content

Equipment Shutdown and Layup



- Turbines
 - Steam side
 - Fog with VpCI®-337 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
 - Oil side (if M-528, M-530, M-531 is not used during operation)
 - Fog bearing housings, supply and drain lines, and oil sump with M-528, M-530, M-531 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
- Generators
 - Oil side (if M-528, M-530, M-531 is not used during operation)
 - Fog bearing housings, supply and drain lines, and oil sump with M-528, M-530, M-531 at 0.3-0.5 oz./ft³ (0.31 -0.52 L/m³)
 - Electrical side
 - Spray all electrical contacts with ElectriCorr™ VpCI®-239
 - Install appropriate emitters in junction boxes, control panels, enclosures, and generator housing
- Switchgear
 - Remove any rust with VpCI®-422 or VpCI®-423, followed by VpCI®-414
 - Prime all surfaces to be painted with CorrVerter® Rust Converter Primer
 - Topcoat with VpCI®-396
 - Spray all contacts with ElectriCorr™ VpCI®-239



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- Install appropriate emitter
- Transformers
 - Remove any rust with VpCI®-422 or VpCI®-423, followed by VpCI®-414
 - Apply CorrVerter® Rust Converter Primer to all surfaces that will be painted
 - Topcoat with EcoShield® 386
 - Spray all contacts with ElectriCorr™ VpCI®-239
 - Install appropriate emitter
- Pumps (excluding oil)
 - Flow path
 - Fog with VpCI®-337 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
 - Oil side (if M-528, M-530, M-531 is not used during operation)
 - Fog bearing housings, supply and drain lines, and oil sump with M-528, M-530, or M-531 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)



- Pumps (oil)
 - Flow path
 - Fog with M-528, M-530, or M-531 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
 - Oil side (if M-529 is not used during operation)
 - Fog bearing housings, supply and drain lines, and oil sump with M-528, M-530, or M-531 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
- Piping (oil)
 - Fog with M-528, M-530, or M-531 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
- Piping (non-oil)
 - Fog with VpCI®-337 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³)
- Cooling water system



- **Option 1:**
 - Set up jumper system between condensate injection and condensate inlet to condenser
 - Add between 0.3-1.0% by weight VpCI®-649 to the condensate and circulate for 24 hours
 - Drain or leave wet
 - If system is drained, place Cooling Tower Frog® water soluble bags in the designated cooling water components

• **Option 2:**

- Set up jumper system between condensate injection and condensate inlet to condenser
- Fog with VpCI®-337 at 0.3-0.5 oz./ft³ (0.31-0.52 L/m³) into the condenser and all pumps and piping
 - It may be necessary to isolate certain parts of the system and create a small pressure drop to increase the travel of the VpCI®-337

General Maintenance and Repair

- Clean all rusted exterior surfaces with either VpCI®-423 or VpCI®-422
 - Neutralize with a 10% solution of VpCI®-414
- Clean all exposed machined surfaces with a 10% solution of VpCI®-414
 - Coat with VpCI®-391
- Spray all threaded assemblies such as valve stems, packing body bolts, and fasteners with VpCI® Super Penetrant
- Repair any painted surfaces with the appropriate Cortec® coating

Product Name	Product Data Sheet
Cooling Tower Frog®	https://www.cortecvci.com/Publications/PDS/Cooling_Tower_Frog.pdf
Corrosorber®	https://www.cortecvci.com/Publications/PDS/Corrosorber.pdf
CorrVerter® Rust Converter Primer	https://www.cortecvci.com/Publications/PDS/CorrVerter.pdf
EcoShield® 386	https://www.cortecvci.com/Publications/PDS/EcoShield-386.pdf
ElectriCorr™ VpCI®-239	https://www.cortecvci.com/Publications/PDS/ElectriCorr-VpCI-239.pdf
M-236	https://www.cortecvci.com/Publications/PDS/M-236.pdf
M-528	https://www.cortecvci.com/Publications/PDS/M-528.pdf
M-530	https://www.cortecvci.com/Publications/PDS/M-530.pdf
M-531	https://www.cortecvci.com/Publications/PDS/M-531.pdf
S-15	https://www.cortecvci.com/Publications/PDS/S-15.pdf
VpCI® Super Penetrant	https://www.cortecvci.com/Publications/PDS/VpCI_Super_Penetrant.pdf
VpCI®-101 Device	https://www.cortecvci.com/Publications/PDS/VpCI-101.pdf
VpCI®-105 Emitter	https://www.cortecvci.com/Publications/PDS/105.pdf
VpCI®-111 Emitter	https://www.cortecvci.com/Publications/PDS/VpCI-111.pdf
VpCI®-308 Pouch	https://www.cortecvci.com/Publications/PDS/VpCI-308_Pouch.pdf
VpCI®-337	https://www.cortecvci.com/Publications/PDS/VpCI-337-VpCI-337_Winterized.pdf
VpCI®-371	https://www.cortecvci.com/Publications/PDS/VpCI-371.pdf
VpCI®-375	https://www.cortecvci.com/Publications/PDS/VpCI-375.pdf
VpCI®-384	https://www.cortecvci.com/Publications/PDS/VpCI-384.pdf
VpCI®-386	https://www.cortecvci.com/Publications/PDS/VpCI-386.pdf
VpCI®-386 HT	https://www.cortecvci.com/Publications/PDS/VpCI-386-HT.pdf
VpCI®-387	https://www.cortecvci.com/Publications/PDS/VpCI-387.pdf




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VpCI®-391	https://www.cortecvci.com/wp-content/uploads/VpCI-391NEW.pdf
VpCI®-396	https://www.cortecvci.com/Publications/PDS/VpCI-396.pdf
VpCI®-414	https://www.cortecvci.com/Publications/PDS/VpCI-414.pdf
VpCI®-422	https://www.cortecvci.com/Publications/PDS/VpCI-422.pdf
VpCI®-423	https://www.cortecvci.com/Publications/PDS/VpCI-423.pdf
VpCI®-619	https://www.cortecvci.com/Publications/PDS/VpCI-619.pdf
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VpCI®-649	https://www.cortecvci.com/Publications/PDS/VpCI-649-VpCI-649MF_VpCI-649_Winterized.pdf
VpCI®-658	https://www.cortecvci.com/Publications/PDS/VpCI-658.pdf

CASE HISTORIES


Preservation of Instrumentation and Electricals in H₂S Conditions



HIGH PERFORMANCE VpCI® PACKAGING

CASE HISTORY

Preservation of Instrumentation and Electricals in H₂S Conditions



DATE
February 2021

CUSTOMER
PT. Pertamina Geothermal

CORTEC® REPRESENTATIVE
PT. Pentra Unggul Sejati

LOCATION
Indonesia

PRODUCTS
Corrosorber®
ElectriCorr™ VpCI®-239
VpCI®-111 Emitters


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PROBLEM
Three years prior, Pentra had supplied Schneider Electric with preservation materials that allowed them to successfully support an energy company in Indonesia. In 2021, the energy company wanted to use the same standard of protection to preserve their electricals and instrumentation for three more years. The company produces electricity from geothermal energy, which creates a surrounding environment that is corrosive due to the presence of H₂S mixed with hot steam. The customer approached Pentra for a Cortec® solution that can be implemented right from the start when instrument and electrical panels are installed.

APPLICATION
Pentra visited the site and looked at some of the equipment. The customer wanted to apply preservation materials for the first time to equipment in Building 4 and reapply preservation materials to equipment in Building 5, which was newer than Building 4 and had already used Cortec® solutions successfully. Pentra supplied ElectriCorr™ VpCI®-239 for application to instrumentation and electricals in exposed/open panels. Corrosorber® and VpCI®-111 Emitters were used inside enclosed cabinets.

CONCLUSION
Thanks to Cortec's solutions and the knowledge and longtime field experience of Pentra, the work was successfully done. The customer was very satisfied with the method because it did not require mechanical work, it was very efficient in the field, and the successful impact of the products had already been seen during the first three years of use.



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https://www.corteccasehistories.com/?s2member_file_download=access-s2member-level1/ch712.pdf



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