Alternative Water Policy Assessment for Enhanced Geothermal Systems—A Case Study

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ABSTRACT

This paper is part of a larger analysis that examined alternative water policies for states with active EGS development (Harto et al. 2014). The goal of that work was to better understand the regulatory structure that governs alternative waters in these areas and to assess the potential challenges that future EGS projects may face if they attempt to use such resources. Active development of EGS resources has historically occurred in areas that are water-scarce. Therefore, water availability has the potential to impact the long-term success of EGS development. California was chosen as the main focus of that analysis as it is the largest state in terms of installed geothermal capacity and has a complicated and unique regulatory structure for alternative waters. These waters represent an important but generally overlooked source that could be used by geothermal energy projects to replace the fluids lost during normal power plant operations. This paper shows that in general, regulatory frameworks for using recycled wastewater exist for geothermal projects. However, regulations for using other alternative water sources, such as produced water from oil and gas development, saline groundwater, and mine pool water, could not be found.

Introduction

The Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) projects that geothermal energy generation in the United States will more than triple by 2040 (EIA 2014). This increase, which translates to more than 5 GW of generation capacity, is anticipated because of technological advances and an increase in available sources through the continued development of enhanced geothermal systems (EGSs) and low-temperature resources (EIA 2014; Harto et al. 2014). Studies have shown that air emissions, water consumption, and land use have less of an impact for geothermal electricity generation than for traditional fossil fuel-based electricity generation. Nevertheless, the long-term sustainability of geothermal power plants can be affected by insufficient replacement of operational fluid that was lost as a result of normal operations (Schroeder et al. 2014). Thus, access to water is critical for the increased deployment of EGS technologies and, moving forward, the growth of the geothermal sector (Harto et al. 2014).

To date, all active development of EGS projects in the United States has occurred in the Western part of the country, within states and regions that have traditionally experienced water scarcity issues. Thus, the availability of water has the potential to significantly impact the long- term success of EGS development. Alternative waters represent a significant, but generally overlooked, source that could be used by geothermal energy projects to replace the fluids lost during normal power plant operations (Harto et al. 2014).

I. Methods

Harto et al. (2014) examined alternative water policies for the four Western states with active EGS development projects: California (The Geysers), Idaho (Raft River), Nevada (Desert Peak), and Oregon (Newberry Volcano). This analysis focuses on the review of California, specifically. California, at 2.76 GW, has the largest amount of installed geothermal capacity of any state in the country (GEA 2015). It also is in the midst of a historic drought, making water availability a critical issue. Understanding how alternative water sources are regulated in California is, therefore, especially important.

According to the U.S. Environmental Protection Agency (EPA), the term "alternative waters" includes reclaimed water, grey water, and harvested storm water (EPA 2012). This report uses an expanded definition from a joint alternative waters project run by ALL Consulting and the National Energy Technology Laboratory (NETL), which includes treated wastewater effluent, produced water from oil and gas development, saline groundwater, and mine pool water (ALL Consulting 2010). Analysis proceeded by investigating relevant laws and regulations relating to these sources of alternative waters among state regulatory agencies. Although every effort was made to find regulations dealing with all alternative water types included in the ALL Consulting and NETL database, regulations for treated wastewater dominated the findings. It should be noted that while regulations for reuse were not found for any other type of water in the state of California, news stories in local and national newspapers indicated that reuse of treated, produced waters from oil and gas operations does indeed occur in the agricultural sector (NYT 2014). Attempts to contact state officials mentioned in the press were unsuccessful.

II. Discussion

Reclaimed water use in California is regulated under an intricate series of laws and regulations (Harto et al. 2014). Decision making related to recycled water use operates under an umbrella of regulatory agencies, and understanding how these agencies interact and which agency has regulatory authority for which actions is critical to navigating this process. The main regulatory instruments at play here include the California Water Code (Porter Cologne Water Quality Control Act), Basin Plan(s) adopted by the Regional Water Boards, applicable sections of Health & Safety Code Title 17, and the California Code of Regulations (CCR), Title 22, Division 4, Chapter 3 pertaining to issuance of Recycled Water Permits.

The State Water Resources Control Board (SWRCB or State Board) operates as the senior authority in the state for recycled water reuse. Created by the California state legislature in 1967, the five-member State Board protects water quality by setting statewide policy, coordinating and supporting the efforts of the Regional Water Quality Control Boards (RWQCBs or Regional Boards) (described next), and reviewing petitions that contest Regional Board actions. Together with the Regional Boards, the State Board is authorized to implement the federal Clean Water Act in California. The State Board also is solely responsible for allocating surface water rights. A memorandum of agreement (MOA) with the California Department of Public Health (CDPH) exists to implement CCR Title 22, water recycling criteria, and requirements to protect public health. These criteria detail the permitted uses of recycled water and the treatment required for its reuse.

The Water Recycling Criteria (WRC) are implemented throughout the state through water recycling orders issued by the nine Regional Boards. The nine Regional Boards are semiautonomous and are composed of seven part-time board members appointed by the governor and confirmed by the state senate. Regional boundaries are based on watersheds. Water quality requirements are based on the unique differences in climate, topography, geology, and hydrology for each watershed. Each Regional Board makes critical water quality decisions for its own region, including those involved in setting standards, issuing permits, determining compliance with requirements, and taking appropriate enforcement actions. The water recycling orders are of various types, depending on the type of project, threat, and complexity related to water quality. Regional Boards may issue an individual waste discharge requirements order, master reclamation order, or water recycling requirements order. They may also enroll water recycling projects in the statewide General Order, if found applicable, for proposed recycled water reuse. In addition, each RWQCB has adopted a Water Quality Control Plan (Basin Plan) for its specific region to protect the water quality in that region, although the basin may be subject to additional water quality controls and limitations for water recycling projects within its jurisdiction.

Apart from the various Water Board reviews, the California Department of Water Resources (DWR) also reviews recycled water use. In addition, they update the "California Water Plan" every five years by evaluating the quantity of recycled water being used in the state and planning for future use. The California Recycled Water Task Force (CRWTF) oversees this entire process and published a report in 2003 entitled *Water Recycling 2030* (CRWTF 2003).

a. State Water Resources Control Board

The California SWRCB's 2013 Recycled Water Policy (Policy) has been adopted to enhance and streamline recycled water use in California. The document says, "The purpose of this Policy is to provide direction to the Regional Boards, proponents of recycled water projects, and the public regarding the appropriate criteria to be used by the State Water Board and Regional Water Boards in issuing permits for recycled water projects" (SWRCB 2013). The Policy describes

permitting criteria that are intended to streamline the permitting process for recycled water use, so as to expedite these projects and increase the total amount of reclaimed water in use in California by at least 1,000,000 ac-ft by 2020 and by at least 2,000,000 ac-ft by 2030.

The Policy also details, among other things, appropriate conditions for the use of recycled water in groundwater recharge projects. Initially, it was thought that these types of conditions might be important with regard to EGS projects looking to use recycled water to stimulate their reservoirs. However, further inquiries with relevant stakeholders clearly revealed that EGS reinjection would occur far beneath a groundwater reservoir and thus would not be considered groundwater recharge (Harto et al. 2014). The Policy references the definition for recycled water for groundwater recharge found in the Water Code's Section 13561(c), which states that "the planned use of recycled water" is for "replenishment of a groundwater basin or an aquifer that has been designated as a source of water supply for a public water system." Geothermal reservoirs exist far beneath groundwater reservoirs and are generally hydrologically distinct. As such, they are not covered under this definition.

The Policy further details requirements applicable to recycled water producers for monitoring constituents of emerging concern (CECs) for recycled water. More importantly, the Policy also applies to entities "that further treat or enhance the quality of recycled water supplied by municipal wastewater treatment facilities, as well as groundwater recharge reuse facilities" (SWRCB 2013). CECs regulated in the Policy include birth control hormones, caffeine, triclosan, sucralose, N,N-diethyl-meta-toluamide (DEET), and several others. In the thermoelectric power industry, even though many facilities contract with their local municipal treatment plant to provide water of sufficient quality, it is not uncommon for those facilities to further treat water on site (assuming it is economically viable) if they plan to use recycled water. Although upon initial reading, one might think that EGS projects in California might fall under these regulations, this is not the case in practice. For example, it appears that the level of treatment used at The Geysers (i.e., the addition of hypochlorite to the water to prevent biofouling) is usually done at the recycled water producer's site and not onsite; thus, the CEC monitoring rules do not apply (Harto et al. 2014). It should also be noted that the majority of recycled water used at the Geysers is for injection to maintain reservoir pressure, not for cooling.

Several other earlier resolution and policies from the SWRCB are also worth briefly mentioning. Resolution 7558, the *Water Quality Control Policy on the Use and Disposal of Inland Water for Power Plant Cooling*, from 1975, was the first notable effort by the SWRCB to affirm the importance of recycled waters. It was a direct result of the Waste Water Reuse Law of 1974. The Resolution advises the RWQCBs that when they are considering issuing a permit for power plant cooling, they should consider the reasonableness of the request "in the context of alternative water sources which could be used" (SWRCB 1975). The resolution also encourages the use of alternative waters and wastewater for power plant cooling when appropriate. Two years later, in 1977, the SWRCB issued another resolution, Resolution 771, the *Policy with Respect to Water Reclamation in California*. This later Resolution states that both the State Board and Regional Boards should encourage the reclamation and reuse of water in areas of the state where water is scarce, as long as doing so does not interfere with vested rights and other beneficial uses (SWRCB 1977).

b. Regional Water Quality Control Boards

Although the nine RWQCBs in California function independently, they implement SWRCB policies and issue permits related to the Clean Water Act. The SWRCB is authorized to enact these policies and permits and has delegated authority to the RWQCBs to implement them. In addition to following the SWRCB's *Recycled Water Policy*, the RWQCBs also have the ability to impose further requirements and rules for a water recycling project if they deem it necessary to protect local water resources. These additional requirements are often outlined in the relevant Basin Plans.

Active geothermal areas in California are spread out geographically, but some important RWQCB zones for geothermal development include the North Coast RWQCB (Region 1), which contains part of the EGS site at The Geysers; the Lahontan RWQCB (Region 6), which includes the geothermal areas around Casa Diablo and Coso; and the Colorado River RWQCB (Region 7), which includes geothermal projects around the Salton Sea area. Basin Plans for these areas were analyzed in further detail (Harto et al. 2014). In general, the Basin Plans designate beneficial uses for water bodies and establish water quality objectives, waste discharge prohibitions, and other implementation measures to protect those beneficial uses.

The Regional Boards also typically cite and use Resolution 771; Resolution 7558; CCR Title 22, Division 4, Chapter 3; the Recycled Water Task Force; and other relevant regulations for recycled water use from the SWRCB and CDPH. For example, Order 96011, *General Water Reuse Requirements for Municipal Wastewater and Water Agencies*, was drafted by the San Francisco RWQCB (Region 9) and serves "as a general water reuse order authorizing municipal wastewater reuse by producers, distributors, and users of non-potable recycled water throughout the region." The order applies to producers of secondary and tertiary water under CCR Title 22 and to any distributors that receive water, provide additional treatment to meet CCR Title 22 regulations, and then distribute it to users. This is a general water reuse order

that can be used if a recycled water project meets certain conditions. It is meant to take the place of project-specific permits and to expedite recycled water use in the state of California. However, project-specific permits must still be obtained if a project is sufficiently complex, which EGS projects can be (Harto et al. 2014).

c. California Department of Public Health

The CDPH is charged with protecting public health and drinking water supplies and must therefore develop uniform Water Recycling Criteria (WRC or Criteria) for particular water uses. RWQCBs rely on the CDPH to establish the permit conditions needed to protect public health. Many of these regulations are detailed in *The Purple Book: California Health Laws Related to Recycled Water*, a guide to recycled water use in California published by the Drinking Water Program in the Department of Health Services Division of Drinking Water and Environmental Management (CDHS 2001).

The WRC are administered under the CDPH Drinking Water Program. The criteria are codified in the California Water Code, Sections 13500 through 13583. Section 13550 defines "recycled water" as "water, which as a result of treatment of waste, is suitable for direct beneficial or controlled use that would not otherwise occur and is therefore considered a valuable resource." Section 13500, otherwise known as the Water Recycling Law, gives Regional Boards the authority to issue master reclamation permits and sets forth WRC for specific uses. Master reclamation permits, however, do not cover groundwater replenishment or surface augmentation projects that use recycled water. Instead, individual Waste Discharge Requirement (WDR) Orders are issued for these activities by the relevant Regional Boards.

Specific requirements for wastewater treatment types and levels are specified in Title 22, Division 4, Chapter 3 of the CCR, entitled "Water Recycling Criteria." Article 60306, "Use of Recycled Water for Cooling," states that recycled water used for industrial or commercial cooling that involves a cooling tower, evaporative condenser, or spraying mechanism must be tertiary-treated recycled water. If none of the above, it must be disinfected secondary-treated recycled water.

Wastewater treatment is generally divided into three stages: primary, secondary, and tertiary. Primary treatment is also known as mechanical treatment and includes mechanical processes such as filtering and sedimentation. Secondary treatment involves biological treatment of the waste effluent through activated sludge basins. Tertiary treatment involves disinfection through chlorination or ozonation. In addition, if recycled water is being used for a cooling system with a cooling tower or one that otherwise creates a mist, the facility must use a drift eliminator and chlorine or other biocide to minimize growth of *Legionella* and other micro-organisms. For industrial processes that may come into contact with workers, the water must be tertiary-treated, and for industrial processes that do not come into contact with workers (such as dust control), the water must be secondary-treated. Terms like tertiary and secondary treatment are given specific water quality levels here under Article 60301.

In addition to the WRC, the California Health and Safety Code, Division 104, Part 12, Chapters 4 and 5, deal mainly with site-specific physical safety requirements for recycled water use. Article 2.116800 says that local health officers may maintain programs for the control of cross-connections by water users, within the users' premises, where public exposure to drinking water may occur. Water users must comply with all orders and instructions from the local health official with respect to the installation, testing, and maintenance of backflow prevention devices. Article 2.116805 stipulates that local health officials can also collect fees to maintain programs to protect water. Finally, Article 2.116815 requires all pipes that carry recycled water to be purple so they are readily identifiable as such.

III. Summary and Conclusions

California has several codified definitions for recycled and/or reclaimed water. These definitions are summarized in Table 1. For the most part, the definitions are consistent with each other. One notable difference is the distinction that California makes between recycled and reclaimed water. Reclaimed water is defined in CCR, Title 17, Section 7583, *Drinking Water Supplies*, as "wastewater which as a result of treatment is suitable for uses other than potable." Recycled water is defined in California Water Code Section 13050(n) as "water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use *that would not otherwise occur* and is therefore considered a valuable resource" [emphasis added].

Despite these minor differences in definition, it does not appear that there is a significant definitional barrier to widespread water reuse in California — at least not with regard to the primary terms (Harto et al. 2014). Although California did not specify geothermal energy production as an acceptable reuse, it did not exclude it either (Harto et al. 2014). Thus, the regulatory framework for geothermal projects to use recycled wastewater appears to be in place, although unseen barriers to such use could arise. Regulations on the use of other alternative water sources (e.g., produced water from oil and gas development, saline groundwater, and mine pool water) could not be found for any of the four states; however, as mentioned previously, news stories in local and national newspapers indicate that reuse of treated, produced waters from oil and gas operations does indeed occur in the agricultural sector in California (NYT 2014).

It should also be mentioned that, although there appear to be very few regulatory burdens in this area, geothermal facilities are often operated in remote locations, which may make transmission of recycled water challenging. An in-depth investigation of this issue for the Geysers and Raft River geothermal sites is presented in Harto et al. (2014).

Table 1. California State Laws and Applicable Definitions for Water Reuse.[a]

California Law	Definitions	Regulatory Authority	Permits
California State Water Resources Control Board Resolution 75-58: Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Powerplant Cooling	*Brackish Waters*—Includes all waters with a salinity range of 1,000 to 30,000 mg/L and a chloride concentration range of 250 to 12,000 mg/L. The application of the term "brackish" is not intended to imply that such water is no longer suitable for industrial or agricultural purposes.	California State Water Resources Control Board California Regional Water Quality Control Boards	None
California State Water Resources Control Board Recycled Water Policy	*Recycled Water*—Water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource (California Water Code Section 13050[n]).	California State Water Resources Control Board California Regional Water Quality Control Boards	General permit for irrigation projects using recycled water Permit for groundwater recharge using recycled water (CEC monitoring plan required)
California Regional Water Quality Control Board Basin Plans	*Recycled Water*—Water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource (California Water Code Section 13050[n]).	California Regional Water Quality Control Boards	NPDES permits
California Code of Regulations (CCR) Title 22 Division 4 Chapter 3, "Water Recycling Criteria"	*Coagulated Wastewater*—Oxidized wastewater in which colloidal and finely divided suspended matter have been destabilized and agglomerated upstream from a filter by the addition of floc-forming chemicals. *Filtered Wastewater*—Oxidized wastewater that has either (a) passed through undisturbed soils or a bed of filter media at a rate not to exceed 5 gal/min and that meets turbidity requirements of an average of 2 NTU in 24/h or (b) passed through a micro-, ultra-, nano, or reverse-osmosis treatment membrane such that turbidity does not exceed 0.2 NTU more than 5% of the time in 24 hrs. *Conventional Treatment*—A treatment chain that utilizes a sedimentation unit process between coagulation and filtration and produces an effluent that meets the definition for disinfected tertiary recycled water. *Disinfected Secondary-2.2 Recycled Water*—Water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number of 2.2 per 100 mL. *Disinfected Secondary-23 Recycled Water*—Water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number of 23 per 100 mL. *Disinfected Tertiary Recycled Water*—Water that has been filtered and has been disinfected by either (a) a chlorine disinfection process with a CT (contact time) of not less than 450 mg-min per liter or (b) a disinfection process when combined with filtration that has been shown to inactivate 99.999% of the polio virus. *Recycling Plant*—An arrangement of devices, structures, equipment, processes, and controls that produce recycled water.	California State Water Resources Control Board	None
California Code of Regulations (CCR) Title 17, Section 7583, "Drinking Water Supplies"	*Reclaimed Water*—Wastewater that as a result of treatment is suitable for uses other than potable. *Water Supplier*—The person who owns or operates the public water system. *Water User*—Any person obtaining water from a public water supply.	Not Specified	None
California State Water Code Division 7, Section 13050, "Water Quality Definitions"	*Recycled Water*—Water that, as a result of treatment of waste, is suitable for a direct beneficial use or controlled use that would not otherwise occur, and is therefore a valuable resource. *Mining Waste*—All solid, semisolid, and liquid waste materials from the extraction, beneficiation, and processing of ores and minerals. It includes soil, waste rock, and overburden. *Injection Well*—Any bored, drilled, or driven shaft, dug pit, or hole in the ground into which waste or fluid is discharged and the depth of which is greater than the circumference.	Not Specified	None

[a] Harto et al. (2014)

Although the pathways allowing for geothermal use of reclaimed wastewater appear to have been established in California, these pathways are not always clear. Additional clarification might be needed to explicitly provide for geothermal use of reclaimed wastewater. The reuse of other alternative waters (as identified) might require additional rulemaking or legislative efforts. Laws and regulations that explicitly state the need to reuse alternative water, such as the ones in California, might help open up policies to allow, or even encourage, the use of alternative water for geothermal energy production.

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