Executive Summary: Draft PA No. 16 – Carbon Dioxide Addition for Post Treatment

Description

A carbon dioxide (CO_2) addition project would use CO_2 for post-treatment and corrosion control of the reverse osmosis (RO) permeate at the proposed **scwd²** desalination facility. The CO_2 would be purchased from a facility that recovers and purifies the CO_2 from the waste streams of industrial production facilities that would otherwise be released to the atmosphere, therefore offsetting direct GHG emissions.

Amount of GHG Reduction

The proposed **scwd²** desalination facility would use approximately 250 pounds of CO_2 per million gallons of water treated. Based on projected operation of the desalination plant, a CO_2 addition project is estimated to offset approximately 15 MT CO_2 per year for SCWD and 55 MT CO_2 per year for SqCWD. This project could reduce approximately 10 to 15% of the potential GHG reduction goals for SCWD, and 4 to 5% of the potential GHG reduction goals for SqCWD.

Project Life and Sustainability

A CO_2 addition project would continue to provide GHG reduction for the life of the project and beyond. The project would be sustained by normal maintenance to repair any infrastructure deterioration.

Project Cost

For the estimated life of the project (30 years), the average annual cost would be approximately $52,000 per year, or about $472 per MT CO_2.

Table ES-1: Carbon Dioxide Addition Project Summary

Agency	Project Life	Annualized GHG Reduction (MT CO_2/yr)	Capital Cost ($)	Average Annual Net Cost ($/yr)	Lifecycle GHG Reduction Cost ($/MT)	Space Requirements
SCWD	30+ years (sustainable)	15	$500,000	$52,000	$472	Part of desalination facility footprint
SqCWD		55				

Draft Project Assessment No. 16 – Carbon Dioxide Addition for Post Treatment

Description

This assessment estimates the GHG reduction potential through the use of carbon dioxide (CO_2) for post-treatment and corrosion control of the reverse osmosis (RO) permeate at the proposed **scwd²** desalination facility.

Background

CO_2 has many uses in our society, including corrosion control at potable water treatment plants and carbonation of "soda" beverages. The CO_2 provided for these uses is "food grade" or NSF 60-certified for addition to potable water. In a post-treatment of the desalination process, CO_2 will be added to the RO permeate in combination with calcium carbonate (limestone) to form soluble calcium bicarbonate, which adds hardness and alkalinity to the potable water for distribution system corrosion protection. The chemistry of the water allows CO_2 to be sequestered in soluble form as calcium bicarbonate. Because the pH of the potable water distributed for potable use is in a range at which CO_2 remains in a soluble bicarbonate form (pH of 7.8 to 8.5), the CO_2 introduced in the RO permeate would remain permanently sequestered.

Depending on the supplier, CO_2 is produced one of three ways:

- *CO_2 Recovery:* CO_2 recovery plants produce CO_2 by recovering it from the waste streams of other industrial production facilities which emit CO_2-rich gasses: breweries, commercial alcohol (i.e., ethanol) plants, hydrogen and ammonia plants, refineries, etc. Typically, if these gases are not collected via a CO_2 recovery plant and used in other facilities, such as the desalination plant, they are emitted to the atmosphere and therefore, constitute a GHG release.
- *Atmospheric CO_2 Concentration*: An atmospheric CO_2 concentration plant takes air from the atmosphere and produces compressed and liquefied gases for commercial uses. The natural gases in the atmosphere are separated out to produce nitrogen, oxygen, argon, and others including CO_2.
- *CO_2 Generation:* CO_2 generation plants use various fossil fuels (natural gas, kerosene, diesel oil, etc.) to directly produce CO_2 by fuel combustion.

Vendors

A number of commercial suppliers, including Praxair, Airgas, the Linde Group and Air Liquide, could supply "food grade" NSF 60-certified, bulk liquid CO_2 to the proposed **scwd²** desalination facility. These four vendors would supply CO_2 from CO_2 recovery plants located in Richmond, Benicia, or Martinez, California. Airgas also distributes CO_2 supplied by Dyno Nobel that is collected from the atmosphere in conjunction with the production of other atmospheric gases. However, this product is distributed from farther away in St. Helens, Oregon.

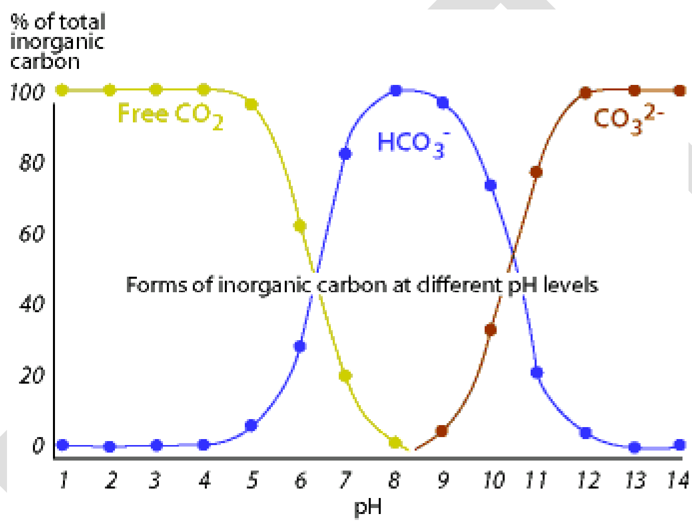
History and Technical Maturity

CO_2 storage, feed, and control equipment have been in use for many years at water treatment plants for this type of application. Typically, bulk CO_2 is supplied and stored in liquid form. The liquid CO_2 would be vaporized into gas and dissolved into the RO permeate water to react with the calcium carbonate which adds hardness (calcium) and alkalinity (HCO_3) into the potable water for distribution system corrosion protection. During the treatment process, the calcium carbonate (calcite – $CaCO_3$) reacts with the CO_2 injected in the water and forms completely soluble calcium bicarbonate [$Ca(HCO_3)_2$] as shown in the following chemical reaction:

$$CaCO_{3\ (solid)} + CO_{2\ (gas)} + H_2O_{\ (liquid)} \rightarrow Ca(HCO_3)_{2\ (liquid\ solution)}$$

At the typical pH range of potable water (pH of 7.8 to 8.5), the CO_2 will remain in the potable water in soluble form (see Figure 1), and the entire amount (100 %) of the injected CO_2 will be completely dissolved.

Figure 1 – Forms of CO_2 at Different pH Levels



Source: Center for Educational Technologies. "The Chemistry of Alkalinity." November 2004. http://www.cotf.edu/ete/modules/waterq3/WQassess3b.html

This chemical reaction and information are taken from texts on the basic chemistry of water. See the American Water Works Association (AWWA) (2007) Manual of Water Supply Practices, M46.

This process also has been thoroughly outlined in the approved Energy Minimization and Greenhouse Gas Reduction Plan for the Carlsbad Desalination Plant (Poseidon Resources):

> Once the desalinated potable water is delivered to individual households, a portion of this water will be ingested directly or with food, and a portion of the water will be used for other purposes, such as human consumption, personal hygiene, or irrigation. The calcium bicarbonate ingested by humans will be dissociated into calcium and bicarbonate ions. The bicarbonate ions will be removed by the human body through the urine (Washington University). Since the CO_2 is sequestered into the bicarbonate ion, human consumption of the desalinated water will not result in release of CO_2. The bicarbonate in the urine will be conveyed along with the other sanitary sewerage to the wastewater treatment plant. Since the bicarbonate is dissolved, it will not be significantly impacted by the wastewater treatment process and ultimately will be discharged to the ocean with the wastewater treatment plant effluent. The ocean water pH is in a range of 7.8 to 8.3, which would be adequate to maintain the originally sequestered CO_2 in a soluble form, as shown in Figure 1.
>
> Other household uses of potable water, such as personal hygiene, do not involve change in

potable water pH, as demonstrated by the fact that pH of domestic wastewater does not differ significantly from that of the potable water.

A significant amount of the calcium bicarbonate in the potable water used for irrigation would be absorbed and sequestered in plant roots. The remaining portion of calcium bicarbonate would be adsorbed in the soils and/or would enter the underlying groundwater aquifer. (Stolwijk et al)

Reliability and Operational Complexity

The operational complexity of a CO_2 system would be low to moderate. Operation of the CO_2 storage and feed system equipment would be mostly automated. O&M activities would include receiving chemical deliveries and performing routine maintenance activities and would be similar to other chemical systems used at water treatment plants.

Sustainability

RO permeate post-treatment would occur for the life of the proposed **scwd^2** desalination facility, which is assumed to be 30 years, so GHG reduction from a CO_2 addition project also would occur for that time period. The project would be sustainable and continue for a longer period of time through routine maintenance and sustained operation of the desalination facility.

Every delivery of CO_2 to the proposed desalination facility would be accompanied by a certificate that states the quantity, quality, and origin of the CO_2. It will also indicate that the CO_2 was recovered as a site product from an industrial application of known type of production and was purified to meet the requirements associated with its use in potable water applications (NSF-60 approved). The desalination facility would archive the certificates for verification purposes. **scwd^2** would place conditions in its purchase agreements with CO_2 vendors that require transfer of CO_2 credits to **scwd^2** and otherwise ensure that the CO_2 is not accounted for through any other carbon reduction program so as to avoid “double counting” of associated carbon credits.

Local Considerations

Economy

Since the CO_2 for post-treatment and corrosion control likely would come from suppliers in the San Francisco Bay Area, the program may benefit local vendors who provide water treatment chemicals and supplies.

Environment

Air: GHG emissions would be reduced by the CO_2 recovery process in the local San Francisco Bay Area direct GHG emissions.

Land: Since the equipment would be located at the proposed **scwd^2** desalination facility, there would be no significant additional land impact.

Water: There is no impact on water quality.

Noise: Since the equipment would be located at the proposed **scwd^2** desalination facility, there would be no significant additional noise impact.

Aesthetic/Visual: Since the equipment would be located at the proposed **scwd²** desalination facility, there would be no additional aesthetic or visual impact.

Waste By-Products: This process would not create waste by-products. The CO_2 recovery process would reduce the waste stream of industrial processing facilities.

GHG Project Eligibility Criteria Compliance

This section describes the six eligibility criteria that a CO_2 addition project must meet in order to be considered a regulatory compliance GHG offset project.

Additional: This program would be additional because it would not occur without the proposed **scwd²** desalination facility.

Quantifiable: The amount of CO_2 injected into the RO permeate would be known and quantifiable.

Verifiable: With adequate recordkeeping, GHG reductions realized through a CO_2 addition project could be readily verified by a third-party.

Enforceable: To make the project enforceable, **scwd²** would place conditions in its purchase agreements with CO_2 vendors that require transfer of CO_2 credits to **scwd²** and otherwise ensure that the CO_2 is not accounted for through any other carbon reduction program.

Real: The CO_2 would be purchased from a facility that recovers and purifies the CO_2 from the waste streams of industrial production facilities that would otherwise be released to the atmosphere, therefore offsetting real GHG emissions.

Permanent: There is no risk of reversibility, since the pH of the potable water distributed for potable use is in a range at which CO_2 remains in a soluble bicarbonate form (pH of 7.8 to 8.5), so the CO_2 introduced in the RO permeate would remain permanently sequestered. The permanence is further described above in the History and Technical Maturity section.

GHG Reductions

The use of CO_2 for post-treatment and corrosion control would reduce GHG emissions by creating an additional demand for CO_2 that would otherwise be released into the atmosphere. The **scwd²** desalination facility would use approximately 400 pounds per day (ppd) of CO_2 when operating at an average flow of 1.6 mgd, which equals 250 pounds of CO_2 per million gallons of water treated. The amount of GHG emissions from the delivery of CO_2 to the **scwd²** desalination facility would be minimal and is included in this estimate.

Table 1 shows the estimated annualized GHG reduction based on the projected annualized operation of the desalination plant.

Table 1: Estimated GHG Reduction for CO_2 Addition Project

Agency	Projected Annualized Operation (MGY)[1]	Annualized GHG Reduction (MT CO_2/yr)
SCWD	131	15
SqCWD	485	55

[1]Assuming a 7 year drought cycle with 5 non-drought and 2 drought years. Annualized over life of project, based on projected operation of the desalination plant from the Energy Projections and Potential Greenhouse Gas Reduction Goals report, July 2011.

This project could reduce approximately 10 to 15% of the potential GHG reduction goals for SCWD, and 4 to 5% of the potential GHG reduction goals for SqCWD.

Cost

Capital Cost: The CO_2 system is estimated to cost approximately $500,000 and would include a storage tank, vaporizer, injector, diffuser, and instrumentation, as well as sitework, a concrete slab, piping, and electrical installations.

Operations Cost: Local distributors of CO_2 provided budgetary quotes for delivered CO_2 ranging between $110 and $240 per ton. Additional delivery charges are expected to cost approximately $60 per delivery. Based on an average use of 400 ppd and a delivery every other month, the annual cost of the delivered chemical would be approximately $12,000 per year. The energy use and labor cost is already included in the overall desalination facility cost.

Table 2 below summarizes the cost for a CO_2 addition program. The average annual net cost is the annual operating costs plus the debt service on the capital cost over the life of the project.

Table 2: Estimated Costs for CO_2 Addition Program

Project Life (yrs)	Capital Cost ($)	Average Annual Net Cost ($/yr)	Lifecycle GHG Reduction Cost ($/MT CO_2)
30	$500,000	$52,000	$472

Summary of Advantages and Disadvantages

Advantages:

- CO_2 system is part of the desalination facility.
- GHG reduction by creating demand for recovered CO_2 that would otherwise be released into the atmosphere.

Disadvantages:

- None

References

American Water Works Association (AWWA) (2007) Manual of Water Supply Practices, M46.

Center for Educational Technologies. "The Chemistry of Alkalinity." November 2004. http://www.cotf.edu/ete/modules/waterq3/WQassess3b.html

Kennedy/Jenks Consultants. Energy Projections and Potential Greenhouse Gas Reduction Goal. July 2011.

Poseidon Resources. Carlsbad Desalination Plant Energy Minimization and Greenhouse Gas Reduction Plan. July 2008.

Stolwijk, J.A.J. and Kenneth V. Thimann. "On the Uptake of Carbon Dioxide and Bicarbonate by Roots, and Its Influence on Growth." February 1957. http://www.pubmedcentral.nih.gov/pagerender.fcgi?artid=540973&pageindex=1.

Washington University in St. Louis. "The Carbonic-Acid-Bicarbonate Buffer in the Blood." 2004. http://www.chemistry.wustl.edu/~courses/genchem/Tutorials/Buffers/carbonic.htm.