Industrial Wastewater Recycling Case Study Phase 1: Technologies, Costs, Benefits, and Barriers

A Study Conducted by:

California Sustainability Alliance

A Navigant Consulting Program,
Sponsored by Southern California Gas Company,
Funded by California utility customers under the auspices of the California Public Utilities Commission

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Southern California Gas Company®

December 2014

The California Sustainability Alliance (the Alliance) is an innovative market transformation program funded by California utility customers under the auspices of the California Public Utilities Commission. The Alliance leverages action on environmental initiatives such as climate, smart land use and growth, renewable energy, waste management, water use efficiency and transportation planning to help the State of California achieve its aggressive energy efficiency goals more effectively and economically. In partnership with public and private organizations throughout California, the Alliance precipitates widespread market transformation by tackling major barriers to sustainability.

For information about the California Sustainability Alliance, go to:

www.sustainca.org

The project team gives special thanks to the following vendors whose input and assistance were critical to the development of this report:

- Avantech, Inc.
- Blue Spring Corporation
- Hydro-Flo Products, Inc.
- Kemco Systems, Inc.
- New Logic Research, Inc.
- Purifics Es Inc.

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We would like to thank Southern California Gas and especially Carlo Gavina for providing overall strategic direction and review of this report. We would also like to thank the equipment vendors who provided input to the research phase of the project.

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GLOSSARY

Effluent – Wastewater or other liquid, partially or completely treated or in its natural state, flowing from a treatment plant.

Primary treatment – A method for removing solids from sewage by mechanical processes or the addition of chemicals.

Recycled water – Municipal, industrial, or agricultural wastewater which, as a result of treatment, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.

Reverse osmosis – A method for removing certain dissolved substances from water, such as salt, by applying pressure sufficient to reverse the natural movement of water through a semi-permeable membrane into a concentrated solution (i.e. osmosis).

Secondary treatment – Biological treatment to remove dissolved organic matter.

Tertiary treatment – Wastewater treatment that includes the processes defined by primary and secondary treatment, plus an additional treatment phase, which may involve removal of additional nutrients and suspended organic matter, and/or additional disinfection.

ABBREVIATIONS AND ACRONYMS

BOD – Biochemical oxygen demand
DAF – Dissolved air flotation
EPA – U.S. Environmental Protection Agency
FOG – Fats, oils, and grease
GPM – Gallons per minute (of flow)
MBR – Membrane bioreactor
NPDES – National
psi – pounds per square inch (of pressure)
RO – Reverse osmosis
SCG – Southern California Gas Company

EXECUTIVE SUMMARY

Background

The California Sustainability Alliance ("Alliance") published a policy brief in December 2013 that, among other policy goals, highlighted the need to promote on-site recycled water at industrial facilities. Subsequently, the Alliance commissioned a case study to assess the water, energy, and environmental benefits of on-site recycled water at an industrial site. Navigant Consulting, Inc. ("Navigant") is conducting the study in two phases. The first phase involved research on recycling technologies currently available in the market and presents findings from interviewing vendors of water recycling equipment. The second phase will consist of a case study estimating the costs and benefits of installing a wastewater recycling system at a specific industrial site. This report addresses the first phase of the study.

Technology Focus

For the case study, we are tentatively focusing on food processing applications due to the potential for gas savings from hot water recycling and avoided disposal costs. Depending on the specific contaminants at the case study site, we will choose the appropriate treatment level—primary, secondary, and/or tertiary—for the system. The system may also include a disinfection step to kill pathogens.

Significant Findings and Recommendations

Interviews with six wastewater treatment equipment vendors yielded important information that will help inform the case study portion of the project (Phase 2), as well as future projects. Key findings include:

Technology Limitations: Vendor interviews revealed that certain types of treatment equipment are limited in the maximum temperature that they can handle, and not all vendors offer systems that can be used with hot water.

Cost/Benefit Considerations: The site-specific cost/benefit analysis will need to consider:

- Costs: First costs, installation costs, maintenance personnel costs, any chemical or other material costs, and replacement costs for relevant components.
- Benefits: Water savings, gas savings, and sewage or waste disposal savings. If relevant to the site, we will consider any avoided regulatory costs.

Vendors also identified informational and economic barriers to implementation. We developed initial recommendations for overcoming these barriers:

Informational Barriers: Vendors suggested that some customers do not investigate wastewater recycling systems because they are unfamiliar with the technology. Showcasing the use of the technology in case studies such as this one will help educate customers on wastewater recycling in general and overcome basic informational barriers.

Economic Barriers: Some vendors said that the main economic barrier is a barrier of perception: customers perceive wastewater recycling systems to be expensive without considering all of the potential long-term cost savings. It may be helpful to develop a simple decision tool that other industrial facilities can use to estimate their own life-cycle cost savings to address the perception that wastewater systems are too costly. Utility incentives can also help address this barrier.

The Alliance recommends Phase 2 continues. Phase 2 would produce a real world case study than can be used to educate other customers breaking down the information barrier and customers' perceived economic barriers.

Organization of the Report

The report is organized in the following sections:

- Section 1 is an introductory section that presents the purpose and methodology of the case study and this report and provides an overview of the technology.
- Section 2 discusses interview findings in detail.
- Section 3 identifies important findings and recommendations from this phase of the case study.

SECTION 1: INTRODUCTION

Purpose of the Study

In May 2008, the California Sustainability Alliance ("Alliance") published a report on the benefits of recycling water in Southern California, which include substantial energy savings and greenhouse gas reductions.[1] In 2012 the Alliance further investigated on-site water recycling for commercial building applications.[2] A subsequent *On-Site Water Generation Policy Brief*, published by the Alliance in December 2013, described policy approaches to promote on-site water recycling, one of which involved conducting further projects to assess the associated water, energy, and environmental benefits of on-site recycled water.[3]

This report and planned case study address the policy goal by presenting a cost-benefit analysis of installing water recycling at an industrial facility. Although the policy brief primarily focused on municipal wastewater recycling in commercial building applications, water recycling at industrial facilities can bring a number of unique benefits to customers and utilities. Industrial facilities often face stringent disposal permit requirements, particularly if they discharge their water directly to a water body instead of a sanitary sewer, and recycling the water can reduce or avoid the cost of these permits. Recycling hot water in industrial processes can also result in natural gas savings. Yet, water recycling is an underutilized technology, primarily due to high initial costs. The purpose of the case study is to encourage other decision-makers at industrial facilities to consider this technology by presenting a cost-benefit analysis that takes both water and energy savings into consideration.

Technology Background and Previous Studies

Wastewater treatment technologies can be characterized by the type and level of treatment that they perform.[4]

- Primary treatment removes solids from sewage. It usually involves mechanical processes such as screening and settling, but may involve the addition of chemicals or dissolved air to coagulate and float fats, oils, and grease to the surface.

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[1] http://sustainca.org/sites/default/files/publications/FINAL%20RECYCLED%20WATER%20MAY%202%202008a.pdf

[2] http://sustainca.org/sites/default/files/On-Site_Water_Generation-Final_Report.pdf

[3] http://sustainca.org/sites/default/files/On-Site_Water_Generation_Policy_Brief.pdf

[4] http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/wastewater-treatment

- Secondary treatment uses microbes to remove biological substances from wastewater. This level of treatment also uses settling tanks or ponds to remove any remaining solids.
- Tertiary treatment is a higher level of treatment that removes almost all substances from the water. Tertiary treatment can include reverse osmosis (RO), which can be used to remove substances dissolved in the water, such as salt.
- After treatment, water can be disinfected using chemicals or ultraviolet light to kill pathogens.

We are currently focusing on food processing applications due to the potential for savings from hot water recycling and avoided disposal costs. Food processing applications tend to produce a number of specific water contaminants:[5]

- Fats, oils, and grease (FOG)
- Organic matter
- Dissolved minerals (e.g., salt)
- Other dissolved chemicals (e.g., ammonia)
- Bacteria or pathogens

Organic matter is the primary concern in wastewater from food processing operations because it contributes to biochemical oxygen demand (BOD). The more organic material that is dissolved in water, the more oxygen microbes need to successfully remove the biological substances. The combination of these contaminants will determine the level of treatment required. Figure 1 shows the type(s) of treatment used to remove each type of contaminant.

[5] http://www.ciprocess.co.uk/pdfs/article-wastewater.pdf

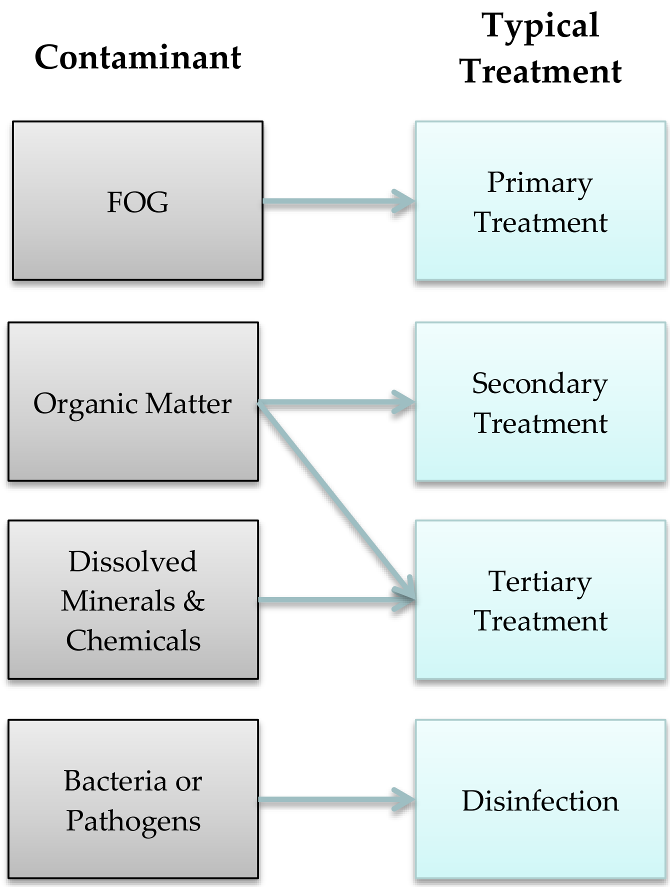

Figure 1: Treatment Types Used to Remove Contaminants

As part of our background research, we reviewed previous wastewater recycling case studies conducted at food processing plants in California. Table 1 summarizes the types of contaminants produced by each plant, as well as the wastewater recycling method used in the recycling process. Some of the plants had completely closed-loop systems (where the water was re-used in the same process indefinitely), while for others, the water was used for other purposes such as cleaning or as makeup water for boilers and cooling towers.

Table 1: Previous Food Processing Case Studies

Name of Facility	Product	Contaminants in Water	Description of Wastewater Recycling Equipment	Water End Use
Hilmar Cheese Co.[6]	Cheese	• Lactose • Soluble protein • Salts (ash)	• Holding tank • pH balancing • Dissolved air flotation (DAF) • Anaerobic digestion • 3 Sequential batch aerobic reactors • Second DAF step • 2 RO membrane systems	Irrigation and boilers
Stone Brewery[7]	Brewery	• Sugars • Proteins • Carbohydrates • Yeast	• Membrane bioreactor (MBR) • 5-micron cartridge filters • RO	Boilers, cooling towers, and washing
Tri Valley Grower[8]	Olives	• Salinity • BOD • Suspended solids • Other salt-laden materials	• Mobile Test & Demonstration Unit: modular equipment with the following steps: • Brineless grader (to reduce salt) • 50-75 micron screen • Holding tank • Ultrafiltration • RO • Evaporator (to concentrate solids) • Charcoal filter	Closed loop re-use
Bell-Carter[9]	Olives	• Not specified	• Chemical Treatment	Not specified
Dr. Pepper Snapple Group[10]	Soft Drinks	• Not specified	• Media and carbon filtration • Nanofiltration • RO • UV disinfection	Beverage manufacturing

[6] Clark, J. Peter. "Minimizing and Reusing Wastewater." Food Technology, February 2011 Issue, pp. 81-85.
[7] http://www.membranes.com/docs/papers/New%20Folder/AMTA%202012%20Paper-%20Naomi%20Jones%20FINAL.pdf
[8] Fok, Stephen and Moore, Bob. "Zero-Discharge: An Application of Process Water Recovery Technology in the Food Processing Industry." ACEEE 1999 Summer Study on Energy Efficiency in Industry Proceedings, Volume 1, pp. 595-603.
[9] Hann, Beverly J. "Internal Recycling at Olive Packing Plant Helps Mitigate Financial and Environmental Risk." Industrial Water Reuse Specialty Conference, December 9, 2013.
[10] http://sustainablemfr.com/water/water-reuse-recycling-conservation-manufacturing

We also researched state and federal regulations that limit contaminated effluent discharges from industrial facilities. Industrial facilities that discharge wastewater to surface waters within the state of California must obtain a permit from the appropriate Regional Water Quality Control Board and pay a fee according to the type of wastewater being discharged.[11,12] By recycling the water, so that there is no wastewater discharge, facilities can avoid the cost of permits altogether. Industrial facilities that discharge wastewater to sewer systems must meet certain requirements for pre-treatment.[13] For example, food processing plants are limited in the BOD level of the water they discharge to a sanitary sewer (for a specific example relating to dairy manufacturing, see Title 40 of the U.S. Code of Federal regulations, part 405[14]). These facilities also incur the sewer company's utility rate.

Methodology

This project is being conducted in two phases. Phase 1 involved research on industrial water recycling technologies currently available in the market and data were gathered by interviewing vendors of water recycling equipment. Phase 2 will consist of a case study estimating the costs and benefits of installing a wastewater recycling system at a specific industrial site. This report presents the interview findings from Phase 1 of the project.

[11] http://www.waterboards.ca.gov/water_issues/programs/npdes/
[12] http://www.waterboards.ca.gov/resources/fees/
[13] http://www.waterboards.ca.gov/water_issues/programs/npdes/pretreat.shtml
[14] http://www.law.cornell.edu/cfr/text/40/part-405

SECTION 2: INTERVIEW FINDINGS

This section discusses the findings from interviews with six vendors of wastewater treatment equipment. The interviews covered the following topics:

- Technology offerings and capabilities
- Cost and benefit considerations, including regulatory requirements driving technology design
- Barriers to implementation

Technology Offerings and Capabilities

The vendors we interviewed offer a range of wastewater treatment equipment addressing one or more of the treatment steps described in Section 1. The types of equipment included:

- Mixing and aerating equipment
- Filters to screen particles of various sizes
- RO membranes
- Chemical delivery systems (e.g., coagulants and flocculants)

Systems vary in modularity - while some are built up of standardized subsystems, others are custom-designed to fit each customer's needs. In modular systems, each treatment module is designed to handle a certain throughput of wastewater and enlarging a system only requires adding modules. The modules are often joined together with standard parts available from component manufacturers. Conversely, one of the vendors we spoke with offers completely custom-built systems, and manufactures all of their own parts. Any of these systems may incorporate a storage tank to handle intermittent flows. Both modular and custom-designed systems enable the vendor and customer to design a complete system that will meet the specific treatment needs of the facility's process.

The case study will focus on systems that can re-use hot water to achieve gas savings in addition to water and sewer cost savings. For systems that incorporate filtration, the maximum operating temperature depends on the filtration medium. One vendor claimed that their ceramic ultra-filtration membrane can operate at three times the boiling point of water and under pressure; their standard offering is suitable for 150 psi and 150 °C (302 °F). Another said that Teflon media membranes can operate up to 110 °C (230 °F). Reverse osmosis membranes seemed to be most constrained with respect to temperature. Two vendors mentioned that standard RO membranes can only operate up to about 45-55 °C (110-130 °F), while one vendor noted that another manufacturer has developed a "high-temperature" RO membrane that can operate at temperatures up to 70 °C (158 °F).

Given our focus on food processing applications, the system is likely to require a minimum of tertiary treatment (see Figure 1) which may need to incorporate RO. Thus, the system design for the case study will need to balance the goal of achieving gas savings by retaining heat in the water with the water quality needs of the customer.

Cost and Benefit Considerations

Vendors generally believed that the benefits of installing an industrial wastewater recycling system tend to outweigh the costs when considered over time. The three factors to consider when evaluating the cost-effectiveness of a system are its costs, the savings it achieves, and the system lifetime.

Costs

Costs to account for include initial equipment cost, installation and commissioning costs, and operating costs. Equipment costs are highly variable, depending on the method required to treat the water (see Section 1), as well as the volume of water that the system needs to handle. One vendor noted that their system costs range from $50,000 to $10 million, with an average cost of $2.5 million. Previous Alliance research estimated that a 50 gallon per minute (GPM) system incorporating RO would cost approximately $6,000-$8,000 per GPM or $300,000-$400,000 in total.

Installation and maintenance costs also vary. Two vendors said that they provide installation and commissioning, but they charge the customer for the time and travel expenses of the technicians. This may also include training the customer to operate and maintain the system. Another vendor, however, said that for their systems, most customers find a local contractor to do their startup.

Operation and maintenance expenses consist of the time incurred by maintenance staff and materials needed to maintain the system. Customers' own technicians are almost always able to perform the system maintenance; one vendor even provides a system with automatic cleaning to minimize operator involvement. For many types of systems, customers must also purchase chemicals to clean the membranes on a regular basis. Other minor ongoing costs include the cost of electricity and other utilities to run the system and the cost of the floor space that the system occupies (which vendors said could be as little as four square feet per module for modular systems).

Savings

By recycling hot water, an industrial facility can save on water and gas costs. However, vendors noted that an even more significant factor was saving the cost of water disposal and compliance with effluent discharge regulations. Vendors noted that the regulations that apply to effluent water quality are getting tighter at the local level. Companies must apply for U.S. Environmental Protection Agency (EPA) permits to discharge water into the environment. If a closed-loop system is installed, and there is no effluent water leaving the facility, customers can avoid the discharge regulations altogether. One vendor noted that due to the high cost of the permits needed for EPA compliance, particularly for large companies, a closed-loop system can pay for itself in as little as two years. Another speculated that the cost of regulations was almost entirely responsible for customers installing water-recycling systems.

Disposal requirements also depend on the substances in the water. A vendor mentioned the case of a facility that produced salt water and could not drain it to the municipal sewer. The facility incurred high expenses by hauling the water away in trucks. They were able to install a water recycling system to produce highly concentrated brine, and the savings on the hauling costs resulted in a three-month payback.

Lifetime

The cost-effectiveness of the system should be gauged in terms of its overall lifetime. The costs of replacing parts must also be considered. Customers must replace certain parts (motors, membranes, pumps, etc.) at various points in the life of the system. Vendors consistently reported that most RO membranes last two to five years. One vendor said that some electrical parts must be replaced yearly, motors typically need to be replaced every seven years, and pumps may need to be replaced every two years. Besides the replacement costs, the system overall can last 15-20 years in municipal and other "standard" applications (i.e., applications with noncorrosive water, such as food processing). Another vendor said the design life of their system is 30 years.

Barriers to Implementation

Vendors described both economic and technical barriers to implementation. The primary barrier to implementation that vendors mentioned was the system cost, although vendors disagreed whether this was an actual or perceived barrier. One noted that customers are operating under the assumption that closed-loop systems are expensive, but are concerned about saving money and would be on board once the cost efficiency of a wastewater recycling system was demonstrated. This vendor suggested that a standard costing model demonstrating the life-cycle cost savings of a system would help convince more customers to implement such systems. Another suggested that the primary barrier was availability of up-front capital, and that agencies like water districts could introduce copayment or rebate systems to help with this.

In terms of technical barriers, vendors mentioned that there is a general lack of information about wastewater treatment technologies among their customers. One vendor found that their customers do not pursue the possibility of implementing a wastewater treatment system because it is not the main part of their business and they are not familiar with the more complicated systems that involve RO and chemicals. The vendor said that because their customers are already familiar with the EPA permit process, they tend to reapply for permits rather than pay to install a system with which they and their maintenance staff are unfamiliar. Another vendor mentioned that for most customers, it takes a precipitating factor to push them to consider adding wastewater recycling to their facility. More stringent regulatory requirements that increase the cost or the effort of continuing to conduct business as usual often drive customers to seek alternative approaches to handling wastewater.

SECTION 3: KEY FINDINGS AND RECOMMENDATIONS

Conversations with vendors yielded important information that will help inform the case study portion of the project (Phase 2). Key findings and recommendations include:

Technology Limitations: One aspect of the case study will be to assess the gas savings that can be achieved by recycling hot water. However, vendor interviews revealed that certain types of treatment equipment are limited in the maximum temperature that they can handle, and not all vendors offer systems that can be used with hot water. The system design for the case study will need to balance the goal of achieving gas savings with the water quality needs of the customer.

Cost/Benefit Considerations: The site-specific cost/benefit analysis will need to consider:

- Costs: First costs, installation costs, maintenance personnel costs, any chemical or other material costs, and replacement costs for relevant components
- Benefits: Water savings, gas savings, and sewage or waste disposal savings. If relevant to the site, we will consider any avoided regulatory costs.

We also developed initial recommendations to overcome some of the informational and economic barriers to implementation that the vendors identified.

Informational Barriers: Vendors suggested that some customers do not investigate wastewater recycling systems because they are unfamiliar with the technology. Showcasing the use of the technology in case studies such as this one will help educate customers on wastewater recycling in general and overcome basic informational barriers.

Economic Barriers: Some vendors said that the main economic barrier is a barrier of perception: customers perceive wastewater recycling systems to be expensive without considering all of the potential long-term cost savings. Although this case study will address the life-cycle cost savings of implementing a wastewater treatment system at an example site, it may be helpful to develop a simple decision tool that other industrial facilities can use to estimate their own life-cycle cost savings to address the perception that wastewater systems are too costly. In cases where up-front costs are prohibitive due to a lack of capital, we would recommend that water districts and energy utilities come together to offer incentives for the water and energy savings. Incentives could be in the form of equipment rebates to address initial capital costs, or some alternative form of financial assistance.

The Alliance recommends Phase 2 continues. Phase 2 would produce a real world case study than can be used to educate other customers breaking down the information barrier and customers' perceived economic barriers.

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APPENDIX A: INTERVIEW QUESTIONS AND RESPONSES

Technology	
Vendor	**What types of systems do you offer?**
1.	Closed loop systems with ceramic membrane process and UV oxidation.
2.	Depends on the industry and intended use of recycled water. We can make systems that produce drinking-quality water.
3.	All of our technologies deal with settling of sludge or floating of oil and grease. Chemical treatment we manufacture helps materials float or settle.
4.	Our system is made up of components on a skid: Pre-treatment + RO (patented system). May also include clarification, volume reduction of impurities, an extra RO pass to get TDS of 40 PPM, and/or deionization to get to 2 ppm.
5.	Offer everything from 10 micron filters to RO.
6.	Clarifiers, filtration, ion exchange, and membranes – ultrafiltration and RO
Vendor	**How are systems constructed?**
1.	Modular - Single piece of equipment from source to discharge. Size of a desk.
2.	Modular by subsystem and size
3.	Industry-specific solutions. Space restrictions define the system
4.	Some sizes pre-assembled (50 GPM)
5.	Modular. Throughput depends on membrane size and water quality. Modules are 4 ft2 on the floor and 17 feet tall.
6.	Custom built to the application
Customers	
Vendor	**What are the most typical industries or processes that you develop systems for?**
1.	All over the board: nuclear, explosives, high purity water, solvent recovery, drinking water, cholera, DOE, bacteria, hexavalent chromium. Don't handle salt removal
2.	Food, removing chemicals for customers wanting to go beyond compliance
3.	Manufacturing facilities, tap-quality water. For dairy, we have supplied components, not exactly a whole system
4.	Electroplating
5.	We don't deal with easy applications.
6.	Industrial (Petrochemical, automotive, semiconductors, utilities, Nuclear waste from contaminated sites.) Don't do evaporators or crystallizers.

Vendor	Do you produce systems with 50+ GPM throughput?
1.	Yes – 50 GPM is smallest platform
2.	Yes
3.	Yes
4.	Yes, by component – 50 GPM comes preassembled; 500 GPM does not
5.	Yes, depends on the application
6.	No

Vendor	Do you handle heated water and up to what temperature?
1.	Yes. Can operate at 3x the boiling point. Can operate under pressure. Standard offering is 150 C (302 F) and 150 psi. Already do condensate/boiler feedwater. No heat losses - can provide the system insulated.
2.	Somebody else built a high-temp RO membrane that goes up to 70 C (158 F) – highest temp known for RO (previously, 45 C (113 F) was highest temp).
3.	*No response.*
4.	*No response.*
5.	The heat retention is a function of the membrane tolerance. RO membrane – limited to 55 C (131 F). You can recover heat up to that. As media get more open, temperature tolerances go up. Systems can go up to 110 C (230 F) but then you are using a Teflon media membrane.
6.	Not sure, previous projects only up to ~44 C (110 F).

Vendor	What is your warranty? What's the estimated design life of the system?
1.	*No response.*
2.	Ceramics last forever. RO has a 3-5 year life
3.	Design life is 30 years
4.	System lasts 4 years in electro-plating where the water is corrosive 15-20 years for municipal applications Replacement maintenance, on schedule o Yearly – some electrical parts o Every 7 years – motors o 2-4 years – RO membranes o 2 years - pumps
5.	1 year mechanical warranty RO membranes last 2-3 years, everything else has a 20 year life
6.	It's site-specific.

Cost/benefit considerations	
Vendor	**Roughly how much is the upfront (installed) cost of your system?**
1.	*No response.*
2.	*No response.*
3.	*No response.*
4.	At least $350,000 for a 50GPM system
5.	Installed cost is expensive. Our technology is overkill for some applications
6.	Average is $2.5 million. Ranges from $50k to $10 million depending on application. In ion exchange for heavy metals, media is priced per cubic foot
Vendor	**How much are installation and maintenance costs? Do you provide these services?**
1.	*No response.*
2.	Not including RO, this is 75% of total costs in very general terms
3.	Most people tend to maintain this stuff on their own. They hire an engineering company that will help them develop the entire system. Other costs include: - Manpower required to operate the equipment. - Cost of chemicals required for process - Cost of electricity and other utilities - Cost of the building and floor space that it takes up
4.	We provide a commissioning service: (charged daily wages and airfare, etc. - $2,000 – 3,000) customer gets trained (3 days), includes start up and operating and performance qualification to ensure the effluent meets customer's standard.
5.	We provide startup as part of system purchase and charge for costs incurred by startup technicians. Maint costs: - Personnel cost – visual and auditory checks (system cleaning is automatic) - Membrane cleaners and chelating agents
6.	95% of customers find a local contractor to do their startup

Regulatory requirements	
Vendor	**What regulatory requirements do you need to abide by for treatment and discharge (not recycling)?**
1.	Regulatory body is only involved if there is discharge [to the environment].
2.	*No response.*
3.	Regulations are getting tighter on companies that regulatory agencies feel can afford the surcharges – it's a money generator. Regulations affect: - Oil and grease discharges (affects meat processing industry) - pH Heavy metals disposal in areas w/ heavy industry like plating. Any kind of plating cannot operate without qualified water treatment.
4.	EPA permits
5.	Used to be BOD, COD, suspended solids, chrome 6. More difficult to deal with are TDS and tiny metals like selenium, which are on the horizon for regulation. Limits for selenium are so low. Arsenic is being talked about. Chrome 6 is coming back.
6.	The government is forcing them to discharge less or use less.
Vendor	**Is standard practice driven by regulations or customer needs?**
1.	Customer-specific. If it is a closed-loop system, the regulator is out of it, and treatment requirements are driven by internal needs.
2.	POTWs (like EBMUD) regulate industry – they're usually consistent from one to the next
3.	The driving factor is cost.
4.	compliance
5.	Mostly regulation-driven. One system installed two years ago was driven by corporate sustainability and savings from [wastewater] hauling.
6.	Regulation is almost 100% of the reason people do this.

Vendor	Do regulations influence the cost/benefit considerations of treating and discharging vs. recycling water?
1.	Customers install water recycling systems to save money. Example system reduced cost of surface water discharge by 75%. Not affected by re-use stigma; on the industrial side, it's all about saving money, and if you can get an environmental benefit at the same time, it's a bonus.
2.	*No response.*
3.	If it costs the customer less to discharge water and pay the surcharge, they will do it. If they can save a penny by installing our system, they'll do it. Financing of projects isn't an issue.
4.	With the cost of EPA permits, the cost of non-compliance can be $5,000 per day for large companies; The system pays for itself in 2-10 years.
5.	Regulations vary over time. Salt is an issue. Instead of draining salt water to municipal wastewater (tough to deal with) one example site was able to produce highly concentrated brine, which they were able to haul away. 3 month payback on 7 million (dollars?) from not having to haul dilute water.
6.	Government uses fines or the possibility of shutting down the facility if they can't comply.

Barriers to Implementation

Vendor	What barriers to implementation do you see?
1.	Paradigm that closed-loop has to be expensive. Once you demonstrate cost efficiency, customers are on board. Suggested that there could be a standard costing model for LCC that people could follow, as a common basis for economic assessment.
2.	Availability of capital. Suggested that agencies like water districts could put on board copayment systems or rebates.
3.	*No response.*
4.	They don't want to apply new technology. Technical ignorance and lack of information.
5.	No barriers – financial benefit means there's no reason you wouldn't want one. But most customers need to have a need, and a regulatory agency to make you do it is most typical.
6.	Cost. Has not seen customers go beyond regulation.