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ADC spreads the word

How do you prove SWRO is more affordable? Form a collaboration, and use it to operate – and publicise – a pilot project with low energy requirements, says John MacHarg.

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Introducing the ADC

The **Affordable Desalination Collaboration (ADC)** was formed in 2004 as a USA, California-based non-profit cooperation. This group of interested parties – made up of government agencies, municipal water providers and leading desalination equipment suppliers – aimed to fund and execute the first part of what is hoped will be a multiple-phase *Affordable Desalination Demonstration Project – ADC 1*.

The ADC has several objectives. The first is to demonstrate 'affordable desalination' using proven advancements and designs; this objective has an important caveat, however – all the equipment and designs must be commercially proven to ensure that the results can be repeated and scaled up at other sites.

The second is perhaps the most important, and that is to communicate the results to the appropriate decision makers and stakeholders. Engineers and technical people often focus on the technology, but the adoption of that technology depends largely on communication.

ADC 1 built – and is now operating – a demonstration plant at the US Navy's Seawater Desalination Test Facility in Pt. Hueneme, California. To date, *ADC 1* has achieved remarkable results by desalinating seawater at energy levels between 1.5-2.0 kWh/m^3 (5.7-7.6 kWh/kgal). On average, these numbers make the power for desalination comparable to the power required for several other projects in the USA – namely the *Southern California State Water Project (SWP)*, and the *Colorado River Aqueduct (CRA)* projects. *ADC 1*'s energy levels are approximately 35% lower than area experts had been projecting for seawater desalination (*see box opposite for the specification and concept of ADC 1*).

The energy factor

SWRO technology has improved tremendously over the past 20-25 years. From 1980 to 2000, the energy consumption of these systems was cut in half – from 30.3 kWh/kgal (8 kWh/m^3) in 1980 to approximately 15.1 kWh/kgal (3.9 kWh/m^3) in 2000. This represented 20 years of progress.

However, it is remarkable that in only the past five years, largely due to the introduction of the isobaric energy recovery technologies and recent improvements in membranes, we have halved the energy requirements again.

For various reasons it is sometimes difficult for industry and decision makers to adopt and take advantage of these kinds of rapid improvements. Therefore, the ADC is intended as a vehicle to help accelerate the uptake and dissemination of the knowledge – namely that SWRO now uses much less energy than is generally believed.

Proving the theory – Testing *ADC 1*

The ADC is attempting to prove this energy argument through a demonstration plant, which is producing fresh water from natural Southern California seawater, in the range of **1.5-2.0 kWh/m^3 (5.7-7.6 kWh/kgal)**.

These are remarkably low energy levels that approach those used to generate many traditional sources:

- As *figure 1* shows, in Southern California – where the ADC is operating the demonstration facility – 50% of the water supply is imported via the State Water and Colorado River Aqueducts;
- The *State Water Project (SWP)* consumes 2.5 kWh/m^3 (9.5 kWh/kgal) of energy to transport water from Northern California to Southern California, and this number can rise to as high as 3.5 kWh/m^3 (13.2 kWh/kgal) depending on the specific distribution point;
- The *Colorado River Aqueduct (CRA)* also consumes significant amounts of energy starting at 1.6 kWh/m^3 (6.1 kWh/kgal).

It is remarkable to realise that we can now desalinate seawater in Southern California for less energy than the majority of methods currently being used for their water supply.

ADC 1 pilot plant test protocol

Since 1983, the US Navy Test Facility at Pt. Heuneme has been evaluating and testing desalination equipment, and it provides the highest level of skilled operation and data collection for the project.

The test protocol was provided by the engineering and consulting firm of Carollo Engineers, and consists of running three different sets of *FILMTEC* membranes through a three-stage test protocol as shown in *Table 2*.

The results from the nine operating points collected in Stage 2 are then run through a detailed financial net present value (NPV) model that determines which of the nine operating points would have the lowest operating costs.

The financial analysis took a conceptual look at the 20 year life cycle for a 50 mgd SWRO

The *ADC 1* pilot plant - specification

Over the past five years, the introduction and commercial adoption of isobaric energy recovery technologies has had the most significant impact on the energy consumption and design of desalination systems. The ADC's demonstration facility takes advantage of this fact by using:

- An ERI pressure exchanger in combination with a 90% efficient David Brown Union Pump;
- New *FILMTEC* low energy membranes with an optimal low-flux, low-pressure design.

Other notable features that have improved the reliability and smooth performance of the pilot system include:

- Corrosion-resistant *AL6XN* high pressure pipes supplied by Rolled Alloys;
- *Duplex SS* pipe couplings supplied by Piedmont Pacific;
- Suction and discharge pulsation dampeners supplied by Young Engineering;
- Easily-maintained and corrosion-resistant cartridge-filter housing supplied by the Eden Equipment company.

The ADC 1 pilot plant - design concept

The plant uses an **open intake off a pier** in the Pacific Ocean. The **feed water** goes to an equalisation tank where it is then gravity fed to the intake of the ADC system. The **pre-filtration** system is composed of a single stage multi-media filter followed by five micron cartridge filtration.

To improve the performance of the pre-filtration system the ADC uses Avista's *RoQuest 4000* for **flocculant chemical injection.** The RO process is a pressure exchanger design that includes a main HP pump sized to match the permeate flow, a 3 vessel x 7 (each 8") element pressure vessel RO array, a pressure exchanger energy recovery, and a PX booster pump. It is this RO process that ADC energy numbers target.

The ADC target range does not include energy for water supply, pre-filtration, and distribution.

However, the NPV model that it is using to select the most affordable operating point does include average energy allowances for the supply, filtration and distribution systems.

The ADC containerised demonstration system at the US Navy's Seawater Desalination Test Facility in Port Hueneme, California.

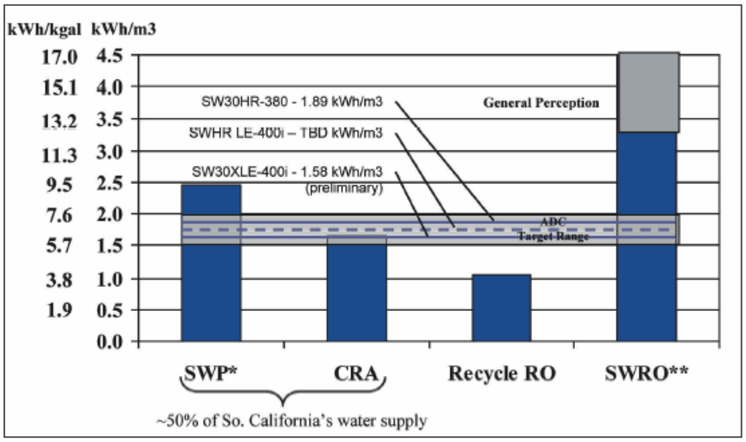

Figure 1: energy requirements for various water supplies and the ADC

plant and included overall treatment costs such as intake and distribution power, chemicals, maintenance, replacement, labour, capital costs and interest on capital. The model did not include land, depreciation, distribution improvements or intake capital costs and it assumes co-location with an existing power plant or other existing intake system. Furthermore, the test protocol and model did not address long-term operating issues such as membrane life, membrane fouling, cleaning cycles and overall system reliability, although all nine operating points were generally considered to be well within "good practice" and the membrane manufacturers' recommendations.

On average the RO process consumes 70-80% of the total energy required by the SWRO treatment process.

[Note: the complete NPV model and data are available on ADC's web site at www.affordabledesal.com. Live operating data can also be viewed on their website through a unique "real time" monitoring service supplied by the WaterEye Corporation. Carollo Engineering also provides testing oversight and will deliver the final report for the project].

The future for the ADC

ADC I will be finished in April 2006, and the ADC is planning to hold a workshop in Los Angeles in July 2006 to invite industry professionals and members to participate in the dissemination of the results.

Following this, the ADC plans to launch an ambitious demonstration – *ADC II* – which they hope to fund through a *California Proposition 50* grant proposal. The *ADC II* project carries a projected budget of US$2.2 million, and will pursue the following demonstration and development tasks over a period of 21 months:

- Test and demonstrate additional manufacturers' membranes through a similar protocol as phase I, where the ADC used *FILMTEC* membranes exclusively. Demonstrating additional manufacturers' products will validate *ADC I*'s original results and show that they can be achieved with several manufactures' membranes. It will also allow the ADC to provide a "head to head" comparison matrix of performance from four leading membrane manufacturers **(FilmTec Corp, Hydranautics, Toray, Koch)** using natural seawater and a full-scale eight inch diameter (x 7)-element membrane array.
- Test and demonstrate FilmTec's next generation "hybrid-membrane". This new concept includes internally staging membranes of different performance down a single 7-element pressure vessel. FilmTec indicates that these new membranes will provide improvements in energy consumption over and above its latest "low energy" membranes, and the hybrid-membrane should also produce better water quality than the existing low energy membrane if used alone.
- Develop and demonstrate new process designs that are possible as a result of the isobaric energy recovery technologies. As a natural result of the pressure exchanger (PX) technology in particular, new kinds of flow schemes are available that can improve the performance of higher recovery seawater and brackish water systems. The ADC will use the pilot system to test and demonstrate these new flow schemes, in order to push the recoveries above 50%, while still maintaining good water quality and low energy performance.
- Test and demonstrate Zenon ultrafiltration (UF) technology ahead of the ADC pilot system. Although pre-filtration is not necessarily an energy issue, adding this equipment to the system will allow the ADC to run more reliably through a wider range of feed water qualities. As a bonus to that reliability, the test will offer additional information about how Zenon's UF system performs on Southern California natural seawater. This data should build on (and complement) the other pre-filtration studies that are taking place in the region.

Conclusion

From the initial results, the ADC can conclude that desalinating seawater at 1.6-1.9 kWh/m^3 (6.1-7.2 kWh/kgal) is achievable for SWRO systems designed and optimised around isobaric energy recovery technology, state of the art "low energy" membranes and a high efficiency main HP pump. ●

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