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Flue Gas Desulfurization (FGD) Evaporator Operation Report, ENEL Brindisi

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Paper Abstract

Environmental quality remains a high priority in the power industry. These quality requirements result in the advancement of treatment techniques to provide plant discharges air and water to be minimized by reuse or of a quality that is either equal or higher in purity of the influents. Applications of existing technology are often employed but not validated with reports of performance. Historically FGD wastewater treatment methods have centered on physical chemical and biological methods. Zero Liquid Discharge thermal solutions have been applied and are presently in use. The potential users and the EPA have yet to determine if thermal treatment techniques are the best available technology (BAT) for this pollution source. This paper is a report on the operation of a plant in Italy that is operated and maintained by ENEL.

Five FGD ZLD plants were installed at ENEL power plants in Italy. They have been operating for 4 years. How have they lived up to the expectations regarding expected operation? This paper is a report of the operation of one of the units at ENEL 4 years after their startup.

Keywords

Flue Gas Desulfurization (FGD), Wastewater Treatment, Zero Liquid Discharge (ZLD), Brine Concentrator (BC), Falling Film Evaporator, Forced Circulation Crystallizer (FCC), Thermal Evaporation

In the EPA report "Determination of Technology Based effluent Limits for the Flue Gas Desulfurization Wastewater at Merrimak Station in Bow, New Hampshire" dated 9/23/2011, the EPA "concluded that it cannot based on current information determine this technology (Vapor-Compression Evaporation) to be the BAT for treating FGD wastewater.

In 2006 ENEL contracted with Aquatech International Corp to supply Zero Liquid Discharge systems to treat FGD wastewater. The systems were to be installed in 5 generating stations owned by ENEL. Criteria for design were that the system could handle varying chemistries, had high reliability and on stream availability, utilized high alloys to combat the corrosiveness of the chlorides present in the water.

Plant	KW	BC	FC	Total
Brindisi	4x660	2x50%	1x100%	2x35 m^3/H & 1x10 m^3/H
Fusina	2x320, 2x165	2x50%	1x100%	2x17.5 m^3/H & 1x5 m^3/H
Torrevaldaliga	3x660	2x50%	1x100%	2x175 m^3/H & 1x10 m^3/H
La Spezia	1x600	1x100%	1x100%	1x15 m^3/H & 1x4.3 m^3/H
Sulcis	1x240	1x100%	1x100%	2x12 m^3/H & 1x2.6 m^3/H

TABLE 1

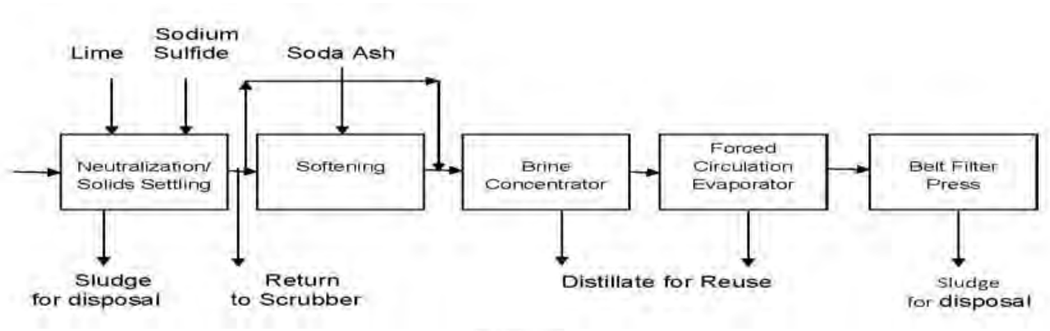


FIGURE 1

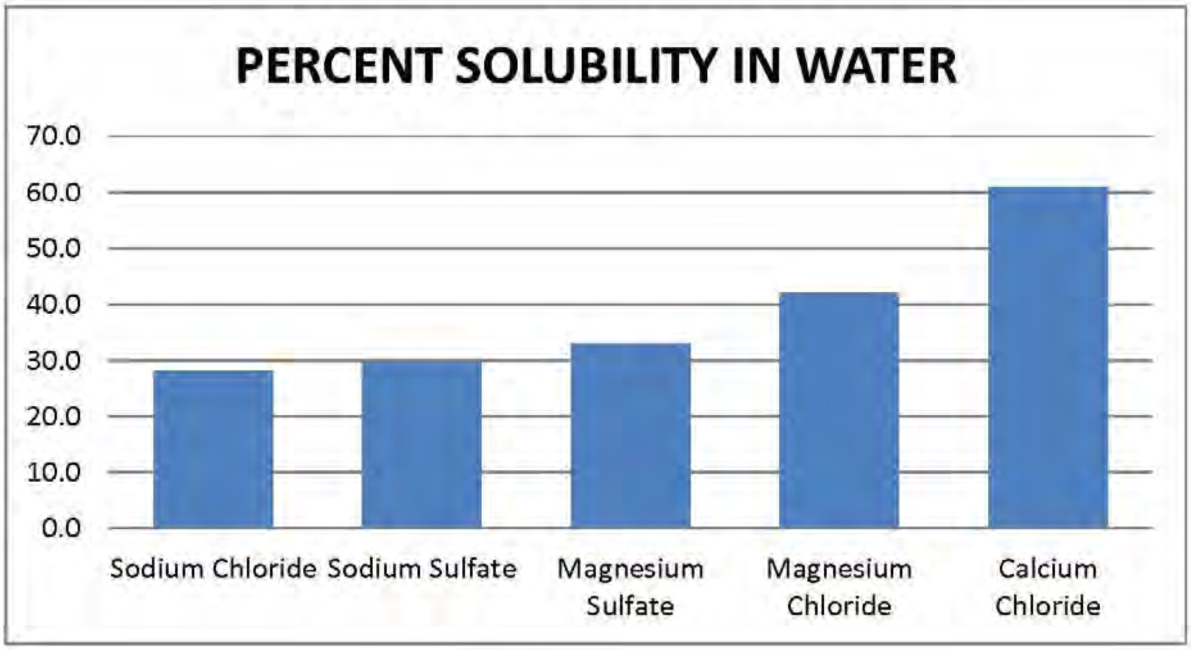
The systems were composed of Physical Chemical pretreatment, followed by a Brine Concentrator, Forced Circulation Evaporator using a Thermocompressor and an Automated Belt Filter Press. Guarantees included power consumption and steam consumption.

To address the upstream availability of the evaporation system, redundancy of the BC's was added for three of the plants and redundant pumps were added where practical.

The chemistry issue was more difficult. The projected chemistry ranges among the five plants are shown in Table 2. The items to note is the wide range in maximum and minimum ranges in the chemical components shown in Table 2. These ranges were caused not only by the method of operation of the scrubbers but mostly from the composition of the coal burned and the limestone used to scrub the flue gas. The other issue was the high ratio of calcium and magnesium compared to sodium. Looking at the relative solubilities of sodium salts, calcium salts and magnesium salts, we see that the solubilities of the calcium and magnesium salts are very high in relation to the solubility of the sodium salts (Graph 1).

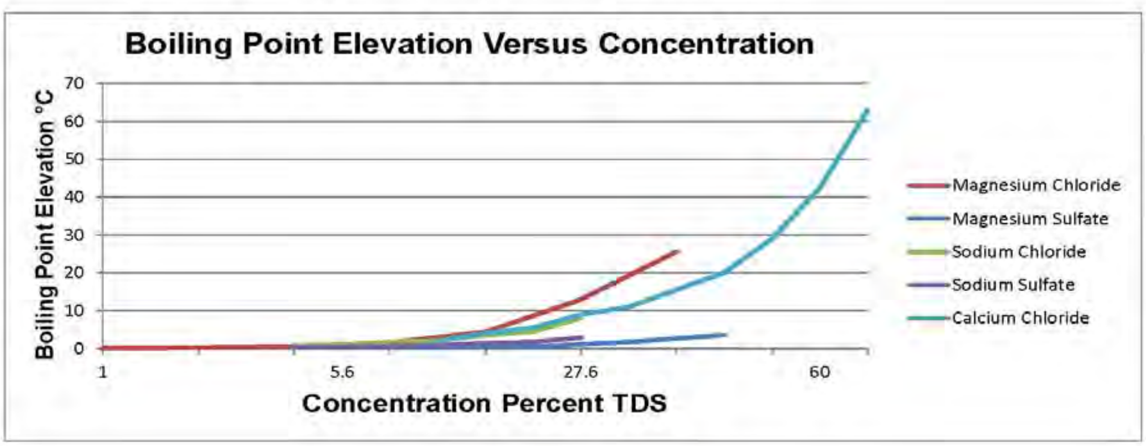
		Ca	Mg	Na	SO4	Cl	NO3	TDS
Max	PPM	12000	6400	13624	24500	30000	300	47461
Min	PPM	650	100	1690	900	5800	300	23610
Avg	PPM	3310	1380	7876	7099	16060	300	36298

TABLE 2



GRAPH 1

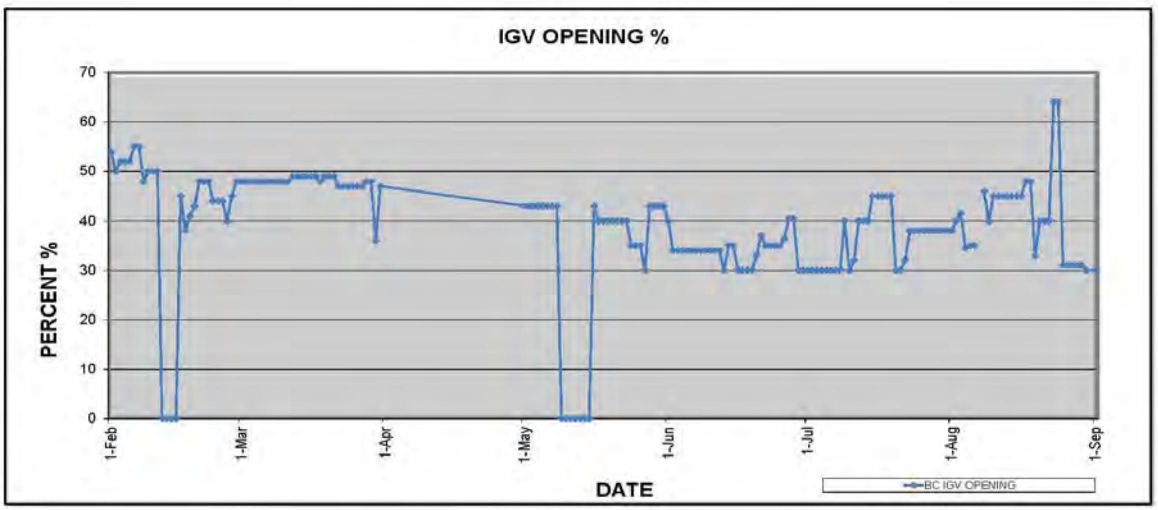
The problem is not the solubility but the impact on the physical properties of the brine, the corrosiveness of the brine and the boiling point elevation of the concentrated brine. As can be seen in graph 2, sodium chloride has a maximum BPE of 8C with sodium sulfate a maximum BPE of 3C. The



GRAPH 2

BPE of the calcium chloride, magnesium chloride and magnesium sulfate are 63C and 26C. The solubilities of these two components is high also, 62% for calcium chloride and 42% for magnesium chloride. When combined with the high BPE's, we face a significant challenge with the selection of materials and resulting cost of equipment.

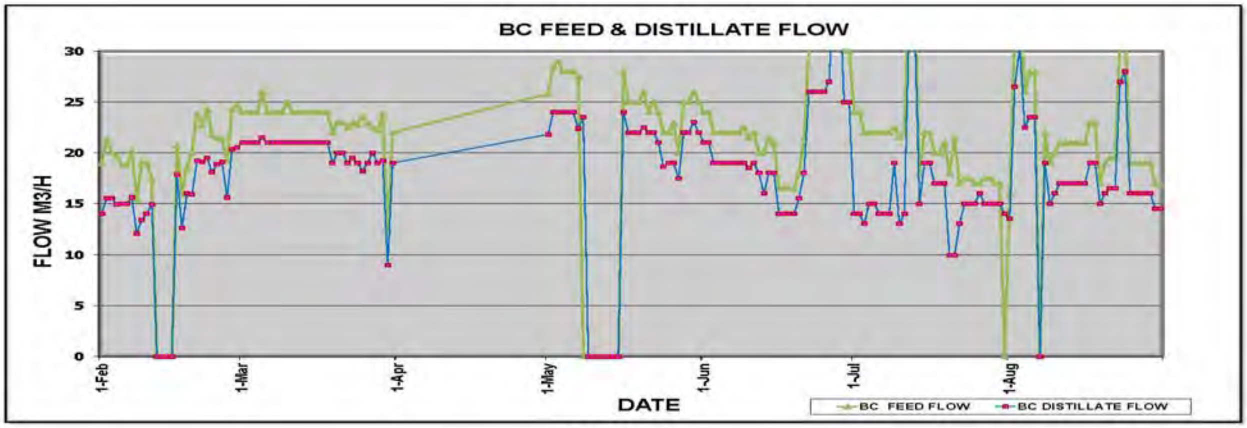
To treat the FGD Scrubbber blowdown, the feed was softened and neutralized to reduce the calcium and magnesium to acceptable levels. The FGD blowdown was first dosed with lime to reduce the magnesium to acceptable levels by precipitating magnesium hydroxide. Soda ash was then dosed to precipitate the calcium as calcium carbonate . These additions and precipitations didn't change the TDS of the brine. They changed the chemical composition of the brine to replace the hardness with sodium ions making the brine amenable to Zero Liquid Discharge at reasonable boiling point elevations and soluble chloride levels.



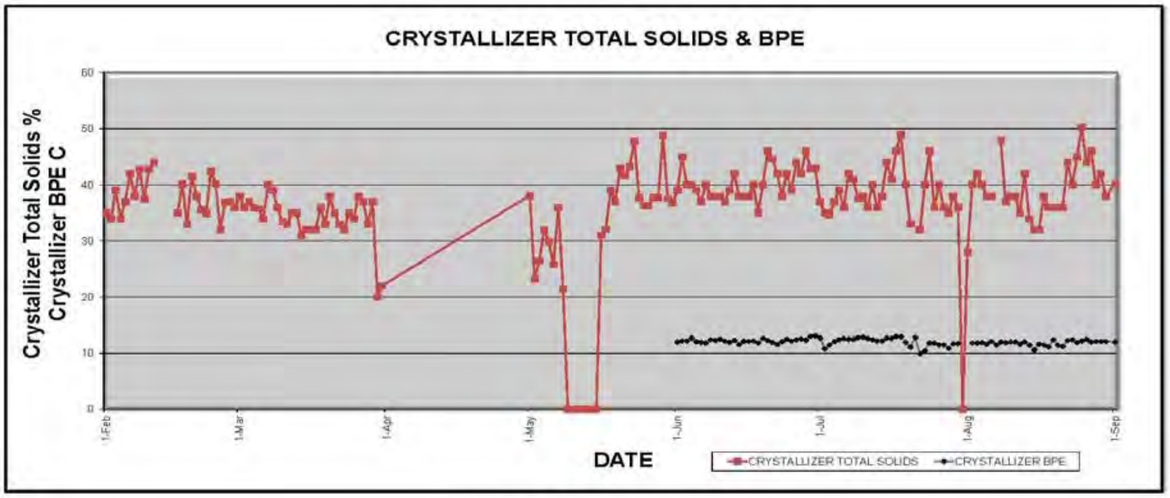
GRAPH 3

While it would be very simple to remove almost all the magnesium and calcium, it would also be very expensive. The cost of lime and soda ash are approximately 10 & 17 cents per pound, making the annual cost to remove the hardness from 100 GPM brine, $250,000 & $800,000. To reduce the cost while still controlling the properties of the brine, only a portion of the hardness was removed. The hardness would be lowered to a level where we could use a seeded brine concentrator followed by a thermocompression system for the crystallizer to reduce the steam and cooling water consumption . Both these systems were proven in cooling tower blowdown operations where hardness was present and unremoved.

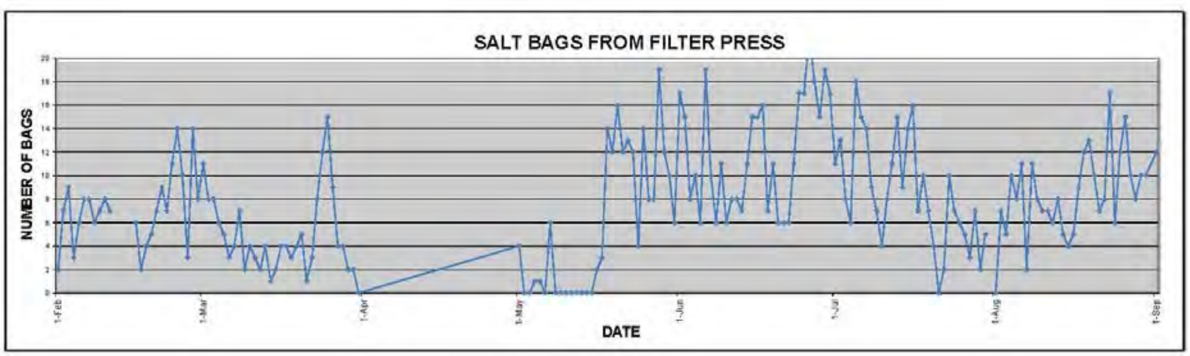
The challenge was to provide a robust system that could respond to variable chemistries but maintain a controlled feed chemistry to the evaporator system while not breaking the bank. How did the plant do?



GRAPH 4



GRAPH 5



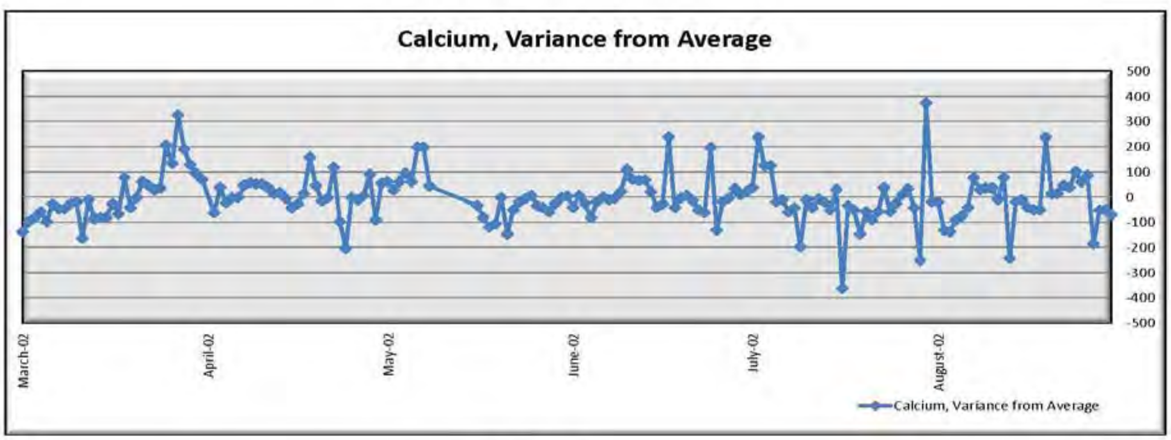
GRAPH 6

The Brindisi plant will be the one we focus on. The graphs for BC Feed Flow and Distillate production from the BC are shown in Graph 4.

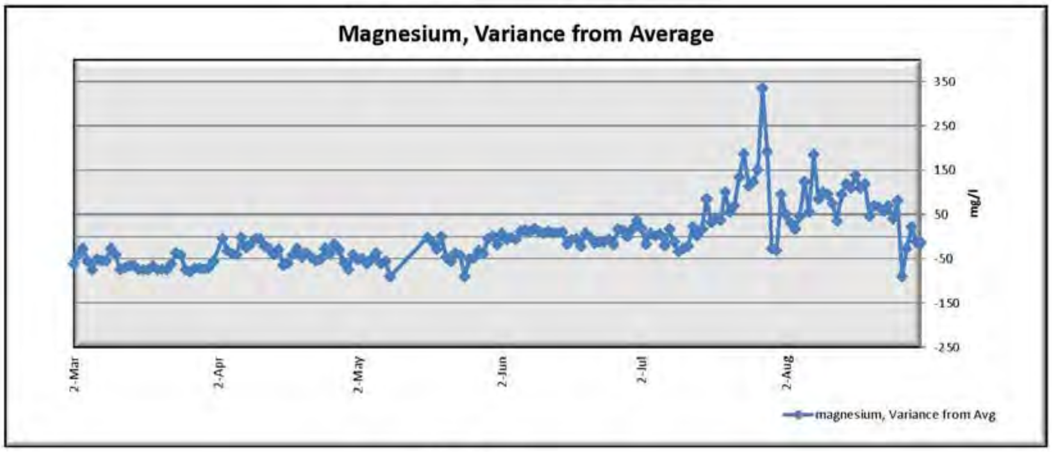
We also need to see the incoming feed chemistry and how it varied. The feed chemistry is affected by several

variables. The coal and limestone are naturally occurring elements and the composition changes based on the location. Additionally there is the operation of the scrubber. This is not only a function of the manufacturer of the system but also how it is operated by the plant. As we can see the chloride content of the incoming feed had a range of 13000 mg/l with a standard deviation of 1677 mg/l over the period of the data. We can also see the ranges of calcium and magnesium were very wide also. This could be attributed to the variability of the chemistry of the coal and the limestone. However, if we look at the range of the calcium and magnesium in the feed to the Brine

Concentrator, shown in graphs 8 and 9, we can see that the range for that was very small, 92 mg/l and 64 mg/l respectively. This is borne out by the boiling point elevation in the crystallizer. We can see how stable the BPE was in the crystalizer, Graph 5 and the amount



GRAPH 7



GRAPH 8

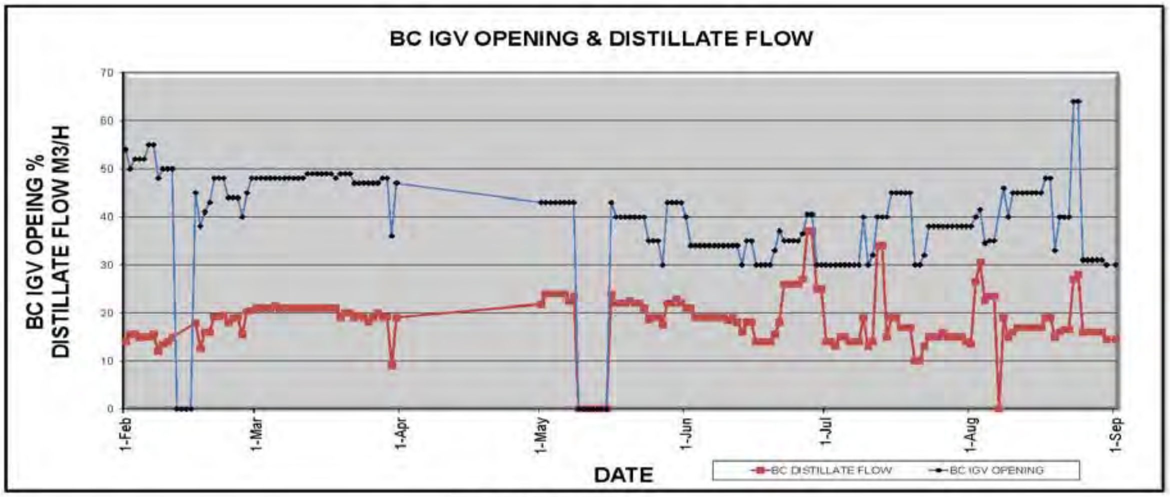
of solids (bags) discharged from the belt filter press, Graph 5. We also see the thickness and dryness of the cake in the photographs indicating a cake that passes the EPA Paint Filter Test and is suitable for disposal in a landfill.

In graph 9 we see the correlation of IGV openings to distillate production and the stability of the distillate production over the period in question, This is due in part not only to the control of the chemistry coming into the plant but the control of the chlorides in the feed coming to the plant. ENEL controlled the effluent chloride from the scrubbers and positively impacted the operation of the evaporation plant.

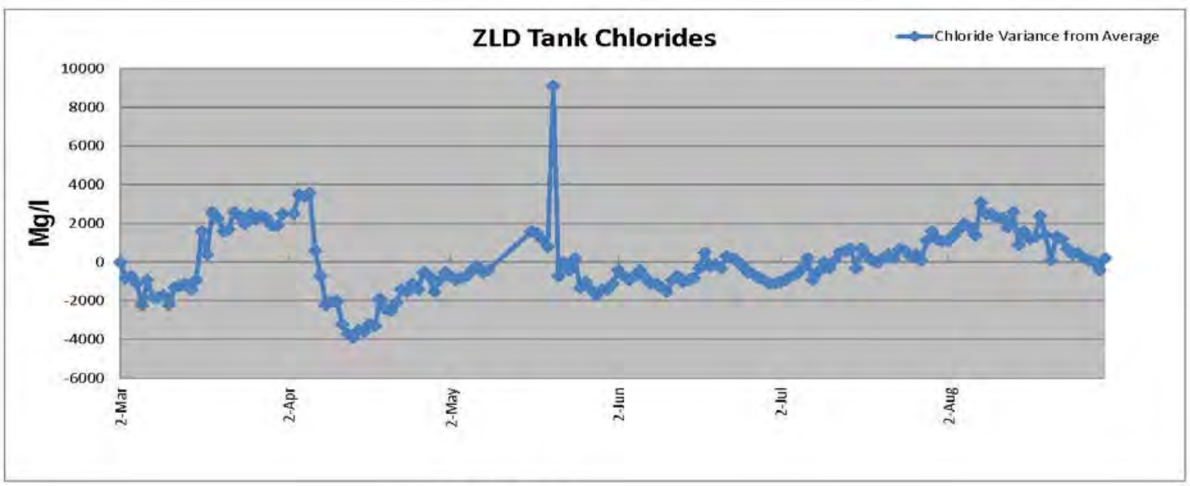
During the 6 months examined in this report, we see the following:

1. No liquid has been discharged from the plant site.
2. Scale is controlled as indicated by the IGV and distillate flow chart.
3. The calcium and magnesium concentrations are controlled within acceptable limits.
4. The total solids and the BPE in the crystallizer are predictable and within acceptable limits.
5. The percentage recovery of distillate averages 83% in the BC.
6. Distillate purity ranges between 23 and 55 µsiemens.

The major maintenance issue of the of the Brindisi plant has been the hydroclone and the small lines discharging concentrate. This has been addressed and resolved by adding additional flushing points and the ability to disassemble the small lines. This is still an area where operators are practicing vigilance. The BC had one issue with a bearing failure and that caused a significant amount of



GRAPH 9



GRAPH 10

downtime for the repair. During startup, the Belt Filter Press had issues with platen seals. In addition there have been instances of premature fouling and scaling of the feed preheater. During the transition to steady state operation, the dryness of the filter cake was not acceptable. This was resolved by the increase in drying time of the cake.

In a 2010 memorandum from James Hanlon, Director of the office Wastewater management to the Regional Water Directors, he states that the EPA, based on the completed 2009 report on the wastewater discharges from power plants, has decided to reexamine the pollution limits in discharges and expects to have revised effluent guidelines promulgated in 2013.

The time frame has been extended to 2014.

If we look at how effluent guidelines are determined, “The BAT standard requires achievement of: effluent limitations . . . which . . . shall require application of the best available technology economically achievable . . ., which will result in reasonable further progress toward the national goal of eliminating the discharge of **all pollutants**, as determined in accordance with regulations issued by the [EPA] Administrator" In the lawsuit Chemical Manufacturers. Ass'n v. U.S. Envtl. Prot. Agency, 870 F.2d 177, 239 (5th Cir. 1989) the court stated In setting BAT, EPA uses not the average plant, but the optimally operating plant" This means that if there is one plant using the technology and it is functional and performing, that plant can be used as the basis for the effluent guideline and not the limits achieved by the majority of the plants.

BAT is not the only method of determining limits. Best Professional Jusdgement (BPJ) can also be used to establish effluent guidelines. These can be determined based on an individual's examination of the technology available and the application of that technology. And the court has stated in Natural Resources Defense Council v. U.S. Envtl. Prot. Agency, 859 F.2d 156, 199 (D.C. Cir. 1988), "the resultant BPJ limitations are as correct and as statutorily supported as permit limits based upon an effluent limitations guideline."

Conclusion:
ENEL has determined that the existing ZLD technolocy is viable and reliable. KCPL has shown the technology to be feasible with discharge onto the ash pile. Public Service New Hampshire, whose report was quoted at the beginning of this paper that the process was unproven installed a ZLD unit and it is operating in conjunction with physical chemical treatment.
The EPA is promulgating new rules and they will be based on current demonstated ZLD technology. Several plants have realized that and have either installed plants in front of the new rules or are in the process. It's only a matter of time and the clock is ticking.

Location	Equipment	Status
Matsushima, Japan	BC	Out of Service
Transalta, Washington USA	Cooling Tower/FC	Out of Service
CWLP, Springfiled, IL USA	BC/Spray dryer	Never Installed
DOE Pilot, Milliken	BC	Out of Service
Vattenfall, Vodskov, Denmark	Spray Dryer	Operating
KCPL, Kansas City, USA	BC	Operating
A2A, Monfalcone, Italy	CT/BC/FC	Operating
ENEL Brindisi, Italy	CT/BC/FC	Operating
ENEL, Torrevnord, Italy	CT/BC/FC	Operating
ENEL, Sulcis, Italy	CT/BC/FC	Operating
ENEL La Spezia, Italy	CT/BC/FC	Operating
ENEL Fusina, Italy	CT/BC/FC	Layup
PSNH, Bow NH USA	CT/BC/FC	Operating
Duke Energy, Mayo, NC USA	CT/BC/FC	Installation

TABLE 3

References

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