Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants

Final Report

Project Dates: 7/31/06 – 9/30/09

September 30, 2009

For DOE Funding Opportunity –

Advanced Technologies and Concepts to Minimize Freshwater Use in Coal-Based Thermoelectric Power Plants

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DISCLAIMER

ABSTRACT

This program was undertaken to build and operate the first Air2Air™ Water Conservation Cooling Tower at a power plant, giving a validated basis and capability for water conservation by this method. Air2Air™ water conservation technology recovers a portion of the traditional cooling tower evaporate. The Condensing Module provides an air-to-air heat exchanger above the wet fill media, extracting the heat from the hot saturated moist air leaving in the cooling tower and condensing water. The rate of evaporate water recovery is typically 10% - 25% annually, depending on the cooling tower location (climate).

This program verified the Air2Air™ Water Conservation Cooling Tower capability as described.

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Executive Summary:

A Test Cooling Tower termed a "Validation Cell", including experimental Air2Air™ Water Conservation Technology, was completed and is operating at Public Service of New Mexico, San Juan Power Station. The Air2Air™ Validation Cell began continuous operation in early 2008 and has seen nearly 2 full years of operation to date.

This Air2Air™ Water Conservation Validation Cell provides cooling for 35 MegaWatts of plant generating capacity at Public Service of New Mexico, San Juan Power Station.

Testing, as delineated in the test protocol, was completed for the Validation Cell per the project milestones. Data from the testing in 2008 and 2009 has been analyzed and conclusions are included in this report. Photos are also included. The project was completed on an extended schedule, with this final report presented 9/30/09.

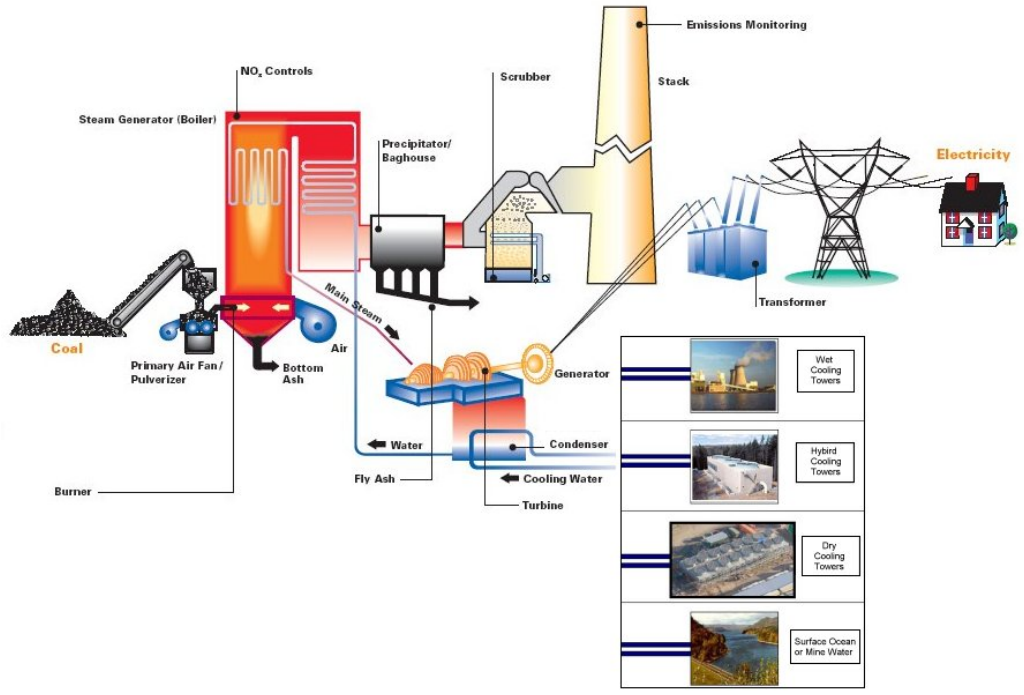
CONCLUSIONS

1. The Air2Air™ Water Conservation Validation Cell performed substantially as predicted.
2. Air2Air™ Water Conservation by condensation from the cooling tower evaporate was 97% of predicted over the range of temperature and humidity conditions at the Farmington, New Mexico site.
3. Air2Air™ Water Conservation by condensation from the evaporate was 18.5%, compared with a predicted 19%, over the range of temperature and humidity conditions at the Farmington, New Mexico site.
4. The condense Total Dissolved Solids ranged from 3 to 6% of the circulating water solids.
5. The Air2Air™ Water Conservation Validation Cell has operated without freezing water in dry ducts and without damage to components for the two full winters.
6. The Air2Air™ Water Conservation Validation Cell provided very effective plume abatement capability in substantial cold weather exposure.

Description of The Project

Water Use in Thermoelectric Power Plants

The generation of electricity from steam requires that power plant process steam be condensed at the aft end of a turbine. The process is greatly simplified in the Figure 2 illustration.



Adapted from http://www.eei.org/industry_issues/environment/air/New_Source_Review/coal1.pdf

Critical to the operating efficiency of a power plant, is the pressure differential between steam turbine inlet and outlet. Low aft end pressures are achieved most frequently through the use of cooling water on a cooling tower. Steam, as it condenses, reduces its volume 1700 times. This compaction creates suction on the exit end of the turbine, which draws steam efficiently through the turbine from the inlet.

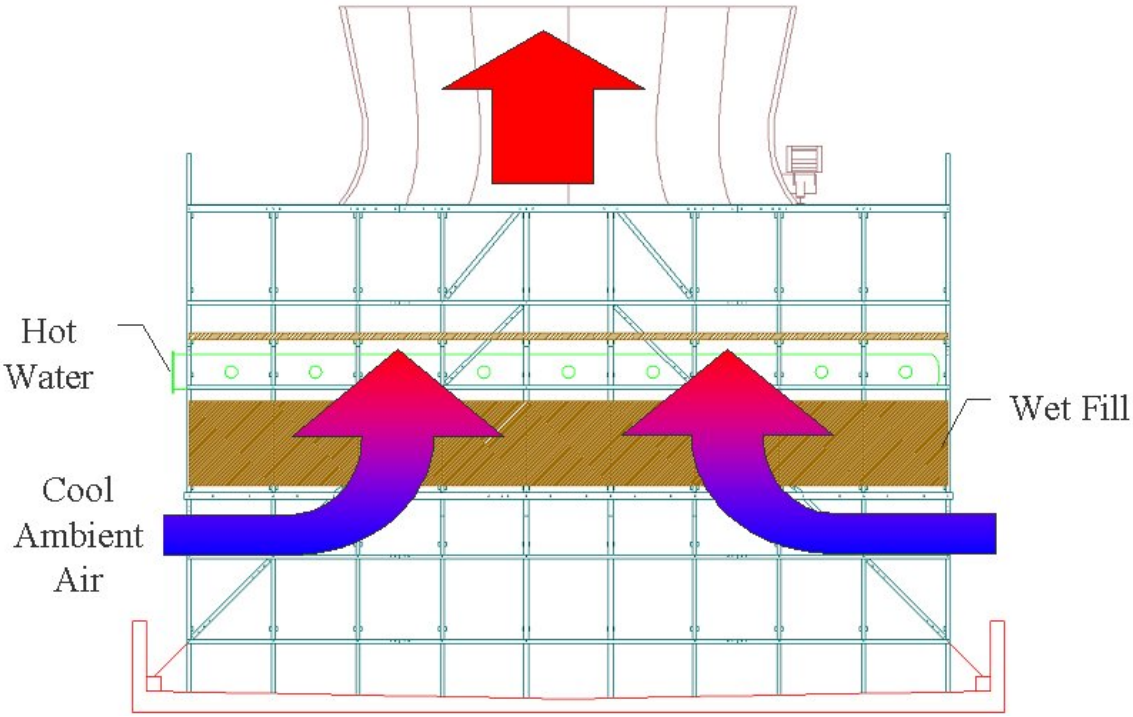
Technical approach

In response to the DOE funding opportunity (number: DE-PS26-05NT42411), Advanced Cooling Technology, Marley Cooling Technologies Inc. (MCT) proposed testing of Air2Air^{TM} innovative water conservation technology.

Traditional wet cooling tower

As illustrated in Figure 3, a traditional evaporative cooling tower uses the latent heat of vaporization to transfer heat. By evaporating a small portion of the

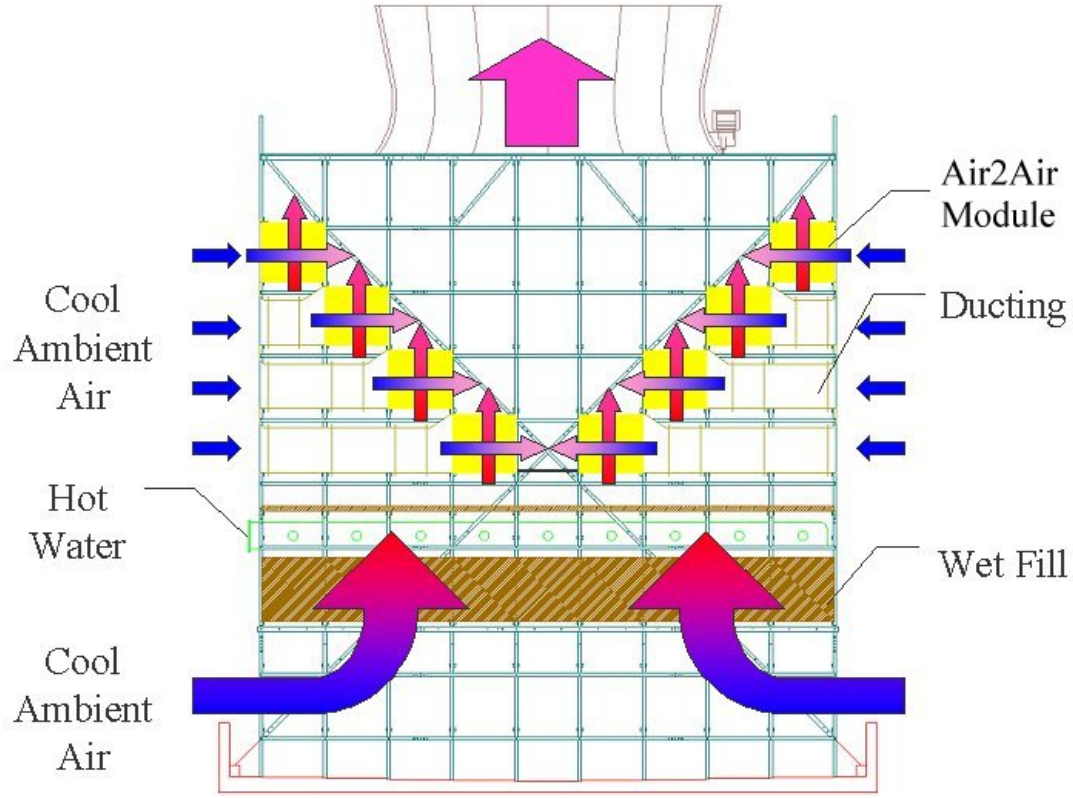
circulating water flow through the tower, the remaining water is cooled. The tower's exit air stream is saturated with water vapor that is typically discharged.



Sketch of a traditional wet cooling tower

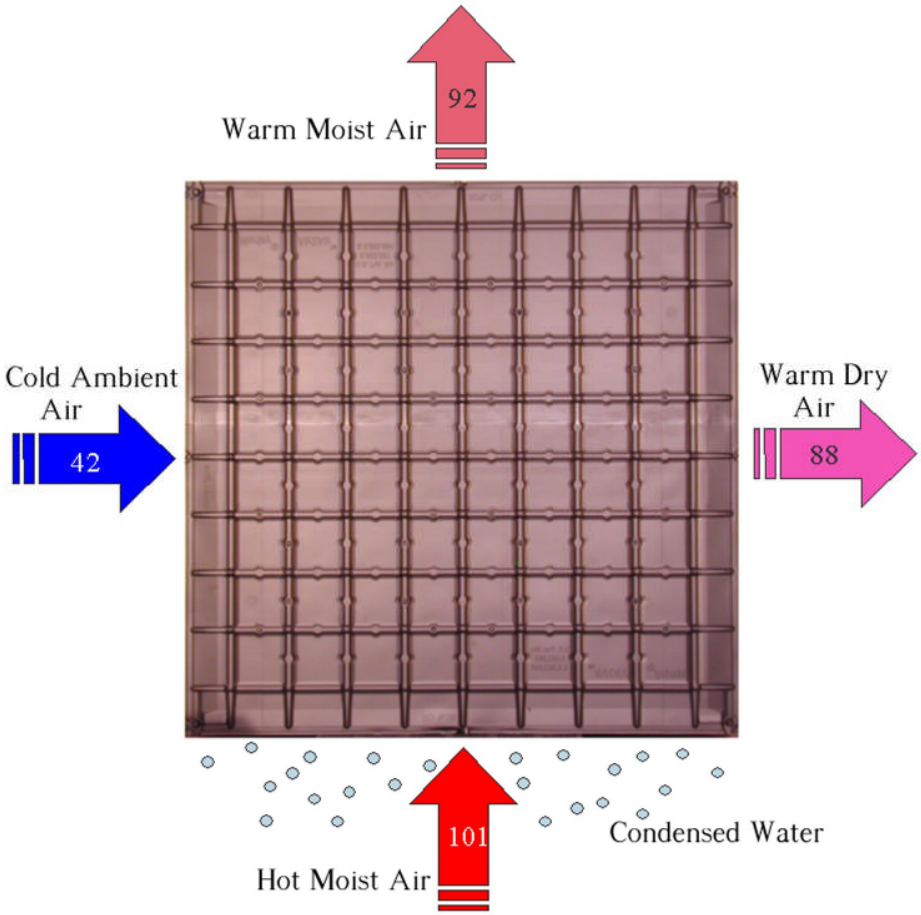
Air2Air™ water conservation cooling tower

An Air2Air™ water conservation technology as shown in Figure 4 recovers part of the traditional cooling tower evaporate by using relatively cool ambient air to condense evaporate and retain water that would otherwise be lost to the atmosphere. This test program will build and operate the first Air2Air™ water conservation cooling tower at a power plant.



Sketch of Air2Air^{TM} water conservation cooling tower

The Air2Air^{TM} Condensing Module (Figure 5) serves as an air-to-air heat exchanger above the wet fill media in the cooling tower. Cool ambient outside air extracts the heat from a separate stream of hot saturated moist air leaving the traditional cooling tower. Water is condensed in the Air2Air^{TM} modules. The temperatures noted in Figure 5 are typical of a thermo-electric power plant. The rate of evaporate water recovery is typically 15% - 25% annually, depending on the cooing tower location (climate).



Air2Air™ Condensing Module

Anticipated public benefits of Air2Air™ technology

Thermoelectric power generation is water intensive. As the nation's growing economy drives the need for more electricity, demands on the use of water for power generation also will grow. The direct and indirect demand for water for energy production will increasingly compete with demands from other sectors of the economy. The implementation of Air2Air™ technology on existing cooling towers (retrofit) and new cooling towers would reduce freshwater consumption by thermoelectric power plants.

In a typical 300 MW coal-fire power plant, its cooling tower recirculates 140,000 GPM of water at a cooling range of 20 °F. The water consumption due to evaporation is about 3 million gallons per day. By using the Air2Air™ condensing technology, 15% to 25% of the evaporation can be recovered. If assuming 20% water conservation, that is 600,000 gallons per day. This is a significant water savings.

In addition to water conservation, following benefits also apply:

- Plume abatement
- Possible other uses of conserved high quality water within the power plant, such as reducing outside purchase or on-site demineralized water production

Technical Objectives of Project – Pilot-Scale Results

After successful laboratory-scale testing, a pilot-scale test was completed to resolve practical issues. SPX/Marley partnered with a utility in the western United States to install and research the performance potential for the Air2Air^{TM} condensing technology for use in thermoelectric power plants. This research of a pilot scale evaluation is a necessary step to bring the Air2Air^{TM} technology to actual practice.

There were seven major tasks for the proposed project which were completed as follows:

Task 1: Retrofit one cooling tower cell using Air2Air^{TM} technology

The Construction process proceeded in the following general steps: Customer Identification and Discussion, Contracting, Site Evaluation, Preliminary Design, Specials Identification and Ordering, Design, Materials Procurement, Shipping, Receiving Materials, Construction, Commissioning, and Operation.

The Host Agreement was completed on 8/24/06. This agreement was concluded with Public Service of New Mexico, for test at their San Juan Generating Station in Farmington, New Mexico. The specific items that were required for agreement were: Construction Agreement, No. 1011874, 5/23/06, Confidentiality Agreement, No. 1011276, Appendix E, and Amendments, Appendix F, 8/24/06, and Individual Task Agreement, Contract No. 01011874, ITA 01, 8/24/06. A2A Cooling Tower General Arrangement Drawings showing the overall design were provided, Drawing #'s 06-4299 and 06-4300, dated 9/21/06.

SPX Cooling Technologies visited the San Juan Site on 9/19/06 to discuss the project scope, schedule, and work plan with Russell Huffman, PNM San Juan Plant Manager and his Staff. Attending from SPX Cooling were Tom Dendy, VP of R&D and Marketing, Glenn Brenneke, Director of R&D, and Ken Mortensen, Technical Director for Water Resources. The Public Service of New Mexico San Juan Site Environmental Questionnaire was completed 10/9/06.

Engineering design has been undertaken, after all legal agreements were in place. Among the high priority design tasks was identification of long lead time items, such as the fan motor required for the A2A Technology, a 300HP/460V/224KW/1785RPM motor, to provide airflow for cooling and water conservation. That item was identified as long lead-time and advance ordered for the project on 9/20/06. Other special design areas were Piping Design for

integrating water flow from existing Cell 2 to the New Cell 1 A2A, and Make-up Piping and Basin Dam designs for water management.

SPX Cooling Technologies optimized and finish detailing the test cooling tower cell for the PNM San Juan Generating Facility, as detailed in the following description:

1. W496-6.56-01A2A General Arrangement of A2A Validation Cooling Tower Cell with the Existing Tower
2. Existing Tower End-wall Casing
3. A2A Validation Cell Basin Dam
4. A2A Validation Cell Cooling Tower Structure
5. Eliminator
6. Air Seal
7. Spray System
8. Mechanical [Fan blades, fan hub, gear-reducer, driveshaft, motor, torque tube support]
9. A2A Components/Extended Plenum
10. Access
11. Collection System

The completed design, described above generates a parts “Bills of Material” for each design group. These BOM’s have been transmitted to SPX Cooling Technologies materials procurement group. The Validation Cell cooling tower materials of construction including experimental Air2Air^{TM} Water Conservation Technology were then procured and scheduled in the order of construction. Delivery dates ranged from 10/16/06 to 3/2/07.

The first on-site work was installation of connecting valves at Cell 2 of the existing tower to allow water shut-off for construction. Demolition of the existing tower cell was then completed. Specific tasks were undertaken to close off the end-wall of the existing cooling tower and provide a fire-partition protecting that existing tower from the Validation Test Cell, re-route make-up water feed pipes for the existing tower located in cell #1, and construct a basin dam to keep tower water from flowing back into cell#1. Construction of the Validation Cell cooling tower including experimental Air2Air^{TM} Water Conservation Technology was completed in the general sequence layed-out above during the May through August, 2007 period.

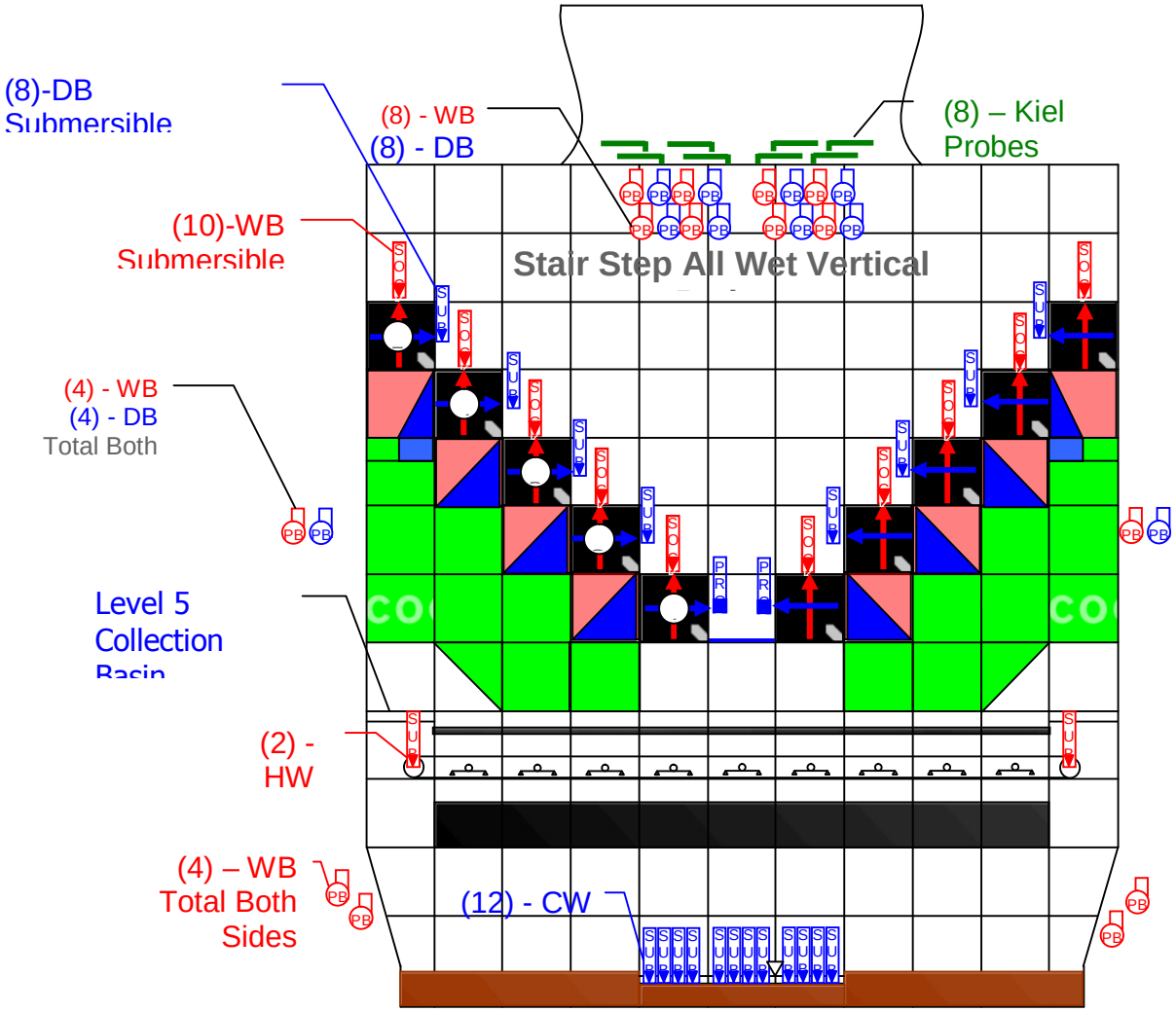
With these tasks completed, the Validation Test Cell was ready for water feed piping and electrical fan circuit hook-up to provide a completely operable water conservation cooling tower cell. This circuit is to be provided during the San Juan Unit 4 Maintenance Outage starting on and running 9/8/07 through 11/4/07. Additional Starter protection for the fan circuit will be procured and installed after the outage. This electrical service will finish out a completely operable water conservation cooling tower cell. The completed cell was then ready for start-up, check operation, and measurement of water conservation. A number of test

instruments have been installed and wired to retrieve the required data on the evaporation, cooling, and water condensation/conservation using the Air2Air™ Condensing Module.

Progressive Construction Photos


JLG LIFT

Task 2: Monitor the Air2Air^{TM} Condensing Module annually and check the water recovery prediction math model for validation



Performance Testing of the Air-2-Air Validation Cell

The Air2Air™ Water Conservation Validation Cell began operation in December 2007. It was fully instrumented and has been monitored since that time. The analysis of performance has been approached by splitting testing into two groupings: 1) Full Thermal and Water Conservation Performance Testing in April 2008, and 2) Ongoing Monitoring from December 2007 through 2008 and 2009. Detailed below are results from both test groupings

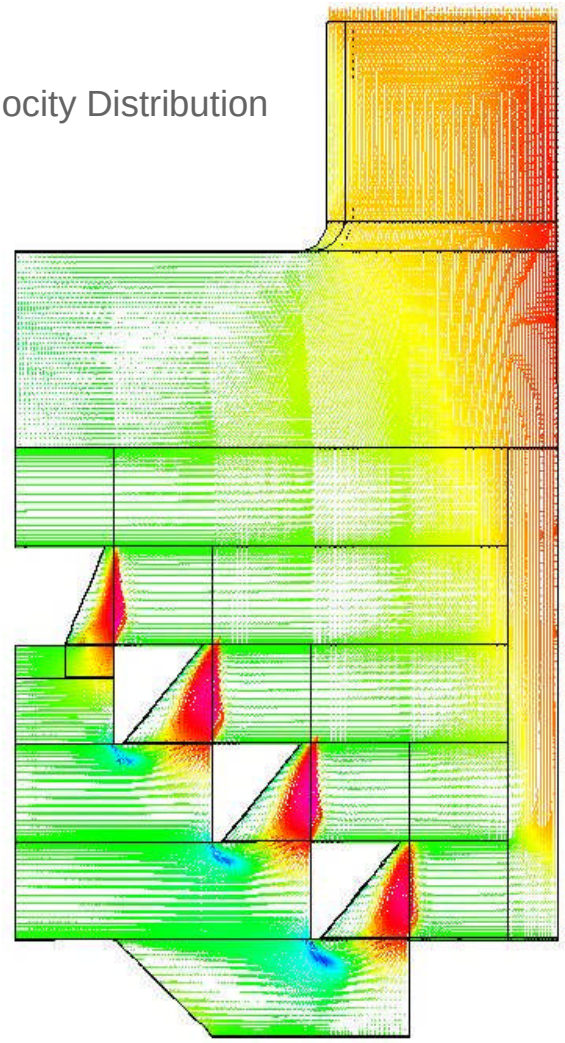
A full thermal and A2A water conservation performance test of the A2AValidation cooling tower cell was completed on April 24-28, 2008. The A2A validation Cell was instrumented per the figure above, to conduct sequentially, the thermal and A2A water conservation portions of the testing. Factors affecting this testing included: wind, because of interference from adjacent Class 600 Tower with its fan off, leakage at the common cold water basin weir wall, air leakage at some fill and duct discontinuities, and condensate collection issues described in a later

section. Both tests were satisfactory for verification of tower function, as described in the results below.

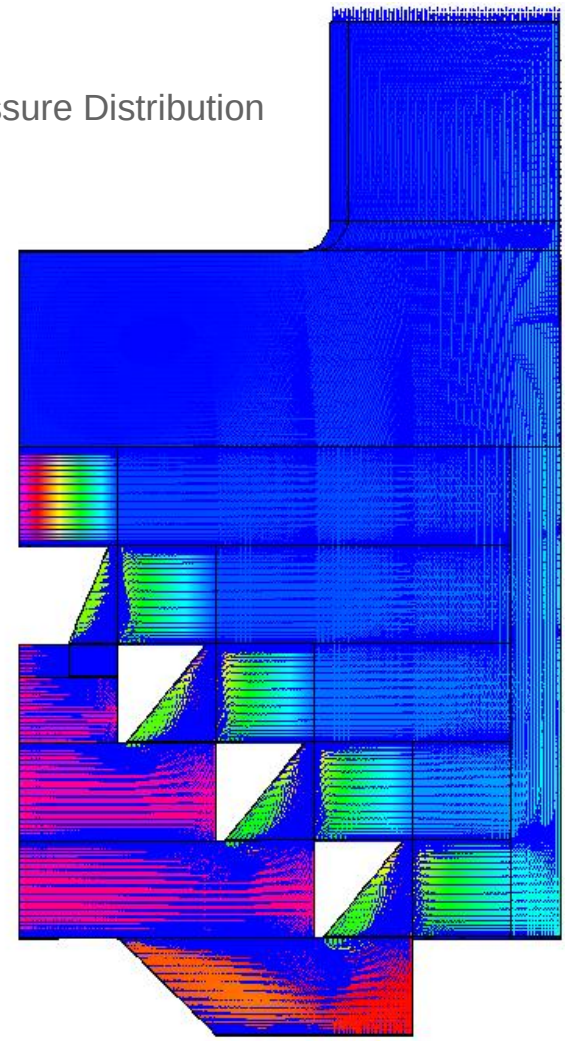
The thermal performance test used hot water, cold water, flow, ambient temperature, and fan airflow probes, during (2) 1-hour test periods, measuring 8842 GPM flow at 102.79 degrees F hot water/71.31 degrees F cold water/43.43 degree F Wet Bulb with and ambient temperature of 60.6 degrees F. The actual thermal performance of the cell was 98.1% and 97.6% of predicted with vent doors closed, in the two tests. This testing equates well with the predicted duty for the cooling tower Validation cell was 7,756 GPM of water from 105.42deg.F inlet to 82.3 deg. F outlet at an entering wet bulb temperature of 66 deg. F with dampers closed.

The A2A water conservation test used hot water, cold water, flow, ambient temperature, fan airflow probes, duct wet bulb probes, duct dry bulb probes, fan wet bulb probes, fan dry bulb probes, A2A pack anemometers, and condensate flow measurements. Airflow in the ducting was traversed for airflow to provide specific A2A pack conditions throughout the plenum crossection, as illustrated in the plenum velocity and pressure profiles below.

Velocity Distribution



Pressure Distribution



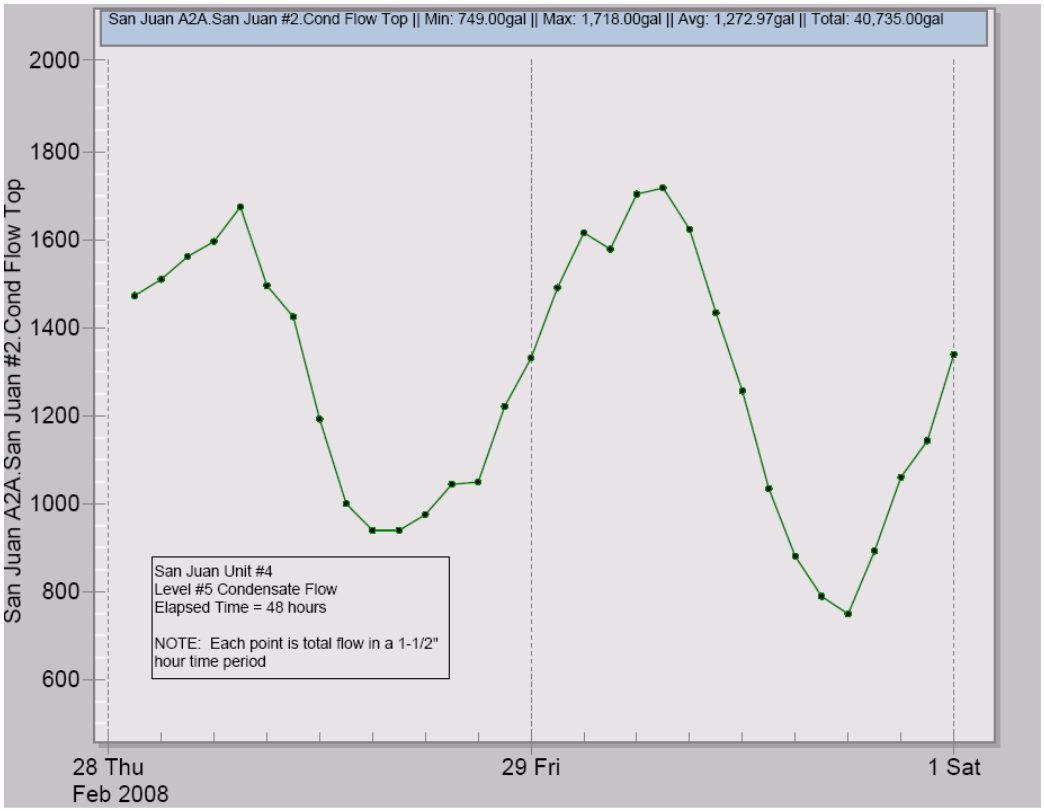
During the full thermal performance testing, Level 5 condensate collections were 4.58 to 7.22 GPM, depending on ambient temperature at the time of the A2A traverse. This traverse took from 11AM to 5PM, and the ambient temperature varied. Consistent with the discussions in the operations section that follows, the condensate quantity varies significantly with temperature and relative humidity at the time of collection. The condensate collection was 97% of predicted over the range of temperature and humidity conditions at the Farmington, New Mexico site.

Air2Air Tower Operation Notes and Condensate Performance

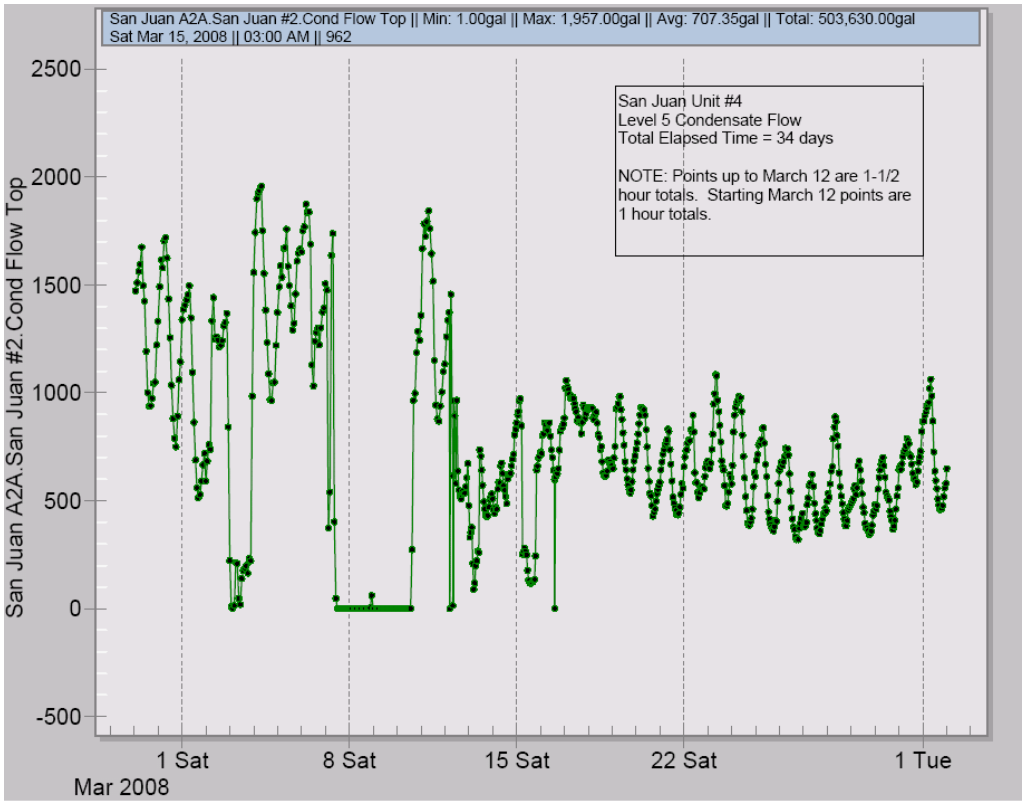
The description in this section comes from various time periods in the Ongoing Monitoring portion of the analysis, dates as noted.

Attachment “San Juan Chart 2.pdf” below, shows the "Saved Water" as Condensate Flow, Air2Air^{TM} Water Conservation Validation Cell, Level #5 for 48

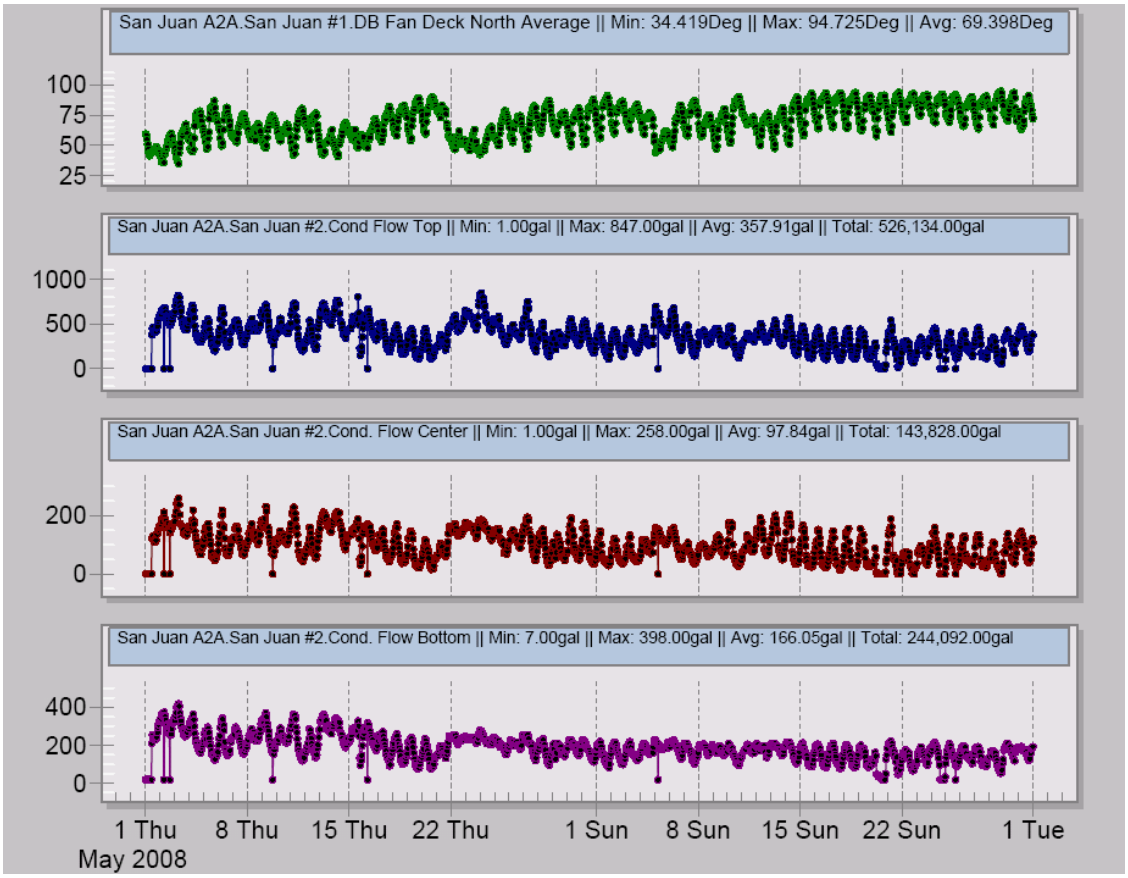
Hours, February 28 - March 1, 2008. A total of 40,735 Gallons was collected with an average 14.1 Gallons Per Minute for that period. Te variation of water condensed from warmer daytime hours to cooler nighttime conditions.



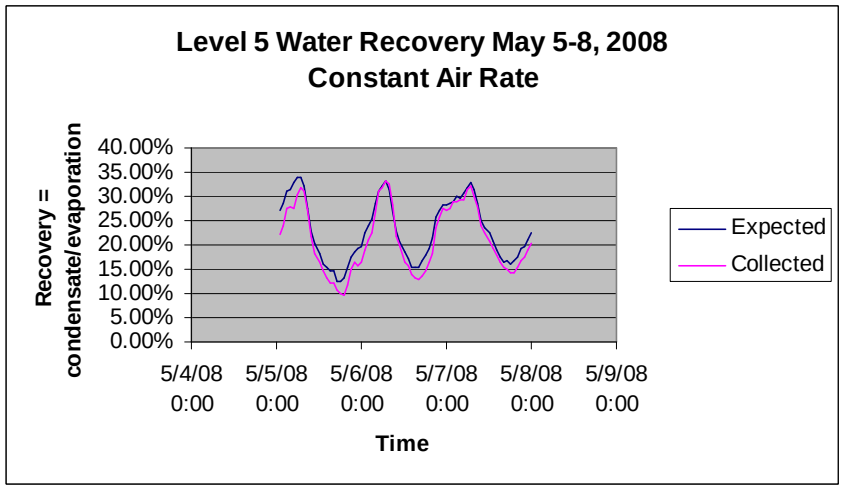
Attachment “San Juan Chart 3.pdf” below, shows the "Saved Water" as Condensate Flow, Air2Air^{TM} Water Conservation Validation Cell, Level #5, for 34 days, February 28 - April 2, 2008. The total is 503,630 Gallons reflecting unit operation for the full period, except 4 days. Water Collected averaged 11.8 Gallons Per Minute for that period. Variation of weather conditions accounts for changes in the condensed water quantity.



Attachment “San Juan A2A” below, shows data for the month of May-June, 2008. The top graph is Ambient or Dry Bulb Temperature for the period. The next 3 graphs are the "Saved Water", as Condensate Flow, from three distinct A2A levels in the Air2Air™ Water Conservation Validation Cell: Top, Center, and Bottom. The total for May-June, 2008 is 914,054 Gallons conserved. Notice the variation of water saved from warmer daytime hours to cooler nighttime conditions and as temperatures increased during the month. This data is provided as an example of A2A System capability. It does not equate with full cell capability or percentage of total tower evaporation, because it is only part of the total condensate collected. It shows an A2A system operating consistently over a long period of time and producing substantial water savings.



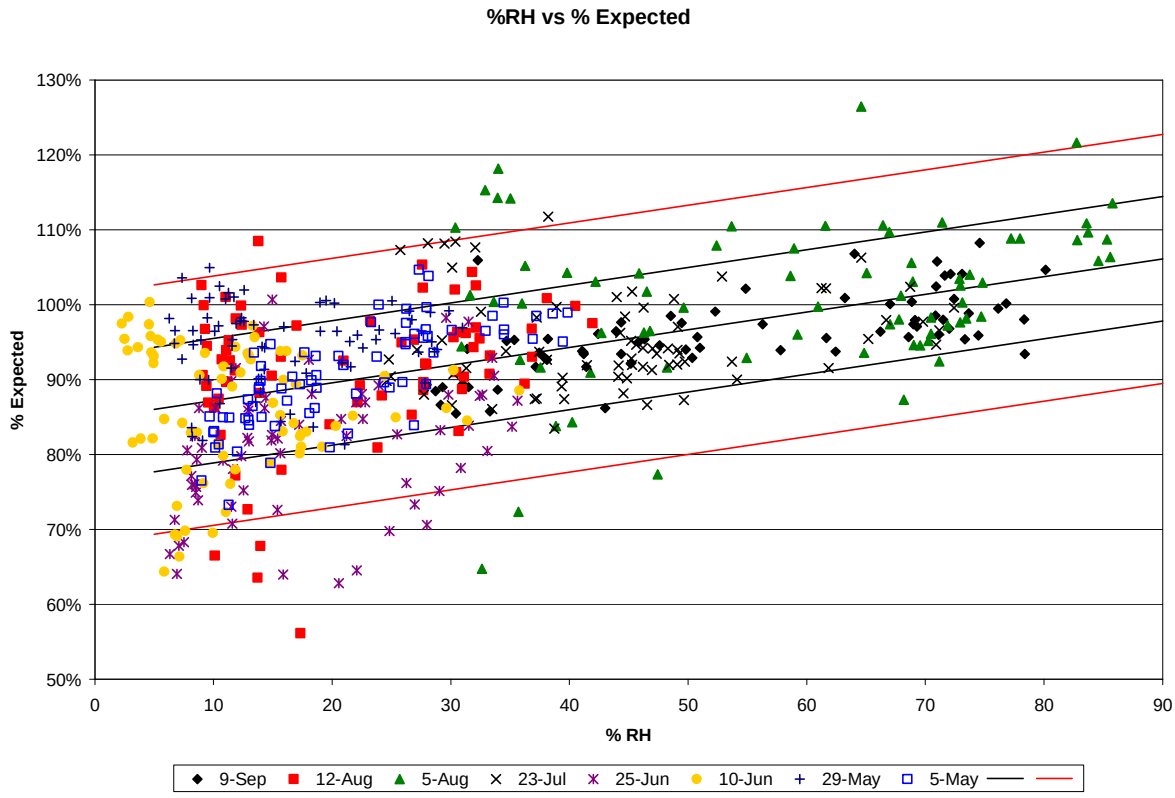
Attachment “Level 5 Water Recovery” below, shows comparative data for the May 5-8, 2008. The graph is Predicted vs. Actual Condensed Water for the period. This data is provided as an example of A2A System capability. It does not equate with full cell capability or percentage of total tower evaporation, because it is only part of the total condensate collected. It shows an A2A system operating consistent with prediction model over an extended period of time and producing substantial water savings percentages.



Performance Test Calculations

Using the above detailed testing from the two groupings, Full Thermal and Water Conservation Performance Testing, and Ongoing Monitoring, an annualized performance evaluation for the Air2Air™ Water Conservation Validation Cell was completed. The table below uses the Farmington weather data and the Water Conservation with Relative Humidity relationship to calculate an annualized Water Return Percentage [WRP] for the Test Unit. The prediction model is more accurate at higher relative humidity conditions and is less accurate at lower Relative Humidity.

Farmington, NM	Dry Bulb	MC Wet Bulb	RH	Hours/ Year	Data %	Weighted Data %
	107	66.5	12.52%	0	0.878	0.000
	102	61.9	9.90%	2	0.872	0.000
	97	61.0	12.57%	33	0.878	0.003
	92	60.6	16.85%	143	0.888	0.014
	87	59.4	20.58%	265	0.897	0.027
	82	57.9	24.54%	370	0.906	0.038
	77	56.1	28.68%	446	0.916	0.047
	72	54.3	33.85%	563	0.928	0.060
	67	52.4	39.99%	664	0.943	0.071
	62	49.8	44.92%	757	0.955	0.082
	57	45.7	44.43%	659	0.953	0.072
	52	42.1	46.35%	655	0.958	0.072
	47	38.8	50.53%	669	0.968	0.074
	42	35.5	56.02%	698	0.981	0.078
	37	32.3	64.01%	730	1.000	0.083
	32	28.9	71.47%	776	1.017	0.090
	27	24.9	79.17%	590	1.036	0.070
	22	20.6	83.86%	368	1.047	0.044
	17	16.1	87.81%	194	1.056	0.023
	12	11.6	93.55%	97	1.070	0.012
	7	6.9	98.05%	48	1.080	0.006
	2	2.0	100.00%	33	1.085	0.004
				8760		97.2%



PNMSJ Water Return Percentage = Predicted % X Weighted Data %
PNMSJ Water Return Percentage = 19.0 X 0.972
PNMSJ Water Return Percentage = **18.5%**
This is Public Service of New Mexico Condensed Water Return percentage [PNM-WRP] of the Evaporated water for the cooling process.

Task 3: Develop and evaluate a water collection system

Several water collection configurations were applied in the validation cell, as the design provided 2 different geometries for condensed water release from the A2A media. The first and most direct was a collection basin or pan that covered the full plan area below the level 5 A2A media. This space was available for level 5 because this is the butterflied A2A media in the validation cell, i.e. there is no fill below the condensing media. SPX theorized this provided the best opportunity to collect at or near 100% of the condensed water for verification of A2A media efficiency. Based on results analysis this was a verified conclusion. [add level 5 collection vs. heat transfer #'s]. Use of this full plan area collection system is not possible in most of the A2A Validation cell design because by the design's very nature it blocks all airflow from fill below to A2A media above. An alternate angular panel with collection trough design was devised for the other 4/5 of the tower A2A media as shown in crossection and detail sketch. This system proved much less efficient for condensate collection [add level 2,4 collection vs. heat transfer #'s]. These results indicate significant leakage, by-pass, and structure interference with condensate water collection at most locations in the tower. Such a design is not recommended for general use in this product. It is also not recommended as a verification method for A2A media performance, unless collection system improvements and overall tower configuration changes allow for more complete water capture.

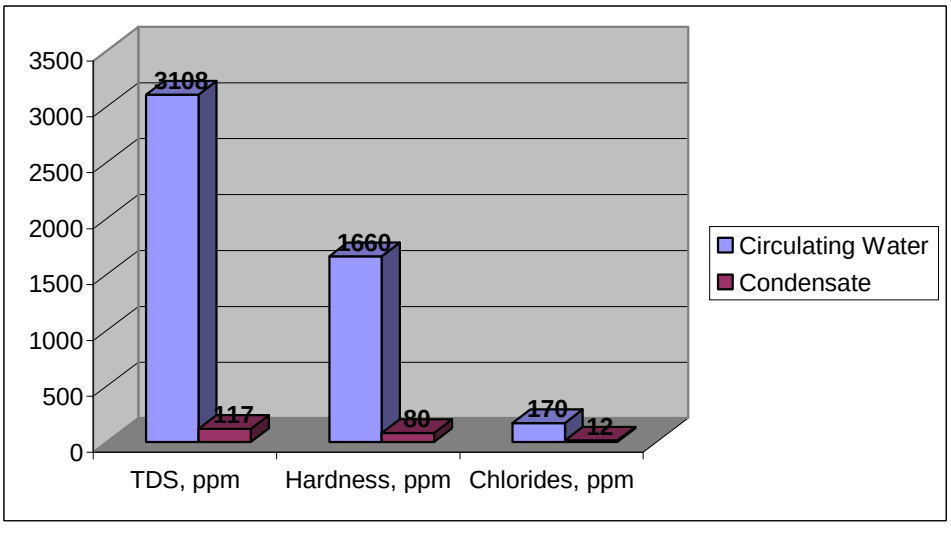
Task 4: Analyze the water quality of the collected condensate and identify applications that are able to use the collected water.

Tower circulating and A2A condensate water samples were collected throughout the operating period. Condensate samples were retrieved from each of the 3 collection systems in the tower. Samples were tested for dissolved and suspended constituents. Lab tests were total dissolved solids (TDS), pH, Conductivity, Total Alkalinity CaCO3, Total Hardness CaCO3, Bicarbonate as HCO3, Carbonate as CO3, Hydrogen as OH, Nitrate Nitrogen, Nitrite Nitrogen,

Chloride, Fluoride, Phosphate, Sulfate, Iron, Calcium, Magnesium, Potassium, and Sodium.

In general circulating TDS is fairly high at this power plant, as water is scarce and the cooling water is cycled up to substantial solid levels to minimize tower bleed losses. TDS ranged from 3108ppm to 7480ppm. The condense TDS ranged from 101ppm to 200ppm or 3 to 6% of the circulating solids. In theory no solids are carried from the circulating stream through the evaporation process and subsequently into the condensate, but it is known that rainwater TDS is not zero, so a small portion of the dissolved solids probably migrates with the water molecules as they are evaporated and then condensed in the A2A heat exchanger. Also the air contacting the condensate contains a small amount of solids even after it is “scrubbed” in the evaporative cooling process by large quantities of water. Then there is condensate combination with drift, circulating water that has escaped the evaporative cooling chamber by entrainment in the airflow through the base cooling tower. These sources account for the solids measured in the condensate. [Level 4, 5 ave vs. 2 drift by-pass] TDS above; compare to Sodium, Chloride, and Sulfate [calc lvl 4,5].

	Circulating Water	Condensate	
TDS, ppm	**3108**	**117**	3.8%
Hardness, ppm	**1660**	**80**	4.8%
Chlorides, ppm	**170**	**12**	7.1%
pH	**7.66**	**7.51**	



More detailed water analyses from a broader range of times is given in the Table Below.

	Sample Date 5/20/2008			Sample Date 8/5/2008				% Reduction			Sample Date 9/24/2008				% Reduction		
	Circulating	Condensate	% Reduction	Circulating	Cond. Lvl. 5	Cond. Lvl. 4	Cond. Lvl. 2	Cond. Lvl. 5	Cond. Lvl. 4	Cond. Lvl. 2	Circulating	Cond. Lvl. 5	Cond. Lvl. 4	Cond. Lvl. 2	Cond. Lvl. 5	Cond. Lvl. 4	Cond. Lvl. 2
pH	7.66	7.51		7.94	7.03	7.78	7.81				7.26	6.74	7.55	6.72			
Conductivity	5840	211	96.39%	6380	219	140	2090	96.57%	97.81%	67.24%	1E+05	351	207	1810	94.50%	96.76%	71.63%
TDS @ 180° C	3580	112	96.87%	3490	112	54	1030	96.79%	98.45%	70.49%	6760	204	100	1140	94.15%	97.13%	67.34%
TDS Calc	3108	117	96.24%	3881	101	59.3	1090	97.40%	98.47%	71.91%	7480	200	122	1075	94.85%	96.86%	72.30%
SAR	3.2	0.2		6.9	1.4	2	2.7				1.5	0.1	0.2	1			
Total Alkalinity CaCO3	88.8	9.2	89.64%	100	32	38	52	68.00%	62.00%	48.00%	82	20	21	35	80.00%	79.00%	65.00%
Total Hardness CaCO3	1660	79.6	95.20%	1510	37.3	13	491	97.53%	99.14%	67.48%	4940	132	55.1	640	91.26%	96.35%	57.62%
Bicarbonate as HCO3	88.8	9.2	89.64%	100	32	38	52	68.00%	62.00%	48.00%	82	20	21	35	80.00%	79.00%	65.00%
Carbonate as CO3	0	0		0	0	0	0				0	0	0	0			
Hydrogen as OH	0	0		0	0	0	0				0	0	0	0			
Nitrate Nitrogen	0.5	0.1	80.00%	6.99	0.566	0.198	2.19	91.90%	97.17%	68.67%	0	0.465	0.417	1.43	93.35%	94.03%	79.54%
Nitrite Nitrogen	0.004	0.004		0	0	0	0				0	0	0	0			
Chloride	170	11.6	93.18%	136	4.77	0.791	32.6	96.49%	99.42%	76.03%	280	42	21	43.2	69.12%	84.56%	68.24%
Fluoride	3.3	0.12	96.36%	1.74	1.65	0.041	0.463	5.17%	97.64%	73.39%	2.67	0.005	0	0.438	99.71%	100.00%	74.83%
Phosphate	6	0.3	95.00%	2.48	0.01	0.164	1.11	99.60%	93.39%	55.24%	0.769	0.037	0.069	0.403	98.51%	97.22%	83.75%
Sulfate	1940	63.5	96.73%	2480	39.2	12.9	700	98.42%	99.48%	71.77%	4880	48	21	656	98.06%	99.15%	73.55%
Iron	0.001	0		0.027	0	0	0.037				0.038	0.021	0.01	0.061			
Calcium	500	24.5	95.10%	492	12.5	4.56	163	97.46%	99.07%	66.87%	1880	48.4	20.1	227	90.16%	95.91%	53.86%
Magnesium	100	4.5	95.50%	67.3	1.47	0.401	20.3	97.82%	99.40%	69.84%	58.8	2.67	1.18	17.7	96.03%	98.25%	73.70%
Potassium	37.1	0.78	97.90%	13.9	0.07	0	3.03	99.50%	100.00%	78.20%	43.3	0.605	0.298	8.37	95.65%	97.86%	39.78%
Sodium	296	4.7	98.41%	619	19.9	16.2	135	96.79%	97.38%	78.19%	243	3.29	31.7	57.6	99.47%	94.88%	90.69%

Task 5: Complete a freezing study on the Air2Air™ Condensing Module

Farmington, New Mexico in the high desert of the American West, has substantial periods of cold weather during a yearly cycle. The Air2Air™ Water Conservation Validation Cell has operated over two winters with 1300+ hours below freezing annually. The Air2Air™ unit has operated without freezing water in dry ducts and without damage to components for the period.

This is because condensate remains on the wet/plenum side of the Air2Air™ module, where it is substantially exposed to a warm air stream that prevent freezing. While the plant is at heatload, there will be no freezing. If heatload is lost, evaporation quickly falls as the warm plenum air cools and condensation stops. Hence there is no water stream to freeze.

Task 6: Develop a plume dissipation wet/dry air mixing system and prediction model for the Air2Air™ Condensing System.

Plume abatement is a natural side effect of water conservation for the Air2Air™ Water Conservation Validation Cell. The photos below illustrate the very effective plume abatement capability of the Farmington unit in cold winter temperatures, without use of mixing baffles or other internal enhancements to the original Air2Air™ unit.

A2A Tower Operation - Operating A2A pictures during the period:

Date 2/09/09 Temperature 35 degF Relative Humidity 50%

Date 1/21/09 Temperature 27 degF Relative Humidity 65%

Task 7: Reporting

This report completes the project.

CONCLUSIONS

1. The Air2Air™ Water Conservation Validation Cell performed substantially as predicted.
2. Air2Air™ Water Conservation by condensation from the cooling tower evaporate was 97% of predicted over the range of temperature and humidity conditions at the Farmington, New Mexico site.
3. Air2Air™ Water Conservation by condensation from the evaporate was 18.5%, compared with a predicted 19%, over the range of temperature and humidity conditions at the Farmington, New Mexico site.
4. The condense Total Dissolved Solids ranged from 3 to 6% of the circulating water solids.
5. The Air2Air™ Water Conservation Validation Cell has operated without freezing water in dry ducts and without damage to components for the two full winters.
6. The Air2Air™ Water Conservation Validation Cell provided very effective plume abatement capability in substantial cold weather exposure.

Appendix:

"Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants"

Objectives -

The main goal of the proposed project is to research the benefits of deploying the Air2Air™ condensing technology in a cooling tower application at coal-fired electric power plants. The project will detail the ramifications of joining this new technology with an existing evaporative cooling process in coal-fired power plants, thereby equipping the power plant with the water recovery potential of the Air2Air™ condensing modules. The project will quantify the water conservation capability of the Air2Air™ condensing technology in plant cooling, segmented by time of day and season, and determine the pressure drop and energy use to conserve this water. The project will also develop a collection method for the recovered water, analyze this condensed-water quality, and identify specific in-plant recovered water usage potentials.

Performance of the Air2Air™ condensing technology will be determined by monitoring the Air2Air™ condensing module section of the hybrid cooling tower throughout the test period, entering collected water volume, pressure drop, temperature, relative humidity, and horsepower data in evaluation programs, and checking math model predictions versus results.

A study of freezing condition operation of the Air2Air™ Condensing technology will be completed. Cold weather exposure problems could pose a significant problem for this technology's application in much of the Western U.S., where water shortages and drought have been the most acute in recent years. Will the modules freeze to any great extent, and will this freezing do any structural damage to the modules or supports degrading the effectiveness of the modules?

Finally, the project will develop a wet/dry air mixing system for plume abatement, and study the dissipation of plume discharged from the cooling tower fan. CFD analysis will be performed on several mixing baffle configurations to develop the best plume characteristics from the Air2Air™ Hybrid Cooling Tower system. It will then compare this technology's plume abatement capability to that of existing conventional coil systems.

Scope of Work -

Tasks to be Performed

Retrofit Existing cooling tower cell with Air2Air™ condensing technology

- Engineering Design / Drafting – Marley Engineering will review and inspect the existing cooling tower structure to determine its ability to accept added weight, structural loads, and physical changes that would result from this research condensing unit's construction on the particular chosen site. Marley Engineering will design the required structure in the base unit. Additional member size, location, and attachment will be documented in project drawings. Marley Engineering will design the suitable Air2Air™ Condensing Unit for addition to the base tower. A bill of materials [BOM] for the base tower modifications along with the Air2Air™ Condensing Unit will be prepared and materials purchased to complete the construction of the Test Tower, as detailed in the budget references attached. It is expected that this task will be completed prior to the award of the grant, therefore no costs were assigned to this task.

- Construction and Installation – Marley Construction will receive materials and prepare the site for retrofit construction work from the basin [foundation] of the existing tower on up adding modifications to the base tower structure, and attaching the new Air2Air™ Condensing structure to the fan deck level of the base tower. The Air2Air™ Condensing Unit consists of structure supporting the Air2Air™ Condensing Modules, air ducting to channel cooler external air to the modules while keeping it separate from the hot moist tower exit air, casing and dampering to enclose the structure and manage airflows, fan deck, and finally fan components to move air through the evaporative cooling and Air2Air™ Condensing sections of the hybrid cooling tower.

- Install Testing/Monitoring Instruments – The purpose of testing and monitoring instrumentation is to determine the functional results of operating Air2Air™ Condensing Technology with an evaporative cooling tower system. This comparison requires measuring to a consistent and verifiable level the performance of the base Cooling Tower and the Air2Air™ Condensing water conservation system, represented by the Modules, as applied to that same power plant cooling system. The overall data requirements include air and water stream temperatures, air and water flows, and water quality determinations at multiple locations.

Figure 8 gives an overall indication of the critical mass balance that must be reconciled in order to determine the net effect of the added Air2Air™ Condensing Technology on the evaporation rate of the Cooling Tower.

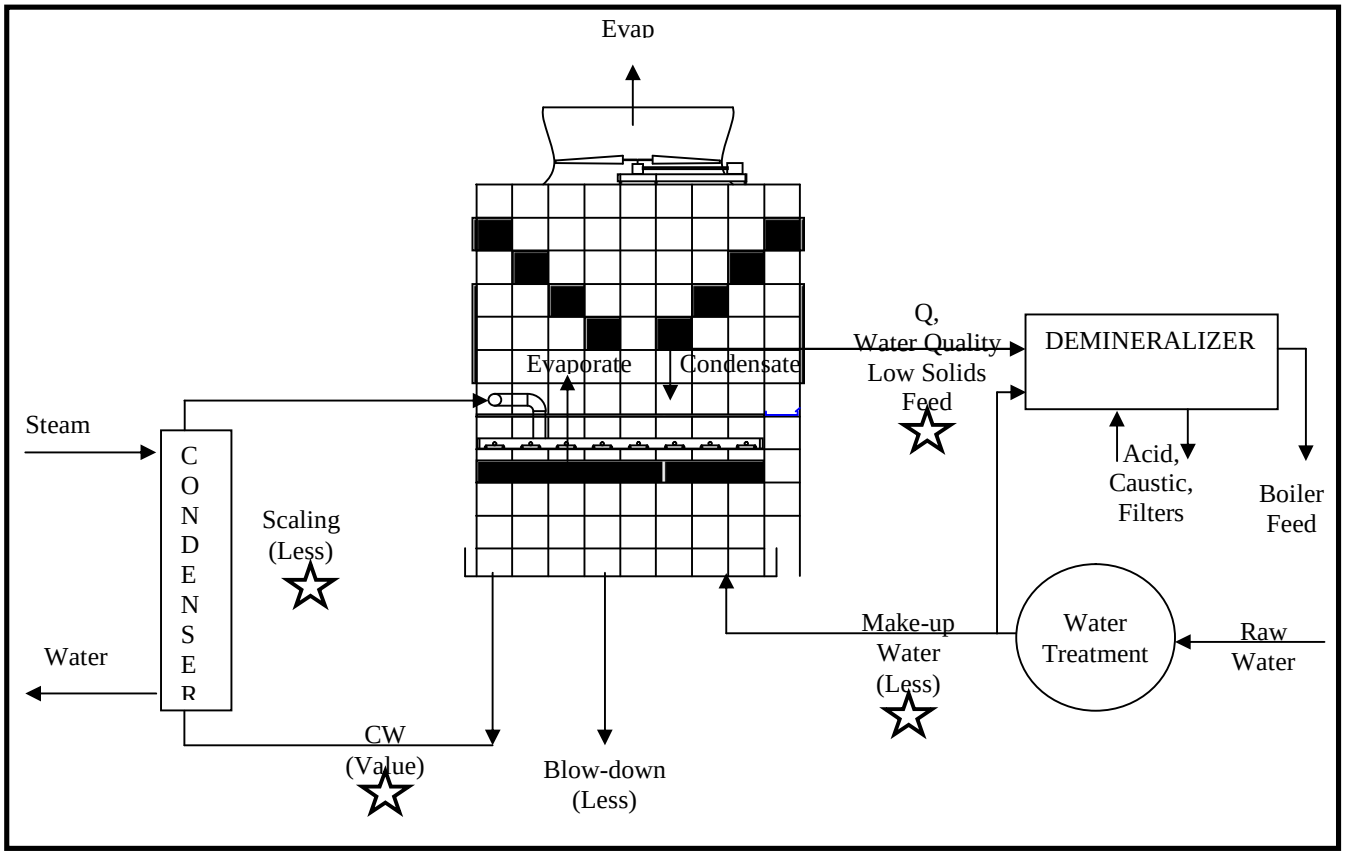


Figure 8 – Mass Balance of Air2Air™ Condensing System

Previously Completed Tasks

Milestone1/Year1, “Finalize Host Site Agreement with Power Company”- The Host Agreement was completed on 8/24/06. This agreement was concluded with Public Service of New Mexico, for test at their San Juan Generating Station in Farmington, New Mexico. The specific items that were required for agreement were:

1. Construction Agreement, No. 1011874, 5/23/06
2. Confidentiality Agreement, No. 1011276, Appendix E, and Amendments, Appendix F, 8/24/06
3. Individual Task Agreement, Contract No. 01011874, ITA 01, 8/24/06

Milestones2/Year1 “Engineering Design and Procurement” – Engineering design has been undertaken full speed at this time. The steps taken in this reporting period provide the following specifics:

1. DOE NETL Kick-off Meeting – SPX Cooling attended this meeting at NETL in Pittsburg, Pennsylvania, on 6/20/06. Tom Dendy, VP of R&D and Marketing, Glenn Brenneke, Director of R&D, and Ken Mortensen, Technical Director for Water Resources attended. Ken Mortensen reported on progress to that date.

2. Motor Special – The A2A Technology design requires a special 300HP/460V/224KW/1785RPM motor, larger than any currently used on SPX Cooling Towers, to provide airflow for cooling and water conservation. That item was identified as long lead-time and advance ordered for the project on 9/20/06.

3. A2A Cooling Tower General Arrangement Drawings showing the overall design completed, Drawings are numbered 06-4299 and 06-4300, dated 9/21/06.

4. Piping Design for integrating water flow from existing Cell 2 to the New Cell 1 housing the A2A Technology was defined on Drawings 06-25381 and 06-25382, dated 9/27/06.

5. Make-up Piping and Basin Dam designs for water management were considered, but not finalized during the period. [Dated 10/4/06]

6. Site Kick-off Meeting – SPX Cooling Technologies visited the San Juan Site on 9/19/06 to discuss the project scope, schedule, and work plan with Russell Huffman, PNM San Juan Plant Manager and his Staff. Attending from SPX Cooling were Tom Dendy, VP of R&D and Marketing, Glenn Brenneke, Director of R&D, and Ken Mortensen, Technical Director for Water Resources.

7. PNM San Juan Site Environmental Questionnaire – Substantial information for this submission was collected during the period. [Submitted 10/9/06]

Tasks Completed During the Period, 10/1/06-12/31/06**:**

Task 1 [Milestone 2 of Year 1] - Retrofit one cooling tower cell using Air2Air^{TM} technology:

The Validation Cell cooling tower design was completed during the period. SPX Cooling Technologies optimized and finish detailing the test cooling tower cell for the PNM San Juan Generating Facility. That A2A Validation Cell detailed design completed during the period, is reflected in the following description of engineered component groups as planned by SPX cooling technologies:

12. **W496-6.56-01A2A General Arrangement of A2A Validation Cooling Tower Cell with the Existing Tower** - Design and Drawings, showing the overall arrangement and basin details are numbered 06-4299, 06-4300, 06-4301, and 06-4302 completed 9/21/06. An Acrobat file of these drawings is included on page 12 at the end of this document.

13. **Existing Tower End-wall Casing** – to close up existing tower at the location the A2A Validation Cell is added. Design of structure and casing panel attachment to existing Class 600 tower end-wall, design completed 10/16/06.

14. **A2A Validation Cell Basin Dam** – Support and panel materials designed to separate the cold water in the A2A Validation cell from the water flowing through the remainder of the existing tower for temperature and flow volume measurement purposes, design completed 10/20/06.

15. **A2A Validation Cell Cooling Tower Structure** – This A2A cell is comprised of connected longitudinal frames, running along the cell length, made up of columns, girts, and diagonals, and transverse frames running the cell width and also made up of columns, girts, and diagonals. The structure is 66'-8" wide X 36'-8" long X 76'-3 1/8" tall to the fan deck, with an 18' fan cylinder/housing on the top. Structure is described as built below:

    a. Longitudinal frame bents, 12 in all on 6' centers, type 1, 2, 3, and 4, design completed 11/9/06.
    b. Transverse frame bents, 7 in all on 6' centers, type 1, 2, and 3, design completed 11/9/06.

16. **Fill** - PVC Film Fill media 6.56' tall installed across a 54' X 36' segment of the A2A Validation Cell plan area at a 14'-3/4" elevation and chosen for compatibility with the water conditions in the tower, design completed 10/13/06.

17. **Eliminator** – PVC Film tri-pass eliminators 5-3/4" tall installed across a 54' X 36' segment of the A2A Validation Cell plan area at a 28'-9 ¼" elevation, design completed 10/14/06.

18. **Air Seal** – Wood eliminator air seals installed at structural penetrations of the eliminators, design completed 10/11/06.

19. **Spray System** – Nozzles, connectors, header, and branch pipes set out in an array above the fill and below the eliminators at an elevation of 22'-9 ¼", with connection to the existing cooling tower piping, design completed 10/11/06.

20. **Mechanical** – Fan blades, fan hub, gear-reducer, driveshaft, motor, torque tube support providing the airflow through the film fill and the A2A media, based on previous design information included in this tower 10/06.

21. **A2A Components/Extended Plenum** – Separate dry air and wet air chambers with inlet screens leading to multiple levels of A2A heat exchange modules with eliminators at the wet air release surface at elevations from 34'-9 ¼" to 58'-9 ¼", design completed 11/8/06.

22. **Access** – Multiple ladders and landings with air seal doors for entry to the A2A modules, completed 12/5/06.

23. The completed design, described above generates parts "Bills of Material" for each design group. These BOM's have been transmitted to SPX Cooling Technologies materials procurement group. The project is proceeding with procurement to meet the construction schedule as laid out in the project milestones provided to the DOE.

Tasks Completed During the Period, 1/1/07-3/31/07**:**

Task 1 [Milestone 2 of Year 1] - Retrofit one cooling tower cell using Air2Air™ technology:

The Validation Cell cooling tower materials of construction including experimental Air2Air™ Water Conservation Technology were largely procured during the period, as reflected in the following description of engineered components:

1. **Existing Tower End-wall Casing and Fire Partition** – Bill of Materials completed 10/16/06-2/07, delivered 10/25/06-3/2/07
2. **A2A Validation Cell Basin Dam** – Bill of Materials completed 10/16/06, delivered 10/25/06
3. **A2A Validation Cell Cooling Tower Structure** – Structure is described as built below:

    a. Longitudinal frame bents, 12 in all on 6' centers, type 1, 2, 3, and 4, BOM completed 11/9/06, delivered 1/25-2/27/07
    b. Transverse frame bents, 7 in all on 6' centers, type 1, 2, and 3, BOM completed 11/9/06, delivered 1/25-2/27/07

4. **Fill** - MVC20 PVC Film Fill media, BOM completed 10/13/06, delivered 1/25-3/2/07
5. **Eliminator** – TU12 PVC, BOM completed 10/13/06, delivered 1/25-3/2/07
6. **Spray System** – Nozzles, connectors, header, and branch pipes, BOM completed 10/13/06, delivered 1/25/07
7. **Mechanical** – Fan blades, fan hub, gear-reducer, driveshaft, motor, torque tube support, BOM completed 10/06, delivered 1/24-2/4/07
8. **A2A Components/Extended Plenum** – Separate dry air and wet air chambers with inlet screens, A2A heat exchange modules, BOM completed 11/8/06, delivered 1/25-3/2/07 [A2A Modules delivered 3/1/07-5/1/07
9. **Access** – Multiple ladders and landings BOM completed 12/5/06, delivered 1/25-3/2/07

The completed design generated parts "Bills of Material". These BOM's have been procured to meet the construction schedule as laid out in the project milestones provided to the DOE.

Demolition of the existing tower cell was completed during the period. See pictures of the demolition progress and procured materials of construction below:

Tasks Completed during the Period, 4/1/07-6/30/07**:**

Task 1 [Milestone 2 of Year 1] - Retrofit/Construct one cooling tower cell using Air2Air™ technology:

Construction of the Validation Cell cooling tower including experimental Air2Air™ Water Conservation Technology was substantially completed during the period, as described in the following task listing and pictures:

10. **Existing Tower End-wall Casing and Fire-Partition** – Close off the end-wall of the existing cooling tower and provide a fire-partition protecting that existing tower from the Validation Test Cell; Construction task completed by about 4/2/07.

11. **Make-up Pipe Re-routing –** The make-up water feed pipes for the existing tower were located in cell #1. In order to anchor the new validation cell to the basin [foundation], a dry basin floor had to be created. The make-up water pipes had to therefore be re-routed into cell#2. This construction task completed by about 4/30/07.

12. **A2A Validation Cell Basin Dam** – Once the make-up water pipes were re-routed into cell#2, see item 2, a basin dam had to be constructed to keep tower water from flowing back into cell#1. This construction task completed by about 5/21/07.

13. **A2A Validation Cell Cooling Tower Structure** – Structure construction began about 4/13/07 and continued until task completion about 6/21/07. This structure was staged in 12' to 18' lifts, built on the ground, and hoisted into place. Structure construction was ongoing, as other Cooling Tower and Air2Air™ components were installed in the framework. The types of erection bents are described below:

    a. Longitudinal frame bents, 12 in all on 6' centers, type 1, 2, 3, and 4.
    b. Transverse frame bents, 7 in all on 6' centers, type 1, 2, and 3.

14. **Fill** - Film Fill Cooling Tower media was installed in the Validation cell frame by about 5/14/07.

15. **Eliminator** – Eliminators were installed in the Validation cell frame by about 6/4/07.

16. **Spray System** – Nozzles, connectors, headers, and branch pipes, installed in the Validation cell frame by about 5/21/07.

17. **Mechanical** – Fan blades, fan hub, gear-reducer, driveshaft, motor, torque tube support, and fan cylinder were installed in the Validation cell frame by about 6/28/07.

18. **A2A Components/Extended Plenum** – A2A heat exchange modules were installed in the Validation cell frame by about 6/4/07.

19. **Access** – Multiple internal access ladders and landings were installed in the Validation cell frame by about 6/28/07.

With these tasks complete the Validation Test Cell was ready for water feed piping and electrical fan circuit hook-up to provide a completely operable water conservation cooling tower cell. The completed cell is being readied for start-up, check operation, and measurement of water conservation, as laid out in the project milestones provided to the DOE. Several additional construction tasks are being finished, as the test cell proceeds towards full operation:

1. **Instrumentation** – A number of test instruments have been installed and wired to retrieve the required data on evaporation, cooling, and water condensation/conservation.
2. **Access Stairs** – The external stairs to the internal walkways and fan deck of the Validation Test Cell are still being constructed.

See pictures of the construction progress below:

Tasks Completed During the Period, 7/1/07-9/30/07**:**

Task 1 [Milestone 1 of Year 2] - Construction of one cooling tower cell including Air2Air™ technology:

Construction of the Validation Cell Cooling Tower including experimental Air2Air™ Water Conservation Technology was completed during the period, as described in the following task listing and pictures. Several external construction tasks were finished, as the test cell proceeds towards full operation.

3. **Ducting** – Screens and Air Dams were added.
4. **Water Feed Piping** –Leaks and alignment were fixed.
5. **Instrumentation** – Test instrumentation was completed to retrieve the data on evaporation, cooling, and water condensation/conservation.
6. **Access Stairs** – The external stairs, the internal walkways, and fan deck access of the Validation Test Cell were completed.

Validation Test Cell is ready for and electrical fan circuit installation to be provided by Public Service of New Mexico. This circuit is to be provided during the San Juan Unit 4 Maintenance Outage starting on

and running 9/8/07 through 11/4/07. Additional Starter protection for the fan circuit will be procured and installed after the outage. This electrical service will finish out a completely operable water conservation cooling tower cell. See pictures of the construction progress below. The completed cell is being readied for start-up, check operation, and measurement of water conservation, as laid out in the project milestones.

Tasks Completed During the Period, 10/1/07-12/31/07**:**

Task 1 [Milestone 1 of Year 2] - Construction of one cooling tower cell including Air2Air^{TM} technology:

Construction of the Validation Cell Cooling Tower including experimental Air2Air^{TM} Water Conservation Technology was completed during the previous period, as described in the task listing and pictures in the next section. Several SPX Cooling "punch-list" construction tasks were finished and the Fan Electrical Circuit was completed during the period. The Air2Air^{TM} Validation Test Cell saw some very limited operation during the period.

7. **Collection System** – Sealing of the Condensate Collection Basins was improved.
8. **Instrumentation** – Test instrumentation was enhanced to retrieve the data on evaporation, cooling, and water condensation/conservation.
9. **Fan Electrical Circuit** – Installation provided by Public Service of New Mexico. Additional Starter protection for the fan circuit was procured and installed.

Task 2 [Milestone 1 of Year 3]: Monitor the Air2Air^{TM} Condensing Module annually and check the water recovery prediction math model for validation:

Validation Test Cell was operated for a very limited period after the outage during the period. The completed cell is ready for check operation, and measurement of water conservation, as laid out in the project milestones. This begins the data collection and analysis phase of the project. See operating picture below:

Tasks Completed During the Period, 1/1/08-3/31/08**:**

Task 2 [Milestone 1 of Year 3]: Monitor the Air2Air^{TM} Condensing Module annually and check the water recovery prediction math model for validation:

Validation Test Cell was operated for approximately 2 months of the period after the plant placed Unit #4 on-line again. The completed cell was evaluated for operation, instrumentation, and measurement of water conservation/collection, as laid out in the project milestones. Some re-work of water collection and cold-water measurement capabilities were identified and are being completed. This begins the data collection and analysis phase of the project.

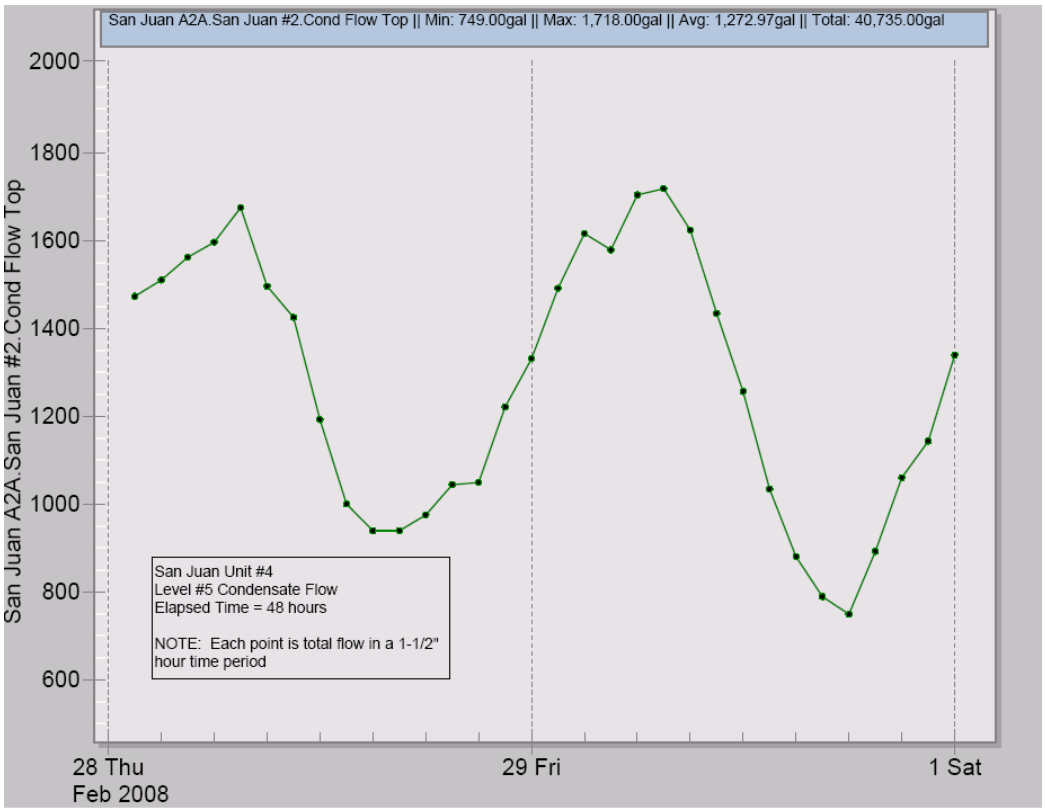
A2A Tower Operation:

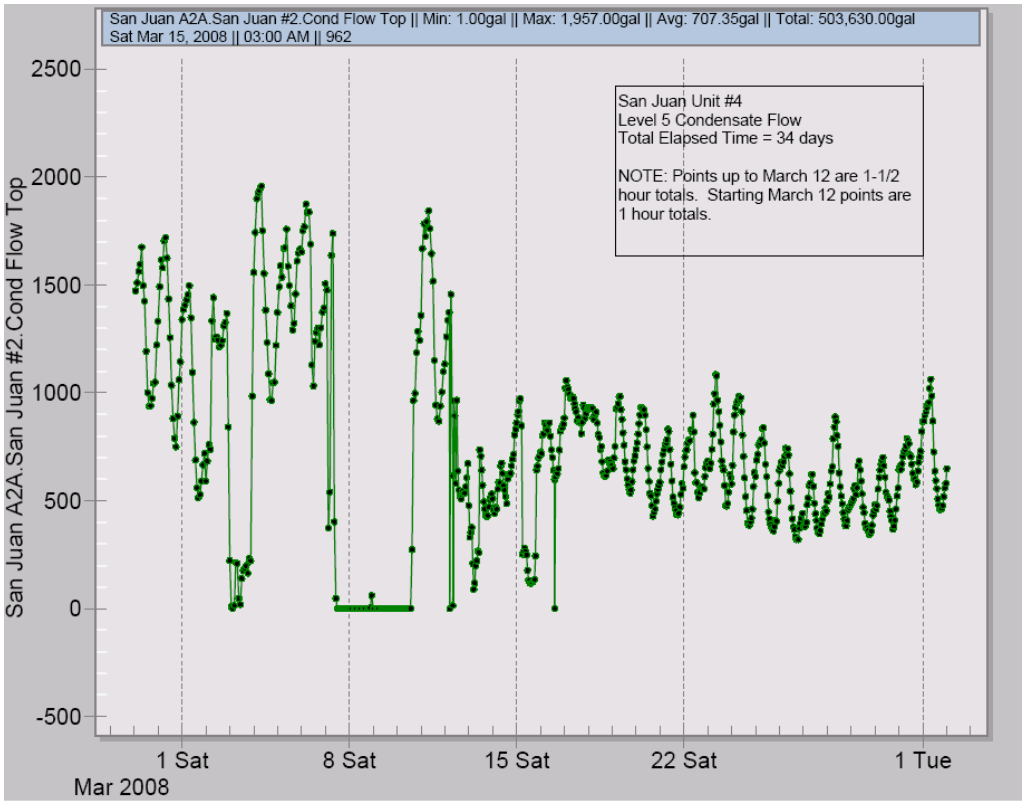
- Attachment "San Juan Chart 2.pdf" below, shows the "Saved Water" as Condensate Flow, San Juan Unit #4, Level #5 for 48 Hours, February 28 - March 1, Total = 40,735 Gallons collected and averaging 14.1 Gallons Per Minute for that period. Notice the variation of water condensed from warmer daytime hours to cooler nighttime conditions.
- Attachment "San Juan Chart 3.pdf" below, shows the "Saved Water" as Condensate Flow, San Juan Unit #4, Level #5, for 34 days, February 28 - April 2, Total = 503,630 Gallons collected, with the unit operating all that time except 4 days, and averaging 11.8 Gallons Per Minute for that period. Variation of weather conditions accounts for changes in the condensed water quantity day to day.

Based on the measurements made so far, SPX Cooling Technologies R&D believes that the A2A tower "water savings" are in and “as predicted” range for our model. The A2A Modules and Tower are operating well. These results however are not a complete picture of the cell operation yet. Issues as follows:

- Thermal Performance Test without A2A in operation [Scheduled April 21]
- Thermal Performance Test with A2A in operation [Scheduled for April 28]
- A2A Air Traverse, Temperature and Airflow
- Basin Cold Water Temperature, segregated for the A2A cell

Collection System Integrity





Tasks Completed During the Period, 4/1/08-6/30/08**:**

Task 2 [Milestone 1 of Year 3]: Monitor the Air2Air™ Condensing Module annually and check the water recovery prediction model for validation. The testing steps completed during the period are as follows:

- Thermal Performance Test without A2A in operation [Week of April 21]
- Thermal Performance Test with A2A in operation [Week of April 28]
- A2A Air Traverse, Temperature and Airflow [Week of April 28]

A2A Validation Cell Water Conservation Test Summary:

The A2A Cell and Modules are operating well. The SPX Cooling Technologies R&D A2A Test Team believes that, based on all of our observations, the A2A Validation Cell is performing in a range that includes its predicted total tower water conservation performance. The actual performance may be slightly above or below that predicted performance. The A2A Test Team is not able to produce “Performance Guarantee” quality data to support this overall observation based on the April 2008 site testing.

Additional focused testing on a specific more limited segment of the A2A modules will be undertaken, with the goal of aligning the A2A Condensate Water Collection more rigorously with simultaneous A2A exit temperature and airflow data and comparing that to the predicted Water Condensate quantities. A2A verification is an iterative process, with each test building on and improving the accuracy and methodologies of the previous steps.

The data gathered at the April 2008 site testing for several diverse indicators of A2A performance are giving differing results when analyzed. These results are scattered around the 100% of predicted mark, some higher and some lower. They are generally in a +/- 20% band, although there are some outliers.

Data Analysis Method 1, using on-site temperature traverse data and distributed airflow based on fan performance, shows 97 to 120% performance for Level 2 and 118 to 134% for Level 5, as derived from water collected. For Level 4 on the other hand, Method 1 shows only 43 to 55% performance.

Data Analysis Method 2, using air velocity distribution from the prediction model, shows 79 to 93% performance for Level 2 and 77 to 96% for Level 5 as derived from water collected. For Level 4 on the other hand Method 2 shows only 37% performance.

Task 3: Developing a Water Collection System for the Condensate- A2A condensate water collection in an operating tower is difficult. Attaining collection of 100% of the water condensed by the A2A system has not been accomplished here.

Condensate Water Collection, Level 5 Condensate Water Collection is the most complete, with Level 2 Collection being fairly good. Level 4 Collection is believed to be substantially off the mark.

Overall A2A Testing Goals Progress:

1. A2A Cell Airflow Evaluation – there is reasonable agreement between actual airflow and model prediction, as verified by this test. This indicates potential for predicted heat exchange and condensation.

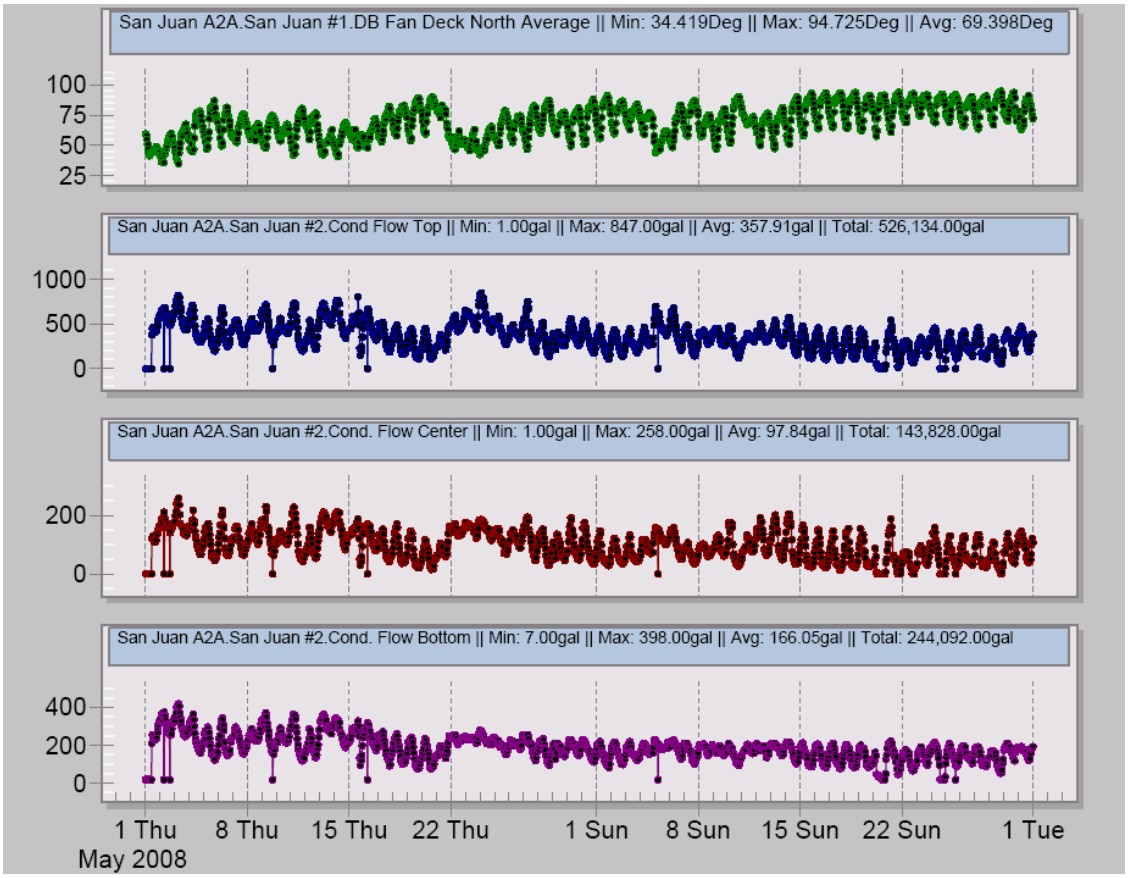
2. A2A Pack Heat Transfer Evaluation – pack heat transfer, as measured by traverse temperatures, leads us to believe that heat transfer is in a range around the prediction.

3. A2A Condensate Water Collection Capability – the collection of condensed water in a full-sized tower is difficult. It is not reasonable to use this method wholesale, as a verification of A2A performance.

4. Continued Testing - test a specific more limited segment of the A2A modules to further define the A2A capability relative to prediction.

A2A Tower Operation:

Attachment “San Juan A2A” below, shows data for the month of May 2008. The top graph is Ambient or Dry Bulb Temperature for the period. The other 3 graphs are the "Saved Water", as Condensate Flow, from three distinct A2A levels: Top, Center, and Bottom, Total for May = 914,054 Gallons conserved and averaging 20.47 Gallons Per Minute for that period. Notice the variation of water saved from warmer daytime hours to cooler nighttime conditions and as temperatures increased during the month. This data is provided as an example of A2A System capability. It does not equate with full cell capability or percentage of total tower evaporation, because it is only partial collection of total condensate. It shows an A2A system operating consistently over a long period of time and producing substantial water savings.



Tasks Completed During the Period, 7/1/08-9/30/08**:**

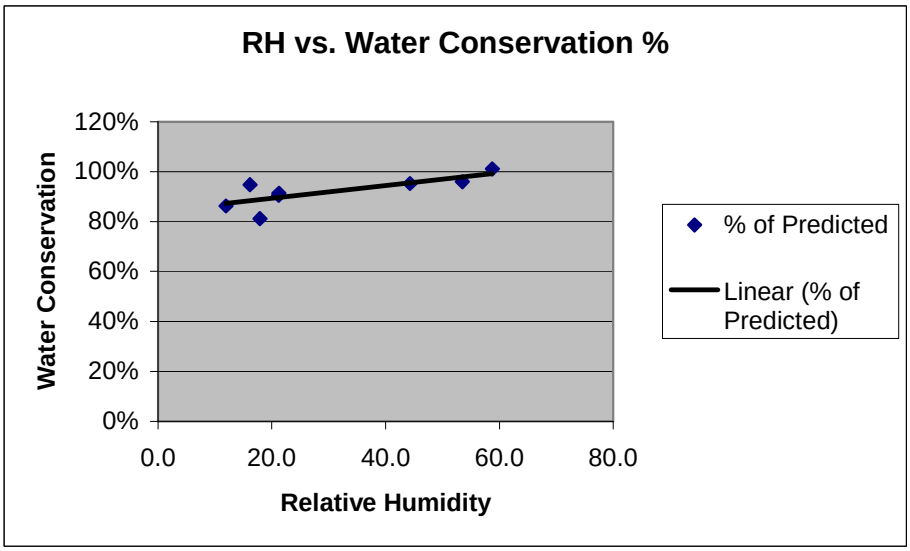
Task 2 [Milestone 1 of Year 3]: Monitor the Air2Air^{TM} Condensing Module annually and check the water recovery prediction model for validation. The testing steps completed during the period are as follows:

- Ongoing Thermal Performance Data Analysis with A2A in operation

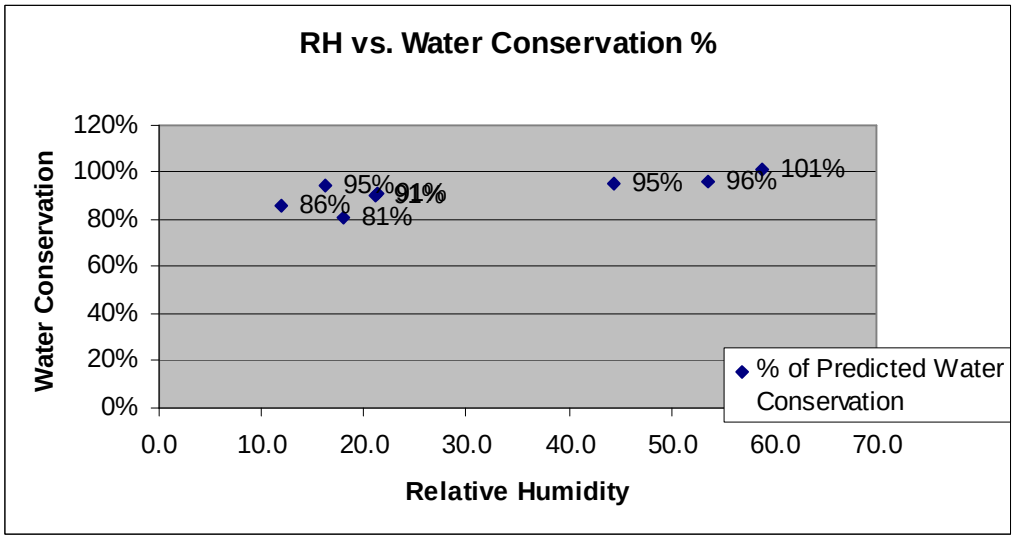
A2A Validation Cell Water Conservation Test Summary:

The SPX Cooling Technologies R&D A2A Test Team has analyzed the A2A Validation Cell performance based on the April 2008 site testing and ongoing monitoring of the day-to-day site operations. The graphs below illustrate the accuracy level of the Air2Air performance prediction model at various conditions. The model is more accurate at higher relative humidity conditions, averaging 97% at several test points with a 52% Relative Humidity average. The model was on average 88% accurate at a 17% Relative Humidity average.

The Air2Air cell is performing at 95%+ in conditions that prevail at most U.S. locations. The changing accuracy of the prediction model with Relative Humidity will be added to the prediction process for Air2Air applications.



RH vs. Water Conservation with Trend Line



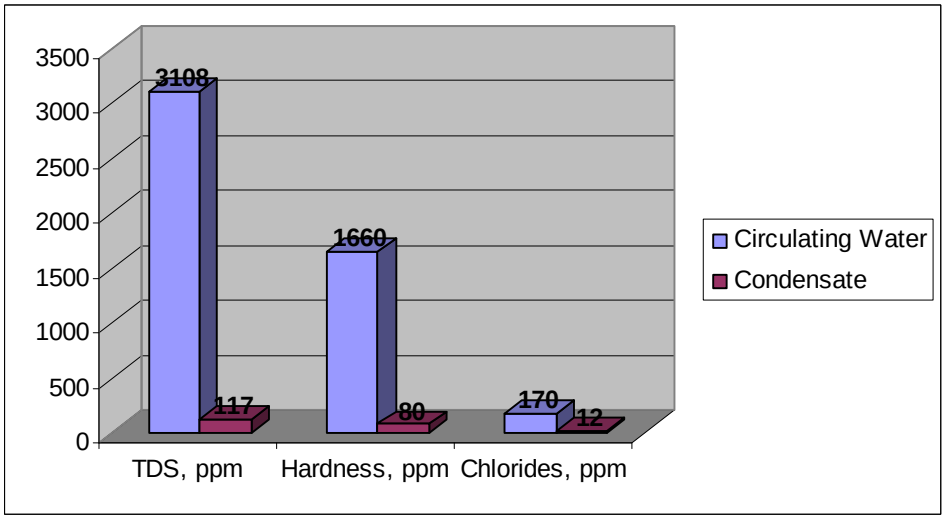
RH vs. Water Conservation with Data Specifics

Task 3: Developing a Water Collection System for the Condensate- A2A condensate water collection in an operating tower is difficult. Attaining collection of 100% of the water condensed by the A2A system has not been accomplished here.

Condensate Water Collection, Level 5 Condensate Water Collection is the most complete, with Level 2 Collection being fairly good. Level 4 Collection is believed to be substantially off the mark.

Task 4: Analyze the water quality of the collected condensate and identify applications that are able to use the collected water.

Condensate water was collected and analyzed for Total Dissolved Solids, Hardness, and Chlorides, during the period. As illustrated in the graph below, TDS and Hardness were reduced by over 95% and Chlorides by nearly 93% by the condensing action of the A2A Validation Cell.



Overall A2A Testing Goals Progress:

5. A2A Performance Prediction Model - The Air2Air cell is performing at 95%+ in conditions that prevail at most U.S. locations.

    a. The prediction model is more accurate at higher relative humidity conditions, averaging 97% at several test points with a 52% Relative Humidity average. The model is less accurate, average 88%, at a 17% Relative Humidity average.
    b. A2A Pack Heat Transfer Evaluation – pack heat transfer, as measured by traverse temperatures, reinforces the conclusion that heat transfer is in a range near prediction.
    c. A2A Cell Airflow Evaluation – there is reasonable agreement between actual airflow and model prediction, as verified by this test. This reinforces the conclusion that heat transfer is in a range near prediction.

6. A2A Condensate Water Collection Capability – the collection of condensed water in a full-sized tower is difficult. It is not reasonable to use this method wholesale, as a verification of A2A performance.

7. A2A Condensate Water Chemistry – In operation, 93-95% reductions in solids in the circulating water were achieved.

A2A Tower Operation - Operating A2A pictures were provided in the 9/30/08 Report.

Tasks Completed During the Period, 1/1/09-3/31/09**:**

Task 2 [Milestone 1 of Year 3]: Monitor the Air2Air™ Condensing Module annually and check the water recovery prediction model for validation. The testing steps completed during the period are as follows:

- Ongoing Thermal Performance Data Analysis with A2A in operation

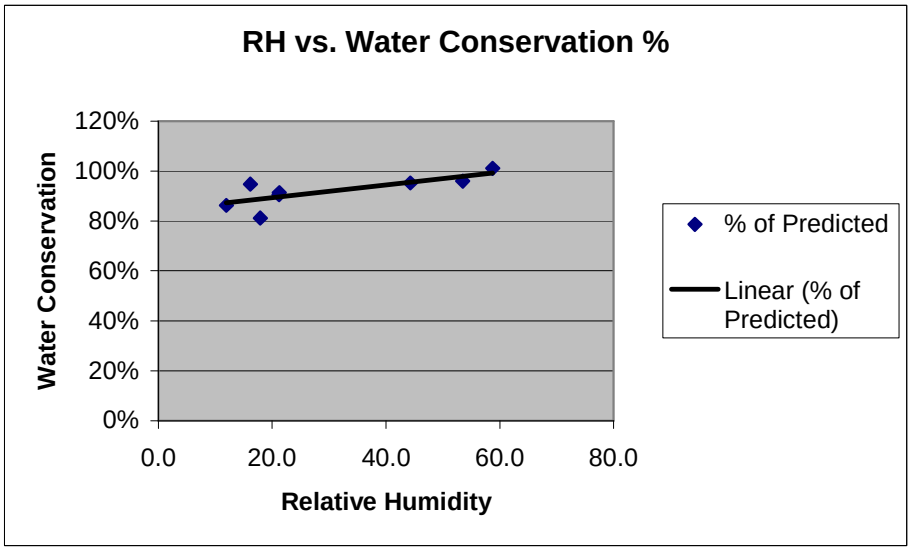
Task 4 [Milestone 1 of Year 3]: Analyze the water quality of the collected condensate and identify applications that are able to use the collected water. The testing steps completed during the period are as follows:

- Water Quality Testing

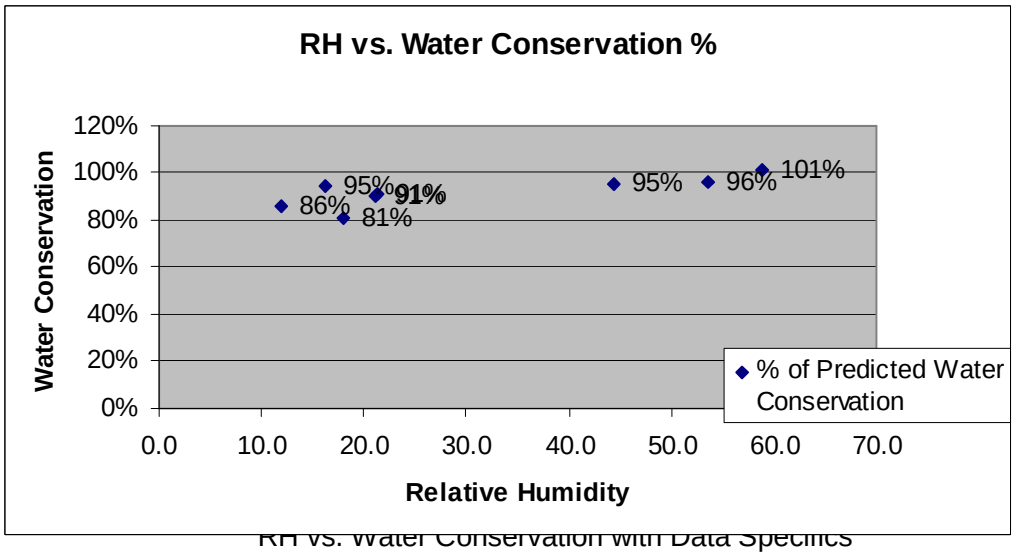
A2A Validation Cell Water Conservation Test Summary:

The SPX Cooling Technologies R&D A2A Test Team has continued to monitor and analyze the A2A Validation Cell performance based on the April 2008 site testing and ongoing monitoring of the day-to-day site operations. The graphs below were included in the 9/30/08 Report and illustrate the accuracy level of the Air2Air performance prediction model at various conditions. The model is more accurate at higher relative humidity conditions, averaging 97% at several test points with a 52% Relative Humidity average. The model was on average 88% accurate at a 17% Relative Humidity average.

The Air2Air cell is performing at 95%+ in conditions that prevail at most U.S. locations. The changing accuracy of the prediction model with Relative Humidity will be added to the prediction process for Air2Air applications.



RH vs. Water Conservation with Trend Line



RH vs. Water Conservation with Data Specifics

Overall A2A Testing Goals Progress:

8. A2A Performance Prediction Model - The Air2Air cell is performing at 95%+ in conditions that prevail at most U.S. locations.

    a. The prediction model is more accurate at higher relative humidity conditions, averaging 97% at several test points with a 52% Relative Humidity average. The model is less accurate, average 88%, at a 17% Relative Humidity average.
    b. A2A Pack Heat Transfer Evaluation – pack heat transfer, as measured by traverse temperatures, reinforces the conclusion that heat transfer is in a range near prediction.
    c. A2A Cell Airflow Evaluation – there is reasonable agreement between actual airflow and model prediction, as verified by this test. This reinforces the conclusion that heat transfer is in a range near prediction.

A2A Tower Operation - Operating A2A pictures during the period:

Date 2/09/09 Temperature 35 degF Relative Humidity 50%

Date 1/21/09 Temperature 27 degF Relative Humidity 65%

AHEdoeprogressreportfinalreview093009submitted.doc