

## **Utility Perspective**

*Joe Turnage, Constellation / Unistar*

Policy issues surrounding water scarcity and requirements for electricity generation are becoming tightly interconnected. Both operating and proposed new build generation are affected, with the most serious challenges facing new nuclear plants. New technology must be pursued to focus on improving performance and reducing costs with currently identified options and on creating new options.

---

---

## **Energy/Water Interdependencies and Emerging Challenges**

*Mike Hightower, Sandia National Laboratories*

Water is frequently referred to as a “shared” resource, meaning all sectors of society share an interest in its use and health. The ready availability of fresh clean water and energy are essential for societal and economic vitality. Energy is one of the largest water using sectors and emerging electric power needs and alternative transportation fuels production could more than triple water use for energy production by 2025. This will put the energy sector into stiff competition with other sectors for access to increasing limited fresh water resources.

Because the issue of energy and water sustainability cuts across all societal sectors, there is significant value in addressing it with cross-sector collaborations. The presentation will provide an overview of recent national efforts to identify emerging national and regional energy and water related issues and challenges, and recommendations on future research, resource assessment, technology development, and planning directions. Background information on energy and water interdependencies and issues is available in a 2007 Report to Congress on Energy Demands on Water Resources at [www.sandia.gov/energy-water](http://www.sandia.gov/energy-water)

---

---

## **Water for America Initiative: Examining Quantity, Quality, and Use**

*Eric J. Evenson, U.S. Geological Survey*

The 21st century brings with it a new set of water-resource challenges. Water shortage and use conflict have become more commonplace in many areas of the United States—even in normal water years—for irrigation of crops, for growing cities and communities, for energy production, and for the environment and species protected under the law. Much has changed since the last overall assessment of water resources for the Nation was

published by the Water Resources Council in 1978. Over the next ten years, the U.S. Geological Survey (USGS) plans to conduct a new assessment of water availability for the Nation that will track changing flow, use, and storage of water, as well as develop models and predictive tools to guide water-management decisions. The President's FY09 budget for the USGS contains a new initiative, called Water for America. This initiative fulfills an important recommendation of the Subcommittee on Water Availability and Quality of the National Science and Technology Council: to conduct "... *an ongoing census of water that describes the status of our Nation's water resource at any point in time and identifies trends over time.*"

This presentation describes the technical plans for the Water for America Initiative. Published studies from the USGS pilot study of water availability on the Great Lakes watershed are presented. These studies include investigations of trends in surface-water flows and precipitation, estimation of shallow ground-water recharge, changes in ground-water storage and ground-water flow divides, examination of consumptive water-use coefficients and historical changes in Great Lakes levels. Finally, a stakeholder involvement effort, developed to involve interested parties in the final design of the initiative and its products, is discussed.

---

---

## **National Assessment of Water Availability**

*Sujoy Roy, Tetra Tech, Inc.*

This presentation summarizes the results of a study to evaluate the long-term sustainability of water withdrawals in the United States at a county-level. The analysis is focused on the availability of renewable water resources, the current withdrawals from surface water and groundwater sources and the stored water requirements during the warmest months of the year. Estimates of growth in population and electricity generation are used to estimate the change in withdrawals assuming that the rates of water use either remain at their current levels (the business as usual scenario) or that they exhibit improvements in efficiency at the same rate as observed over 1975-1995 (the improved efficiency scenario). The estimates show several areas, notably the southwest and major metropolitan areas throughout the US, as being likely to have significant new storage requirements with the business-as-usual scenario, under the condition of average water availability. These new requirements could be substantially eliminated under the improved efficiency scenario, thus indicating the importance of water use efficiency in meeting future requirements. The national assessment identified regions of potential water sustainability concern; these regions can be the subject of more targeted data collection and analyses in the future.

## **Potential Impacts of Climate Change on Water Resources and Implications for Power Plant Operations**

*Bill Mills, Tetra Tech*

Factors that affect water resource quantity and quality include population, land use, technology, industry, and climate. Changes in these factors could influence how the electric power sector uses water and thus affect power plant siting and design, cooling system operation, and power generation. Integrated risk frameworks can be used to analyze how the factors interact and their relative contributions to potential water resource impacts.

---

---

### **Thermal Load, Dissolved Oxygen, and Assimilative Capacity; Is 316(a) Becoming Irrelevant? – The Georgia Power Experience**

*Terry E. Cheek, Geosyntec Consultants, Inc.*  
*Bill Evans, Georgia Power Company*

The use of Clean Water Act Section 316(a) to avoid costly closed-loop cooling system retrofits is becoming unavailable as regulators increasingly apply dissolved oxygen criteria to force reductions in heat loads in receiving waters. Since 2002, Georgia Power Company has undertaken the retrofit of cooling towers on three coal fired power plants, involving eleven generating units totaling 3,300 megawatts. On one of these plants, a successful 316(a) demonstration proved that a partial capacity, once-through helper tower was sufficient, thereby saving upwards of \$50 million compared to a full capacity, closed loop cooling system. However, on the other two plants, the utilization of a 316(a) thermal variance provided no defense when the receiving stream was 303(d)-listed as impaired for dissolved oxygen (DO) and waste assimilation capacity became limited. Political pressure to support the region's economic growth through increased receiving stream waste assimilation capacity drove the utility away from consideration of 316(a) variances as a means to avoid costly retrofits. Similarly, a fourth plant located on a DO impaired stream in another developing region of Georgia will face the same pressures to remove its thermal loading. A section 316(a) variance will be of no help in addressing the plant's thermal load as it relates to impacts on in-stream DO resources and related reduction in assimilative capacity. This paper will detail the circumstances driving Georgia Power's decisions to convert these plants and the potential implications for use of 316(a) demonstrations going forward.

---

---

## **Zero Liquid Discharge Considerations for a Large Coal-Fired Power Plant**

*Dan Casiraro, Salt River Project*

Zero liquid discharge systems are becoming more of a potential option due to water constraints, NPDES permitting difficulties, discharge liability issues, and air quality issues. Although ZLD has many benefits, careful consideration must be given to the overall costs, design, construction, operational, and maintenance components. Given these challenges, ZLD still remains a reliable solution to eliminating water/wastewater discharges. The Salt River Project's Navajo Generating Station located on the Navajo Nation near Page Arizona is a ZLD facility. The facility began operation in 1974 and has utilized ZLD since that time.

This presentation will discuss the ZLD operations at the Navajo Generating Station and provide insights if there are facilities' that are considering the ZLD approach.

---

---

## **Grey Water Use at Palo Verde NPP**

*Bob Lotts, APS PVNPP*

Palo Verde, located 50 miles west of Phoenix in the Southwest desert, is the nation's largest nuclear power plant and the only nuclear power plant in the world not situated on a large body of water. The plant is owned by a consortium of seven utilities and is operated by APS.

The water reclamation facility processes municipal wastewater, or effluent, into cooling water for the power plant and also produces potable water for the plant's workforce. In addition, it provides cooling water for a nearby 1,060-megawatt natural gas power plant.

---

---

## **Spray Cooling for Performance Enhancement of Air-Cooled Condensers**

*J. Reid, JEA*

*K. Zammit, EPRI*

The presentation reviews the use of brackish water in hyperbolic cooling towers for the St. John's River Power Park, a joint project of JEA and FPL. The power park consist of two 650 MW coal units located in Jacksonville, FL. The FL DEP required SJRPP to use brackish water cooling towers to reduce the aquatic environmental impacts. To further reduce these impacts, the makeup is drawn from the circulating water discharge of a

sister unit, with temperatures ranging to 105F. SJRPP must meet a discharge permit condition of 96F (24 hour average) and 0% of total residual oxidants.

Operation of each tower at full load requires a makeup rate of 18,000 gpm (per tower), of which approximately 5500 gpm is evaporated. They are operated at 1.5 cycles of concentration, with the makeup chloride concentration of approximately 32,000 ppm.

The units went into operation in 1986 and 1987. SJRPP has experienced problems with plugging and performance of the tower packing, salt drift and corrosion of in-plant equipment, and corrosion of concrete reinforcement (loss of concrete and imbedded steel). The presentation will also provide details of the current project to repair this corrosion damage and protect the towers from further corrosion.



## **Reclaimed Water & Contaminated Groundwater Use at SCE's Mountainview Plant**

*Michael N DiFilippo, Consultant*

The 1,100 MW combined cycle Mountainview Power Plant, which is owned and operated by Southern California Edison, uses both reclaimed water and contaminated groundwater for cooling. Half of the cooling water comes from the City of Redlands wastewater treatment plant. The water is treated to meet California Title 22 reuse standards. The other half of the water comes from plant wells. Groundwater in the vicinity of the plant is contaminated with perchlorate a byproduct of rocket fuel testing. The plant discharges its wastewater to a regional interceptor that carries industrial wastewater to a coastal plant for final treatment and discharge to the Pacific Ocean. Mountainview is limited to the amount of wastewater it can discharge and must extensively treat its cooling water to reduce waste volumes. This presentation discusses the treatment system the plant has employed to operate under these conditions and constraints.



## **New Plant Siting at Lee Station (nuclear)**

*Bob Mohr, Duke Power*

Duke Energy is deploying two Westinghouse AP1000 units at a site in South Carolina. The Broad River, the normal surface water supply to the river, is subject to seasonal flow variations. To minimize impact to downstream users during low water flow conditions, the site plans to supplement or even replace withdrawals from the river with water from on-site impoundments.

## **New Plant Siting at Harris Site (nuclear)**

*Mick Greeson, Progress Energy*

Progress Energy Carolinas (PEC) filed a combined construction and operating license application with the Nuclear Regulatory Commission in February 2008 for two additional reactors at its Harris Plant site located 22 miles southwest of Raleigh, North Carolina. PEC is proposing wet, hyperbolic natural draft cooling towers for waste heat dissipation. To provide adequate and reliable make-up water for the towers, PEC proposes to increase the level of the existing Harris Lake by about 20 feet. PEC would also construct a new intake structure on the nearby Cape Fear River to provide make-up water for Harris Lake.

---

---

## **Site Selection Considerations – Oak Creek Power Plant Expansion Project**

*David M. Lee, P.E., We Energies*

In September 2000 Wisconsin Energy Corporation (WEC) announced plans to meet increasing demand for electricity by adding generating capacity. These plans included adding coal-fueled units at the Company's preferred location in Oak Creek, Wisconsin. The existing Oak Creek Power Plant (OCP), located in the southeast corner of Milwaukee County and adjacent to Lake Michigan, has four operating coal-fueled units with a combined capacity of about 1140 megawatts (MW).

Expanding coal-fueled electric generating capacity at the existing OCP provided multiple site selection advantages, including direct and adjacent access to:

- Lake Michigan for cooling water;
- Electrical transmission infrastructure; and
- Rail infrastructure for fuel transportation;

On February 1, 2002, subsidiaries of WEC filed an application with the Public Service Commission of Wisconsin to add two 615 MW advanced technology coal-fueled electrical generating units at the Oak Creek site (a.k.a., Elm Road Generating Station). On November 10, 2003, the PSCW approved two coal units to be added at the OCP site. Following issuance of multiple other major environmental permits, the company commenced construction in June 2005. Units are scheduled to be in-service in 2009 and 2010.

One unique advantage of the Oak Creek site is access to Lake Michigan, a water resource large enough to allow for a once-through open cycle condenser cooling water system. Operation of an open cycle system provides thermodynamic advantages that will allow

these advanced technology generating units to perform at maximum efficiencies. This cooling system has distinct advantages over cooling towers, including:

- It is the most thermally efficient condenser cooling technology (lowest amount of coal per unit of electrical production);
- Allows for lowest emission rates, including CO<sub>2</sub>, per unit of electrical production of any cooling technology;
- Costs less to build and operate; and
- Eliminates the visual impact of cooling towers and the related vapor plumes.

---

---

### **Closed-Loop, Evaporative Cooling Systems**

*Peter G. Demakos, P.E., Niagara Blower Company*

Cooling systems are an integral part of simple and combined cycle power plants. These systems are used for steam turbine condensing, aux loop fluid cooling, and as refrigerant condensers for gas turbine inlet air chilling systems. Closed-loop, evaporative coolers (also referred to as Wet Surface Air Coolers) are one such device.

The WSAC can provide the lowest outlet temperature, and since it requires less parasitic HP than other technologies, more power is available for sale. Less HP also equates to lower carbon emissions (carbon footprint). This presentation will focus on the design and operation, comparison to other heat transfer technologies, and benefits.

---

---

### **GEA - Hybrid Systems - ACCs**

*Luc Debacher, GEA*

---

---

### **Use of Air2Air™ Technology to Recover Fresh-Water from Evaporative Cooling at Power Plants**

*Tom Dendy, SPX Thermal Equipment & Services*

Thermoelectric power generation is water intensive. As growing economies drive the need for more electricity, demands on the use of water for power generation will also grow. The direct and indirect demand for water for energy production will increasingly compete with demands from other sectors of the economy.

This presentation will describe full size cooling tower field validation of this innovative water conservation technology, which reduces wet cooling water consumption for power generation by 10-25%. This can free water for other pressing needs. This testing was undertaken with partial funding by the U.S. Department of Energy.

A Test Cooling Tower termed a “Validation Cell”, including experimental Air2Air™ Water Conservation Technology, is now complete and operating at a major utility. The Air2Air™ Validation Cell has operated for the majority of 2008. Testing is proceeding over the next 12 to 15 months to determine its capability. Preliminary data is discussed in this presentation.

Various potential uses of this technology for water use reduction, and for water purification, desalination water production, and cooling tower plume reduction for are also discussed.

---

---

**HELLER System: The Economical Substitute for Wet Cooling to Avoid Casting a Shadow Upon the Sky**

*András Balogh, GEA EGI*

*Zoltán Szabó, GEA EGI*

In view of shrinking fresh water resources, sinking water table level, polluted ground water and occasional severe droughts, generally there is a consensus about the importance of applying water conservation type cooling solutions. However, when making decision on cooling for a specific power project, even now water conservation is often regarded as a potential extra cost burden. Therefore, without an economic assessment, if license to use water can be received, wet cooling is selected. Water entitlement is often underpriced or a question of permission only. Against this ambivalent attitude it is claimed here, that a group of water saving cooling systems, the advanced version of the HELLER System (an indirect dry cooling) and its dry/wet derivatives can be justifiable purely on economic bases against a wet cooling system even at a medium make-up water cost; thus providing the environmental advantages as an extra benefit.

This paper introduces the system & component designs of the Heller Systems in general as well as their main features via project references. Among others it is shown how the natural draft Heller Systems provide a greener and cheaper opportunity for exhausting flue gases of coal fired power plants by applying the stack-in-tower or FGD-in-tower concept. The results of some case studies assessing cooling systems’ economics are also presented, showing how a natural draft Heller System – if evaluated on lifecycle present value basis – can extend the economic viability of water conservation type cooling systems against we cooling.

## **Dominion - North Anna Unit 3 Plans**

*John Waddill, Dominion*

Dominion was granted an Early Site Permit (ESP) from the U.S. Nuclear Regulatory Commission and applied for a Combined Construction and Operation License (COL) in November 2007 for the addition of two new nuclear units at the existing North Anna Power Station located on Lake Anna in Virginia. During the development and review of the ESP, the cooling system design proposed for the Unit 3 heat sink was changed from a once-through open cycle system using Lake Anna as the source waterbody (Unit 4 was proposed to have dry cooling) to a closed-cycle dry and wet combination (hybrid) cooling system. This change was the result of agency and public review of the Draft Environmental Impact Statement when concerns with thermal impact and evaporative water loss were raised. Information will be presented that describes the conceptual design and operation of the cooling system, water use scenarios, and estimated impacts on water consumption, power consumption and plant efficiency.

---

---

## **FPL Project at the Existing Turkey Point Site**

*Steve Scroggs, FPL*

FPL is planning a two unit AP1000 project at the existing Turkey Point site in Southern Miami-Dade county, Florida. The site is unique from several aspects regarding water resources and usage. The site is surrounded by water, but there are significant considerations to the usage of any proximate source. To the east is Biscayne Bay, with Card Sound to the south. West of the site is the Everglades and agricultural use areas that are targeted for wetland rehydration. Throughout the area are numerous surface canals that are used for flood control. Miami-Dade County currently produces 350 MGD of wastewater that is treated and disposed of through ocean outfall or underground injection wells.

For each potential source of cooling water there are opponents and concerns. The history of Turkey Point itself, and the 4000 acre cooling ponds used to cool Units 1 through 4, promise that water usage and disposition will continue to be a significant issue for the new nuclear project.

---

---

## **ESKOM - New Coal Units / Indirect Dry Cooling**

*Francois du Preez, ESKOM*

Dry cooling was introduced into Eskom in 1971 and today Eskom has a total generating capacity of more than 10 000 MW serviced by dry cooling of both types namely direct and indirect systems. The presentation briefly describes Eskom's experience with each of the two types of dry cooling system in terms of:

- Design details
- Atmospheric influences on performance
- Operational experience

Knowledge gained with the above was used in the preparation of the enquiry for new generating units. An overview of the main changes to the new air cooled condensers will be provided together with current Eskom research activities and suggestions for further development work is provided.

---

---

## **Assessment of Wet, Dry and Hybrid Cooling Technologies**

*John Maulbetsch, Maulbetsch Consulting*

The presentation reviews the status of alternate cooling technologies intended primarily for reducing the amount of water withdrawn and consumed for power plant cooling. A brief review of the relative costs and effect of plant efficiency of wet and dry systems is given along with an indication of the current uncertainty in system costs and cost projections.

Then, for each of the major system types---once-through, closed-cycle wet, closed-cycle dry and hybrid---the important features, drawbacks are summarized and some approaches for dealing with the drawbacks are described. Some of the approaches are underway, requiring development and demonstration; some are more speculative, requiring initial analysis and research-scale testing.

In sum, the message is that we have current technologies that address the problem but they are costly and adversely affect plant performance. The path forward is going to be largely evolutionary rather than revolutionary. However, there are some ideas with promise and research into new ideas tends to bring forth new and often unexpected directions are some ideas with promise

## **Evaluation of Non-Traditional Sources of Cooling Water**

*Sujoy Roy, Tetra Tech, Inc.*

With increasing competition for good quality water resources and restrictions on withdrawals from natural water bodies and aquifers, it is becoming more commonplace for electric utilities to evaluate alternate water sources for cooling power plants. This presentation provides an overview of alternate or non-traditional water sources including reclaimed municipal wastewater, agricultural drainage, saline groundwater, and oil and gas produced water, and in more limited instances, water from mine drainage or from other industrial processes. In most cases these waters are degraded through human use, or are naturally unfit for use in municipal water supply. The use of these alternate sources raises new issues not normally considered when traditional surface water or groundwater sources are used. These include the need for additional treatment, the need for transportation of a source water over significant distances, additional constraints on discharge of cooling tower blowdown, and regulatory requirements specific to degraded waters. This presentation presents summary information on the region-wise availability of these non-traditional sources, the treatment requirements to make this water acceptable for use in power plant cooling, the approximate costs of moving the water source to the point of use, additional regulatory constraints on the use of these waters, and related cost and contractual issues.

---

---

## **Assessment of Produced Water for Cooling in New Mexico**

*Michael N DiFilippo, Consultant*

EPRI, DOE and Public Service of New Mexico jointly funded a project to evaluate the use of produced water for cooling tower make-up. The 1,550 MW coal-fired San Juan Generating Station is operated by PNM. Tree ring studies conducted by climate researchers show a return to very dry weather in this part of the Southwest over the next 30 to 40 years. At the time of the study, the plant withdrew all its cooling water from the San Juan River. Concern over a pending drought spurred interest in looking for non-conventional sources of water for cooling. The plant is located in the San Juan Basin, an oil and gas producing unit in the Four Corners Area. The study investigated produced water volumes, chemistry and points of generation. The presentation will discuss the transportation and treatment requirements to use this resource for cooling.

---

---

## **Field Testing of Wind Effects on Air-Cooled Condensers**

*Charles R. McGowin, EPRI*

*Kent D. Zammit, EPRI*

*John S. Maubetsch, Maubetsch Consulting*

Dry cooling systems with mechanical-draft air-cooled condensers (ACC's) are being selected with increasing frequency as the cooling system of choice for electric power plants both in the United States and around the world. As the use of dry cooling becomes more widespread, the importance of ensuring adequate, predictable cooling performance becomes more critical to the efficient operation of the plant and eventually to the network. A point of particular concern derives from the fact that air-cooled systems impose their greatest limitation on plant output during the hottest hours of the year, which is precisely the time at which power demand is at its peak. A major uncertainty in the performance of air cooled condensers is the effect of wind. This can be especially problematic at sites where high, and sometimes gusty, winds occur concurrently with the highest ambient temperatures, a situation frequently encountered in the Southwest.

This paper presents data on the effects of wind on the performance of air-cooled condensers at power plants and quantifies the mechanisms which cause them. Results are given from five plants chosen to represent differing wind conditions, site topography, proximities of neighboring structures, and fan types. Three of these plants had been retrofitted with screening or barriers to alter the wind patterns under and around the condenser. Recommendations are suggested for potentially useful wind-proofing designs or approaches, monitoring and control strategies and testing criteria.

---

---

### **Numerical Simulation on ACC**

*Franck David, EdF*

It is known that efficiency of ACC can be reduced under windy conditions. EDF R&D have performed extensive numerical simulations, to better understand, confirm and assess the sensitivity of performances with lateral (effect of height of exchangers, fan characteristics, number of fan and layout,..)

A numerical study was performed to evaluate the efficiency of wind screens and their positions on performance for the particular plant of Rio Bravo and also to evaluate the possible interactions between ACCs on the same site under lateral wind.

The presentation will cover the different situations. Current studies on flow distribution on ACC heat exchanger surface will also be mentioned.

---

---

## **Physical Modeling of Wind Affects on Air-Cooled Condensers**

*Daeseong Kim, UC Davis*

The effect of wind onto an ACC facility has been investigating with employing of a wind tunnel and an empirical miniature model at UC Davis. The single unit ACC facility of 5 by 6 fan arrays at El Dorado, Nevada was chosen to conduct the simulation. A wind tunnel model was designed and constructed to simulate the flow at the El Dorado ACC and some preliminary tests are currently undertaken to validate the model. The wind tunnel model and experimental plan for the simulation of exhausted hot air recirculation will be presented at the workshop. Also several kinds of parameters that the wind tunnel model is capable to simulate will be presented and discussed for future investigation.

---

---

## **Spray Cooling for Performance Enhancement of Air-Cooled Condensers**

*J. Maulbetsch, Maulbetsch Consulting*

*M. DiFilippo, Consultant*

*K. Zammit, EPRI*

The presentation reviews the status of using spray cooling to improve the performance of air-cooled condensers on hot days. Air-cooled condensers can be effectively used to provide cooling for thermal (Rankine cycle) power plants. However, ACC's will incur efficiency and/or capacity penalties when operating on the hottest days. These penalties often coincide with peak load demands for the operating utility, so replacement power is most costly during those times.

Spray cooling allows the operator to evaporatively cool the inlet air to the ACC on an as-needed basis. This technology can provide an inexpensive method for reducing the hot-weather penalties, and has already been installed on several full-scale ACC installations. This presentation will provide test results on the efficiency gains and water use for operation of such systems.

This technology is not without drawbacks and these will also be discussed.

---

---

## DOE/National Energy Technology Laboratory's Power Plant-Water R&D Program

*Thomas Feeley, Barbara Carney, and Andrea McNemar*  
*U.S. Department of Energy/National Energy Technology Laboratory*

The operation of the existing fleet of thermoelectric power plants, and the construction of new fossil and nuclear based power systems, is being challenged by a number of water-related issues. Thermoelectric power generation requires large volumes of fresh water, mostly used to cool and condense the steam after it exits the turbine, ranking just behind irrigation/agriculture in total freshwater withdrawal. A Department of Energy/National Energy Technology Laboratory (DOE/NETL) analysis suggests that in 2005 the thermoelectric power generation sector withdrew and consumed 147 billion gallons per day (bgd) and 3.7 bgd of freshwater, respectively<sup>1</sup>. Based on projected increases in energy demand through 2030 by DOE's Energy Information Agency<sup>2</sup>, the analysis further estimates that under a most likely regulatory scenario freshwater withdrawals will likely decrease slightly during this period, but freshwater consumption will increase. This will be driven by retirements of older, once through cooling systems and the deployment of re-circulating cooling systems on new plants. Factoring in the potential impact of deploying CO<sub>2</sub> capture technology on coal-fired power plants, freshwater consumption would increase even further.

The large amount of water required to operate thermoelectric power plants coupled with growing demands for electricity in water constrained regions, concerns about climate change, increased environmental and regulatory restrictions such as the Clean Water Act's §316(b), continuing drought conditions in many parts of the U.S., and competition with other use sectors all point to the critical need to look at ways to reduce power plant dependency on freshwater. DOE/NETL has responded to this need by initiating a research and development (R&D) effort as part of its Innovations for Existing Plants Program directed at minimizing the impact of fossil-based thermoelectric power generation on both freshwater availability and quality. The R&D program is built around four areas: (1) advanced cooling technology, (2) water recovery and reuse, (3) use of non-traditional (impaired) water, and (4) advanced water treatment and detection. In addition, DOE/NETL manages research in produced water from oil and gas extraction, and carries out water-related policy and regulatory analyses. The overall goal of this research is to help ensure that fossil based power generation remains a viable, environmentally sound option for meeting the Nation's future energy requirements.

---

<sup>1</sup> "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements," DOE/NETL-400/2007/1304, September 24, 2007, Revised May 8, 2008

<sup>2</sup> "Energy Outlook 2007 (AEO 2007)," U.S. Department of Energy/Energy Information Agency

## **Ammonia Bottoming Cycle Project**

*Franck David, EDF*

The cycles in use in Thermal or Nuclear power plants require condensing vapour at the exhaust of the low pressure turbine. For EDF power plants, water is needed as cooling source in direct cooling systems and also to ensure water make up in closed cooling systems using wet cooling towers. Unfortunately, the amount of water needed is so high that it doesn't always comply with the local resource. On the other hand, air cooled condenser technology that can prevent from water needs and is therefore applied in many dry region is limited in size because it requires huge heat exchanger surface and number of fans to ensure the air flow.

During the 80s, research programs on dry cooling systems have explored both at EDF and at EPRI, the possibilities for alternative coolant to replace water in order to reduce volume of fluids and heat transfer surfaces. The presentation will give an overview on the 22 MWe experimental CYBIAM program (Binary Cycle with Ammonia) performed at EDF from 1980 to 1990. It will resume the motivation, present the binary cycle and a rapid feed back on the experimental program. Finally it will give information on economic interests for the cycle.

---

---

## **Next Generation ACC Designs**

*Francois DuPreez, ESKOM*

---

---

## **Water and Energy Conservation Using Closed-Loop, Evaporative Cooling Systems**

*Peter G. Demakos, P.E., Niagara Blower Company*

The electric power industry uses approximately 40% of the available water in the US. These plants will continue to compete with agricultural, residential and commercial users for water supplies. There is a cost for water acquisition, treatment and disposal, which can vary dramatically with location. With limitations on water availability and the importance of water quality, closed-loop, evaporative cooling systems can be a cost-effective technology for both heat transfer and water conservation. Closed-loop, evaporative coolers (Wet Surface Air Coolers) are used in a wide variety of industries including simple and combined cycle power plants. Applications include auxiliary fluid loop cooling, direct steam condensing and refrigerant condensing for inlet air chilling systems. In addition to requiring less parasitic energy (HP), the WSAC can use poor

quality water (reclaimed, blowdown, wastewater, etc.) as spray makeup and also act as a first stage evaporator upstream of mandated ZLD systems.

---

---

### **Water Needs for Advanced Coal Generation**

*Ron Schoff, EPRI*

Coal power plant water usage has been and continues to be an important issue. Advances in coal power plant design have led to higher efficiency designs and incremental water usage reductions. In the coming years, climate legislation is expected to result in either mandated or market-based reductions in power plant CO<sub>2</sub> emissions. Addition of CO<sub>2</sub> capture and storage technology will have a negative impact on water usage, imposing new challenges on the coal power sector. This presentation will describe advanced coal power plant technologies, will discuss water usage requirements, and will outline the challenges coal plants will face in the near future.

---

---

### **Cooling of Renewable Energy Power Plants**

*Chuck Kutscher, NREL*

This talk will describe studies done at NREL on improving the cooling of geothermal power plants and also on means for reducing water consumption in concentrating solar power plants. NREL worked with the Mammoth Lakes Geothermal Power Plant to study the use of evaporative pre-cooling of air-cooled condensers to boost power output on hot summer days. NREL also prepared a report to Congress to investigate means for reducing water consumption in concentrating solar power plants. It was concluded that hybrid parallel systems offer promise for reducing water consumption (compared to a water-cooled plant) with only modest performance penalties.

---

---

### **Research Trends in Desalination Research and Applications in Electric Power Generation**

*Mike Hightower, Sandia National Laboratories*

Electric power generation is one of the largest water using sectors and emerging electric power needs and alternative transportation fuels production could more than triple water

use for energy production by 2025. This will put the energy sector into stiff competition with other sectors for access to increasing limited fresh water resources.

Because of the increasing limited supplies of easily available fresh surface and ground water, the treatment and use of non-traditional water resources, such as waste water, brackish ground water, and seawater for domestic and industrial applications is growing at rates of 10-15 percent per year. The presentation will provide an overview of national and international desalination and waste water treatment, emerging national research directions, organizations leading the way in this research, and emerging applications in electric power generation.

---

---

## **EPRI Advanced Cooling Technology Roadmap**

*Charles R. McGowin, EPRI*

*Kent D. Zammit, EPRI*

Water availability for thermoelectric power plant cooling and other uses is threatened in all regions of the U.S., especially in the arid southwest. This will have a significant impact on existing and new power plants that withdraw water or consume water for power plant cooling. Although dry cooling systems do not consume water for cooling, they are expensive and reduce the efficiency and limit the output of the power plant. During 2007, EPRI initiated development of a research roadmap for power plant cooling technology. The objectives of the research program outlined in the roadmap are to: (1) reduce the environmental impacts of once-through cooling; (2) increase the performance and reduce water consumption of existing and new wet cooling systems (3) increase the performance and reduce the cost; and (4) develop advanced cooling technology using bottoming cycles for “next generation” plants.

The once through cooling research focus is on measures to reduce impingement and entrainment. They include barrier nets; fish impingement, capture and return; subsurface water intakes; flow reduction; and fish-friendly hydro turbine designs.

For closed-cycle wet cooling, the emphasis is to reduce fresh water and power consumption and allow use of degraded water for tower makeup. The research includes water recovery from cooling tower plumes; tradeoffs between degraded water treatment and cooling tower design; rain zone head recovery and environmental effects reduction. For natural-draft cooling towers, the primary research focus is on reestablishing design and cost bases through a review of international cost and design data.

The research focus for closed-cycle dry cooling is on improved fin designs and improved wind tolerance for air-cooled condensers. The research scope includes review of compact heat exchanger data and preliminary design analysis of fin designs; and attached and detached wind barriers; forced draft fan design modifications; and wind enhanced

designs for air cooled condensers. Further work on spray enhancement of dry systems will concentrate on advanced spray/mist generators to improve water use efficiency.

Hybrid systems of all types (parallel, series, direct, indirect) will benefit from the advances made for the wet and dry systems. In addition, research will focus on the development of rigorous design and operating algorithms and guidelines for system selection and optimization.