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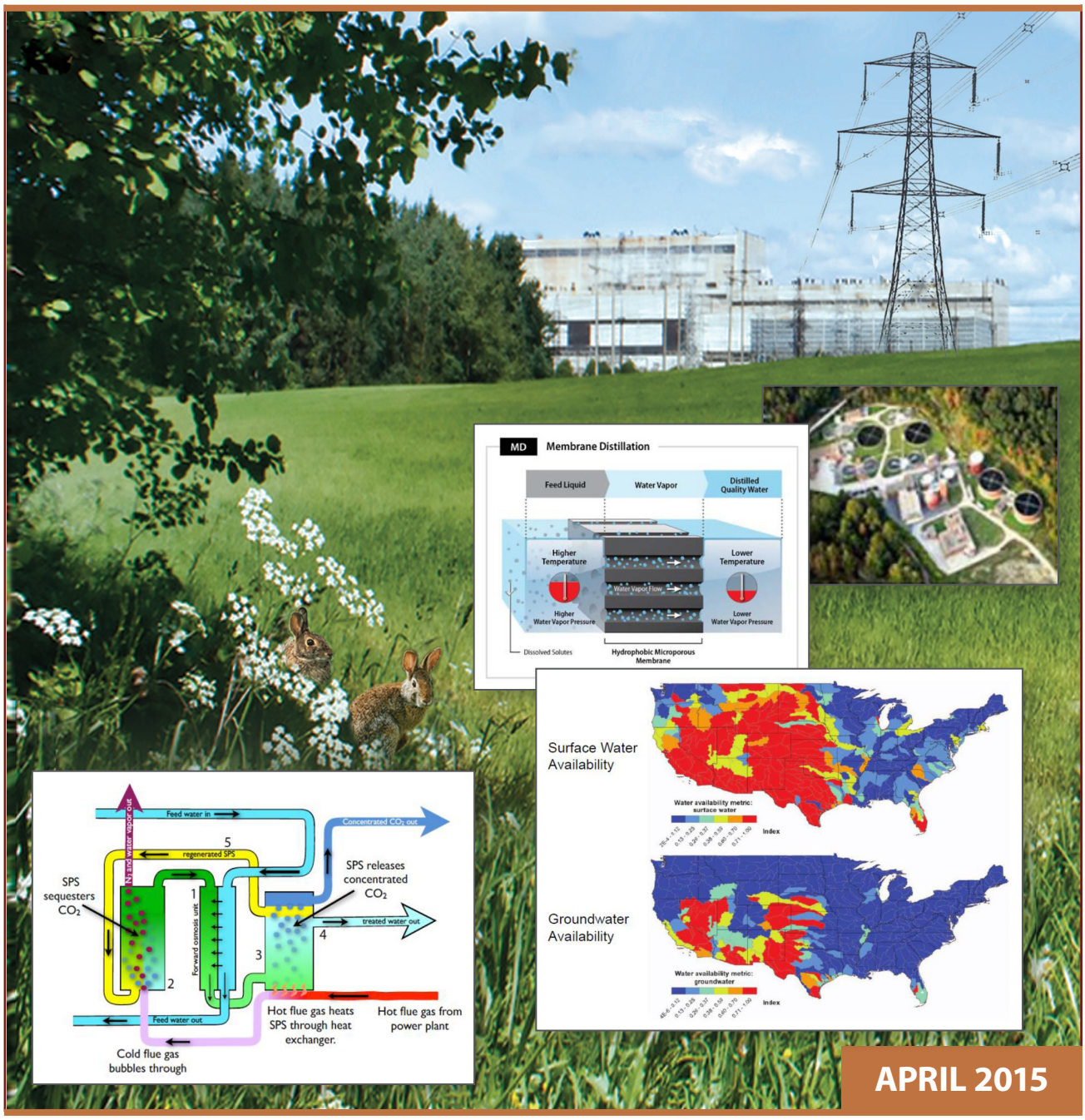
Crosscutting Technology Research Water Management Research and Development Project Portfolio



APRIL 2015

U.S. DEPARTMENT OF ENERGY | the ENERGY lab NATIONAL ENERGY TECHNOLOGY LABORATORY

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Introduction

The Crosscutting Technology Research Program develops a range of innovative and enabling technologies that are key to improving existing power systems and essential for accelerating the development of a new generation of highly efficient environmentally benign fossil fuel-based power systems. The mission space is focused on bridging the gap between fundamental and applied research and development (R&D) efforts. Technologies that successfully bridge this gap are intended to offer viable step-change improvements in power system efficiency, reliability, costs, and environmental impacts.

The Crosscutting Technology Research Program executes the R&D efforts by partnering and collaborating with research institutions and the power generation industry throughout the United States and in select international collaborations. The Crosscutting Technology Research Program also sponsors one of the longest running and most important university training and research programs to reinforce the research-based education of students at U.S. universities and colleges with emphasis on fossil energy science. The major objective for this program is to produce tools, techniques, and technologies that map to the Clean Coal Research Program efforts.

The Program comprises three technology areas: Coal Utilization Sciences, Plant Optimization Technologies, and University Training and Research. A general description of each of these technology areas is detailed below:

Coal Utilization Sciences: The Coal Utilization Sciences technology area research effort is conducted to develop modeling and simulation technologies leading to a suite of products capable of designing and simulating the operation of next-generation near-zero-emissions power systems such as gasification and oxy-combustion. These products are based on validated models and highly detailed representations of equipment and processes. Multinational laboratory efforts are being coordinated through the National Risk Assessment Partnership (NRAP) and Carbon Capture Simulation Initiative (CCSI) to focus on post-combustion capture of carbon, risk assessment, and integrated multiscale physics-based simulations.

Plant Optimization Technologies: The Plant Optimization Technologies technology area exists to develop advanced sensors and controls, materials, and water- and emissions-related technologies. Projects within this funding area enable novel control systems to optimize operations where harsh environmental conditions are present in both current and future applications in power plants and industrial facilities.

University Training and Research: The University Training and Research (UTR) program awards research-based educational grants to U.S. universities and colleges in areas that benefit the Office of Fossil Energy and the Crosscutting Technology Research Program. UTR is the umbrella program under which the University Coal Research (UCR) and Historical Black Colleges and Universities (HBCU) and Other Minority Institutions (OMI) initiatives operate. These grant programs address the scientific and technical issues key to achieving Fossil Energy's goals, and build our nation's capabilities in energy science and engineering by providing hands-on research experience to future generations of scientists and engineers.

In addition to the Crosscutting Technology Research funding programs listed above, NETL uses its participation in the U.S. Department of Energy's (DOE) Office of **Science Small Business Innovation Research (SBIR) Program** to leverage funding, enhance the research portfolio, and most importantly, facilitate a pathway to commercialization. SBIR is a highly competitive program that encourages small businesses to explore technological potential and provides the incentive to profit from commercialization. By including qualified small businesses in the nation's

R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit to meet specific research and development needs. SBIR targets the entrepreneurial sector because that is where most innovation and innovators thrive. By reserving a specific percentage of Federal R&D funds for small business, SBIR protects the small business and enables competition on the same level as larger businesses. SBIR funds the critical startup and development stages and it encourages the commercialization of the technology, product, or service, which, in turn, stimulates the U.S. economy. Since its inception in 1982 as part of the Small Business Innovation Development Act, SBIR has helped thousands of small businesses to compete for Federal research and development awards. These contributions have enhanced the nation's defense, protected the environment, advanced health care, and improved our ability to manage information and manipulate data.

The Crosscutting Technology Research program comprises these key technology areas:

Sensors and Controls: The basis for this research area is to make available new classes of sensors and measurement tools that manage complexity, permit low cost, robust monitoring, and enable real-time optimization of fully integrated, highly efficient power-generation systems. Controls research centers around self-organizing information networks and distributed intelligence for process control and decision making.

High Performance Materials: Materials development under the Crosscutting Technology Research Program focuses on structural materials that will lower the cost and improve the performance of fossil-based power-generation systems. Computational tools in predictive performance, failure mechanisms, and molecular design of materials are also under development to support highly focused efforts in material development.

Simulation-based Engineering: This technology area represents a vast amount of expertise and capability to computationally represent the full range of energy science from reactive and multiphase flows up to a full-scale virtual and interactive power plant. Science-based models of the physical phenomena occurring in fossil fuel conversion processes and development of multiscale, multi-physics simulation capabilities are just some of the tools and capabilities under this technology area.

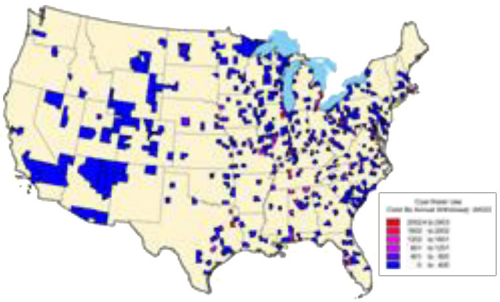
Innovative Energy Concepts: Innovative Energy Concepts is concerned with the development of novel cost-effective technologies that promote efficiency, environmental performance, availability of advanced energy systems, and the development of computational tools that shorten development timelines of advanced energy systems. This area provides for fundamental and applied research in innovative concepts with a 10–25 year horizon that offers the potential for technical breakthroughs and step-change improvements in power generation and the removal of any environmental impacts from fossil energy-based power system.

Water Management Research and Development: Water research encompasses the need to reduce the amount of freshwater used by power plants and to minimize any potential impacts of plant operations on water quality. The vision for this program area is to develop a 21st-century America that can count on abundant, sustainable fossil energy and water resources to achieve the flexibility, efficiency, reliability, and environmental quality essential for continued security and economic health. To accomplish this, crosscutting research is needed to lead a critical national effort directed at removing barriers to sustainable, efficient water and energy use, developing technology solutions, and enhancing understanding of the intimate relationship between energy and water resources.

Water Management Research and Development

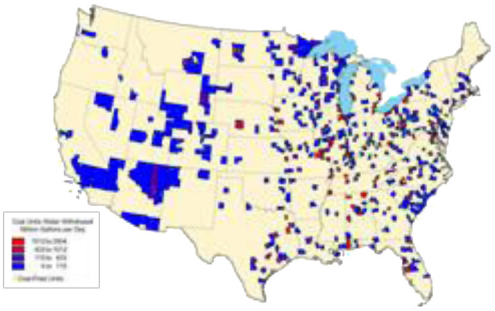
This Project Portfolio report showcases 10 Water Management Research and Development projects within the Crosscutting Technology Research Program of the Strategic Center for Coal (SCC). Each of the pages reporting on each project provides a description that clearly describes the technology, project goals, and anticipated overall benefits.

Water is a vital resource that is inextricably linked to the quality of our lives. The role water plays in the generation of power is well documented and national efforts are underway to minimize such demands on water.



U.S. Water Withdrawal
Coal Fired Units – County Level.

In concert with the Water-Energy Nexus initiative, the challenge for this initiative centers on reducing water use and consumption for thermoelectric power generation. Thermoelectric power generation accounts for over 40 percent of freshwater withdrawals (143 billion gallons of water per day) and over 3 percent of freshwater consumption (4 billion gallons per day) in the United States. Thermoelectric power plant water consumption is slated to increase from 3 percent (1995 USGS data) to as high as 10 percent given the expansion of closed loop cooling and cooling towers. To further exacerbate the problem, water consumption projections for the power generation sector will dramatically increase with the implementation of carbon capture technologies. As the cost associated with water consumption increases so too will the cost of water treatment, recovery and reuse.



U.S. Water Consumption
Coal Fired Units – County Level.

The Crosscutting Technology Research Program has supported water research over the past decade. The current goal is to identify projects which will develop a range of technologies to optimize and/or reduce freshwater use for energy processes through improved waste heat recovery, alternative heat transfer fluids, and new sources of water (i.e., utilizing treated wastewater). Acquisition of these research projects is based on a comprehensive, multipronged R&D approach with a portfolio of technologies on multiple paths to enhance the probability of success of research efforts that are operating at the boundaries of current scientific understanding. The R&D covers a wide range, integrating advances and lessons learned from fundamental research, technology development, and large-scale testing. The success of this effort will enable cost-effective implementation of technologies throughout the power generation sector. These projects are being developed

on 3- to 5-year timelines. The Crosscutting Technology Research technology areas provide a consistent focus on important technologies. The interrelationships between the Crosscutting Technology Research technology areas help ensure that critically important key technologies receive adequate R&D funding and focus. In turn, these important key technologies support various technology areas in other programs.

The Water Management Research and Development project portfolio is categorized into three component key technologies:

Process Efficiency and Heat Utilization

Greater process efficiency and heat utilization will be needed to reduce water needs as improvements in heat transfer technology and better thermal integration of power plant systems (particularly new plants that include carbon capture technologies) are made.

Water Treatment and Reuse

Research is being performed in water treatment and reuse to develop advanced technologies to reuse power plant cooling water and associated waste heat and to investigate methods to recover water from power plant flue gas. Considering the quantity of water withdrawn and consumed by power plants, any recovery or reuse of this water can significantly reduce the plant's water requirements. Water treatment research is focused on high dissolved solids waste streams.

Data Modeling and Analysis

Data modeling and analysis is being undertaken to improve the quality and amount of data collected, conduct comprehensive modeling efforts of complex systems, and provide crosscutting analyses to help decision-makers and support policy development. Stakeholder decision making must target qualitative and quantitative scenarios, probabilistic approaches, insights into system shocks and extremes, and improved uncertainty characterization.

Projects by Research Area

Process Efficiency and Heat Utilization

Performer	Project Title	Page
Carnegie Mellon University	Evaluating the Techno-Economic Feasibility of Forward Osmosis Processes Utilizing Low Grade Heat: Applications in Power Plant Water, Wastewater, and Reclaimed Water Treatment	10
Gas Technology Institute	Simultaneous Waste Heat and Water Recovery from Power Plant Flue Gases for Advanced Energy System	11
Porifera Inc.	The Carbon Dioxide-Water – Utilizing Waste Heat and Carbon Dioxide at Power Plants for Water Treatment	12
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Evaluating the Techno-Economic Feasibility of Forward Osmosis Processes Utilizing Low Grade Heat: Applications in Power Plant Water, Wastewater, and Reclaimed Water Treatment

Performer: Carnegie Mellon University

Award Number: FE0024008

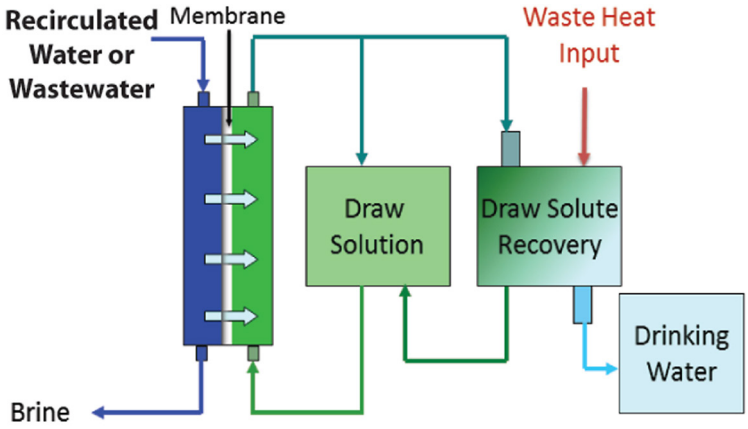
Project Duration: 10/1/2014 – 9/30/2016

Total Project Value: $671,508

Technology Area: Plant Optimization Technologies

This work will evaluate the techno-economic feasibility and environmental benefits of low-temperature heat capture and utilization for forward osmosis (FO) water treatment at power plants. Water treatment applications that will be considered in process modeling include tertiary treatment of municipal wastewater effluent for cooling water make-up, production of ultra-high-purity water for boiler water make-up, and removal of dissolved aqueous contaminants from wastewaters generated by power plant air emission control technologies. The first objective is to develop estimates of heat quantity, quality, and availability from U.S. power generators in light of changes in the electricity mix and the regulatory environment out to 2040. The second objective is to model cost-effective low-temperature heat recovery systems and integrate these models with FO draw solute recovery models. The third objective is to model FO water treatment processes to be used for tertiary treatment of wastewater effluent for recirculating cooling water make-up, production of ultra-high-purity water for boiler water make-up, and removal of dissolved aqueous contaminants from wastewaters generated by power plant air emission control technologies and ash ponds. The fourth objective is to demonstrate the economic feasibility and environmental benefits of recovering low-temperature heat for water treatment in the NETL model pulverized coal combustion (PCC) plant and at an industry partner plant under current and projected policy scenarios for air and water emissions control.

Forward osmosis has the potential to cost-effectively capture low-grade heat that can be utilized to facilitate water treatment at power plants. The project may develop the ability to treat water streams with variable quality and variable flow rates and could help meet rising water treatment needs at power plants. Deployment of FO systems is expected to enable reduced freshwater intake and decrease operational costs and environmental contaminant discharge from power plant wastewaters relative to current and future practices.



Generalized FO system design.

Simultaneous Waste Heat and Water Recovery from Power Plant Flue Gases for Advanced Energy System

Performer: Gas Technology Institute

Award Number: FE0024092

Project Duration: 10/1/2014 – 9/30/2016

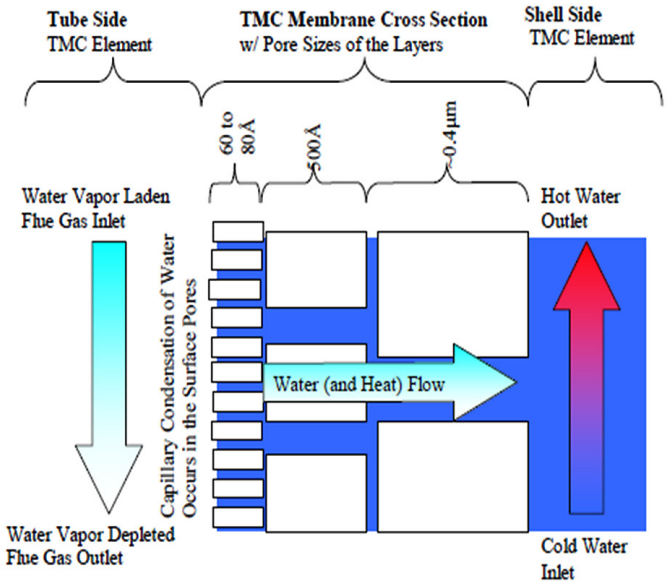
Total Project Value: $630,000

Technology Area: Plant Optimization Technologies

This project will offer a novel, energy-efficient approach to separate and recover flue gas moisture to replace freshwater boiler makeup and supply other plant water usage such as the cooling tower makeup. The heart of this technology is a nonporous ceramic membrane device, the Transport Membrane Condenser (TMC), which was developed by the Gas Technology Institute (GTI) to recover water vapor and its latent heat from boiler flue gases. In the TMC, water vapor from the flue gas condenses and passes through a permselective membrane by direct contact with low-temperature water on the permeate side, so that the transported water is recovered along with virtually all of its latent heat. The conditioned flue gas leaves the TMC at a reduced temperature and a relative humidity below saturation.

The TMC technology will be investigated and optimized for application to coal-fired power plants. Detailed approaches will be developed to reuse the high-quality recovered water in the boiler feed water circuit to replace all the fresh makeup water to save energy. The majority of the remaining recovered water can be used for other power plant processes including cooling tower water makeup, flue gas desulfurization (FGD) water makeup, and other water requirements. In tests with industrial gas-fired boilers, GTI has demonstrated up to 45% recovery of flue gas moisture, but this is limited by the available cooling water which, for industrial boilers, is provided by the boiler makeup freshwater. For power plants, besides the lower temperature turbine steam condensate, the large amount of cooling water (typically 25 times the boiler feed water flow rate) can provide a much larger driving force for the TMC, such that up to 90% moisture removal from the flue gas is possible. For a power plant equipped with a wet FGD, flue gas exiting at 160 to 180 degrees Fahrenheit (°F) and nearly 100% relative humidity contains a much larger amount of water vapor than the flue gas from an industrial gas-fired boiler. For a power plant with a dry FGD, the flue gas moisture content is still comparable with the industrial gas-fired flue gas, with a dew point at 130 to 140 °F, or about 20% by volume of water vapor in the flue gas stream.

This project may offer substantial environmental and economic benefits to the power industry especially for future advanced energy systems with much higher moisture content flue gases. 8.3 billion tons of fresh water could be saved per year in existing U.S plants with an associated cost savings of $4.3 billion. Additionally, this project may increase boiler thermal efficiency by using hot water from the TMC to replace the cold boiler makeup freshwater.



Transport Membrane Condenser (TMC) concept.

The COHO - Utilizing Waste Heat and CO_2 at Power Plants for Water Treatment

Performer: Porifera Inc.

Collaborator(s): Idaho National Laboratory

Award Number: FE0024057

Project Duration: 10/1/2014 – 3/31/2016

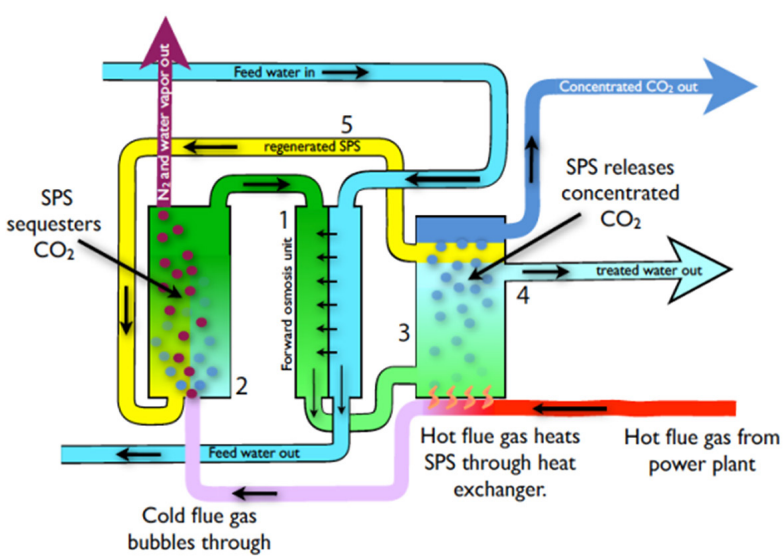
Total Project Value: $500,750

Technology Area: Plant Optimization Technologies

This project will enable the development of a water treatment system, the COHO (CO_2-H_2O), that is powered by low-grade heat and carbon dioxide at power plants. COHO combines the high-performance of a novel forward osmosis (FO) membrane in combination with a carbon-dioxide based switchable draw. The FO technology excels in processing difficult-to-treat waters, such as blowdown waters created by power plants. Porifera's novel FO membrane has higher flux and reduced reverse salt flux compared to conventional membranes. It is more chemically stable, enabling the development of a system that uses a draw solute that can capture carbon dioxide from flue gas. For this project, Porifera will collaborate with Idaho National Laboratory, the developers of a switchable draw solute that can obtain high osmotic pressure and is recyclable for reuse within the system. Porifera and Idaho National Laboratory will design, build, and optimize COHO and determine the economic viability of the system at power plants.

The goals of the project are to first optimize the system process, including carbon dioxide and water processing as well as the draw chemistry. Then the team will build, operate, and test the system for installation at a power plant. A techno-economic model of COHO will be developed and its viability demonstrated.

The expected result of this project is a model that demonstrates that installation of COHO at a power plant will (1) reduce the volume of wastewater, (2) expand the capabilities of water treatment and provide additional water streams, (3) facilitate carbon-dioxide capture from flue gas as part of the water treatment process, and (4) use waste heat to reduce the energy costs of treating wastewater.



Schematic of COHO draw phase switching.

Field Demonstration Study for Heat and Water Recovery at a Coal-Fired Power Plant

Performer: Southern Company Services, Inc

Collaborator(s): Electric Power Research Institute (EPRI), URS Group

Award Number: FE0024085

Project Duration: 10/1/2014 – 4/30/2016

Total Project Value: $422,144

Technology Area: Plant Optimization Technologies

The objective of this project is to conduct an engineering study as a prelude to a field demonstration of how low-grade waste heat can be used to reduce water usage rates and improve system efficiency in a coal-fired power plant. A commercial system combining low-grade heat-recovery technologies and end uses to cost-effectively improve efficiency and reduce water consumption is yet to be developed. Work done in this project will be the next step towards accomplishing that goal.

The key objectives are to (1) establish the relationships required to enable a field demonstration of a low-temperature heat-recovery/use system designed to meet coal-fired power plant needs; (2) make a comparison of the capabilities of commercially available and novel heat-recovery technologies to the heat/temperature requirements of various heat-use options—the project team will identify combinations of heat-recovery/use technologies that match up well for heat and temperature profiles, enabling identification of near-term opportunities for utilities to use waste heat; (3) make a comparison of the costs and benefits of emerging heat-recovery technologies to commercially-available technologies for the recovery of heat from low-temperature flue gas—the project team will quantify the value of potential improvements in heat-recovery technologies with respect to the cost of the technology, potential increased benefits by widening availability of heat-uses that can be coupled with them, and potential water savings in terms of amount of water per unit of power produced; and (4) recommend a combined process to be field tested at a Southern Company plant. The engineering analysis conducted in the project will provide the conceptual design and indicative cost estimate for the field demonstration project.

This project may lead to a developmental breakthrough in water management for coal-fired power plants. The technologies developed, paired with the economic justification, may result in a pilot-scale field demonstration at a full-scale power plant. Interactions with the utility industry and its research and engineering partners will enable technology vendors to gain better understanding of coal power generators' requirements for operation; while utilities will gain a better understanding of the near-term opportunities for viable heat-recovery/use technologies.

Water Treatment and Reuse

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Research Triangle Institute	Fouling-Resistant Membranes for Treating Concentrated Brines for Water Reuse in Advanced Energy Systems	17
Southern Research Institute	Treatment of Produced Water from Carbon Sequestration Sites for Water Reuse, Mineral Recovery and Carbon Utilization	18
University of Pittsburgh	Development of Membrane Distillation Technology Utilizing Waste Heat for Treatment of High Salinity Wastewaters	19

An Integrated Supercritical System for Efficient Produced Water Treatment and Power Generation

Performer: University of Illinois

Collaborator(s): Midwest Geological Sequestration Consortium (MGSC), Illinois Clean Coal Institute (ICCI), Podolsky Oil Company, and Pioneer Oil Company.

Award Number: FE0024015

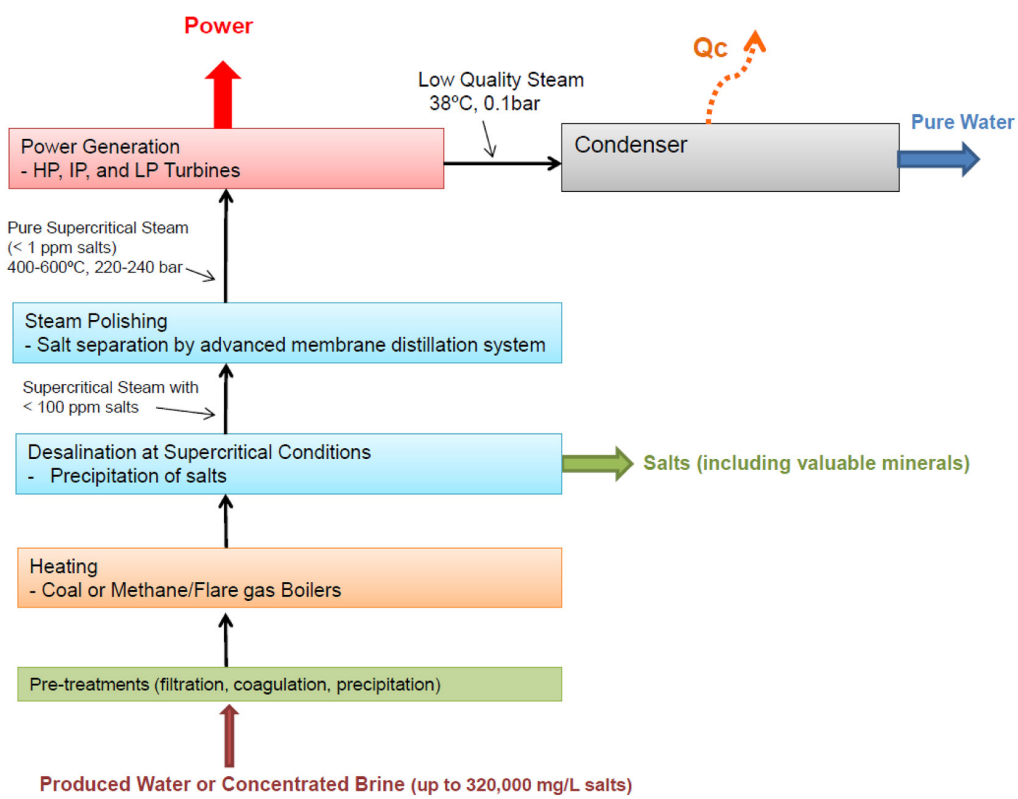
Project Duration: 1/1/2015 – 12/31/2016

Total Project Value: $656,311

Technology Area: Plant Optimization Technologies

The goal of this project is to evaluate the feasibility of an innovative, integrated supercritical cogeneration system for cost-effective treatment of produced waters from carbon dioxide (CO_2) sequestration, oilfields, and coal-bed methane recovery. Methane or coal is used as energy source to drive the proposed system that generates both electricity and pure water. Project tasks include process simulation, thermodynamic analysis, and techno-economic evaluation of the integrated system; design and assembly of supercritical salt precipitation and membrane distillation systems; development and characterization of advanced carbon membranes for supercritical membrane distillation; and desalination and purification of different produced water samples with salt concentrations of 30,000 ppm (mg/L) to 200,000 ppm.

This project may provide a transformative approach to generating power from coal or natural gas, purifying water from high salinity saline or produced water, and recovering valuable and strategic minerals in a zero liquid discharge plant. Produced water is expected be treated at a much lower cost due to the higher efficiency of the proposed supercritical integrated system compared to existing cogeneration or evaporation/crystallization systems.



Conceptual diagram of the proposed supercritical produced water desalination and energy generation system.

Water Desalination Using Multi-Phase Turbo-Expander

Performer: General Electric Company

Award Number: FE0024022

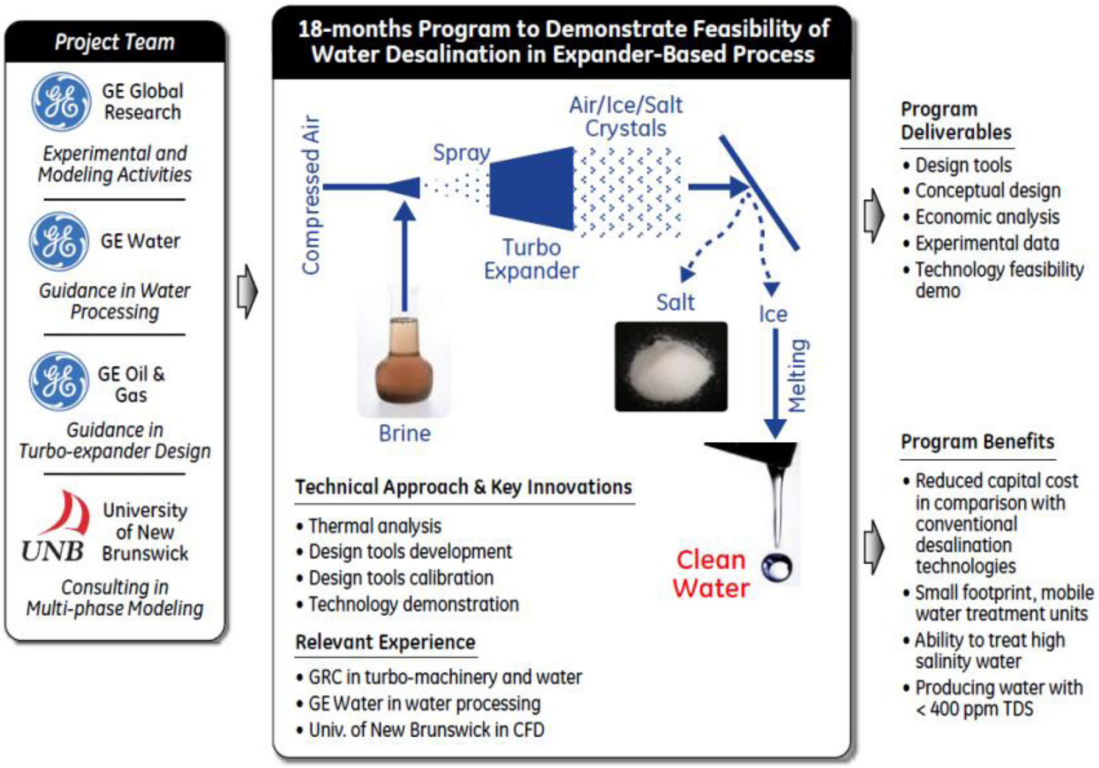
Project Duration: 1/1/2015 – 6/30/2016

Total Project Value: $614,925

Technology Area: Plant Optimization Technologies

The goals of this project are to establish the technical and economic feasibility of the multi-phase turbo-expander-based water desalination process. The main objective is to develop a novel brine freeze desalination process based on brine cooling by expansion of a compressed air/brine stream in a turbo-expander. Ice crystals, formed after water in brine freezes, are separated from salt crystals. The proposed innovative approach to cool the brine droplets by expanding cold air results in very efficient heat transfer between the cooling media (air) and the brine, reducing process power requirements. Since the presence of liquids is not essential to heat transfer in expanding air, water recovery in the process has the potential to be close to 100%. The key component of the proposed process is an expander capable of working with three phases of the expanding fluid: air, liquid (concentrated brine), and solid (ice and salt crystals). The project consists of four modeling and one experimental tasks that will establish process design, develop tools that will be used in the design of the expander, and investigate process economics. The experimental task will provide data needed for calibration of the design tools and will demonstrate technology feasibility.

The successful completion of this project has the potential to reduce treatment costs of high-salinity water by at least 20% in comparison to thermal evaporation. This process may have fewer corrosion problems than thermal evaporation. Less-expensive materials can be used in comparison with thermal evaporation. Furthermore, the developed process will be well suited for mobile applications.



Summary of the proposed water desalination using Multi-Phase Turbo-Expander project.

Fouling-Resistant Membranes for Treating Concentrated Brines for Water Reuse in Advanced Energy Systems

Performer: Research Triangle Institute

Collaborator(s): University of California Riverside, Veolia Water

Award Number: FE0024074

Project Duration: 10/1/2014 – 9/30/2016

Total Project Value: $625,000

Technology Area: Plant Optimization Technologies

The overall project objective is to demonstrate the efficacy of membrane distillation (MD) as a cost-savings technology to treat concentrated brines (such as, but not limited to, produced waters generated from fossil fuel extraction) that have high levels of total dissolved solids (TDS) for beneficial water reuse in power production and other industrial operations as well as agricultural and municipal water uses. In addition, a novel fouling-resistant nanocomposite membrane will be developed to reduce the need for chemicals to address membrane scaling due to the precipitation of divalent ions in high-TDS waters and improve overall MD performance via an electrically conductive membrane distillation process (ECMD). This anti-fouling membrane technology platform is based on incorporating carbon nanotubes (CNTs) into the surface layer of existing, commercially available MD membranes. The CNTs confer electric conductivity to the membrane surface so that an electric potential can be applied to remove and prevent membrane scaling and fouling.

Specific technical objectives are (1) the demonstration of MD to recover at least 50% of wastewater with a concentration of 180,000 mg/L TDS; (2) the development of ECMD membranes having improved fouling resistance as demonstrated by maintaining the relative flux above 0.8 [Relative Flux = Flux(t)/Flux(t=0)] for at least twice as long when compared to the relative flux of a non-conductive membrane during the treatment of highly scaling water; (3) the development of experimentally validated models that can predict the separation performance achievable with the new conductive membrane types; (4) preliminary design of a full-scale ECMD module; and (5) techno-economic and environmental analyses of the MD water treatment processes utilizing these electrically conductive membranes.

The expected benefits of this project include at least a 50% reuse of treated effluent for produced water at 180,000 mg/L, an 80% reduction in water management costs when compared to deep well injection costs, a 35% to > 90% reduction in costs associated with water treatment/disposal, and improvements in membrane fouling relative to existing membranes.

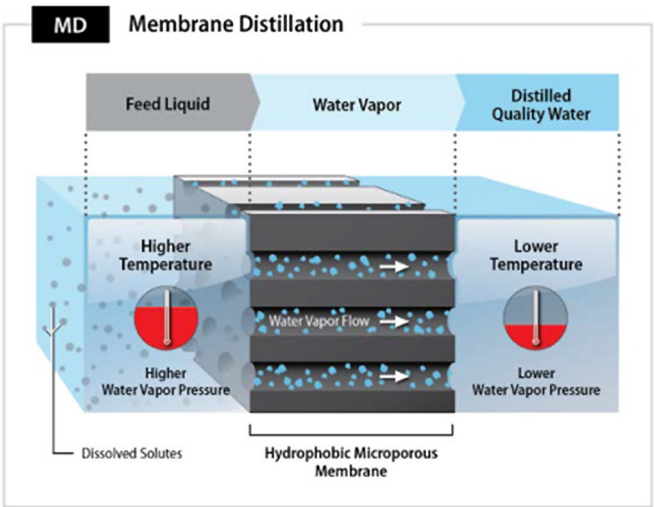


Illustration showing the MD process. Water evaporates in the feed and is transported through the hydrophobic membrane leaving the non-volatile solutes behind and generating high quality product water.

Treatment of Produced Water from Carbon Sequestration Sites for Water Reuse, Mineral Recovery and Carbon Utilization

Performer: Southern Research Institute

Collaborator(s): Advanced Resources International Inc., Heartland Technology Partners LLC, New Logic Research, Southern Company Services, and Electrical Power Research Institute, and DiFlippo Consulting

Award Number: FE0024084

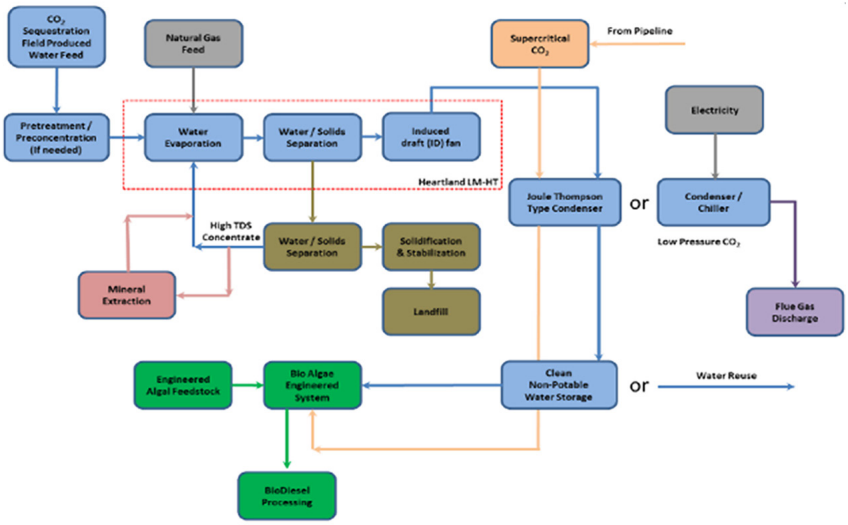
Project Duration: 10/1/2014 – 9/30/2016

Total Project Value: $653,686

Technology Area: Plant Optimization Technologies

The project objective is to demonstrate the feasibility of a novel and innovative approach for managing and maximizing reuse of waters produced for reservoir pressure and plume management during CO_2 injection for storage. Activities for the project will include (1) prediction of the produced water volume and characteristics necessary to facilitate the injection of 3.5 million tons per year (TPY) of CO_2, based on specific project objectives to control reservoir pressure and/or plume dispersion, applied to four distinct representative saline aquifer reservoir settings; (2) development of a process flow diagram for the membrane separation system to concentrate lower total dissolved solids (TDS) produced water; (3) determination of pretreatment requirements and effluent characteristics based on expected composition; (4) development of a process flow diagram for thermal evaporation system to concentrate higher TDS produced water to zero liquid discharge (ZLD) with different characteristics of interest including dominant ionic composition (i.e. Na-Cl, Na-Ca-Cl, or Na-Cl-SO_4); (5) development of process flow diagrams for an integrated evaporation system (membrane and evaporator) design including energy and mass balances; (6) development of optimized solidification and stabilization recipes targeted at the immobilization of the contaminants (benzene, toluene, ethylbenzene, xylenes, naturally occurring radioactive materials, and metals) of concern in the very concentrated brine and solids from the evaporator; (7) development of a byproduct reuse strategy for all available streams including strategic and rare earth metals, water; CO_2; (8) evaluation of economic and technology readiness of the proposed approach and identification of areas of innovation that are needed to further reduce cost and improve process efficiency; and (9) assessment of environmental risk of the proposed approach.

A successful outcome of this project will allow for the treatment of produced waters with large TDS that could not normally be treated using traditional membrane processes. Additionally, this project may reduce the negative environmental and health impacts of contaminants in produced waters.



Proposed Integrated CO_2 Sequestration Produced Water Reuse System.

Development of Membrane Distillation Technology Utilizing Waste Heat for Treatment of High Salinity Wastewaters

Performer: University of Pittsburgh

Award Number: FE0024061

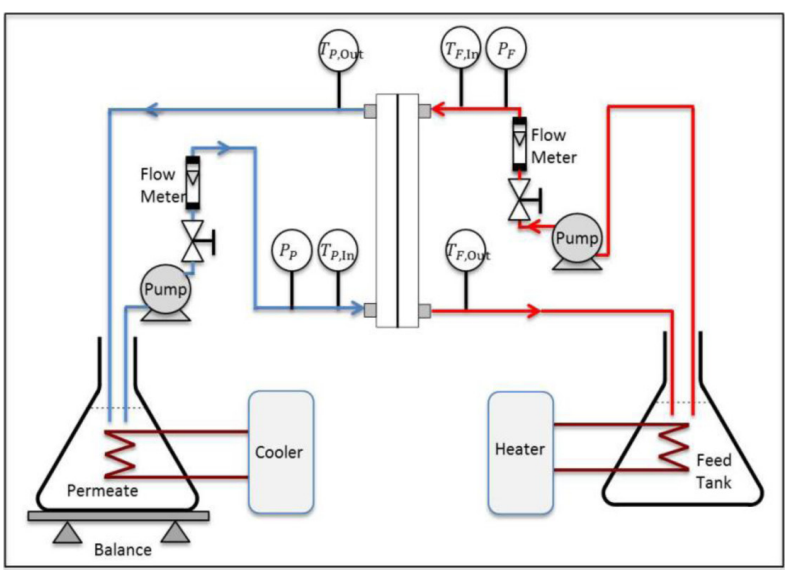
Project Duration: 10/1/2014 – 9/30/2016

Total Project Value: $654,183

Technology Area: Plant Optimization Technologies

The main objective of this study is to evaluate the feasibility of using membrane distillation (MD) technology to treat high salinity wastewaters generated during unconventional gas production or CO_2 sequestration utilizing waste heat that is available in thermoelectric power plants or compressor stations (both natural gas and CO_2 compressors). Laboratory-scale studies with synthetic and actual wastewaters will be used to assess capabilities and limitations of MD technology and define key design and operating parameters for high salinity brines generated by unconventional gas extraction or active CO_2 reservoir management. This information will be utilized for a systems-level analysis and integration of MD process with low-grade heat sources (i.e., thermoelectric power plants and natural gas and CO_2 compressor stations). This study will also conduct a preliminary techno-economic assessment of the proposed integrated system in comparison to competing technologies as well as for the system that uses natural gas as fuel source for MD treatment of high salinity wastewaters in the formations where natural gas is the main target resource (i.e., Marcellus Shale) and those where it is not (i.e., Bakken and Eagle Ford).

This project may advance the use of alternative sources of energy for treatment of wastewaters, promote the recycle and reuse of wastewater, reduce the energy footprint and enhance the mobility of treatment systems, and enhance economic and environmental performance of MD technology.



Direct contact membrane distillation experimental set-up.

Data Modeling and Analysis

Performer	Project Title	Page
Sandia National Laboratory	Exploring Energy-Water Issues in the United States	21

Exploring Energy-Water Issues in the United States

Performer: Sandia National Laboratory

Collaborator(s): Carnegie Mellon University

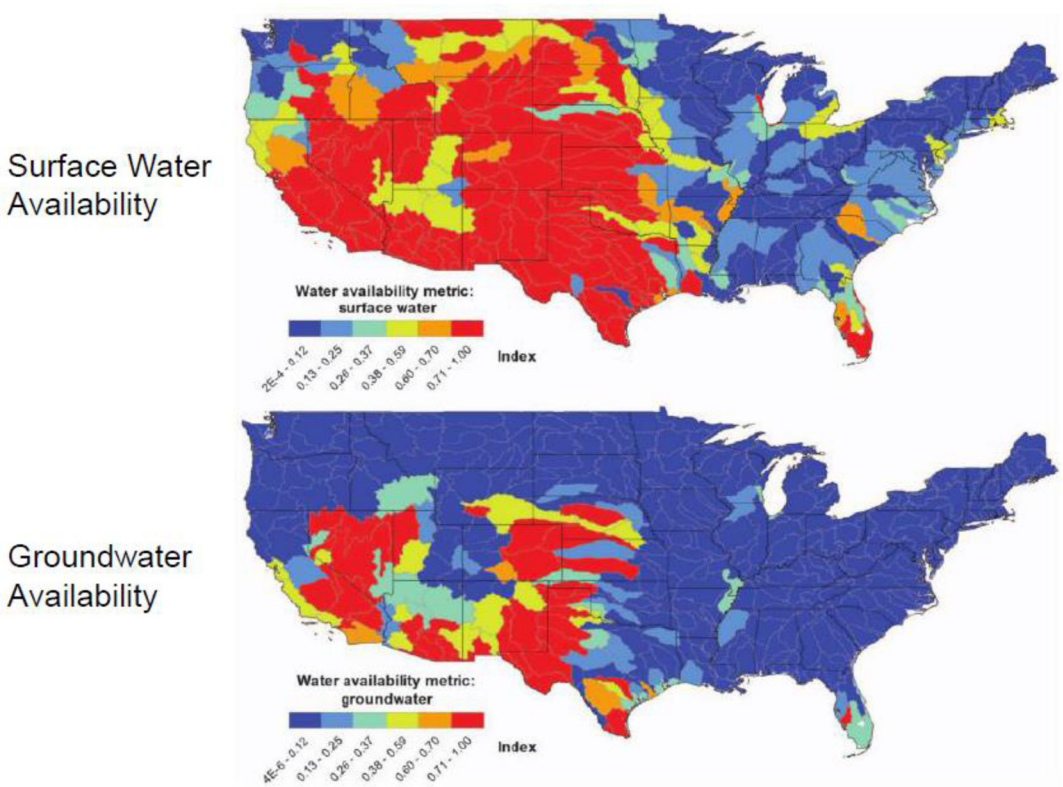
Award Number: FWP-14-017626

Project Duration: 10/1/2014 – 9/30/2015

Total Project Value: $973,000

Technology Area: Plant Optimization Technologies

The objective of the proposed work is to develop both data and models to help understand better the linkage between thermoelectric power generation and water. This effort will involve two broad areas of research, one involving the development of a water atlas and the second that assessing water use requirements of fossil-fueled electric power plants. The water atlas task will compile estimates of water availability, cost, and projected future demand at the watershed level (8-digit Hydraulic Unit Code [HUC], corresponding to roughly 2250 watersheds) for the lower 48 states of the U.S. Water availability and cost metrics will be developed for four sources of water including surface water, groundwater, municipal waste-water, and shallow brackish ground-water. The second task will enhance the analytical capabilities of the Integrated Environmental Control Model (IECM) to assess water use requirements of fossil-fueled electric power plants to consider a variety of alternative water treatment and cooling technologies and processes for CCS. The Enhanced IECM may significantly enhance the ability to analyze and assess water needs, costs, and impacts of fossil energy plants. In addition, it could provide an integrated analysis of low-carbon electricity generation, alternative water technologies, and regional water resource impacts. As a publicly available tool, it could allow a broad range of constituents to utilize the results of NETL-supported research on water and carbon capture technologies.



Project relevancy to Fossil Energy.

Abbreviations

CCS ..... carbon capture and storage

CNT ..... carbon nanotubes

CO_2 ..... carbon dioxide

COHO ..... CO_2-H_2O

ECMD ..... electrically conductive membrane distillation process

FGD ..... flue gas desulfurization

FO ..... forward osmosis

GTI ..... Institute of Gas Technology

H ..... hydrogen

HUC ..... hydraulic unit code

ICCI ..... Illinois Clean Coal Institute

IECM ..... integrated environmental control model

MD ..... membrane distillation

Mg/L ..... Milligrams per liter

MGSC ..... Midwest Geological Sequestration Consortium

PCC ..... pulverized coal combustion plant

PPM ..... Parts per million

SCC ..... Strategic Center for Coal

TDS ..... total dissolved liquids

TMC ..... transport membrane condenser

TPY ..... tons per year

ZLD ..... zero liquid discharge

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http://energy.gov/fe/coal-utilization-science

http://www.netl.doe.gov/research/coal/crosscutting

Acknowledgements

The Water Management Project Portfolio was developed with the support of many individuals. Principal Investigators, Federal Project Managers, Technology Managers, Division Directors, and National Energy Technology Laboratory site-support contractors involved with the preparation of Water Management Project Portfolio played key roles.

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April 2015