R&IC-SEA Water Management Research: Data Modeling and Analysis

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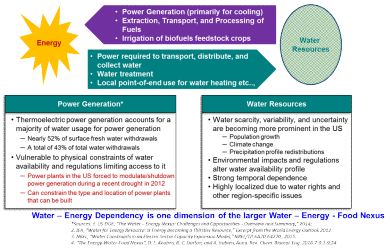
NATIONAL ENERGY TECHNOLOGY LABORATORY

Water – Energy Interdependency



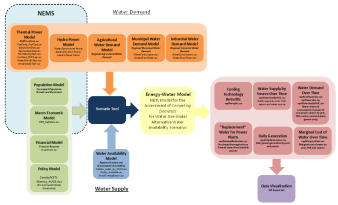
Water – Energy Dependency is one dimension of the larger Water – Energy - Food Nexus

Data Modeling and Analysis
Projects/Analyses

FY16/17
- Water-Energy Integrated Model
  - States Water Availability Data

FY17
- Produced Water Desalination Metrics
- Trace Metals Analysis for advanced power plant streams
- Nontraditional Streams
  - Scoping Study and Follow-on Analysis
- Case Studies on Power Plant Water Use Practices and Future Issues

Water-Energy Integrated Model



Motivation

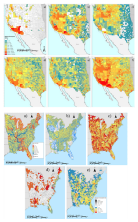
- Water – Energy interdependency is an important factor that has to be taken into consideration in the deployment of power generation technologies
  - Siting considerations
  - Environmental considerations
  - Technology considerations
  - Municipal, Industrial, and Agriculture considerations
- Current energy capacity forecasting tools such as NEMS do not adequately take into account potential water constraints in deployment considerations

Objectives

- Develop tools and metrics that inform electric power generation design choices related to water availability and the cost of power plant water utilization
- Explore electric power technology options and use results to
  - Inform R&D
  - Mitigate the impact of adverse water availability conditions on current and projected future thermoelectric electric power generation capacity

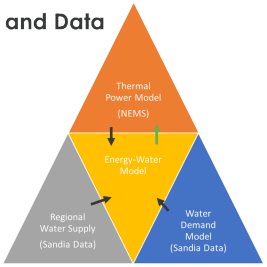
Sandia Water Availability Data

- Original 17 Western States
- NETL funding for 31 Eastern States
- HUC-8 watershed level
- Fresh surface, fresh ground, municipal waste, brackish ground water



Prototype Model Design and Data

- Time Period: 2012 to 2040
- Regions: HUC 8 – Hydrologic Unit Code (8 digits 2,200 HUs, 700 mi²)
- Model Objective Function: Minimize the total cost of satisfying water demand in each HUC 8



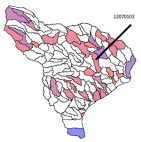
http://energy.sandia.gov/mapping-water-availability-in-the-western-us/

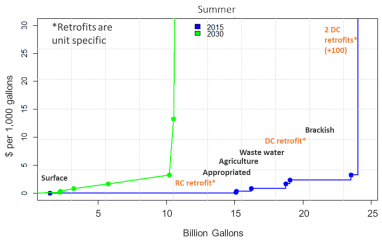
Model Design

- Multi-period seasonal planning model
- Prototype model developed in GAMS
  - General Algebraic Modeling System – Linear programming model
- Optimizes to minimize the cost of satisfying the demand for water
- LP performs an economic trade-off between purchasing water at various costs from constrained water sources or spend capital to retrofit power plants with less intensive water cooling technologies
  - Appropriated water
  - Impaired water (waste or bine waters)
  - Purchase from Ag
  - Retrofit cooling system to recirculating or dry cooling

Marginal Cost Supply Curve for Water
in HUC 12070103 – Navasota, Texas

Forecast cost of water from alternative sources in this HUC8 region.





Future Work

- Refine data
- Update water availability and water demand projections
- Develop and incorporate Drought Scenarios
- Refine cooling system impacts on costs and performance
- Test and perform analysis on Integrated prototype model into EIA's NEMS (two-way coupled model)
  - CF, build, import, purchase water, retrofit cooling technology

Produced Water Desalination Metrics

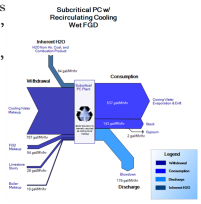
- Detailed systems level analyses will be used to develop metrics for desalination of extracted brines from carbon storage reservoirs to manage plume and pressure or produced water from oil/natural gas production
  - Costs, Performance, Energy, scale, effluent conditions, final conditions
- NETL R&D membrane work may also be incorporated into this subtask

Trace Metals Analysis

- Characterize trace elements in blowdown streams from advanced power systems
  - "Coal contains the periodic table" – heavy metals content in blowdown from pulverized coal combustion relatively well known
  - Conduct literature survey to characterize trace elements in process water streams from IGCC, oxycombustion, CCS, chemical looping, etc.

Nontraditional Streams

- Identify and characterize (chemical constituent) process liquid discharge streams from coal plants (conventional, advanced power, and chemical)
- Identify current and future discharge requirements (i.e., effluent guidelines and/or other drivers that influence technology needs at real plants)
- Identify water treatment technologies that can/could achieve required discharge limits (including zero-discharge options)
- Develop cost and performance models of the "quality" that would allow them to be incorporated into NETL techno-economic analyses
- Incorporate the models into the baseline studies



Case Studies on Power Plant Water Use Practices and Future Issues

- Develop a case study on power plant water use practices
- Conduct several power plants tours with a primary focus on coal plants and a secondary on natural gas combined cycle plants
- A collaborative effort between NETL and plant staff will be established in order to develop a report based on their water use practices and future issues and concerns regarding plant water

- Water use, measurements, conditions, normal ops, turndown ops, permits, disposal, run off, challenges, issues,…