Water Management for Fossil Energy Systems

Current Activities in Water Management Research and Development

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U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

Department Of Energy
National Energy Technology Laboratory

DOE Mission: *Ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions*

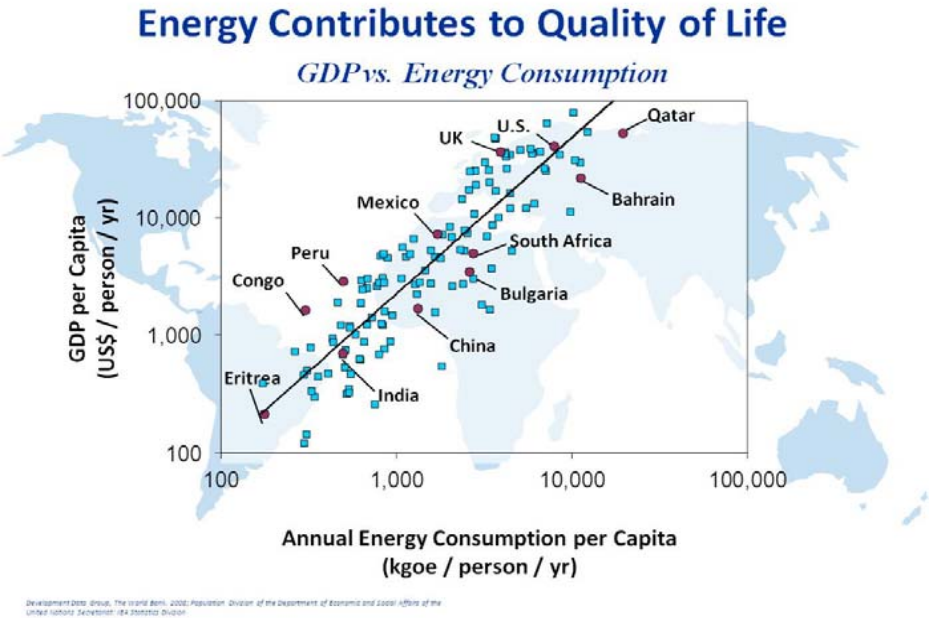
NETL Mission: *Advance energy options to fuel our economy, strengthen our security, and improve our environment*

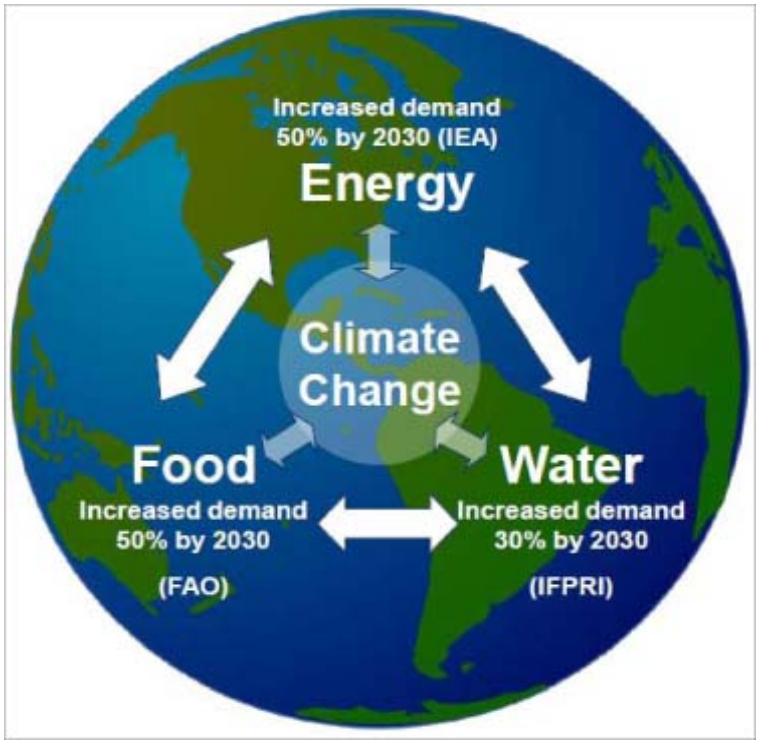
Why and what we do...

- Utilize domestic resources for abundant, low cost power
- Design, develop, and demonstrate highly efficient and environmentally benign power and fuel systems.
- Perform and manage research, development, and demonstration projects in the areas of resource utilization, equipment for energy conversion, separation processes, and approaches to carbon capture & storage.

Overview

- Water
  - Essential, Ubiquitous, & Pervasive
- Water, Food/Land, & Energy are connected
- Water Management for Fossil Energy Based Systems

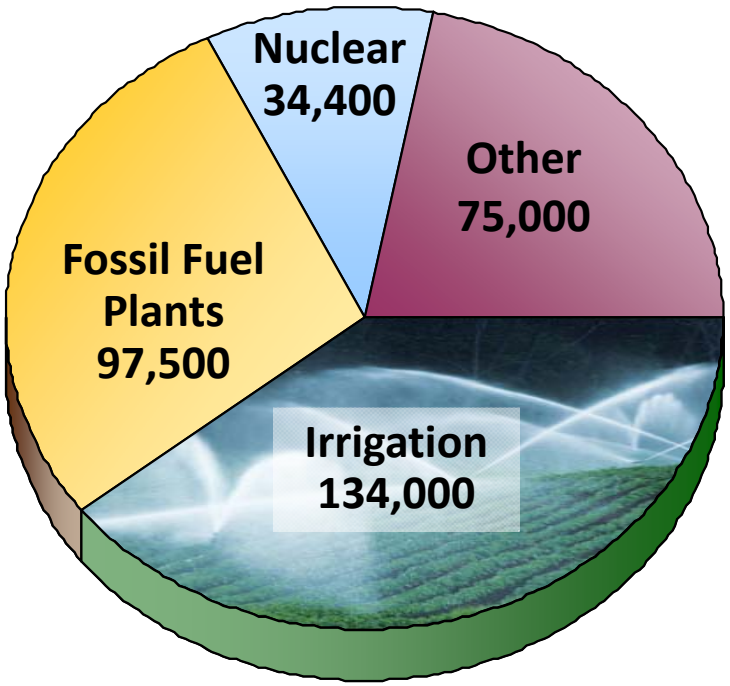




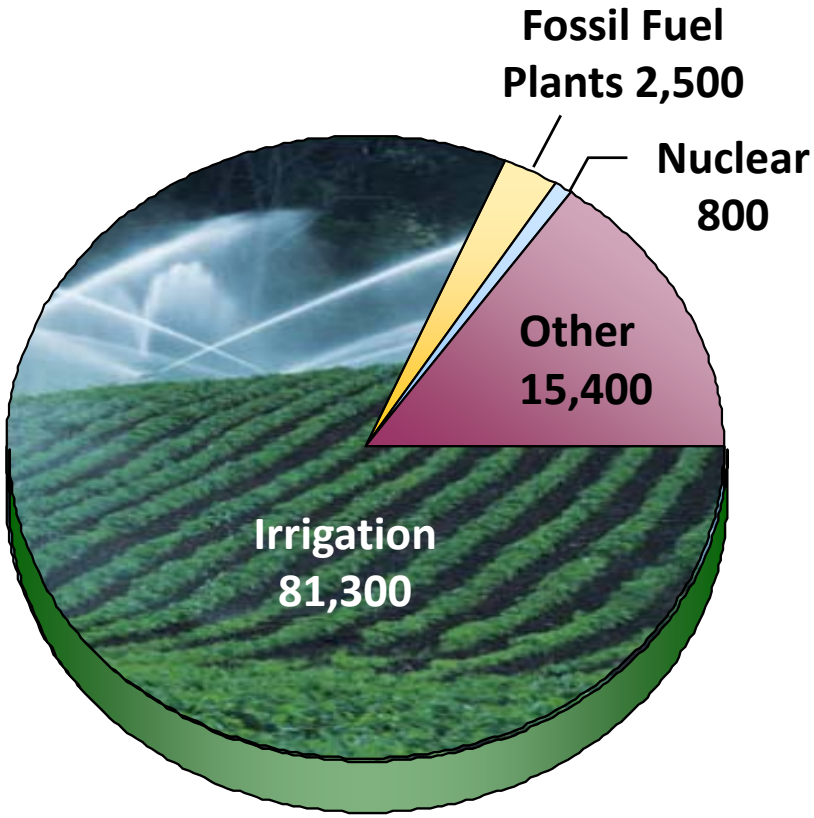
- Data and Information
- Program Planning
- Prioritization of Effort
- Working Together
  - Government
  - Industry
  - R&D Organizations

Water Withdrawals and Consumptive Use

Thermo-electric Power Large User of Water, Relatively Small Consumer



Withdrawals (Mgal/day)

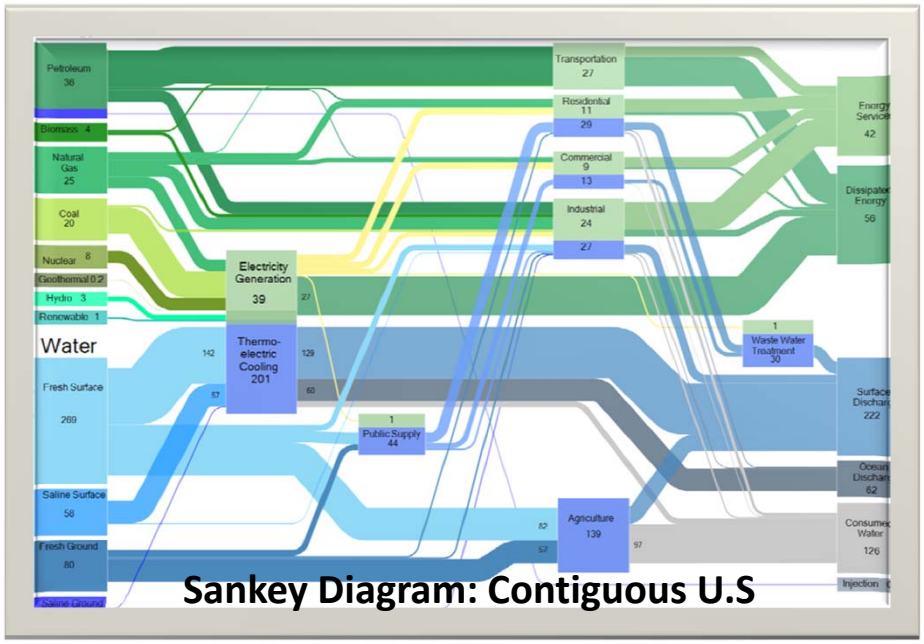


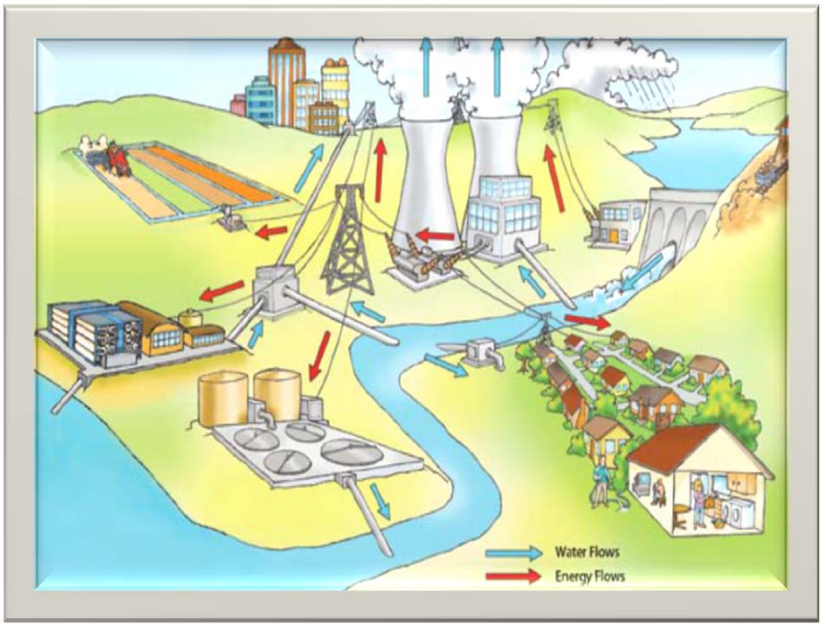
Consumptive Use (Mgal/day)

Source:"Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998

Sankey Diagrams

Useful accounting for Water-Energy Efforts





- Develop State based Sankey Diagrams
- Water Energy Nexus Team, NETL, and LLNL
- Improve and update data/inputs
- Address gaps in water and energy

Water Balances Associated with Deep Gas

State Level Assessment

Objective

- Develop Sankey diagrams to illustrate water usage in shale gas/oil extraction by state

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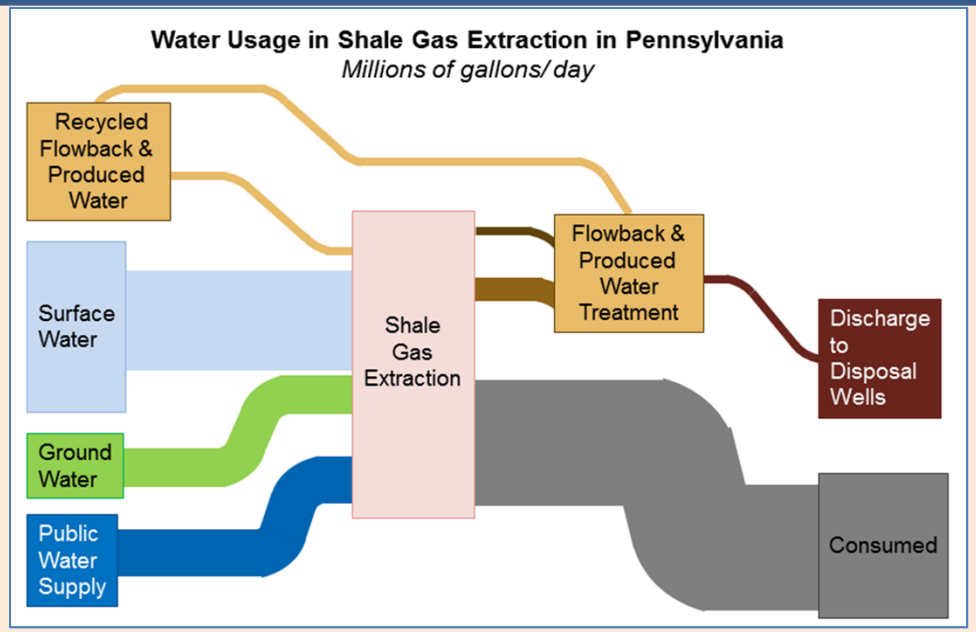
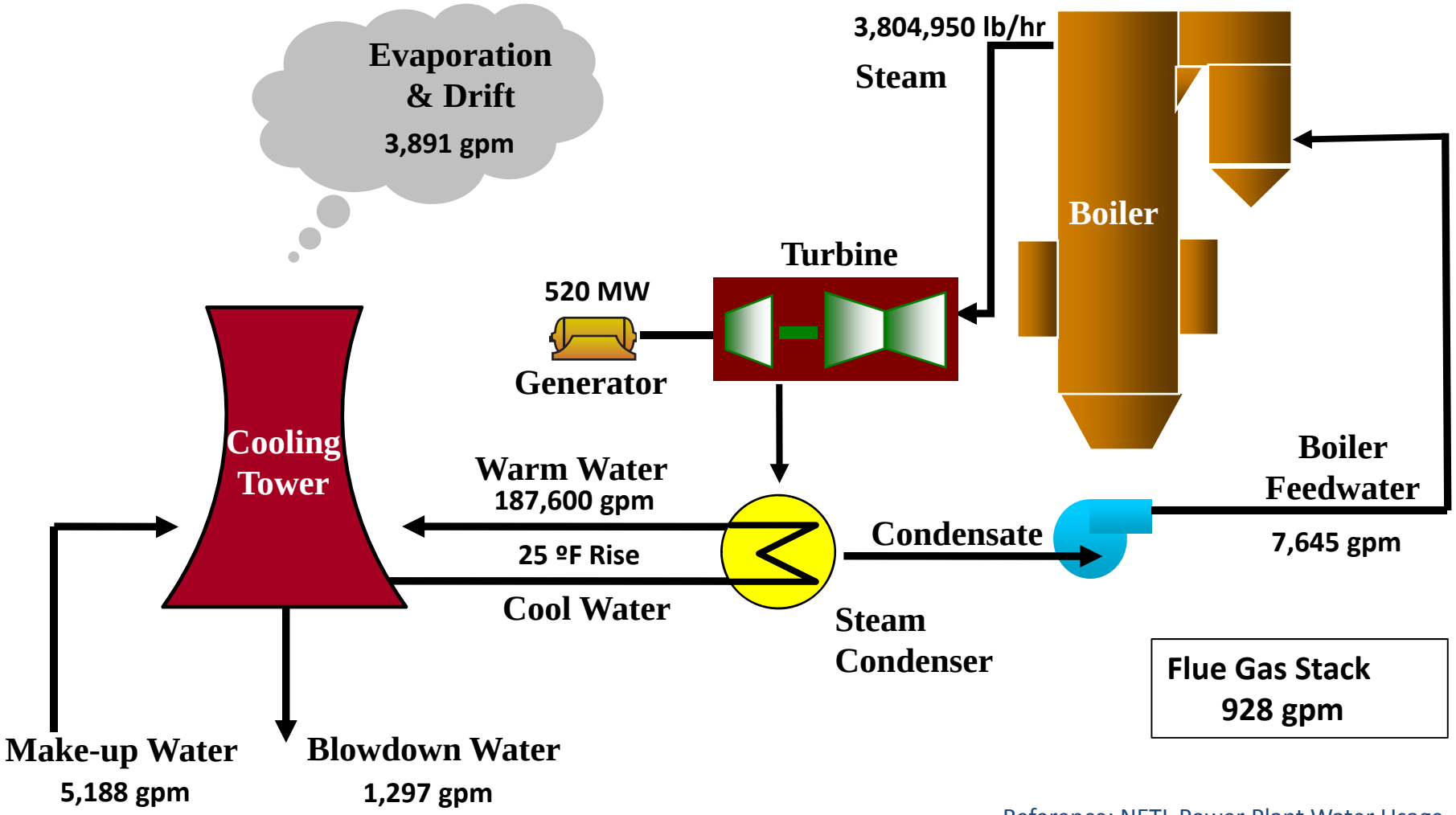
Strategy

- Initially focus on water usage for Appalachian Basin unconventional shale gas/oil extraction
- Identify best sources of water supply and disposition data by state (OH, PA, WV)
- Gather data and develop rationale for quantifying data inputs required for Sankey diagrams by state
- Develop methodology for updating as new data becomes available



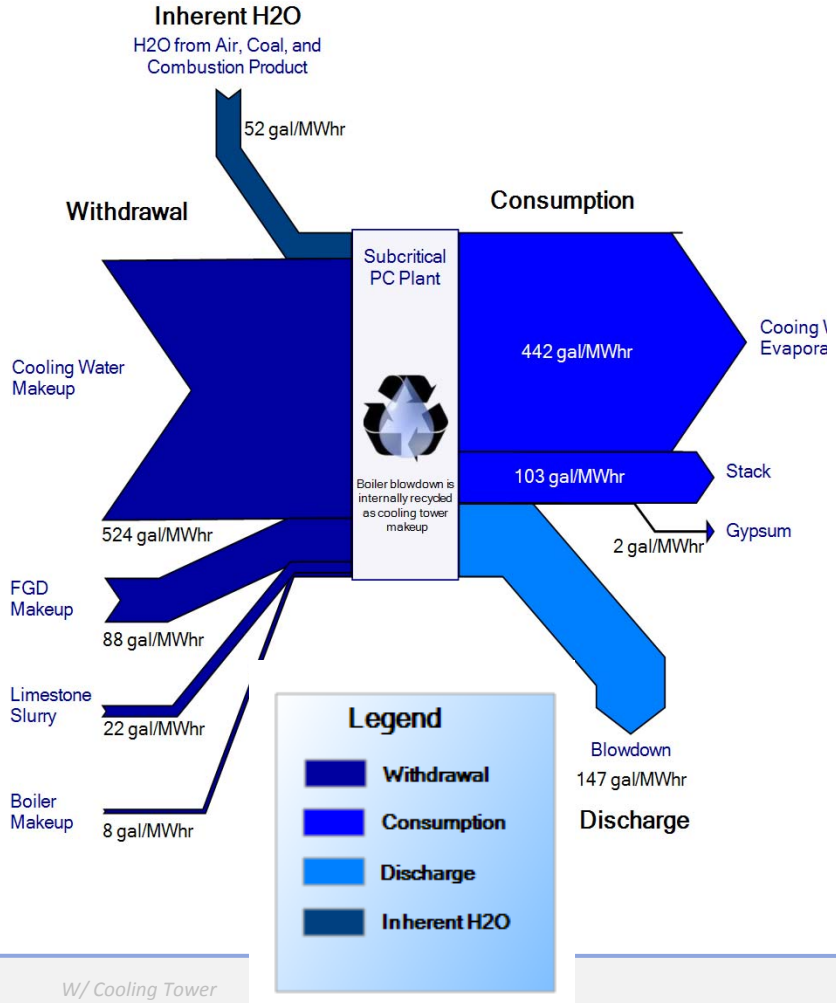
Water Balance for 520 MW Bituminous Coal-Fired Power Plant

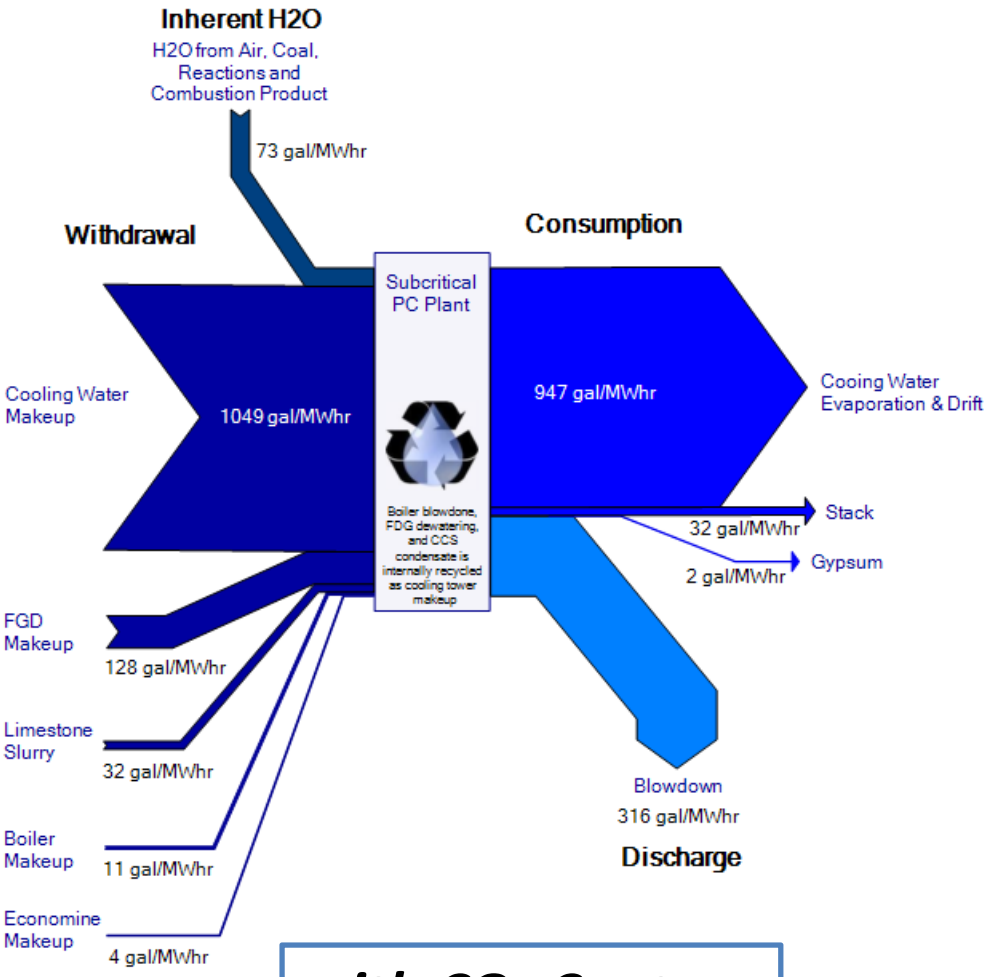


Reference: NETL Power Plant Water Usage and Loss Study, May 2007

Sankey Diagram: Pulverized Coal Plant 500 MW

SOA Environmental Controls With No CO_2 Capture



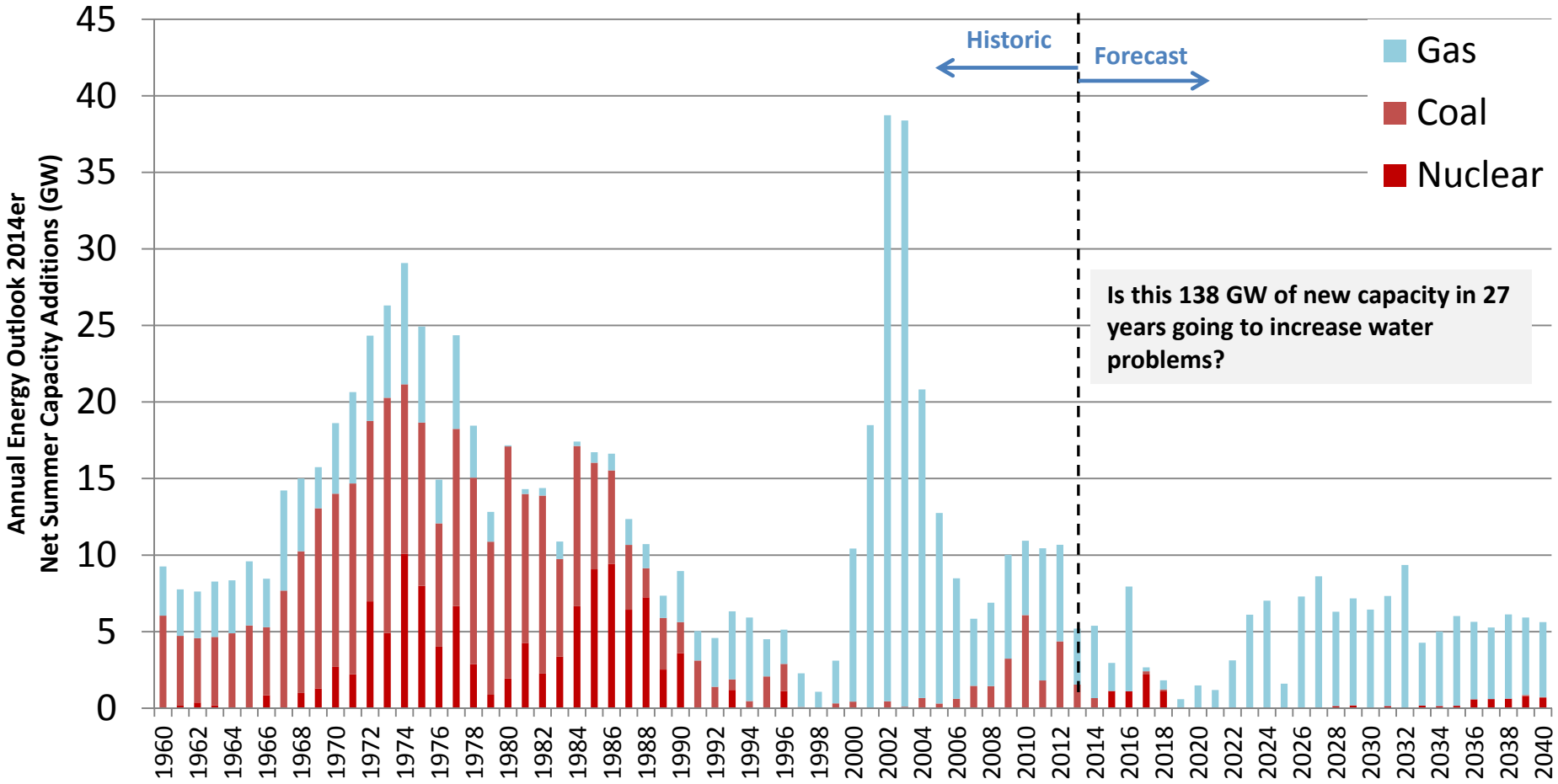


with CO_2 Capture

90% Potential Increase in Withdrawal

Projected Power Generation Deployments

Example 1: Business as Usual Case - Based on AEO 2014 early release



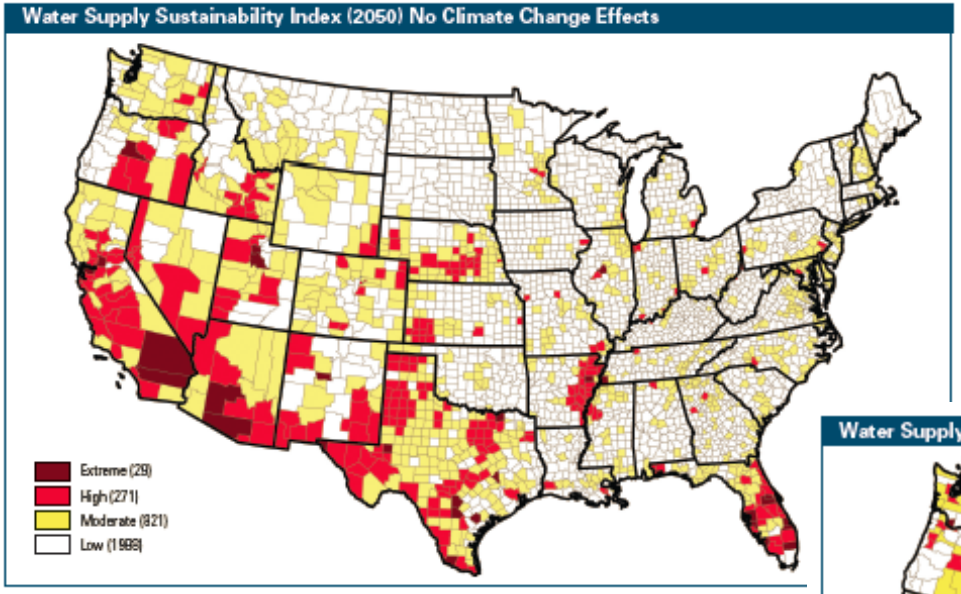
Does not take out retired units

NGCC used ~ 1/3 less water per MW than coal and nuclear steam units

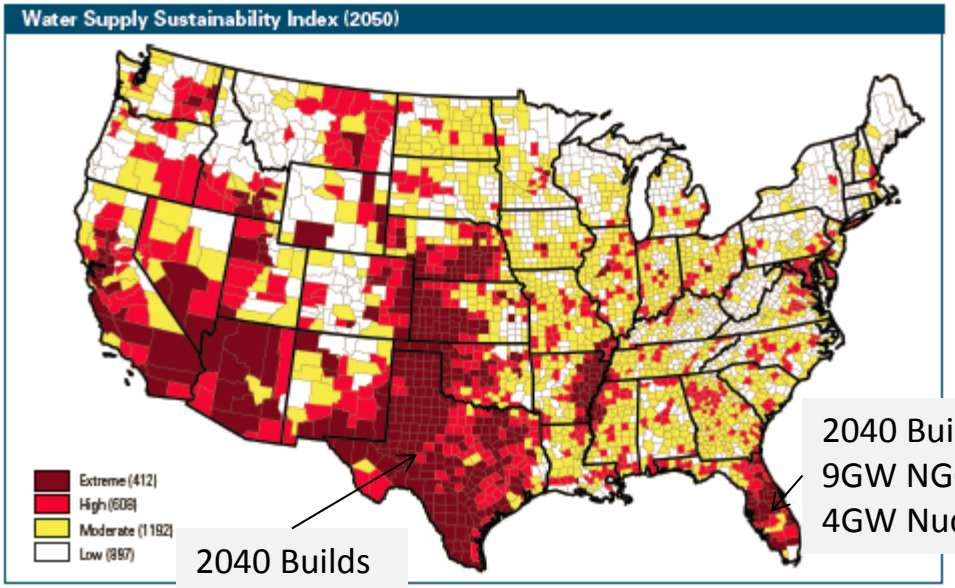
Ventyx Velocity Suite, EIA AEO 2014 er

Gas = gas fired combined cycle and steam units

Current Water Demands Do Not Appear Sustainable in Many Parts of the U.S.



State	Percent of Counties At-Risk for Water Shortage	Value of Crops Produced in At-Risk Counties ($000s)
Florida	96%	4,803,297
Texas	98%	5,333,981

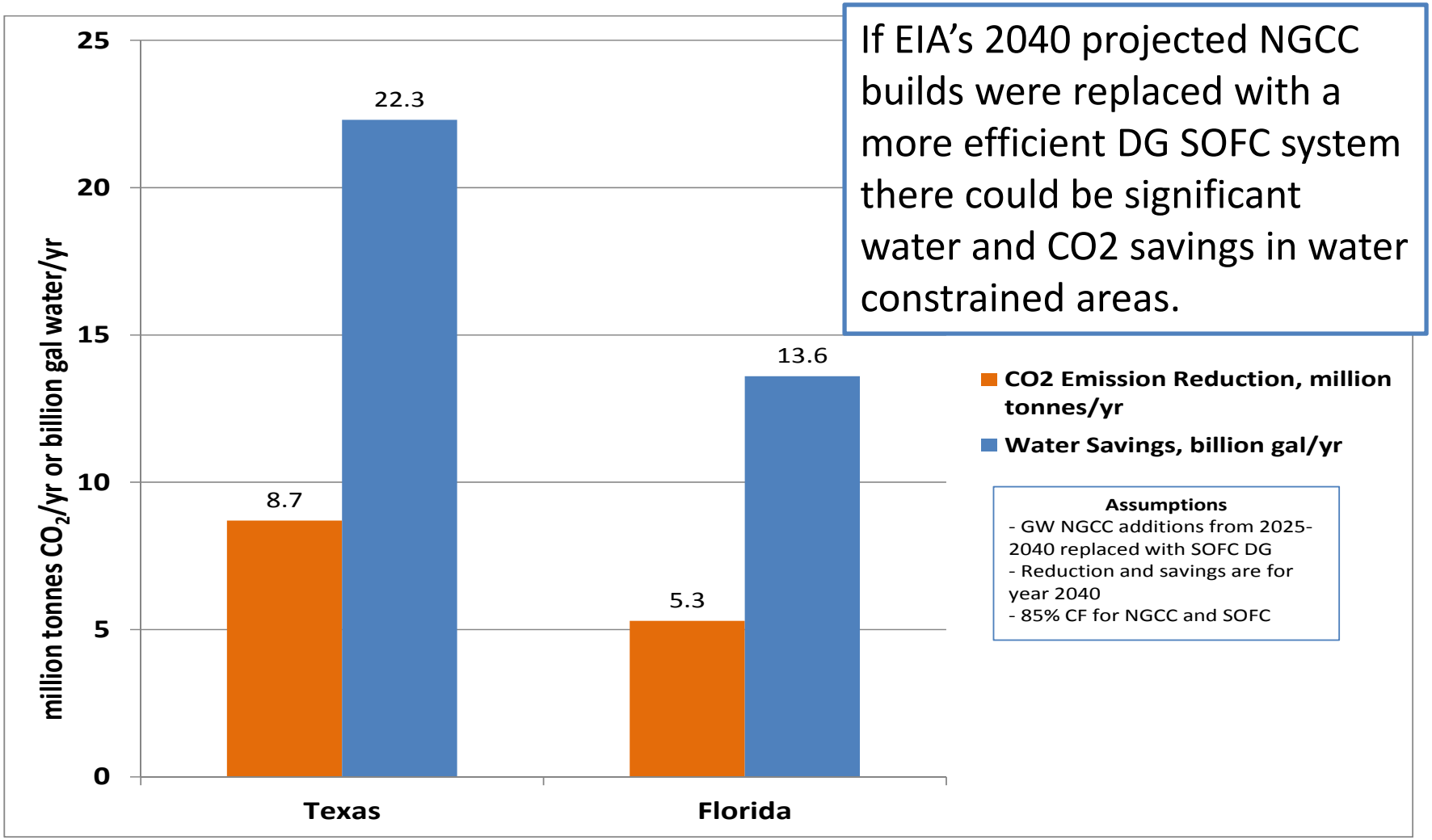


EIA's AEO 2014 shows that the most water constrained areas, FL and TX will see significant population growth and power plant builds by 2040

National Resources Defense Council: http://www.nrdc.org/globalWarming/watersustainability/

Low Water Footprint Technologies

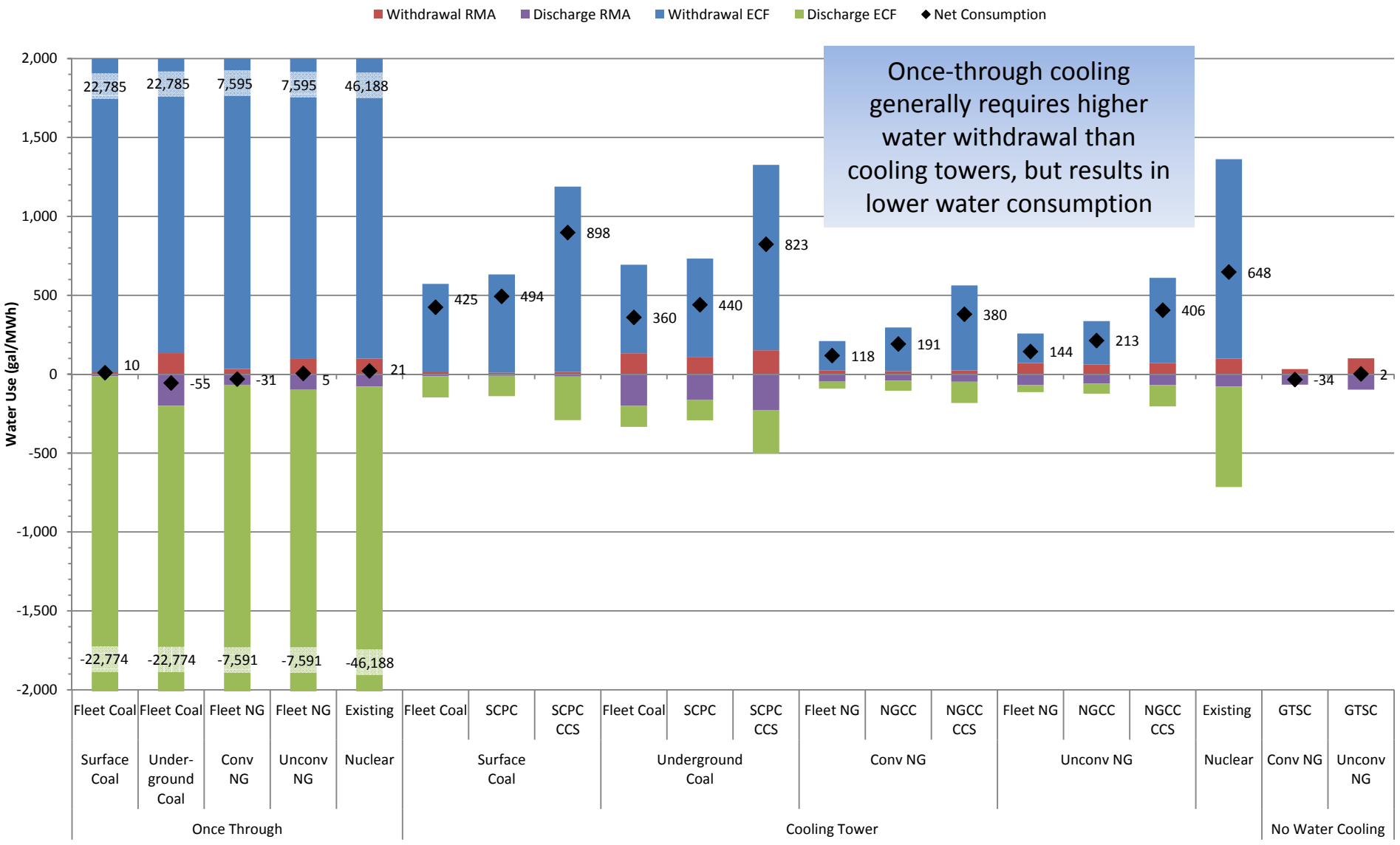
Distributed Generation Fuel Cell Impacts on CO_2 Emissions and Water Use



If EIA's 2040 projected NGCC builds were replaced with a more efficient DG SOFC system there could be significant water and CO2 savings in water constrained areas.

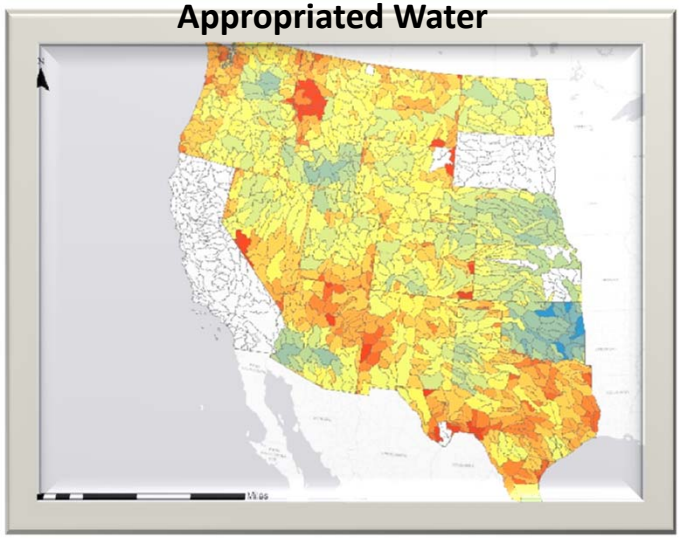
Changes in Capacity Imply Changes in Water Use

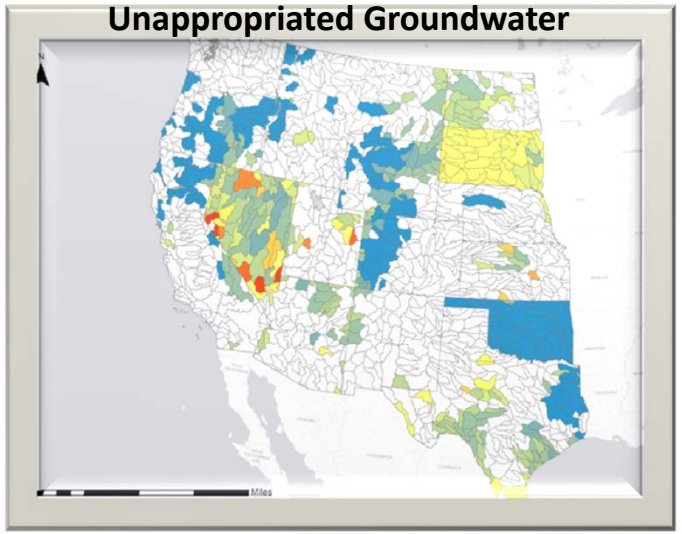
Life Cycle Water Use for Power Generation



Improving Data and Models

- **Collaboration with Sandia National Laboratory**
  - Build from prior work at SNL on water for water states
  - Eastern states data will be merged with existing western states data into aggregate database including detailed supporting metadata
- **Develop a Water Altas**
  - Build from data collection and estimation efforts
  - Build tools/model to support analysis, planning, and prioritization
- **Collaborate with Other DOE Offices and Agencies**
  - ARPA-e, USGS, USDA, Other

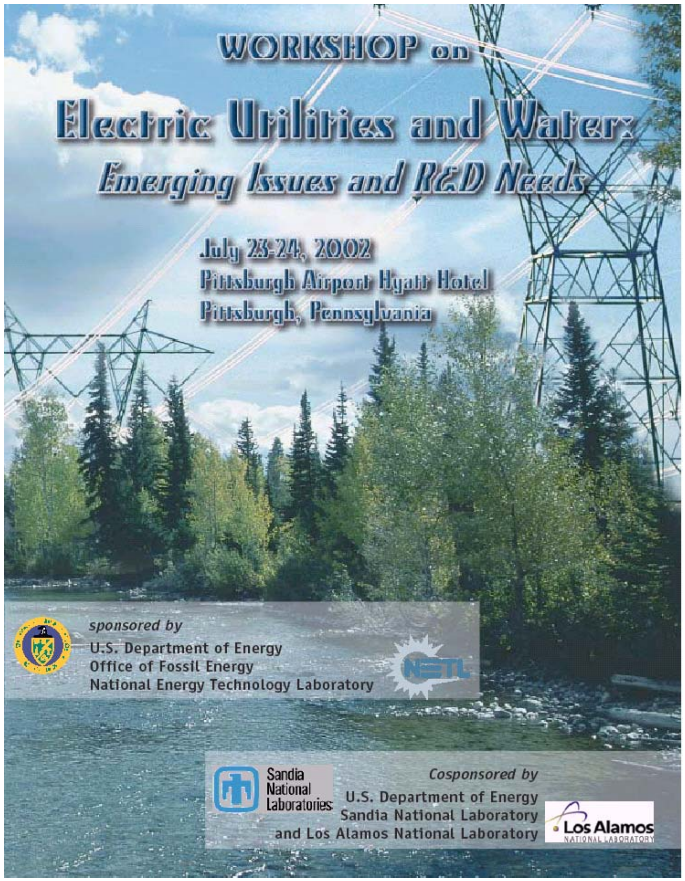




NETL's History in Water Management

- Sponsored workshops focused on power plants and water with SNL
- Long-standing R&D programs in water related to coal, oil & natural gas development and use
- NETL has sponsored over 60 projects focused on water in both the coal and oil & gas programs since 2000

- R&D has included:
  - Thermoelectric water use/management
  - Systems, trends, and life-cycle analyses
  - Advanced treatment/detection technology
  - Produced water treatment and reuse
  - Unconventional oil and shale gas-water interface
  - Geological carbon storage



NETL's 2003 Electric Utility & Water Workshop

Thank You
Questions

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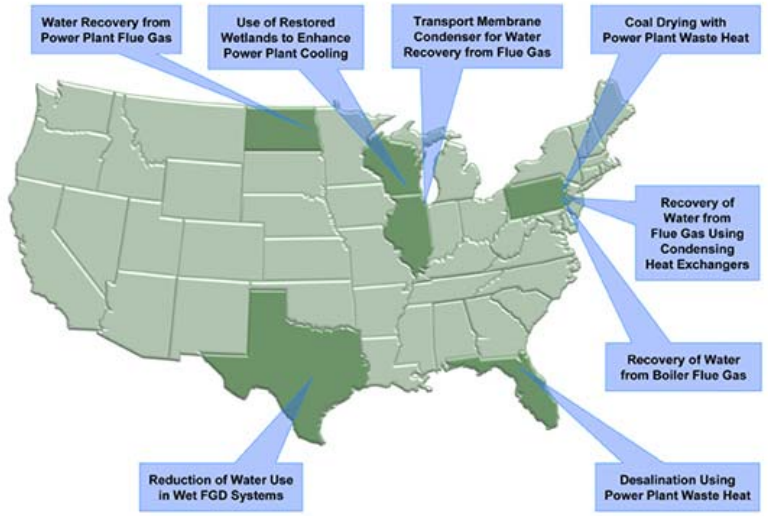
Water Reuse and Recovery

- ~81% power plants have municipal wastewater available within 10 miles
- Advanced treatment necessary, costs $0.91 - $1.32 (in 2009$/kgal) vs. $0.74 for river withdrawal and the city water costs of $2.95 (in 2009$/kgal)
- Economics and availability make this water source second to river withdrawal and widely used



Pilot-scale cooling towers

Use of Treated Municipal Wastewater as Power Plant Cooling System Makeup Water

Carnegie Mellon University

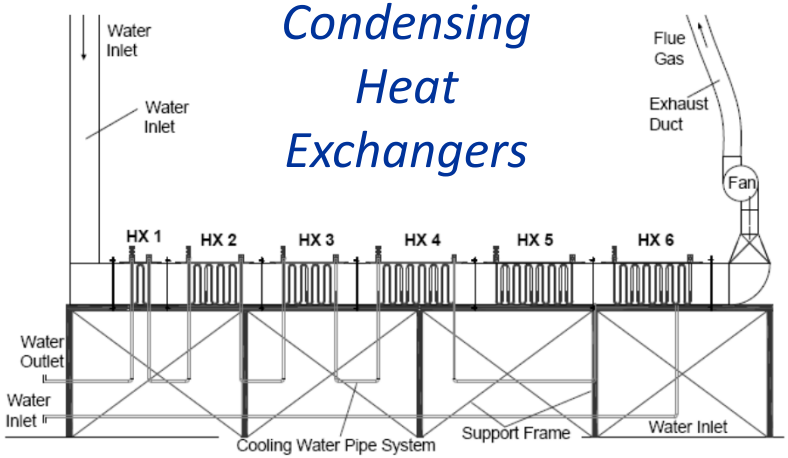
~81% power plants have municipal wastewater available within 10 miles

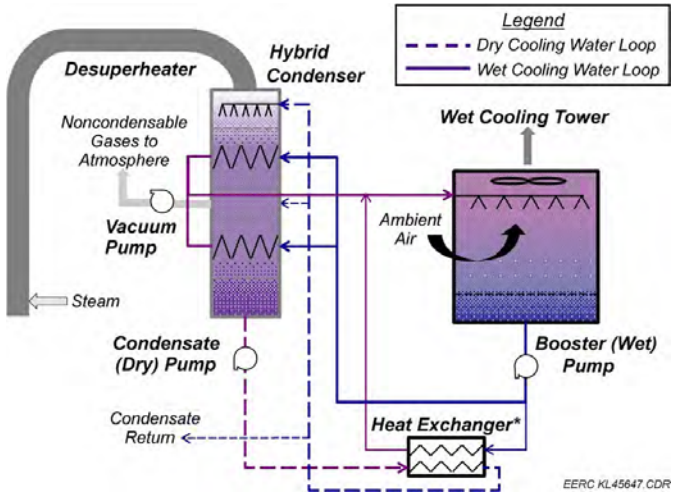
Advanced treatment necessary, costs $0.91 - $1.32 (in 2009$/kgal) vs. $0.74 for river withdrawal and the city water costs of $2.95 (in 2009$/kgal)

Economics and availability make this water source second to river withdrawal and widely used

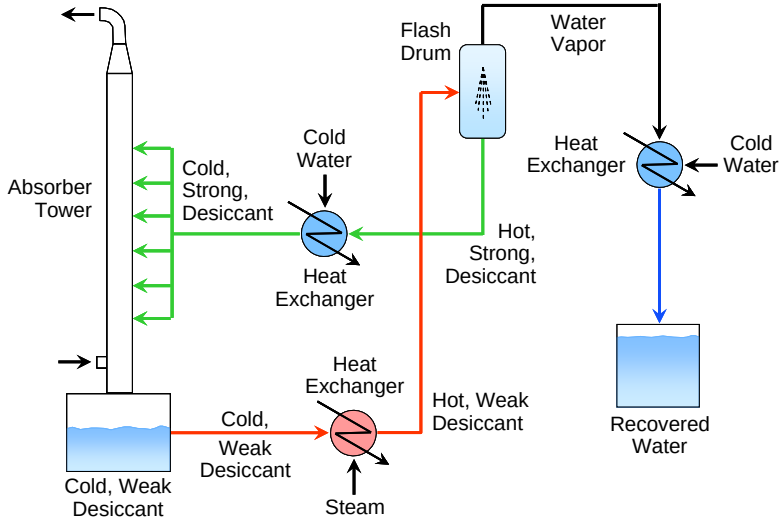
Advanced Cooling Technology

Condensing Heat Exchangers





EERC/GEA hybrid cooling



Absorption with a Desiccant