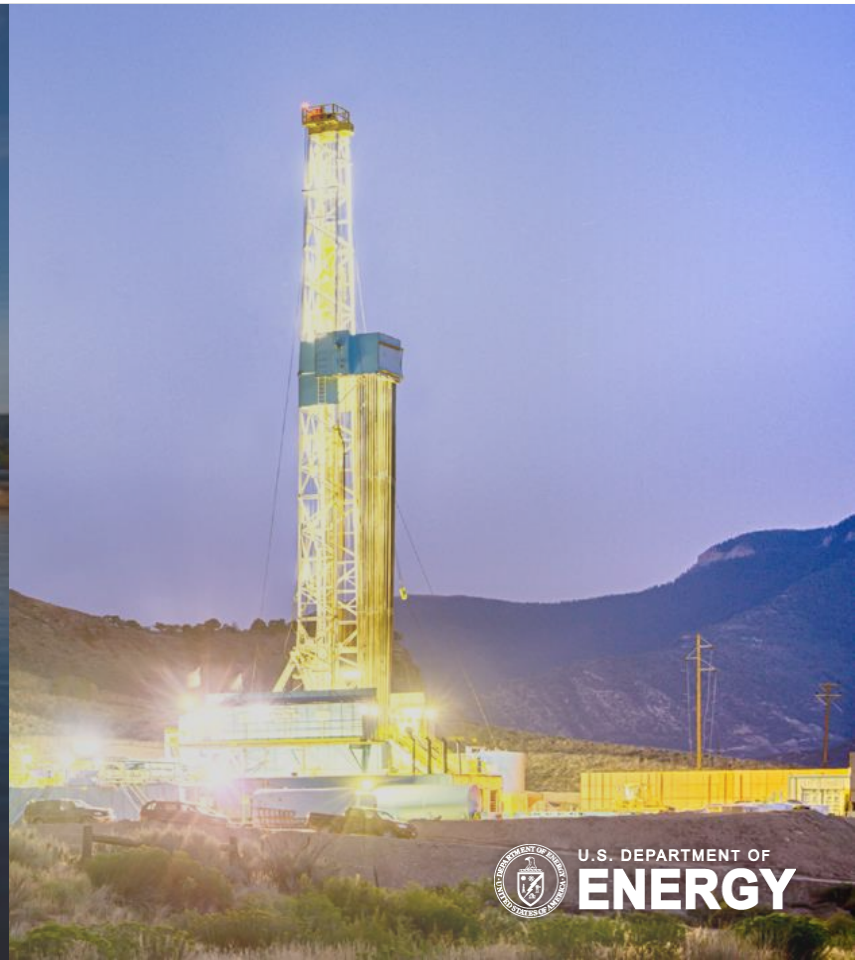
University of Pittsburgh Water Discussion Series

NATIONAL ENERGY TECHNOLOGY LABORATORY

A Research Perspective on the Water-Energy Nexus



Thomas J. Feeley, III
Strategic Partnerships Water-Energy Lead
September 28, 2020
Pittsburgh, Pennsylvania

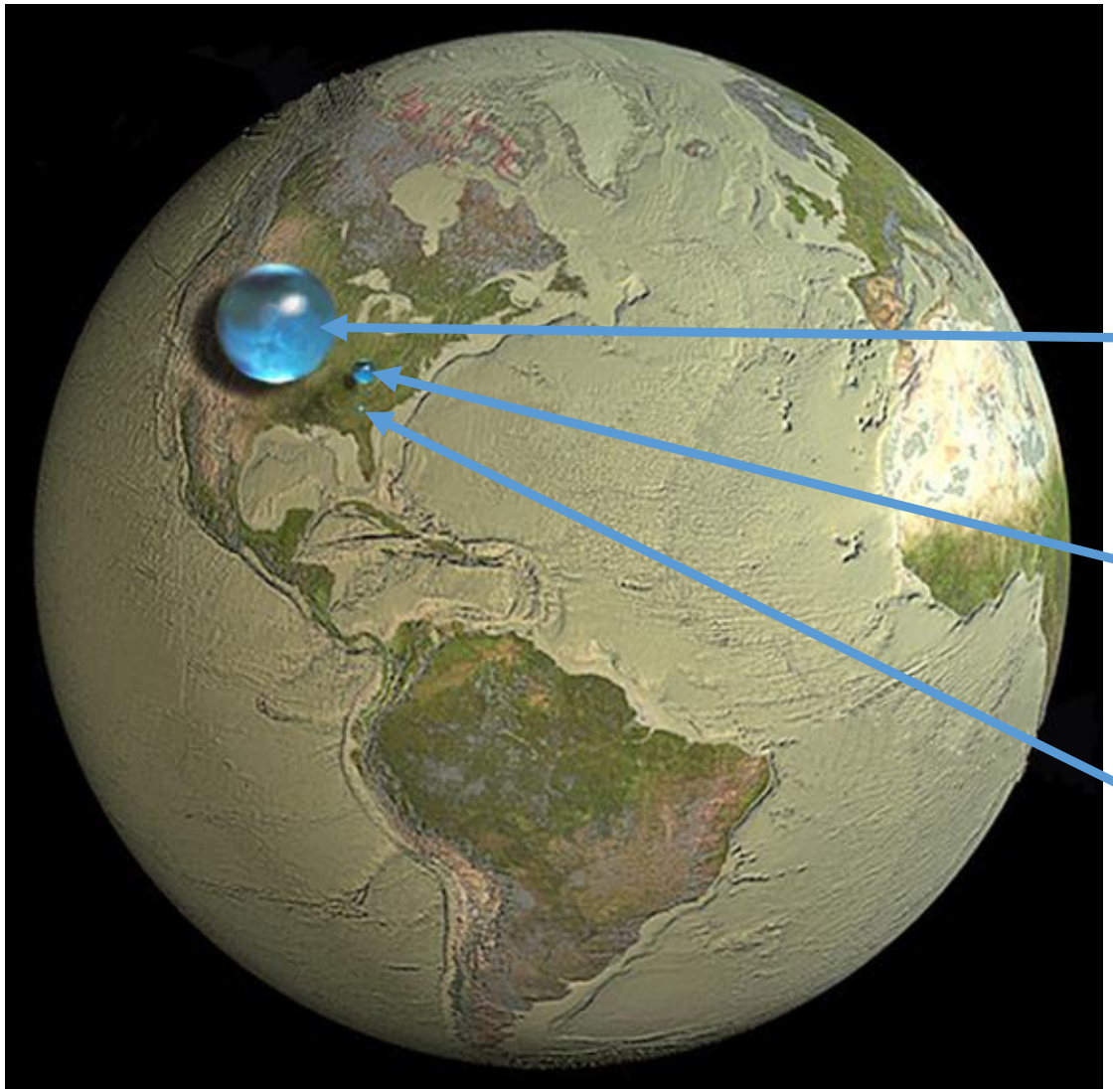
Solutions for Today | Options for Tomorrow

U.S. DEPARTMENT OF ENERGY

"Water, water, every where,
Nor any drop to drink."

The Rime of the Ancient Mariner
Samuel Taylor Coleridge, 1834

Global Water Availability



Only ~2.5% of global water is fresh, with ~99% tied up in ice caps, locked deep in earth, contaminated, or otherwise unavailable

332,500,000 mi^3 -- All water above, in, and on earth

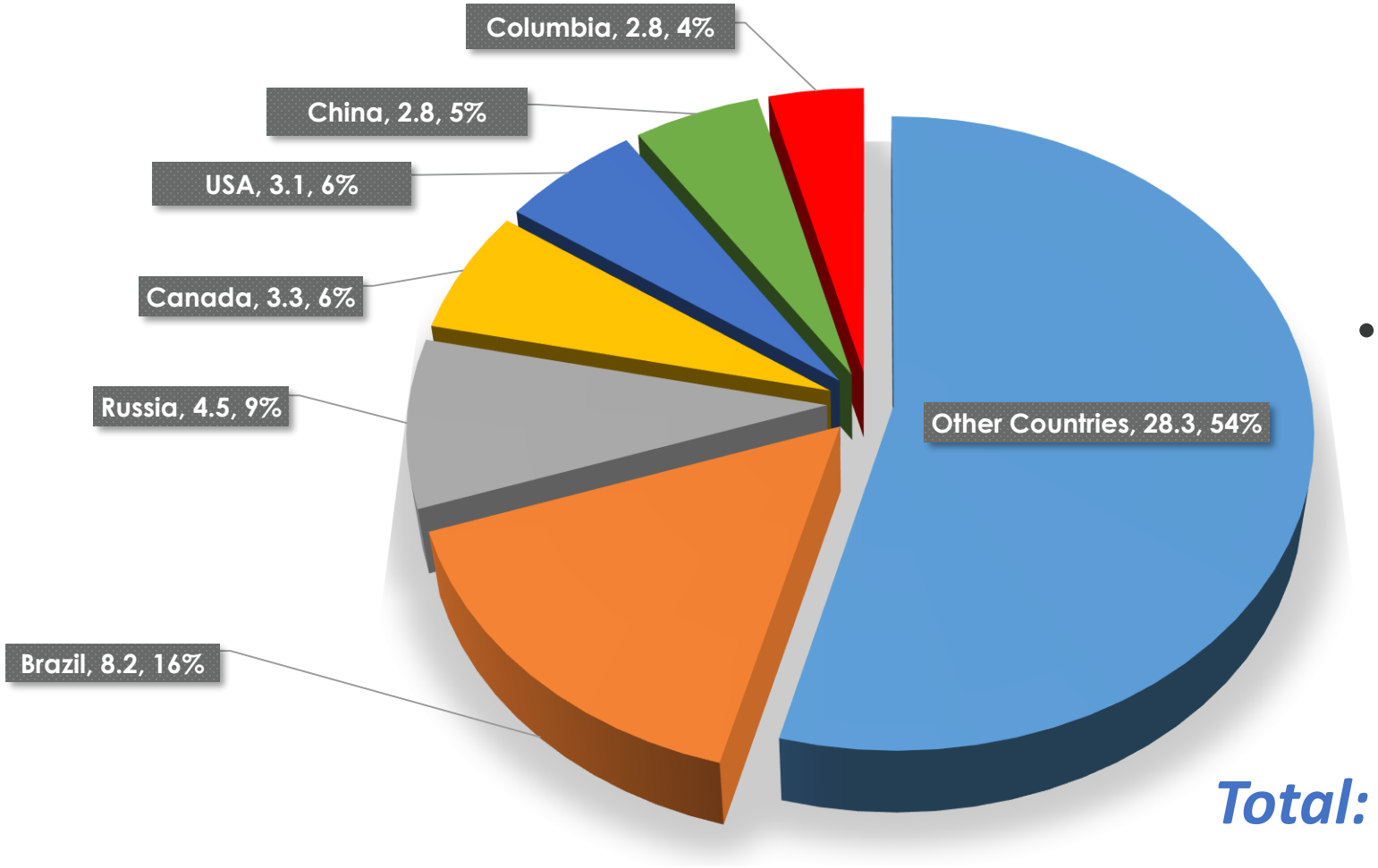
2,551,000 mi^3 -- Liquid fresh water in lakes, rivers, swamps, and groundwater

22,399 mi^3 -- Liquid fresh water in lakes and rivers

Mi^3 = cubic miles (1.1 trillion gal); Earth: 260 billion mi^3

Source: USGS, https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_objects

World Renewable Fresh Water Resources



- U.S. – 3.1 tm^3
  - ~8,846 m^3 per capita
  - m^3 = 264 gallons

Total: 52.3 trillion m^3 (12,547 mi^3)

Water Security Grand Challenge

NATIONAL ENERGY TECHNOLOGY LABORATORY

Announced by White House 10/25/2018, and Led by DOE

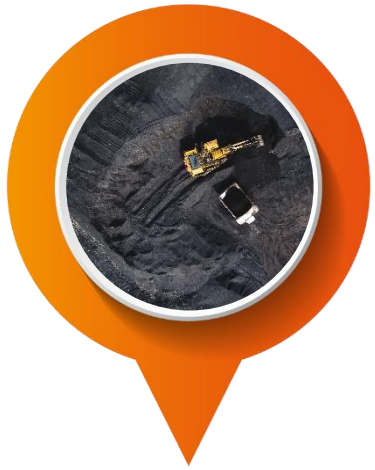
Coordinated suite of prizes, competitions, early-stage R&D funding opportunities, critical partnerships, and other programs by 2030 in order to:

- ***Launch desalination technologies that deliver cost-competitive clean water***
- ***Transform energy sector's produced water from waste to resource***
- ***Achieve near-zero water impact for new thermoelectric power plants, and significantly lower freshwater use intensity within the existing fleet***
- Double resource recovery from municipal wastewater
- Develop small, modular energy-water systems for urban, rural, tribal, national security, and disaster response settings.

Water & Energy Inextricably Linked

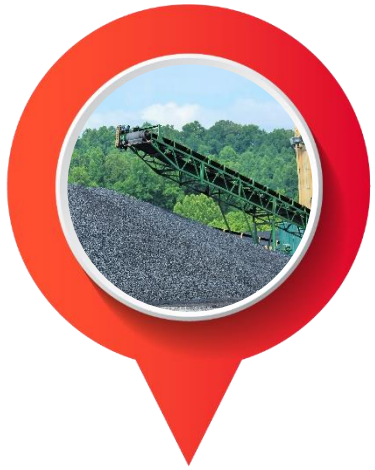
Water needed/impacted throughout fossil-energy lifecycle

EXTRACTION



- Mining
- Drilling/Fracking
- REE Recovery
- AMD/Produced Water

PROCESSING



- Coal Cleaning
- Fuel Upgrading
- REE Recovery
- Coal Conversion

TRANSPORT

- Barge
- Coal-water Slurry
- Fresh /PW

UTILIZATION

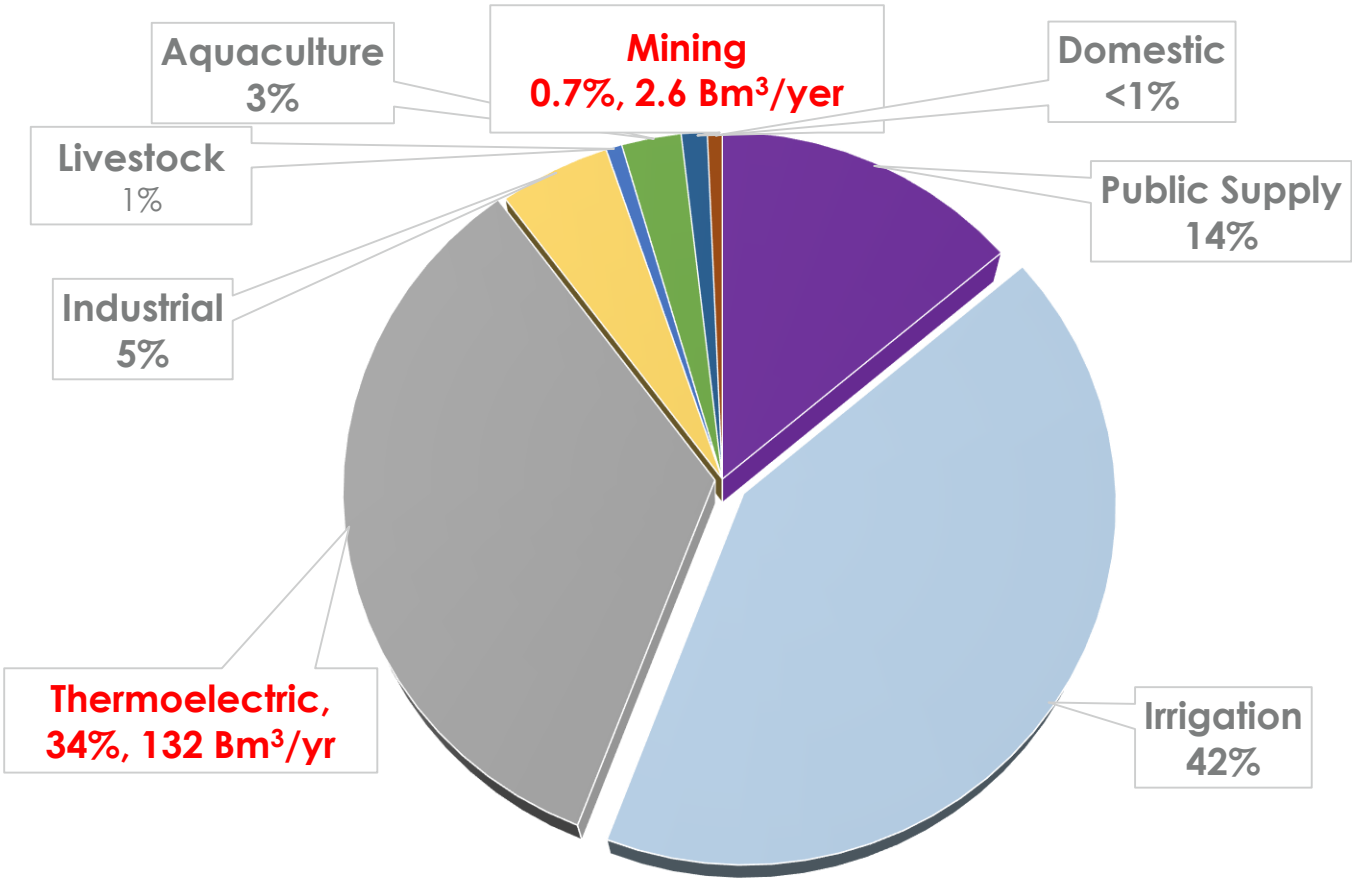
- Cooling
- Steam cycle

ENVIRONMENTAL MANAGEMENT

- Wet Scrubbing
- CO_2 Capture/Storage
- Byproduct Disposal/Reuse
- PW Treatment
- ZLD/Water Treatment

Energy-Related U.S. Freshwater Withdrawal

Thermoelectric generation is second largest water withdrawal sector



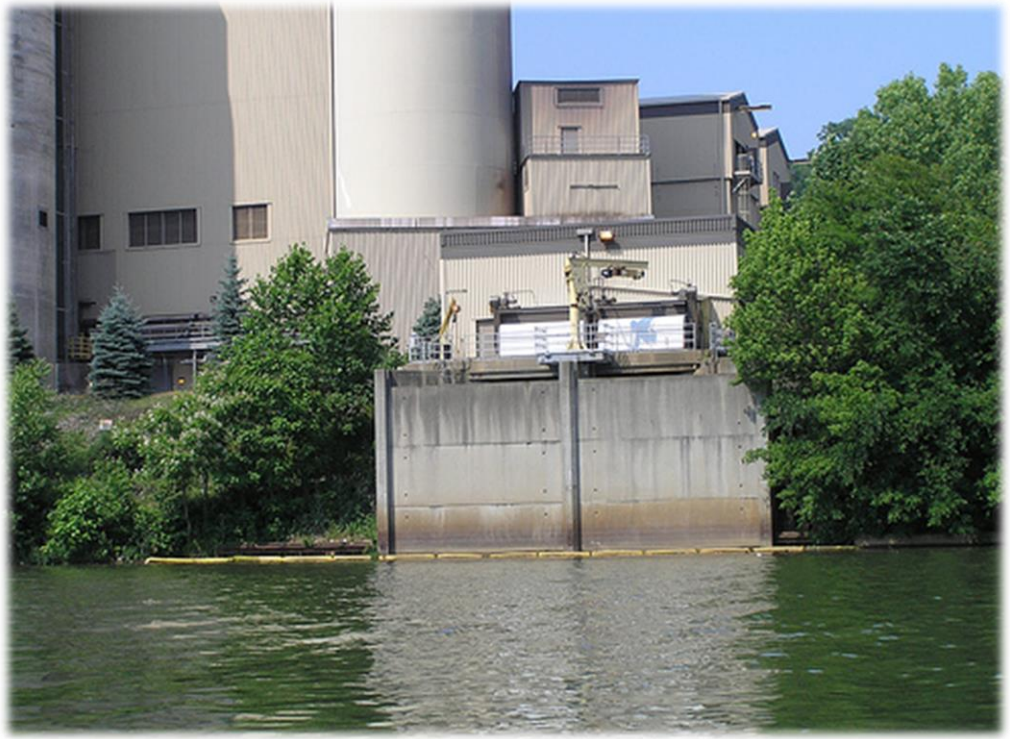
- **Total** U.S. freshwater withdrawal is **389B m³/year**

- **Mining**, which includes oil and natural gas recovery and coal extraction, accounts for **~0.7%** of total U.S. freshwater withdrawals **(~25% groundwater)**
- **Thermoelectric** (primarily cooling) accounts for **~34%** of total freshwater withdrawals **(~100% surface water)**
- **Agriculture** accounts for nearly 80% of nation's consumptive use

Sources: USGS, "Estimating Use of Water in the United States in 2015," and USDA Economic Research Service

Water Withdrawal vs. Consumption

Important to distinguish between the two when discussing fossil energy



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WITHDRAWAL (USE)

Water removed from ground or diverted from surface water source for use.

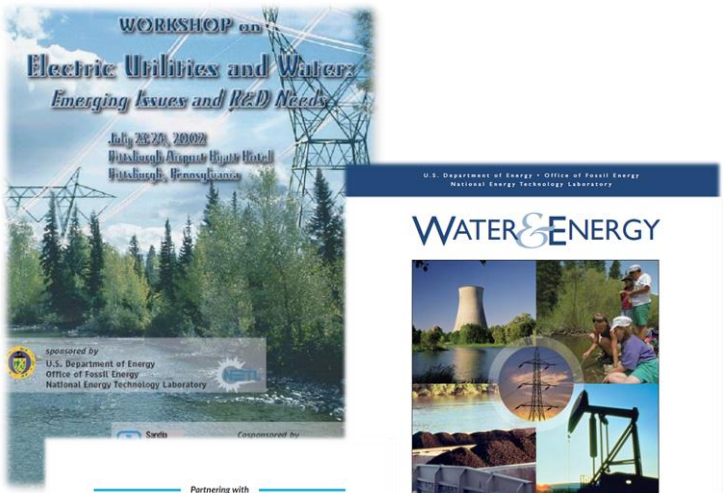
CONSUMPTION

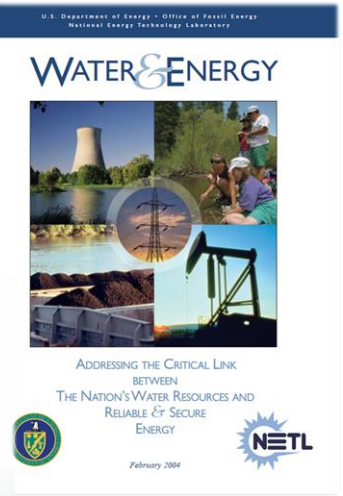
Fraction of water withdrawn that is not returned to source, e.g., water evaporated from cooling towers.

History of Water-for-Energy R&D at NETL

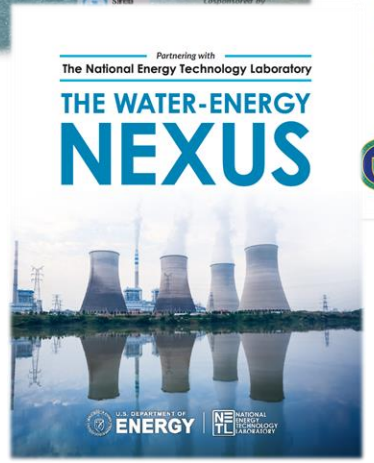
Started in early 2000s as part of NETL's Innovations for Existing Plants Program

2002 Workshop





2004 Brochure



2018 Brochure

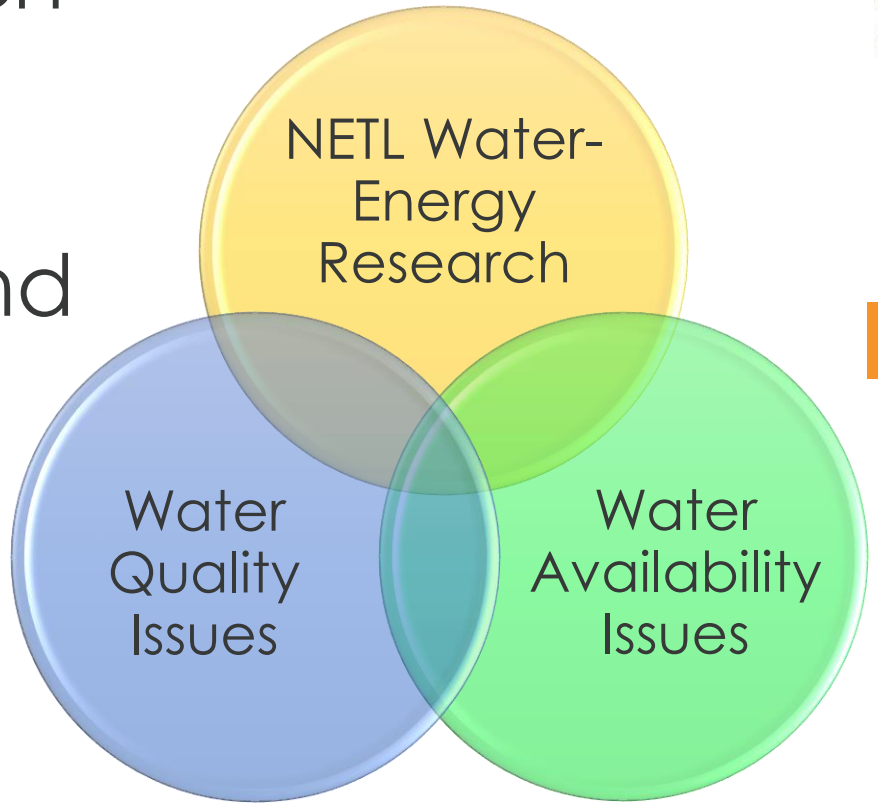
- Prior to 2000 NETL had a loose collection of a few water projects primarily related to former BOM AMD research absorbed by Lab
- In 2002, NETL sponsored 1st public workshop on emerging water issues and research needs associated with thermoelectric power generation
- Research focused initially on water availability and quality affecting the existing fleet of coal-fired power plants
- Since then R&D has expanded to include water issues across NETL's carbon capture & storage, unconventional oil & gas development, rare earths recovery, and related fossil energy programs

Water-for-Energy Research at NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

Partnering key to success

NETL's research addresses **water availability** and **quality issues**, with many projects overlapping both areas.



INDUSTRY

SPORIAN MICROSYSTEMS, INC
Porifera
GROUNDWATER PROTECTION COUNCIL
EPRI gti
RTI INTERNATIONAL
ALTELA Treating water naturally.
oceanit
SPX COOLING TECHNOLOGIES

ACADEMIA

OHIO UNIVERSITY
WestVirginiaUniversity
EERC Energy & Environmental Research Center
TEXAS The University of Texas at Austin
UNM
UK UNIVERSITY OF KENTUCKY
LEHIGH UNIVERSITY

NATIONAL LABS & NON-PROFITS

Sandia National Laboratories
BERKELEY LAB
GROUNDWATER PROTECTION COUNCIL
Argonne NATIONAL LABORATORY

National Alliance for Water Innovation (NAWI)

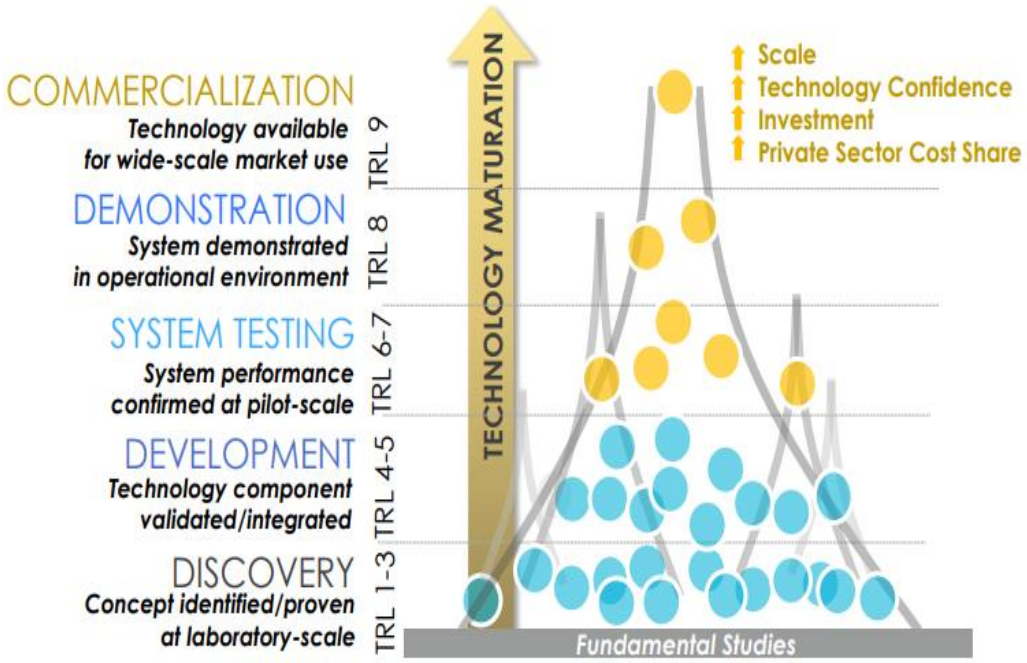
Key component of DOE's Water Security Grand Challenge

Energy-Water Desalination Hub

Establish an Energy Innovation Hub in Energy-Water Desalination to accelerate transformational advances in science and engineering focused on reducing the energy and cost requirements of desalination to provide clean and safe water

Water Research & Innovation at NETL

Research focused on availability and quality Issues



Water research conducted from discovery through demonstration.

NETL has established robust portfolio of intramural (in-house) and extramural water-related research projects directed at availability and quality issues.

Work is being conducted across the following areas:

- **ADVANCED COOLING TECHNOLOGY**
  - Wet, dry, and hybrid cooling
- **NON-TRADITIONAL WATER RECOVERY & USE**
  - Recovery/reuse of mine water, AMD REE recovery,, coal drying, flue gas moisture recover
- **WATER TREATMENT & DETECTION TECHNOLOGY**
  - Desalination, PW treatment, advanced sensors, novel sorbents, power plant wastewater; As & Se detection
- **DECISION SCIENCE & MODELING**
  - Modeling, analysis, and decision-making tools

Current Water-Energy Project Examples

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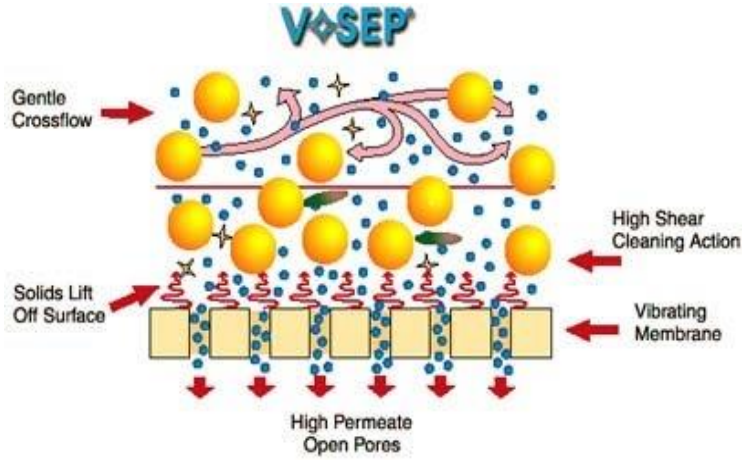
Southwest Research Institute

Developing non-water-based and non CO_2-based stimulation technologies that can be used instead of, or in tandem with, water-based hydraulic fracturing fluids to reduce water usage and the volume of flowback fluids.

Southern Research Institute

Developing technology to treat CO_2 sequestration produced waters with high total dissolved solids not treatable using traditional membrane processes.



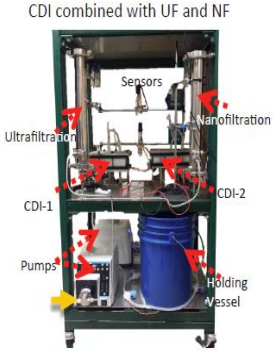
University of Kentucky and *Duke Energy*

Developing advanced electrocoagulation with air-based flotation for removing regulated species from FGD wastewater.

UKy-CAER Separation Modules

Iron-based Electrocoagulation

In-house developed zeolite membrane



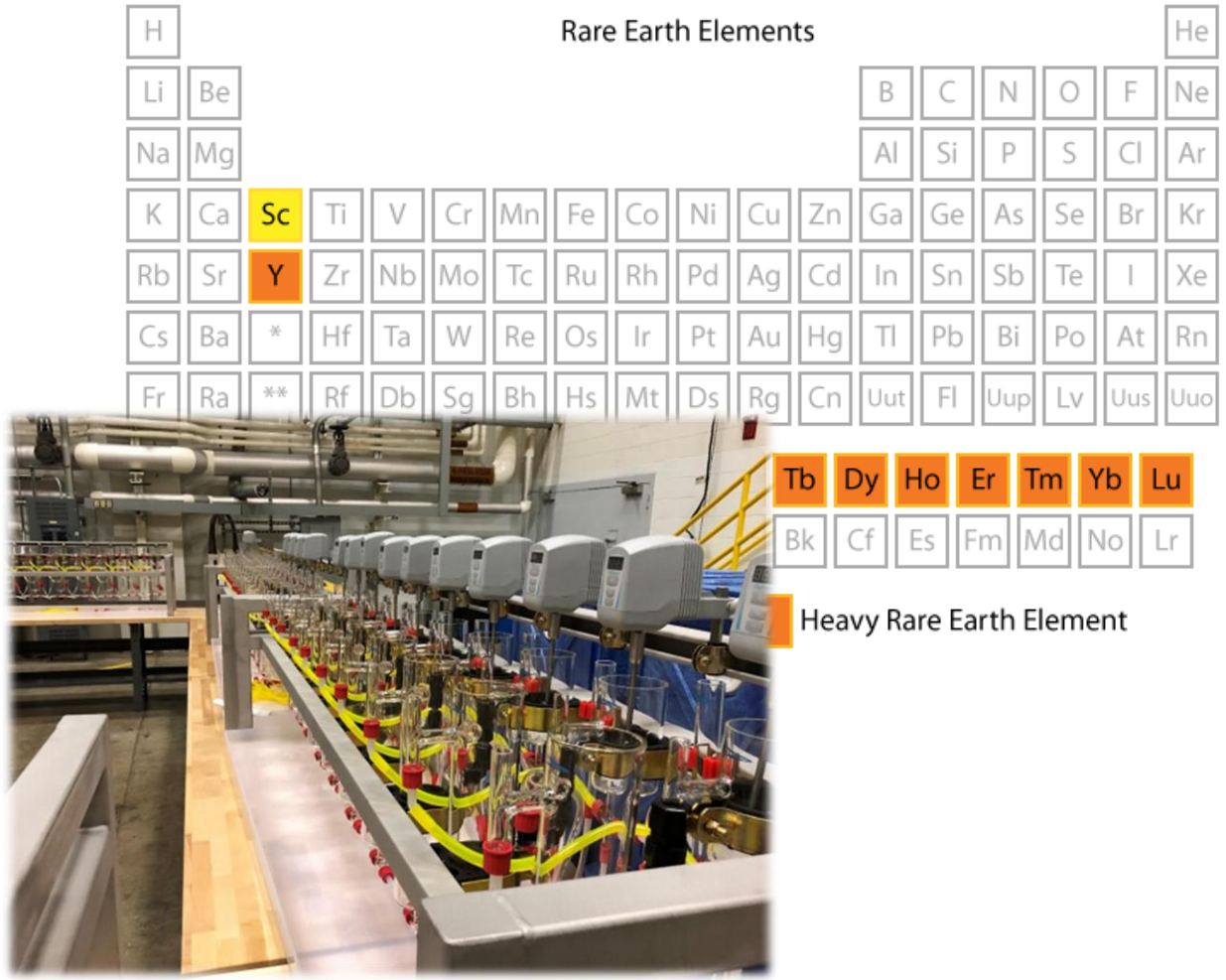
Continuous operation using CDI, UF, and NF

Value Product Recovery

Addressing AMD and recovering rare earths

- Team from NETL, University of Pittsburgh, and Hedin Environmental Inc. assessing recovery of rare earth elements from seventeen active and passive AMD treatment sites.

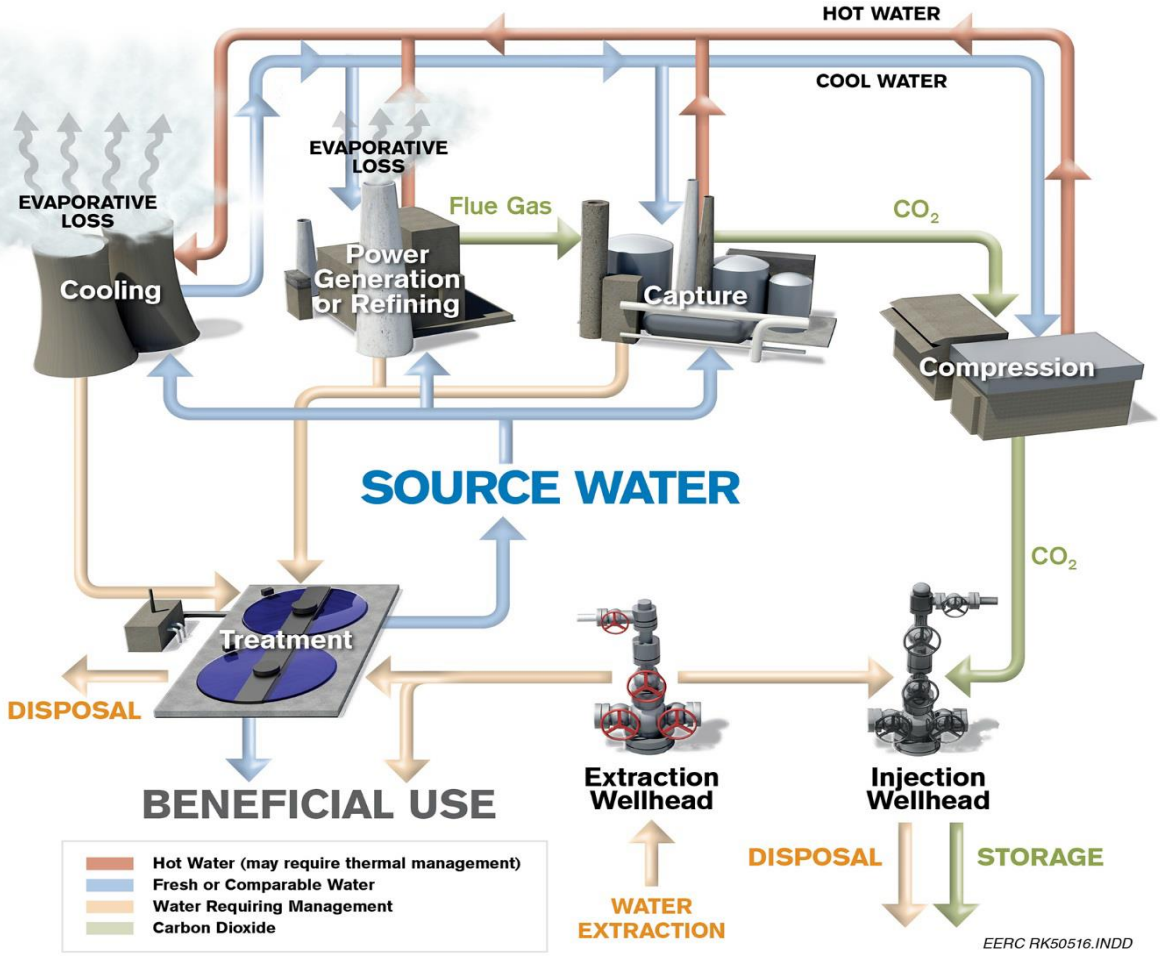
- WVU and partners will design and build bench-scale process to recover REE from AMD-treatment solids.



WVU Rare Earth Element Laboratory

Water Use and Carbon Capture & Storage

Opportunities to treat and reuse extracted water from CO_2 storage



- Water required to operate carbon capture technologies such as amine-based systems.
- Water can also be extracted during geological CO_2 storage to manage subsurface pressure.
- Can we reduce parasitic power (reduce cooling demand) and water needed for capture?
- Can "extracted water" from CO_2 storage be recovered, treated, and reused?

Future Research Opportunities

Applying "big data" to water-energy issues

- **What role can machine learning/artificial intelligence play in treatment and management of water in fossil energy production and use?**
  - Produced water/flowback water treatment
  - Brine extraction and treatment from CO_2 storage
  - Power plant cooling water management
  - Effluent treatment from power generation
  - Management of discharge from coal ash impoundments
  - Treatment and recovery of value products (e.g., REE)

Thomas J. Feeley, III

Strategic Partnerships
Water-Energy Lead

thomas.feeley@netl.doe.gov

QUESTIONS?

Find out more about NETL's water-energy research program at: https://netl.doe.gov/water-energy-research