Reuse of Produced Water from CO_2 Enhanced Oil Recovery, Coal-Bed Methane, and Mine Pool Water by Coal-Based Power Plants

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Illinois State Geological Survey

Project Outline

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- Summary

Objective

Evaluate feasibility of reusing three types of non-traditional water sources (produced water) for cooling and/or process water for coal-based power plants in the Illinois Basin

- CO_2 Enhanced Oil Recovery (EOR)
- Coal-Bed Methane (CBM)
- Active and abandoned coal mines

Extent of the Illinois Basin in Illinois, Indiana, and Kentucky

Power and thermoelectric freshwater demand in the US and Illinois

- U.S. and Illinois power demand will increase ~30% by 2030
- ~82% of total freshwater in Illinois withdrawn for the thermoelectric sector (vs. 39% U.S. withdrawal)
- Illinois thermoelectric water consumption may increase 55-160% by 2030 (vs. 28-50% U.S. increase)
- CO_2 capture will increase the U.S. thermoelectric water consumption considerably
- Emerging/future industries (e.g., biofuels, hydrogen production) will further increase the water demand

Total electricity generation	U.S. (billion kWh)	Illinois (billion kWh)
Year 2006	4,029 (49% coal)	192 (48% coal)
Year 2030	5,219 (54% coal)	257
Increase	30%	34%

Water	U.S. (BGD)	Illinois (BGD)
Total withdrawal	346	14
Thermoelectric	135 (39%)	11.3 (82%)
Total consumption	100	1.2
Thermoelectric	3 (3%)	0.4 (33%)

Increase in thermoelectric water demand by 2030 without CO_2 capture (NETL prediction)	U.S.	Illinois
Withdrawal	-21% to 6%	-16% to 14%
Consumption	28% to 50%	55% to 160%

Sources: Hudson et al. USGS 2004; Solley et al. USGS 1998; DOE/EIA 2008; Phase II MGSC Report, 2007; DOE/NETL 2007 and 2008

Nontraditional sources of water for power plant usage: NETL previous and on-going work

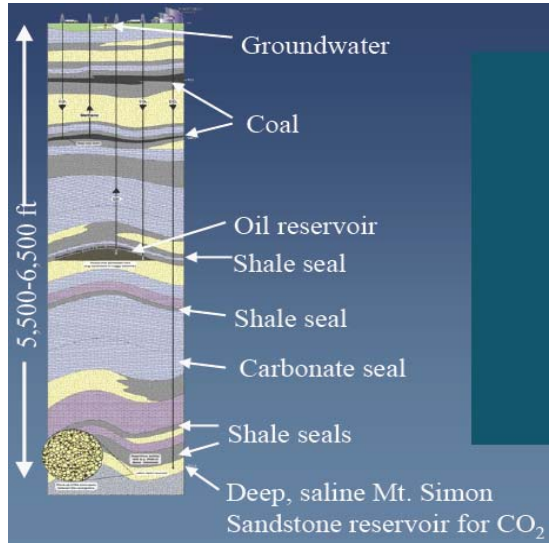
- Techno-economic study on using coal-mine discharges and underground coal mines (as heat sinks) for power plant cooling systems in the Pittsburgh Basin (West Virginia University)
- Modeling of using mine water for thermoelectric power generation in the Pittsburgh Basin (WVU)
- Reuse of three types of impaired water (treated municipal wastewater, coal-mine drainage, and ash pond effluent) for power plant cooling (University of Pittsburgh - Carnegie Mellon University)
- Use of produced water from oil and gas fields to supplement freshwater use in SJPS in New Mexico (EPRI)
- Use of saline water, produced from CO_2 sequestration in deep saline aquifers, for power plant cooling (Sandia National Lab)
- Utilization of advanced separation and chemical scale inhibitor technologies to use impaired water in re-circulating cooling systems (Nalco Company)

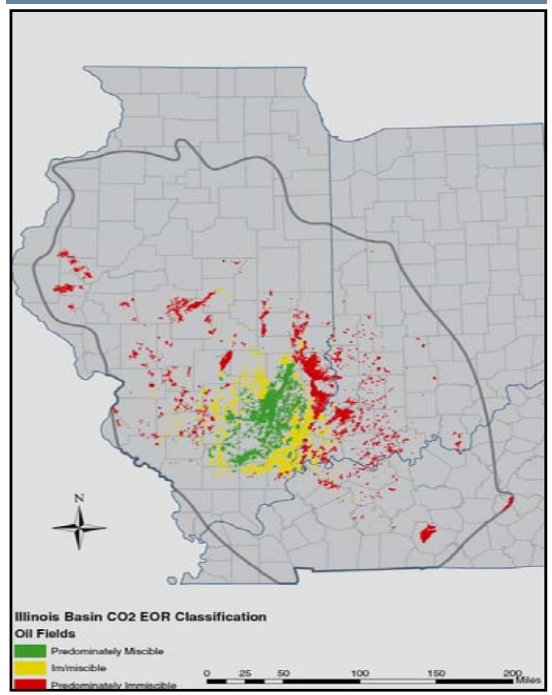
Nontraditional sources of water for power plant usage: Contributions of this project

- Characterize different types of produced water (i.e., from oil, CBM, and coal mines) in the Illinois Basin
- Evaluate feasibility of using produced water from oil and gas recovery and coal mines for power plants in the Illinois Basin
- Assess potential use of produced water from CO_2-EOR for power plants
- Assess potential use of produced water in PC (as cooling, FGD, or boiler water) and IGCC (as cooling, coal slurry, or boiler water) in the Illinois Basin
- Perform an overall techno-economic optimization study for the produced water use by power plants in the Illinois Basin

CO_2-EOR in the Illinois Basin

- ISGS/UIUC is leading Midwest Geological Sequestration Consortium (MSGC), one of 7 DOE partnerships, to capture and sequester CO_2 in the Illinois Basin
- Total CO_2 emission (billion metric tons, BMT) in 2005
  - U.S.: ~ 6
  - MSGS region: ~ 0.3
- MSGC geological CO_2 sequestration capacity
  - Depleted oil and gas reservoirs (0.4 BMT)
  - Coal seams (2.3-3.3 BMT)
  - Saline reservoirs (29-115 BMT)
- ISGS CO_2 sequestration activities
  - Completed a pilot CO_2-EOR project by injecting 43 tons of CO_2 into an oilfield in Southern Illinois
  - Planned to inject 10,000 tons of CO_2 into a deep saline reservoir in Phase II and 1,000,000 tons in Phase III

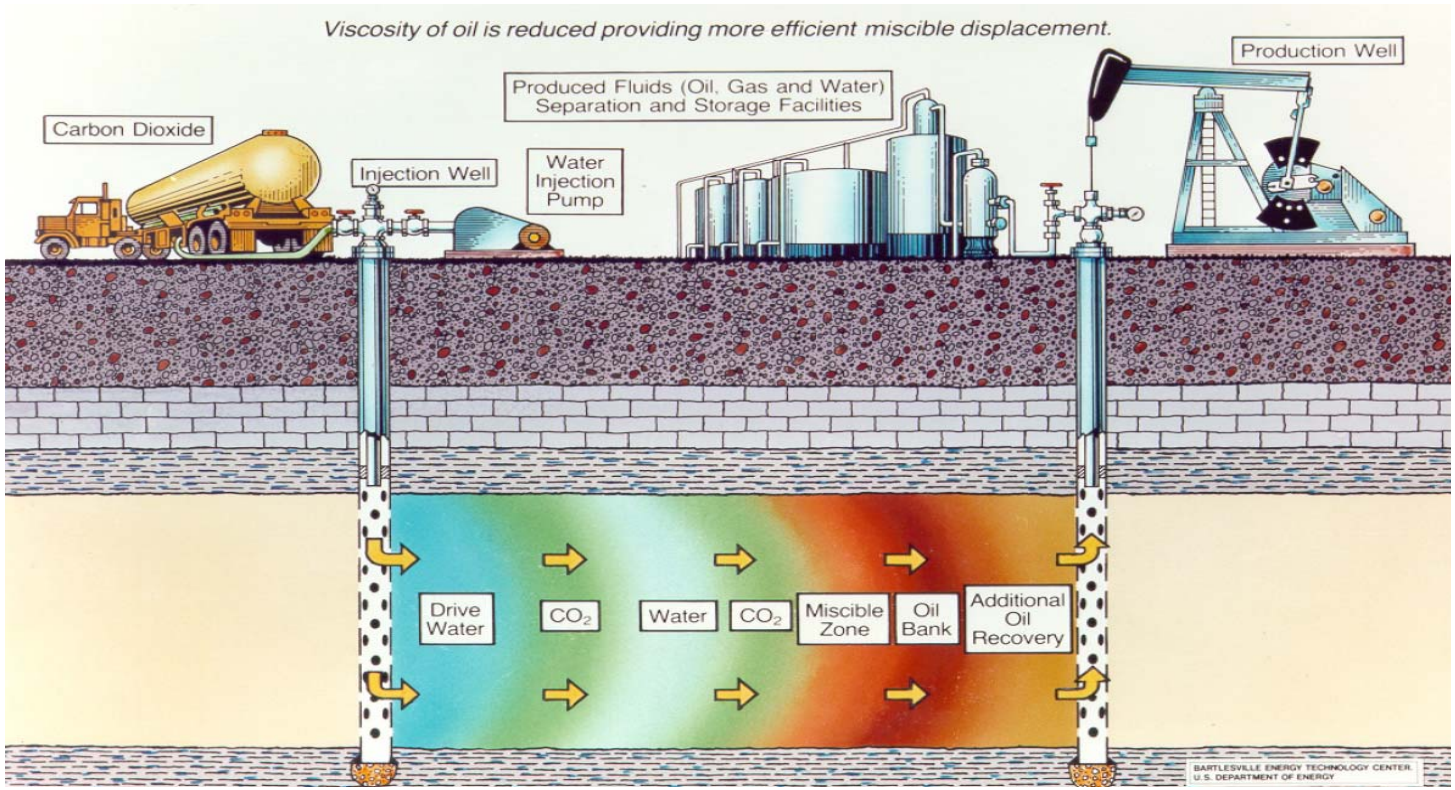




Sources: MSGS, DOE/NETL carbon sequestration atlas

Nontraditional sources of water: produced water from CO_2-EOR

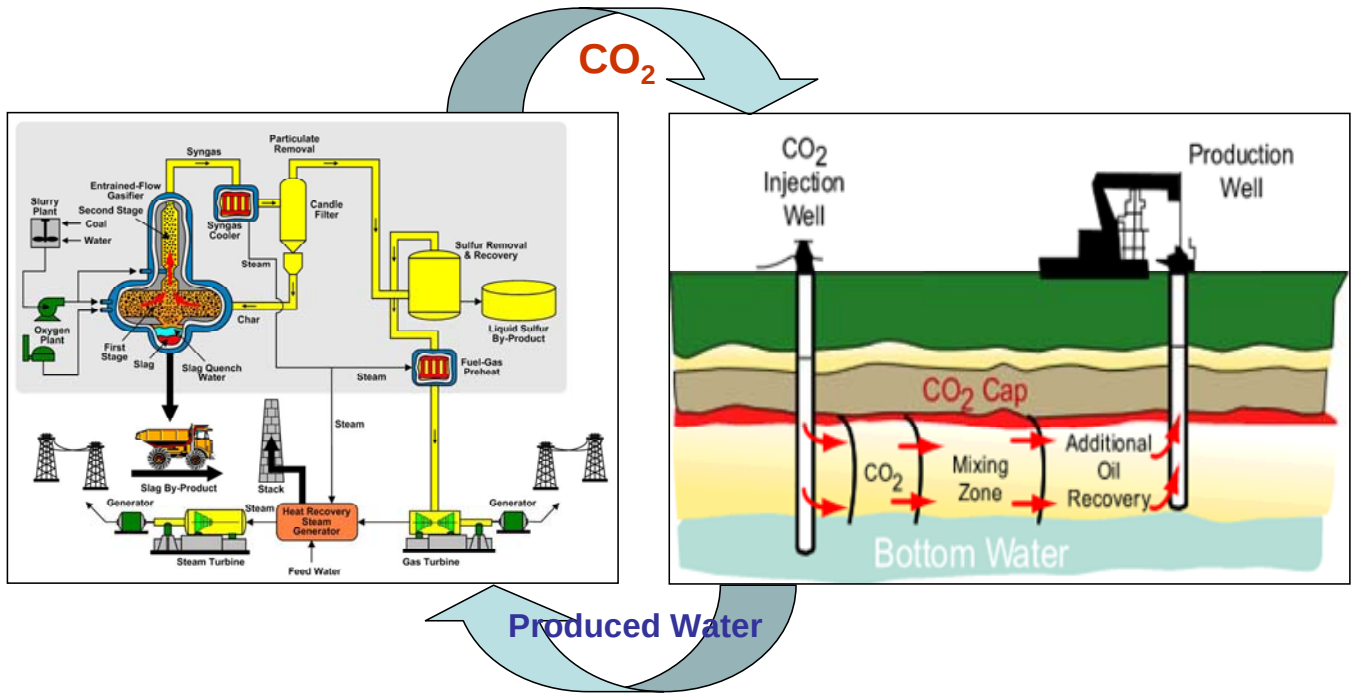
- Potential oil production by CO_2-EOR in the Illinois Bain: ~1 billion bbl (10% of OOIP)
- Produced water/oil ratio ~ 10-100, produced water volume: ~ 10-100 billion bbl
- Water quality: mostly high salinity; TDS = 6,000-200,000 mg/l



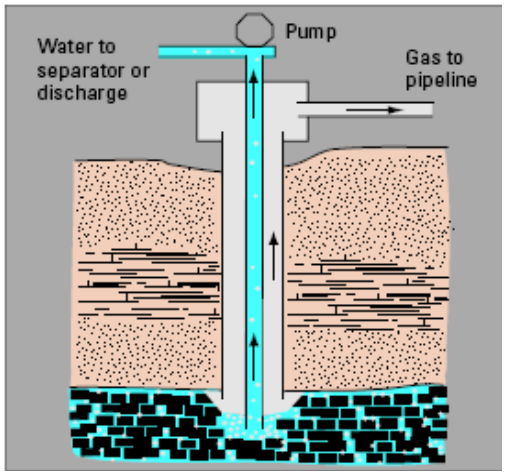
Sources: DOE/NETL, MSGS, USGS produced water database, ISGS floodwater database

Nontraditional sources of water: produced water from CO_2-EOR

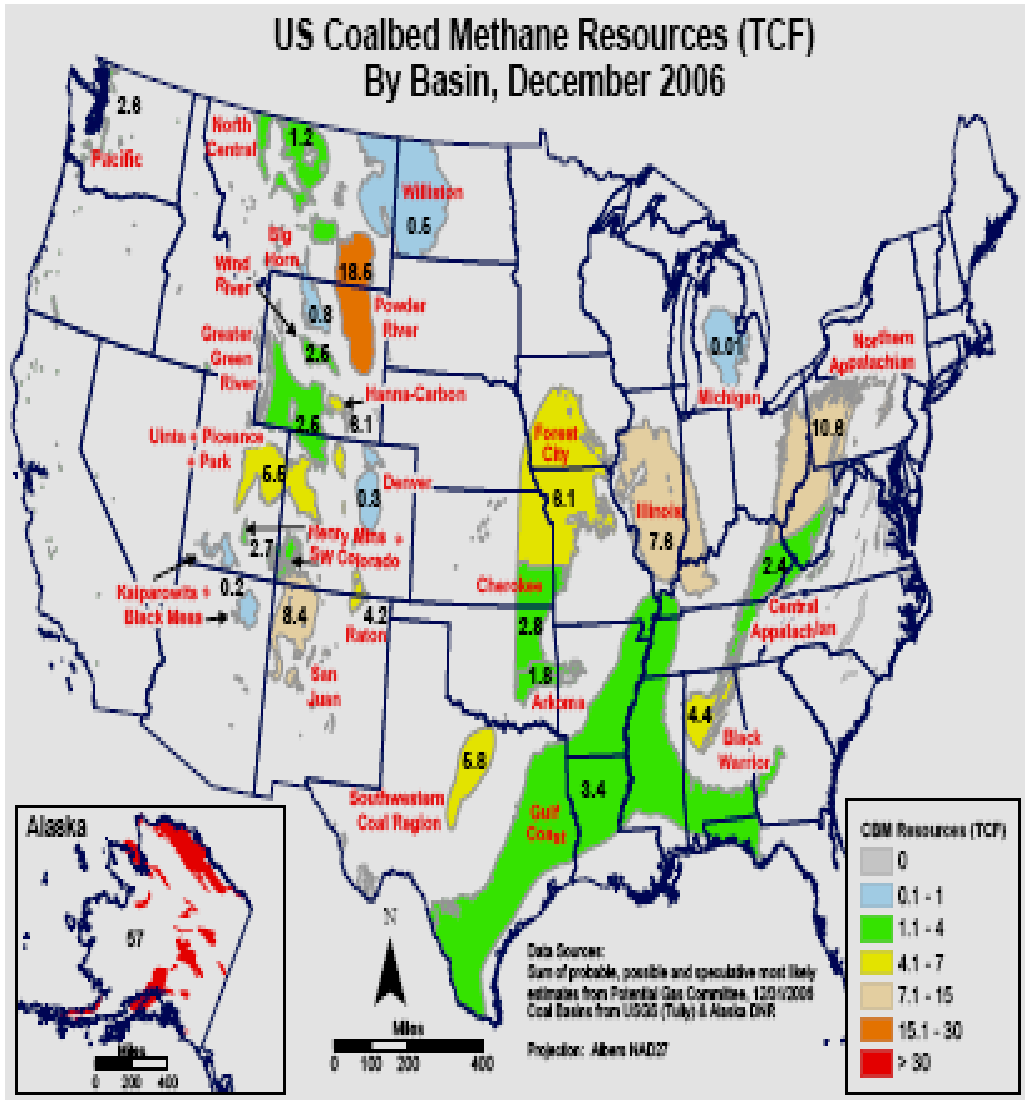
- Depending on future regulations, a large volume of CO_2 might be captured from power plants
- CO_2 geological sequestration by CO_2-EOR is one of the options that may provide economic incentives
- A portion of produced water will be re-injected and the rest should be properly managed
- Produced water could supplement cooling/process water demand of PC and IGCC power plants



Nontraditional sources of water: produced water from CBM



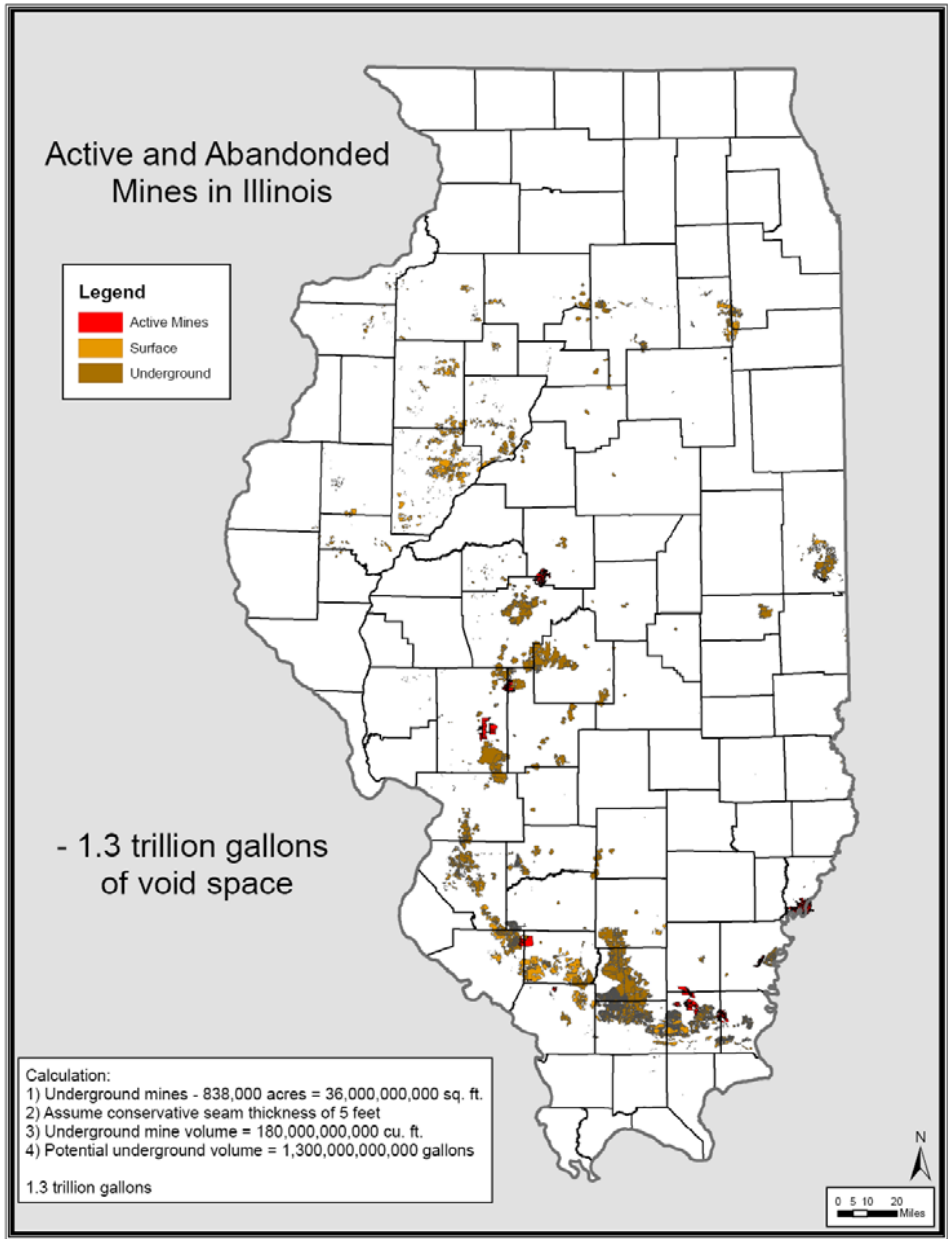
- Coal-bed methane
  - ~7.5% of total U.S. natural gas production
  - CBM resources: U.S.:157.9 tcf, Illinois: 7.6 tcf
- Produced water from CBM
  - Water quantity varies from basin to basin
  - Water/gas ratio: 0.03-2.75 bbl/1000cf
  - Water quantity decreases with time
  - IL estimation: 0.3-20.9 billion bbl water
  - Water quality varies: 200-170,000 ppm TDS



Sources: USGS FS-156-00, DOE/EIA 2007

Nontraditional sources of water: produced water from coal mines

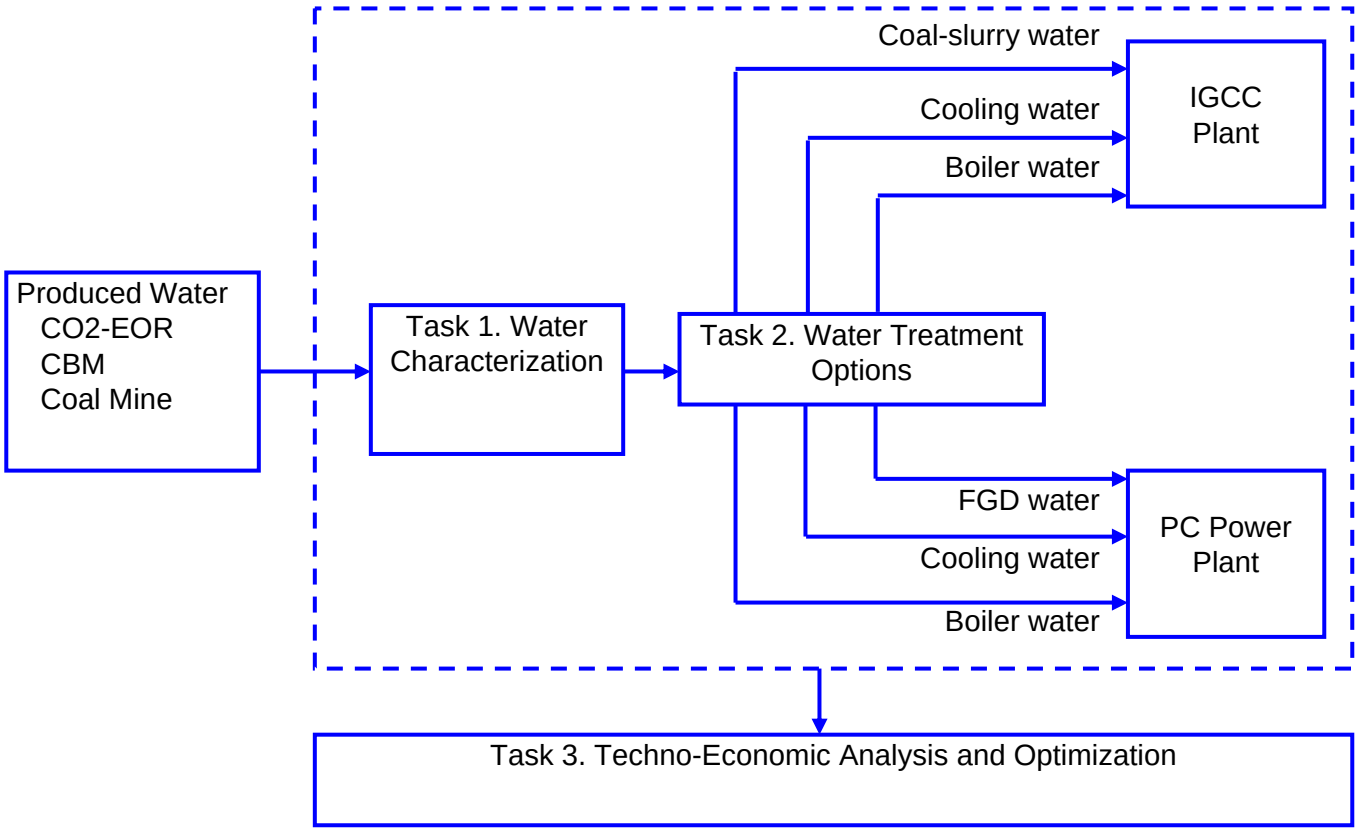
- 21 active and many abandoned coal mines in Illinois
- Potential underground mine volume: > 1 trillion gallons
- Void volume can be partially filled with water or used as a heat sink for power plant cooling
- Pattiki mine in White County produces ~ 0.5-1 MGD water with ~ 9000 mg/l TDS



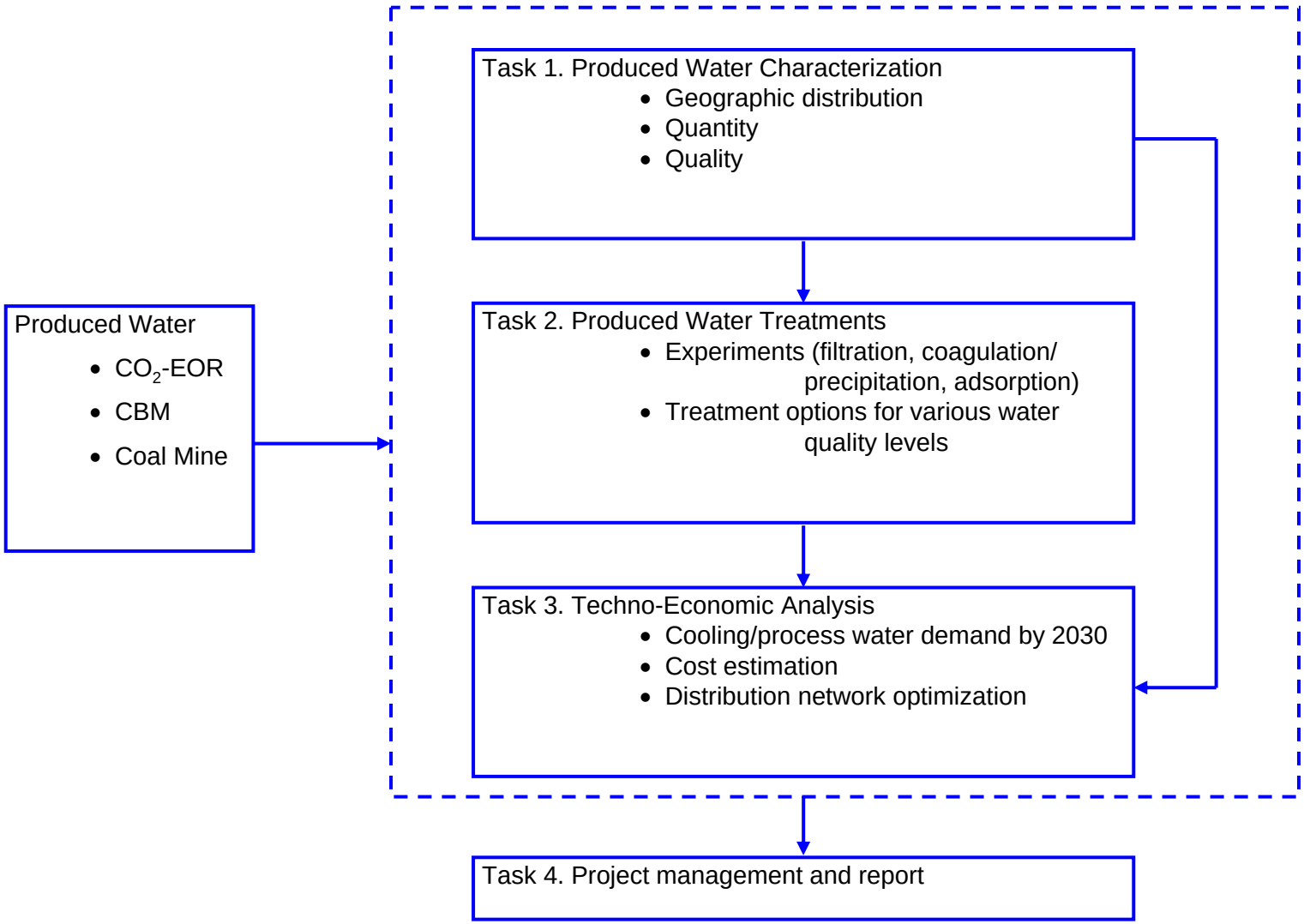
Project Scope

Participants:

- NETL/DOE
- ISGS/UIUS (Illinois State Geological Survey/University of Illinois at Urbana-Champaign)
- DCEO/ICCI (Illinois Department of Commerce and Economic Opportunity/Illinois Clean Coal Institute)
- MGSC (Midwest Geological Sequestration Consortium)
- BPI Energy, Inc. (A CBM producer in the Illinois Basin)
- White County coal, LLC (Pattiki coal mine)
- WaterCAMPWS (Center of Advanced Materials for the Purification of Water with Systems, a UIUC-based NSF research center)

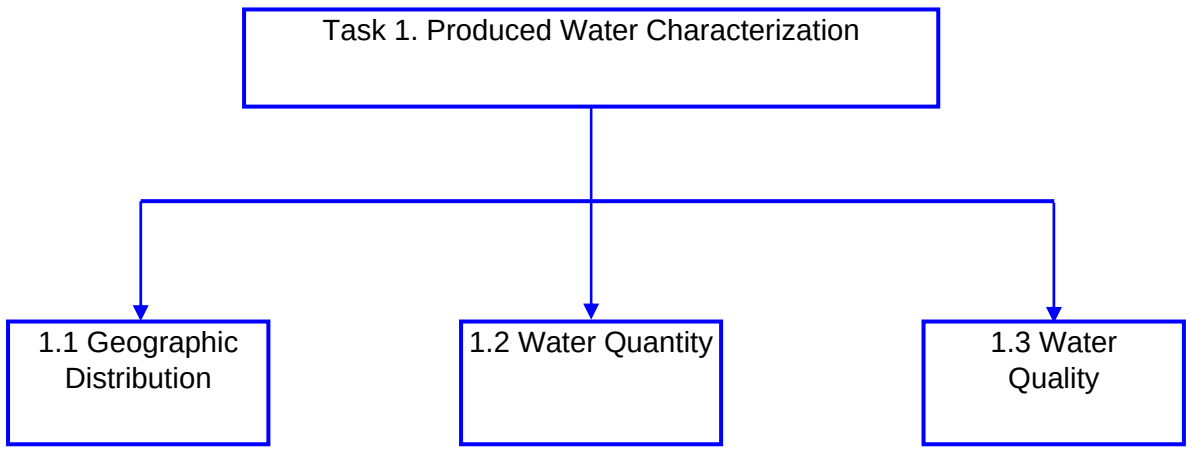


Project Tasks



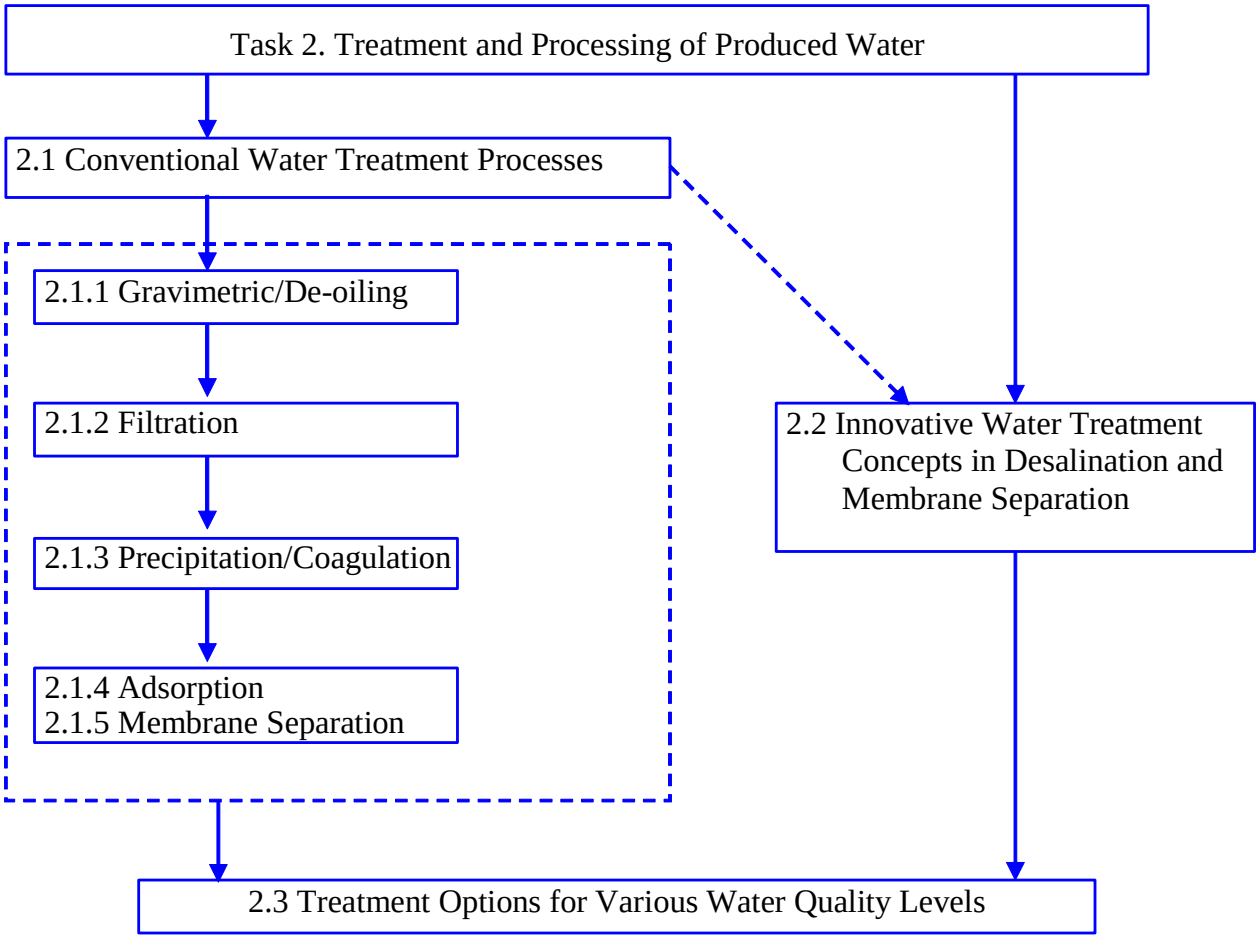
Task 1: Produced Water Characterization

- Use Information collected from the project participants and literature (e.g., USGS and ISGS databases, documents, and maps) to identify location and quantity of produced water sources in the Illinois Basin
- Collect available produced water quality data from USGS, ISGS, and EPA databases/documents
- Collect and characterize water samples from selected sources (pH, TDS, different anions and cations, alkalinity, …)
- Map produced water quantity and quality data for the Illinois Basin



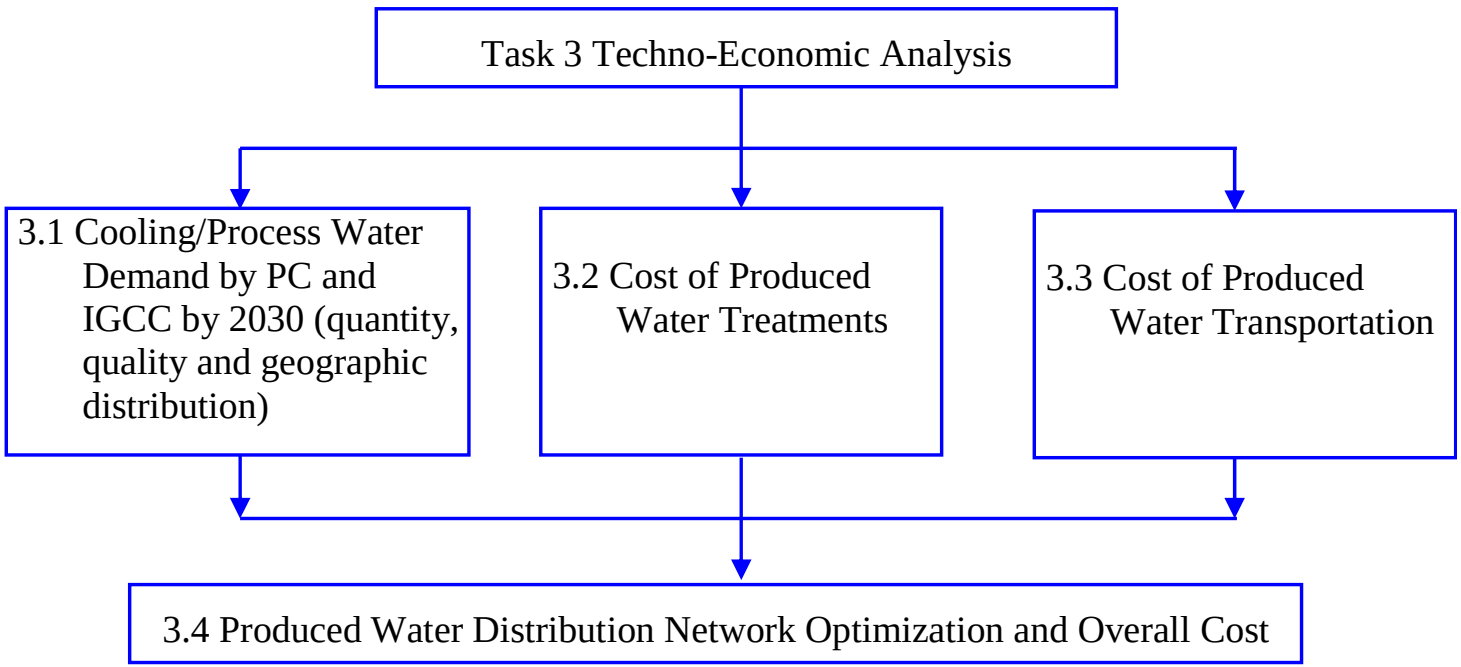
Task 2: Treatment and Processing of Produced Water

- Consider only produced water sources that provide a minimum required quantity of water (e.g., 10% of a 200MW closed-loop power plant water demand)
- Conduct water treatment studies considering the required water quality for different applications for PC and IGCC (i.e., water used for cooling, boiler make-up, coal slurry, and FGD)



Task 3 – Techno-Economic Analysis

- Assess cooling/process water demand by PC/IGCC by 2030 (new additions assumed to be 50/50 supercritical PC and IGCC)
- Collect literature information and conduct process simulation to estimate water demand (different types) in PC/IGCC
- Perform cost estimation of produced water treatment/transportation based on the results of Tasks 1 and 2, literature information, and standard Chemical Engineering cost estimation procedures
- Perform an overall network optimization analysis to identify an optimized pipeline distribution system from local water treatment facilities to the power plants. Optimization scenario will consider the cost of treating water to different quality levels, the demand volume of each quality level, and pipeline transportation cost



Project Schedule

Quarters	1	2	3	4	5	6	7	8	9	10	11	12
Task 1. Produced water characterization												
1.1 Geographic distribution												
1.2 Water quantity												
1.3 Water quality												
Task 2. Produced water treatments												
2.1 Conventional treatments												
2.2 Innovative treatments												
2.3 Treatment options												
3. Techno-economic analysis												
3.1 Cooling/process water demand												
3.2 Cost of produced water treatments												
3.3 Cost of produced water transportation												
3.4. Overall optimization												
Task 4. management & reports												

Summary

- Characterize different types of produced water (i.e., from CO_2-EOR, CBM, and coal mines) in the Illinois Basin
- Assess potential use of produced water in PC (as cooling, FGD, or boiler water) and IGCC (as cooling, coal slurry, or boiler water)
- Perform an overall techno-economic optimization study for the Illinois Basin