

Energy-Water Nexus

GAO's Work Related to the Energy-Water Nexus

Cross-Cutting Findings

- Impacts Vary by Location
- Technology Challenges
- Data and Research Gaps
- Coordination Among Federal/Other Entities Needed
- Policies Must be Robust to Uncertain Future

Additional Federal Action Needed

- Improved and Updated Data and Analysis of Freshwater Supplies
 - Better Lifecycle and Systems Analysis of Energy-Water Tradeoffs
 - Federal Energy-Water Nexus Program Needed
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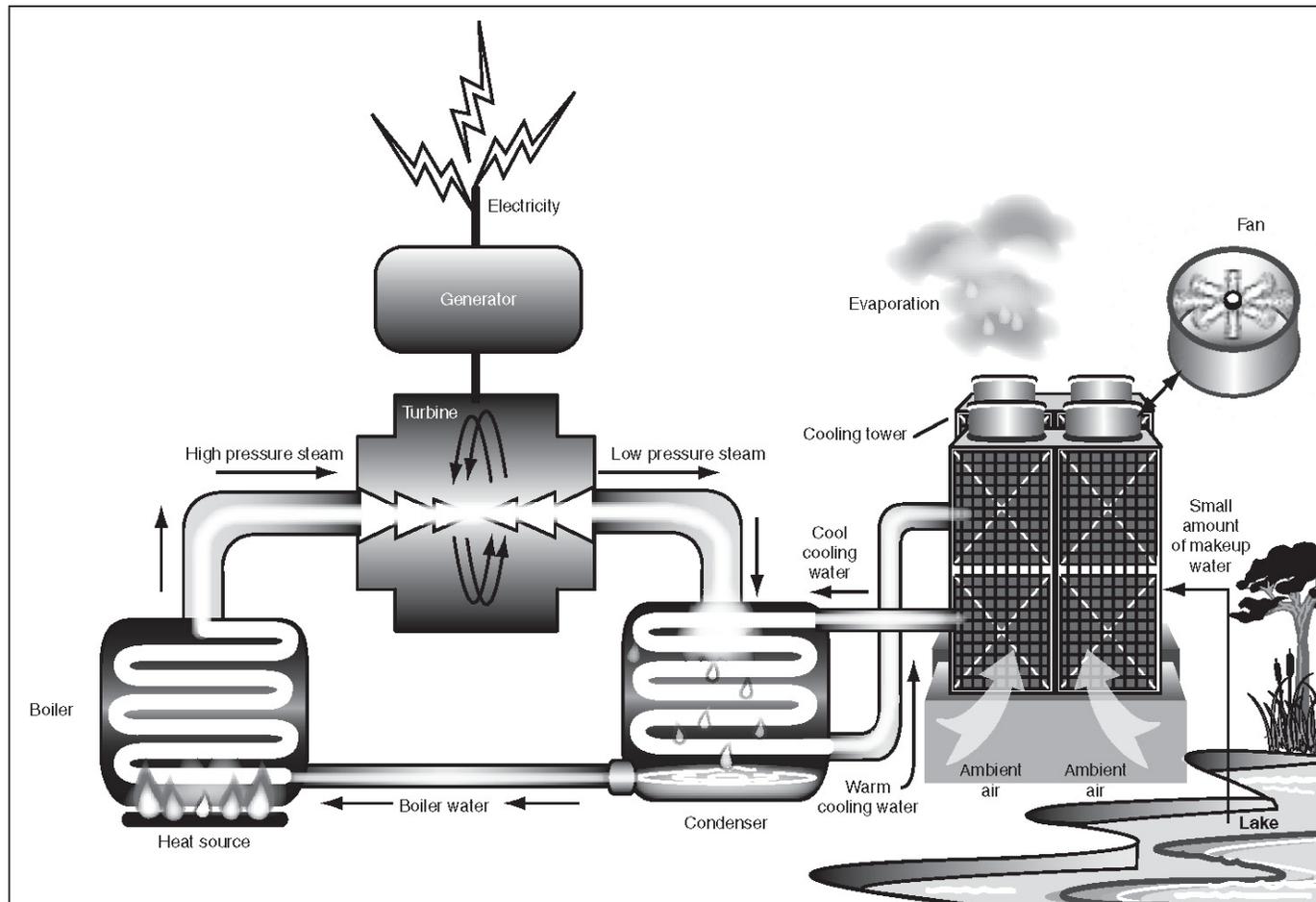
Key GAO Reports Related to the Energy-Water Nexus

- **Thermoelectric power plants** – Energy-Water Nexus: Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use, GAO-10-23
- **Biofuels** – Energy-Water Nexus: Many Uncertainties Remain about National and Regional Effects of Increased Biofuel Production on Water Resources, GAO-10-116
- **Energy for water** – Energy-Water Nexus: Amount of Energy Needed to Supply, Use, and Treat Water Is Location-Specific and Can Be Reduced by Certain Technologies and Approaches, GAO-11-225
- **Oil shale** – Energy-Water Nexus: A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development, GAO-11-35
- **Produced water** – Energy-Water Nexus: Information on the Quantity, Quality, and Management of Water Produced during Oil and Gas Production, GAO-12-156
- **Oil and Gas** – Information on Shale Resources, Development, and Environmental and Public Health Risks, GAO-12-732
- **Unconventional Oil and Gas Development** – Key Environmental and Public Health Requirements, GAO-12-874
- **Energy-Water Nexus** – Coordinated Federal Approach Needed to Better Manage Energy and Water Tradeoffs, GAO-12-880.

Cross Cutting Findings of GAO's Energy-Water Nexus Work

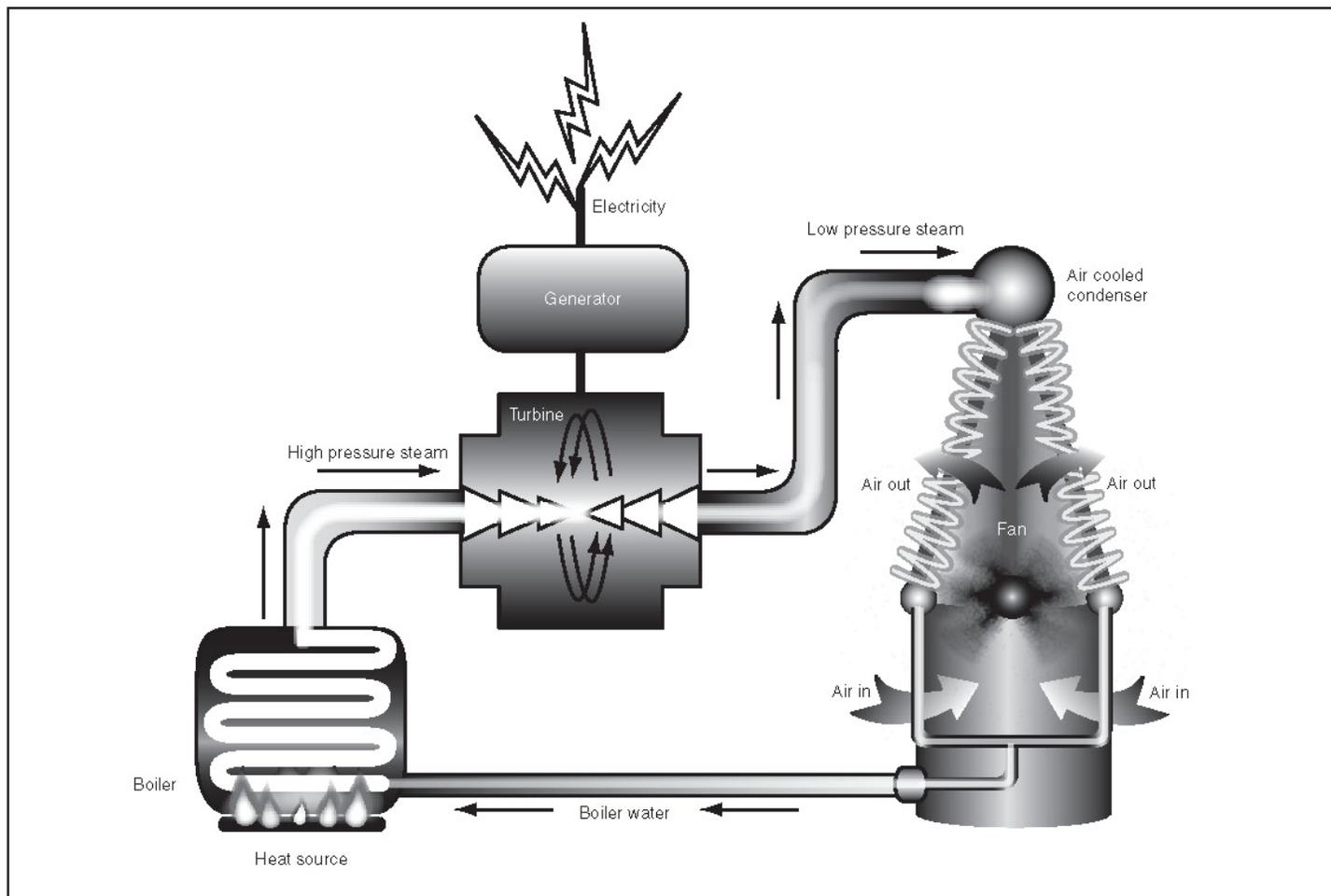
- Because the impacts of federal energy and water policy choices can vary by location, Congress and federal agencies need to consider the effects of national policies. For example:
 - Biofuels – impact of increased production on water resources depends on where the feedstock is grown and whether irrigation is required
 - Produced water – the amount and quality of produced water depends on location-related differences, such as variation in local or regional geography (Barnett wetter formation and produces 3-4 times more water than the Marcellus)

Diagram of a Wet Recirculating System with a Cooling Tower



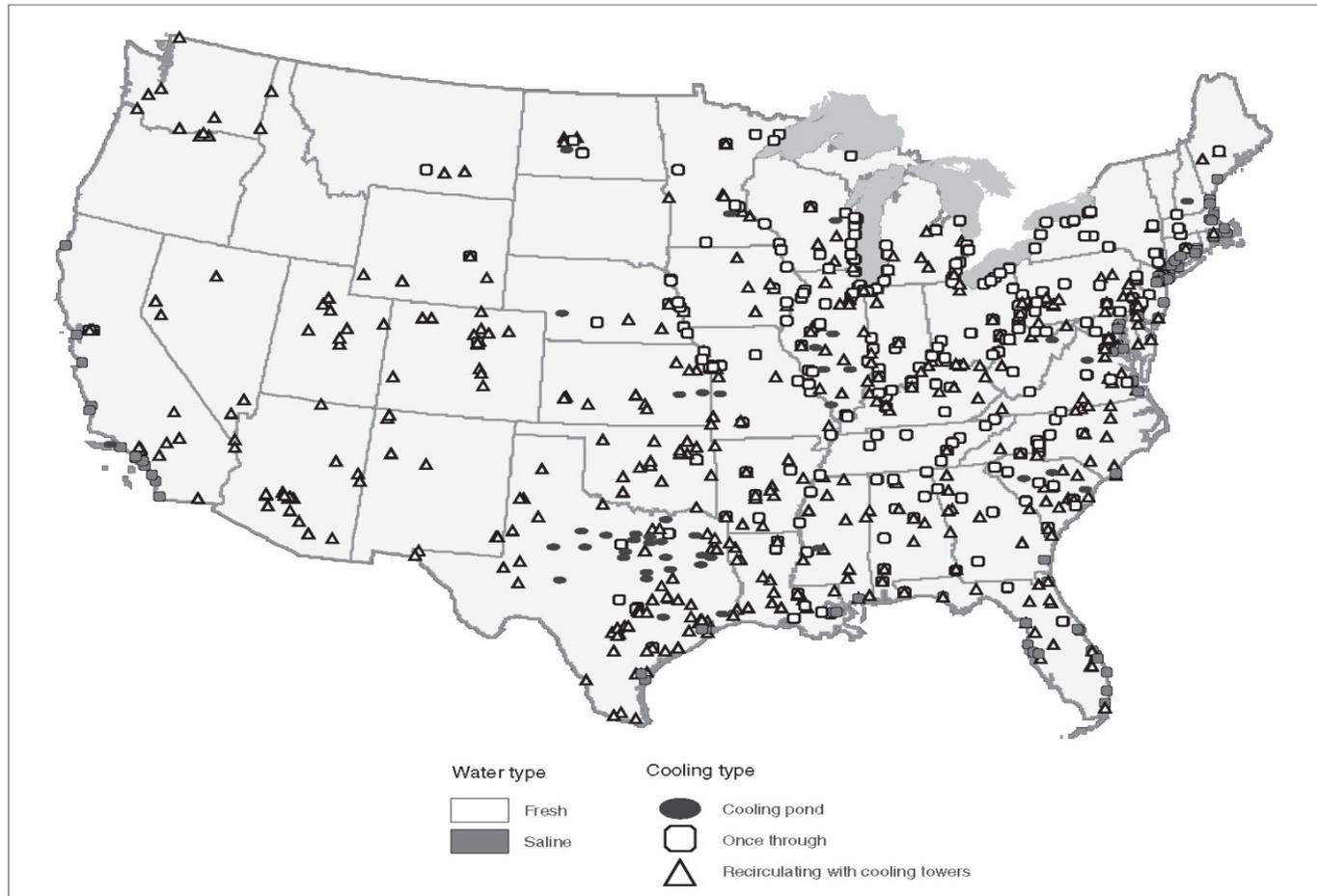
Source: GAO analysis of various national laboratory and industry sources.

Diagram of a Dry Cooling System



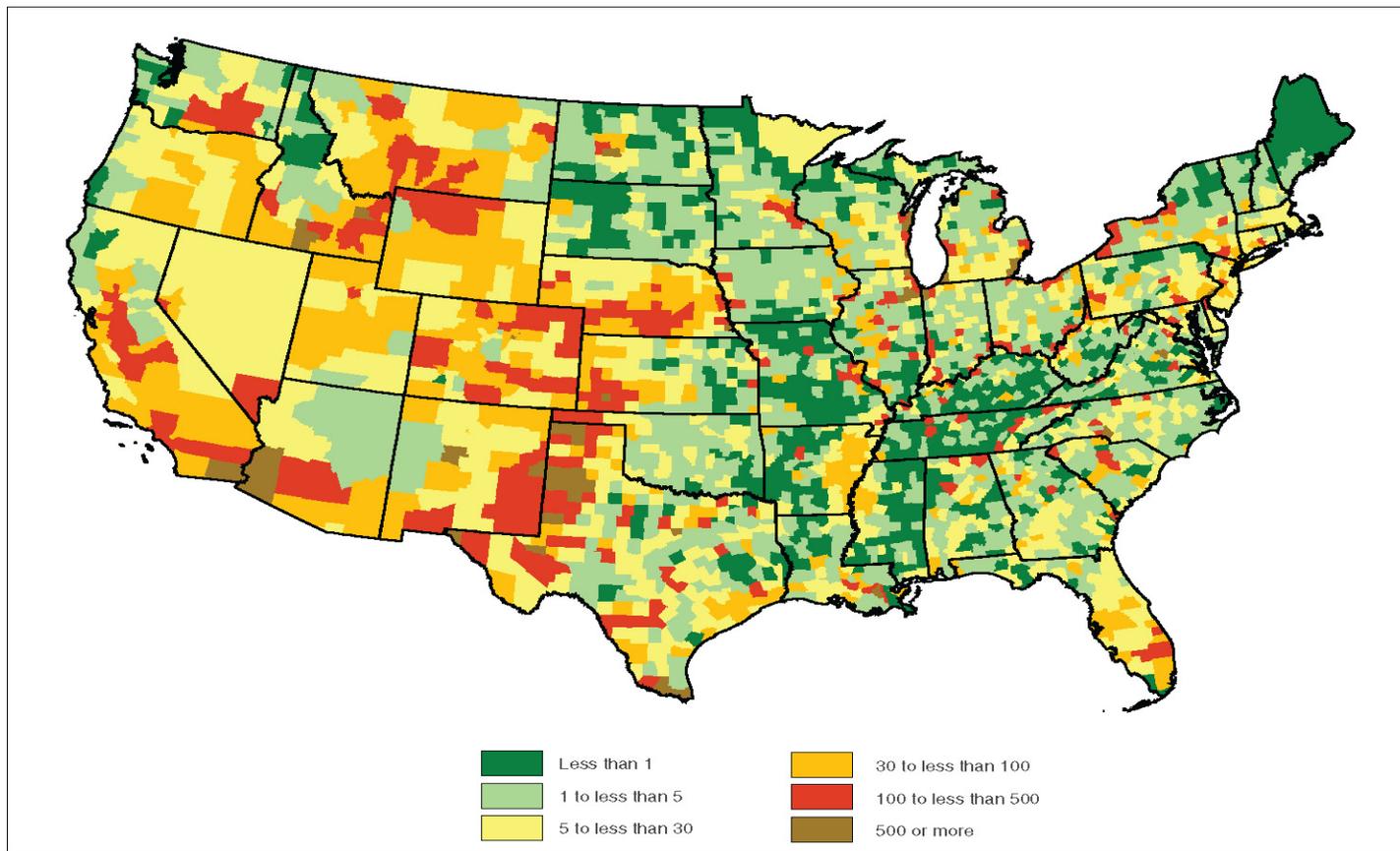
Source: GAO analysis of various national laboratory and industry sources.

Water Based Cooling Systems by Technology and Water Source



Source: National Energy Technology Laboratory, based on EIA-collected data, Map (Mapinfo).

Total Fresh Water Withdrawal in 1995 as a Percentage of Precipitation



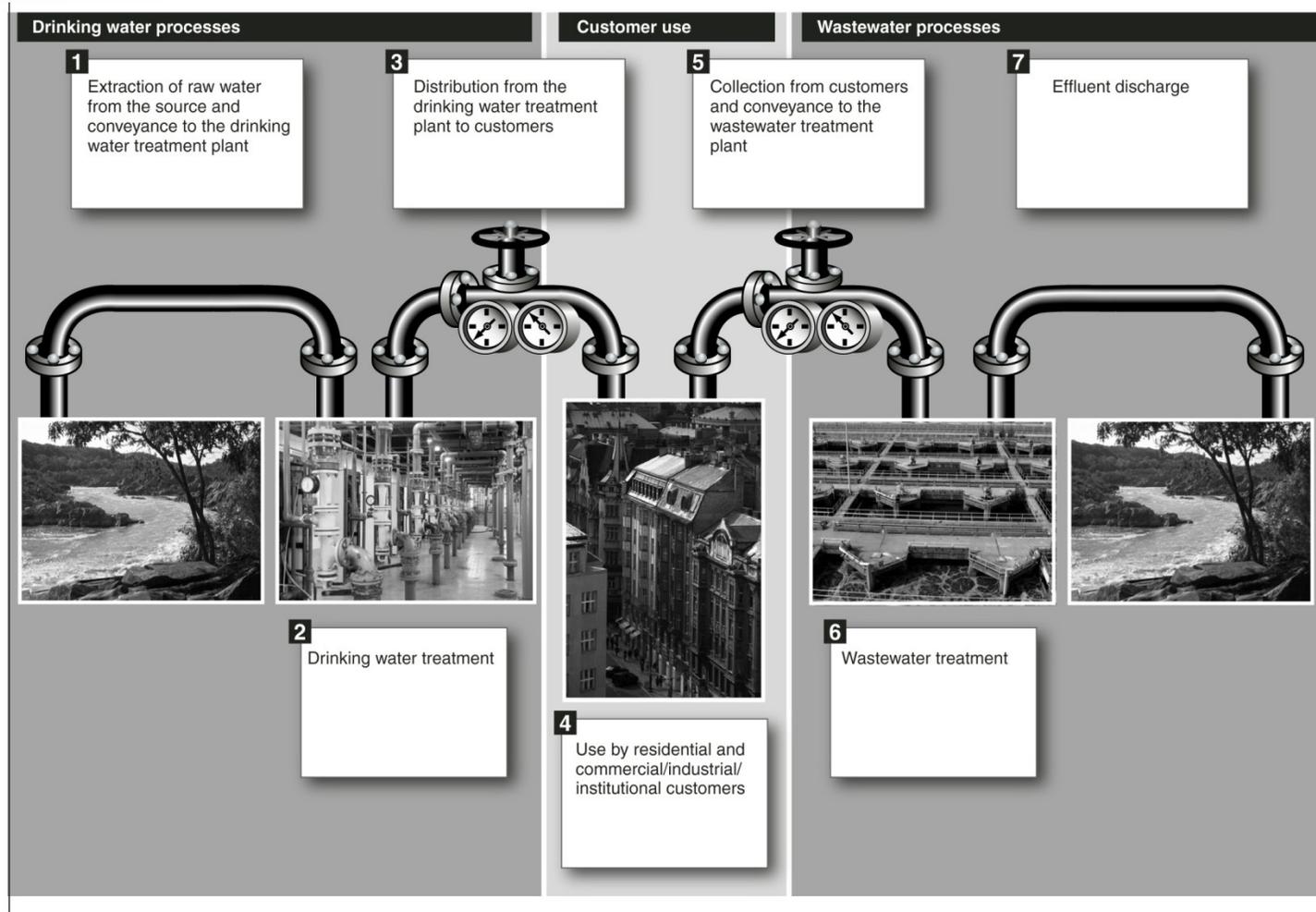
Source: Electric Power Research Institute, *A Survey of Water Use and Sustainability in the United States With a Focus on Power Generation*. (Palo Alto, CA, 2003.) 1005474, Map (Mapinfo).

Note: According to an Electric Power Research Institute official, the organization plans to update this analysis once USGS publishes 2005 freshwater withdrawal data.

Cross Cutting Findings of GAO's Energy Water Nexus Work (continued)

- There are a variety of technologies and approaches to reduce the impact, but there are a number of barriers to their adoption that Congress and federal agencies should consider when deciding whether to promote their adoption.
 - Energy for water – variable frequency drives allow utilities to adjust to varying flows, thereby reducing energy demands, but installation can be cost-prohibitive and they aren't efficient in all circumstances (such as constant flows)

Drinking Water Life Cycle

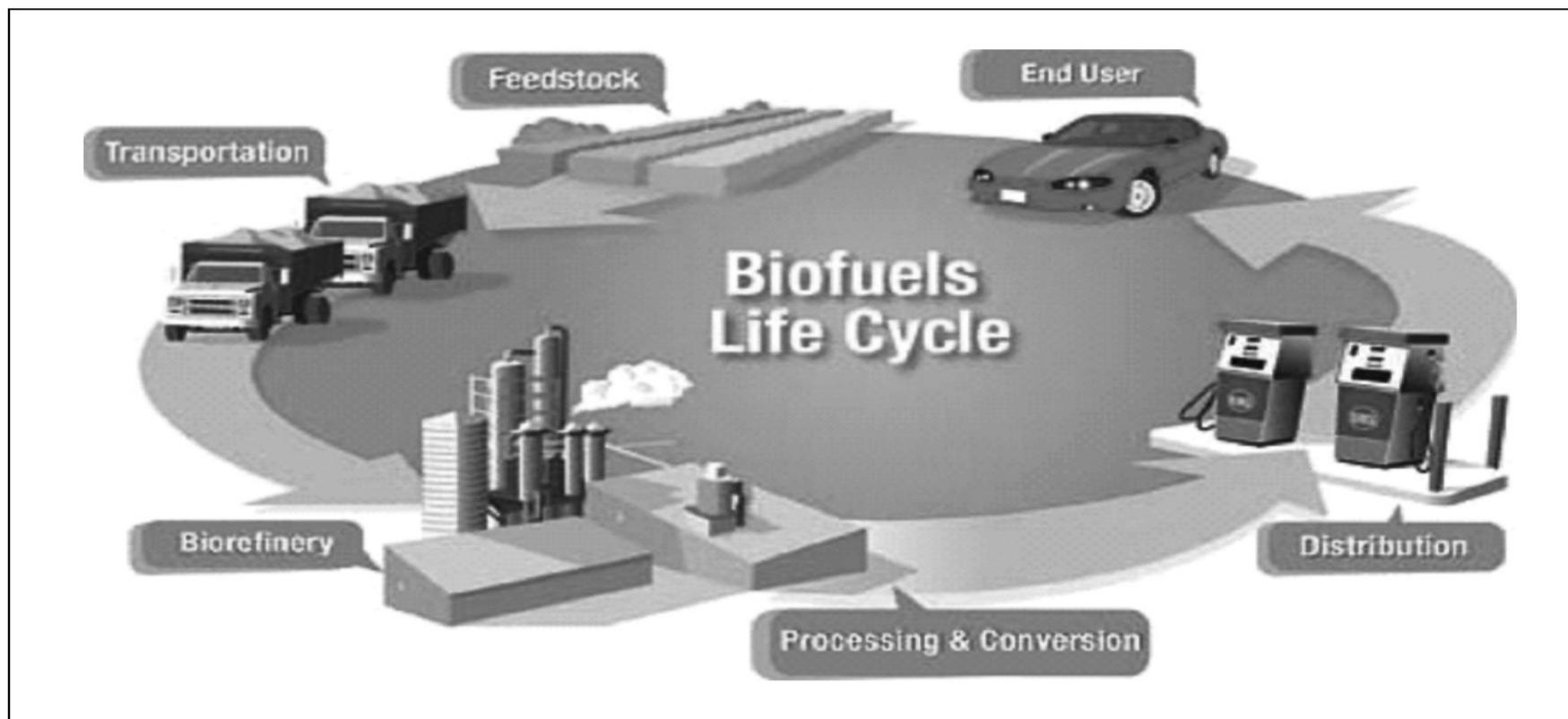


Sources: GAO analysis. Photos from left to right: GAO; US EPA Photo, Eric Vance; Art Explosion; DC Water; and GAO.

Cross Cutting Findings of GAO's Energy Water Nexus Work (continued)

- Comprehensive data and research are needed to make effective policy decisions.
 - Areas needing more data and research include availability of freshwater and alternative water supplies, quantity and quality baseline data, hydrogeological processes (interactions between groundwater and surface water, aquifer recharge rates), effect of new technologies at commercial scales, regional climate models, etc.

Biofuels Life Cycle



Source: DOE.

Cross Cutting Findings of GAO's Energy Water Nexus Work (continued)

- Federal coordination among federal agencies, with other levels of government, and with nongovernmental entities is needed for better decision making.
 - Thermo-electric report – recommended that EIA and USGS regularly coordinate with each other, other federal agencies, and nongovernmental groups.
 - Oil shale report – recommended that Interior coordinate with DOE and state agencies.
 - Some steps have been taken by Congress and federal agencies but actions are incomplete.
 - EAct 2005 – Congress directed Secretary of Energy through Office of Science to carry out a program to address the nexus, but DOE has not yet done so.

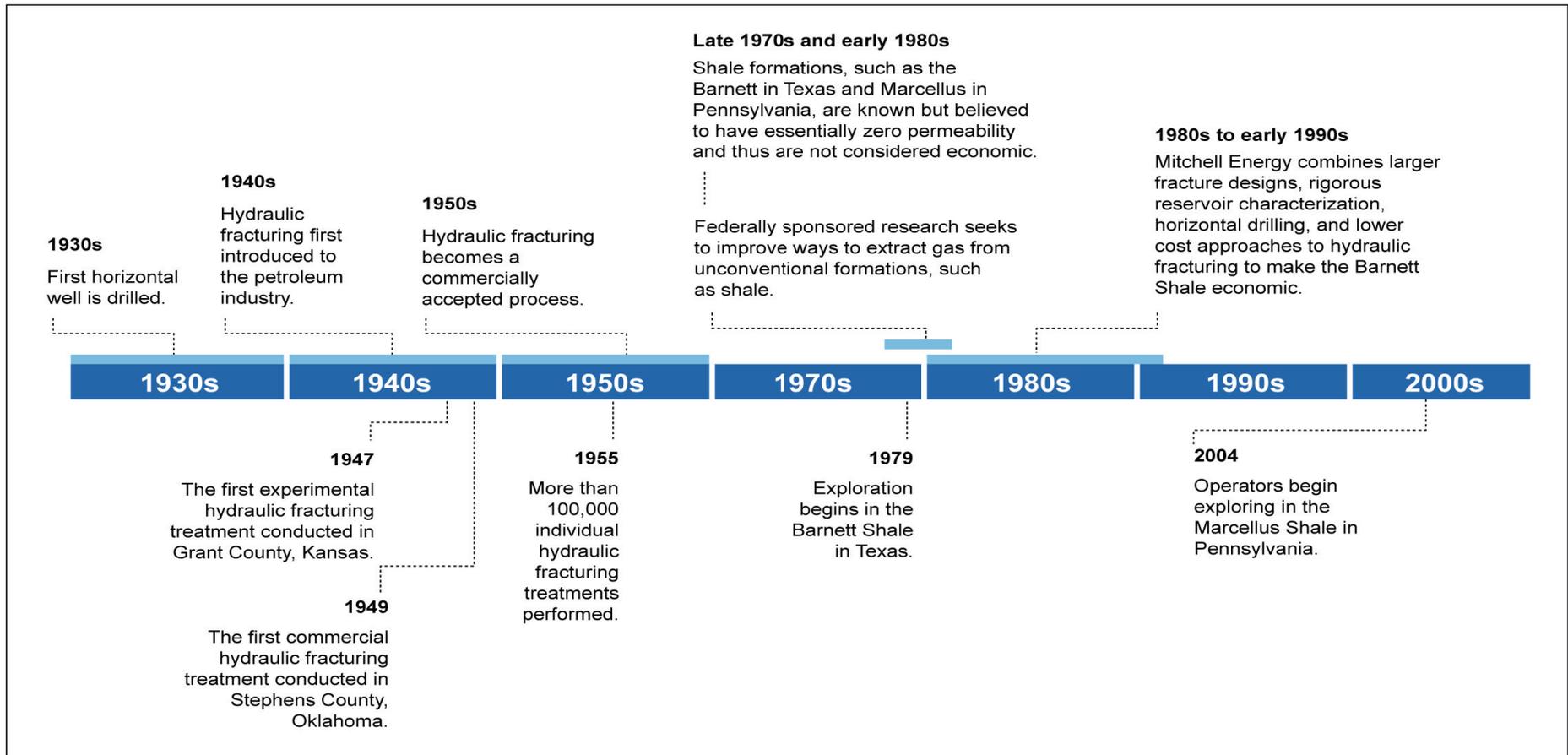
Cross Cutting Findings of GAO's Energy Water Nexus Work (continued)

- Uncertainties must be considered when developing federal energy and water policies.
 - Uncertainties include future makeup of energy, future regulations, climate change, population growth and increased competition for resources, and demographic shifts.

What are Shale Oil and Gas?

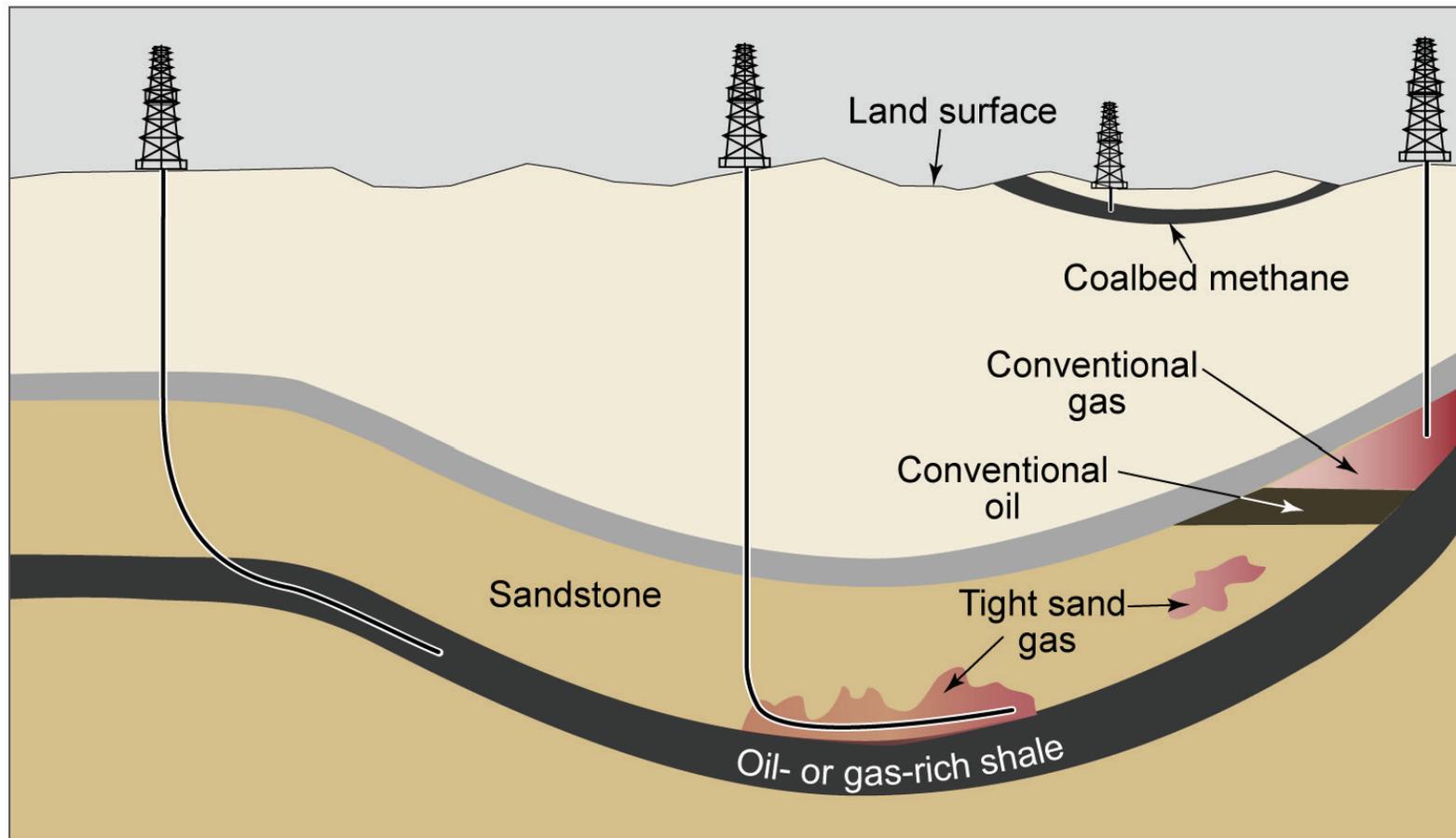
- Shale formations have long been known to contain hydrocarbons—oil and gas—but were until recently thought to be infeasible to develop.
- The technological breakthrough that has led to the accessibility of oil and gas from shale formations is a combination of horizontal drilling techniques and “hydraulic fracturing,” a process that stimulates the formation, increasing the surface area of the rock that communicates with the well bore.

History of Horizontal Drilling and Hydraulic Fracturing



Source: GAO.

Oil and Gas Resources

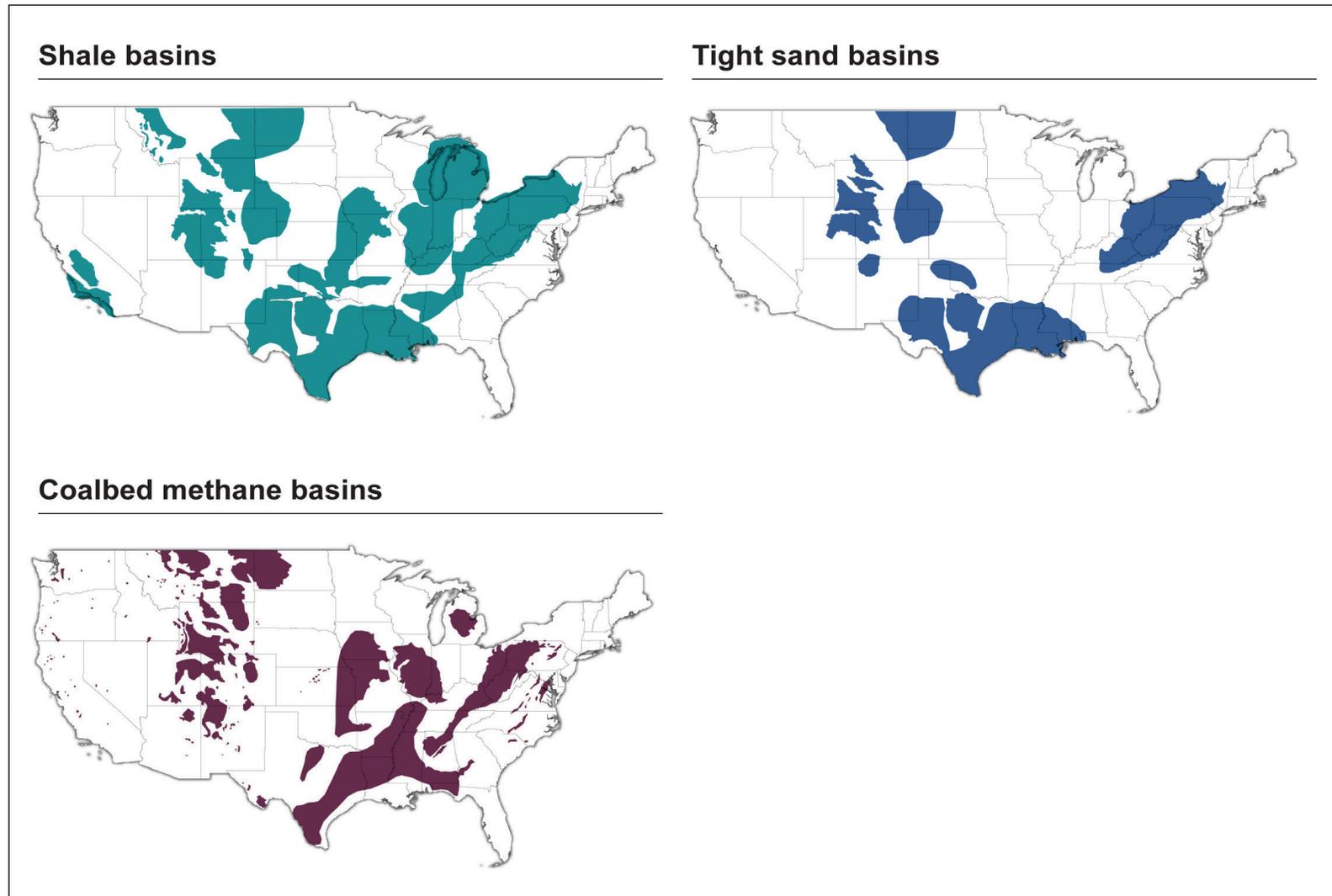


Sources: U.S. Energy Information Administration and U.S. Geological Survey.

Shale Oil and Gas Development: How Big is the Resource?

- In the United States alone, the natural gas resource that is economically recoverable is expected to be on the order of between 30-100 years of current U.S. annual production.
- Globally, estimates are less comprehensive but there are vast resources that are technically recoverable.
- With regard to oil, we do not have as much information but we know that oil companies are talking about rapidly growing domestic production over the next few years.
- Combining oil and gas from all sources including tight formations, people are, for the first time in many decades talking about the United States being a net exporter of energy within the next decade.

Location of Tight Formations in the United States



Source: GAO.

Stages of Oil and Gas Development

Site preparation and construction	Horizontal drilling	Hydraulic fracturing
<ul style="list-style-type: none"> • Transport of materials and supplies • Pad site construction • Pipeline construction • Road construction • Pit construction • Installation of liners 	<ul style="list-style-type: none"> • Mix drilling mud • Drilling • Use of pressure control equipment • Removal and disposal of fluids and cuttings • Casing • Cementing 	<ul style="list-style-type: none"> • Fracture design • Mixing of water, chemicals, and proppant • Penetrate the casing • Inject solution to fracture the formation • Flowback process • Capture fluids • Fluid disposal

Additional Federal Actions Needed

- Collect and Analyze Freshwater Supply, Availability, and Use Data to Perform Lifecycle and Systems Analysis of Policy Effects (Biofuels, for example)
- In our most recent report that developed the key themes common to the energy-water nexus, we recommended that the Secretary of Energy take the actions necessary to establish a program to address the energy-water nexus, with involvement from other federal agencies as described in EPLA 2005.
- DOE agreed and stated it already has a number of research activities underway, such as energy-water data collection and modeling. It also stated it will use an internal workshop to discuss existing activities and clarify priority areas for further data collection and analysis.

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