Energy-Water Nexus
Water Resource Sustainability

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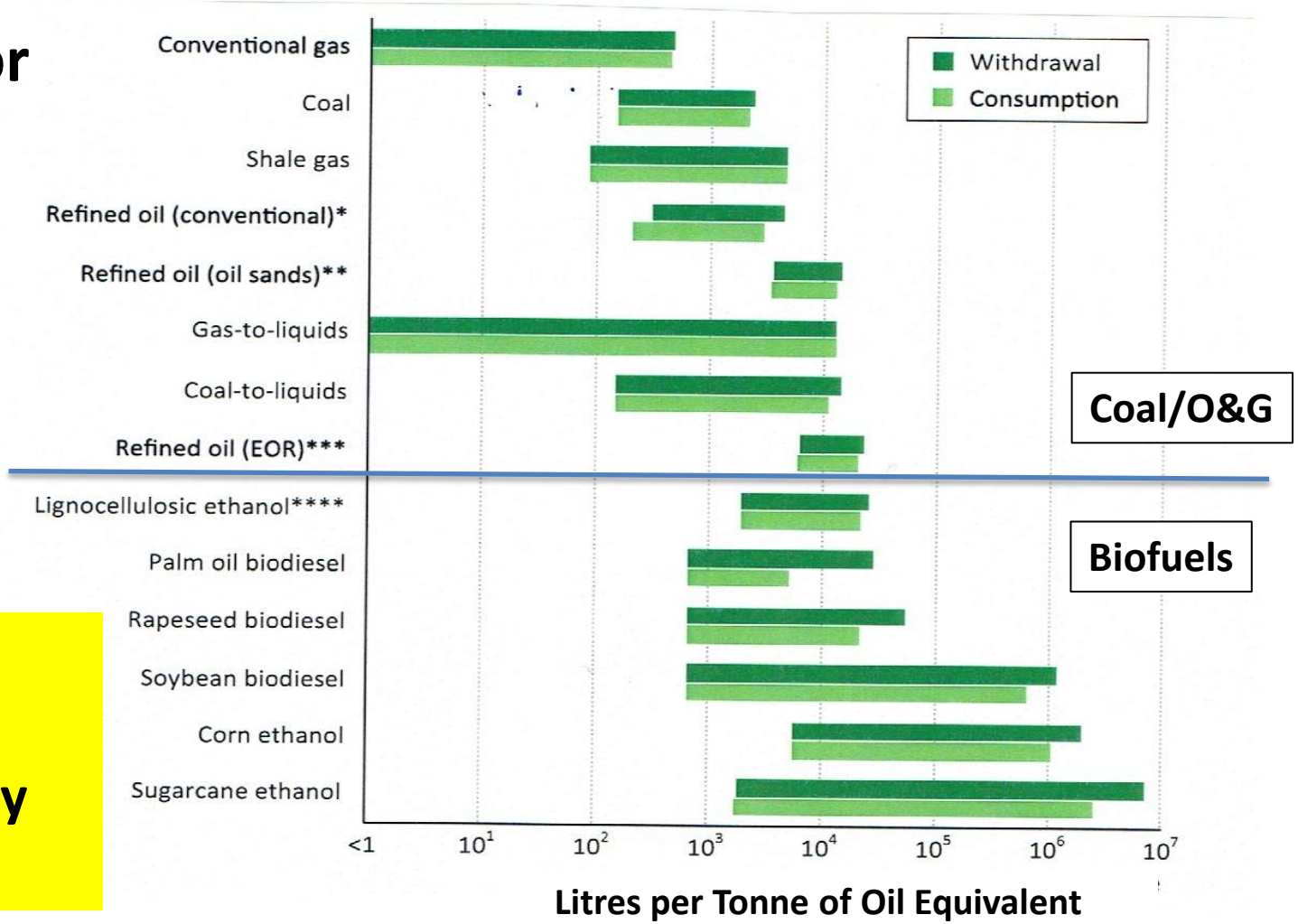
Discussion

- **Impact of Water and Energy Interdependence**
- **Growing challenges for fresh water supply**
  - **Regional economic and social impacts**
- **Potential for non-traditional waters to close demand-supply gap**
  - **Brackish, produced, sea, municipal and industrial reclaimed, runoff …**

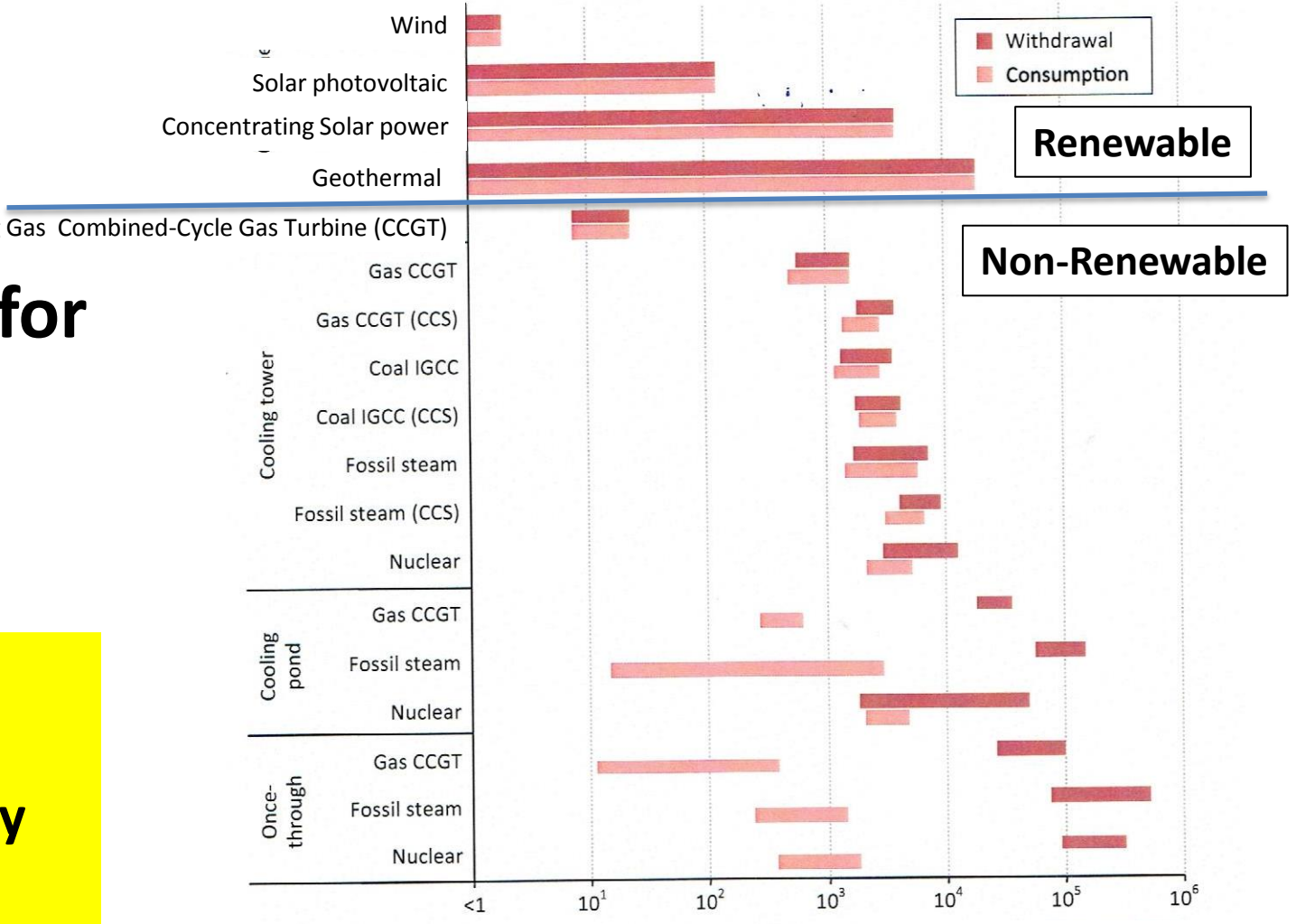
Water Use for Primary Fuel Production



2012 International Energy Agency (IEA) Fig 17.3

Water Use for Electricity Generation

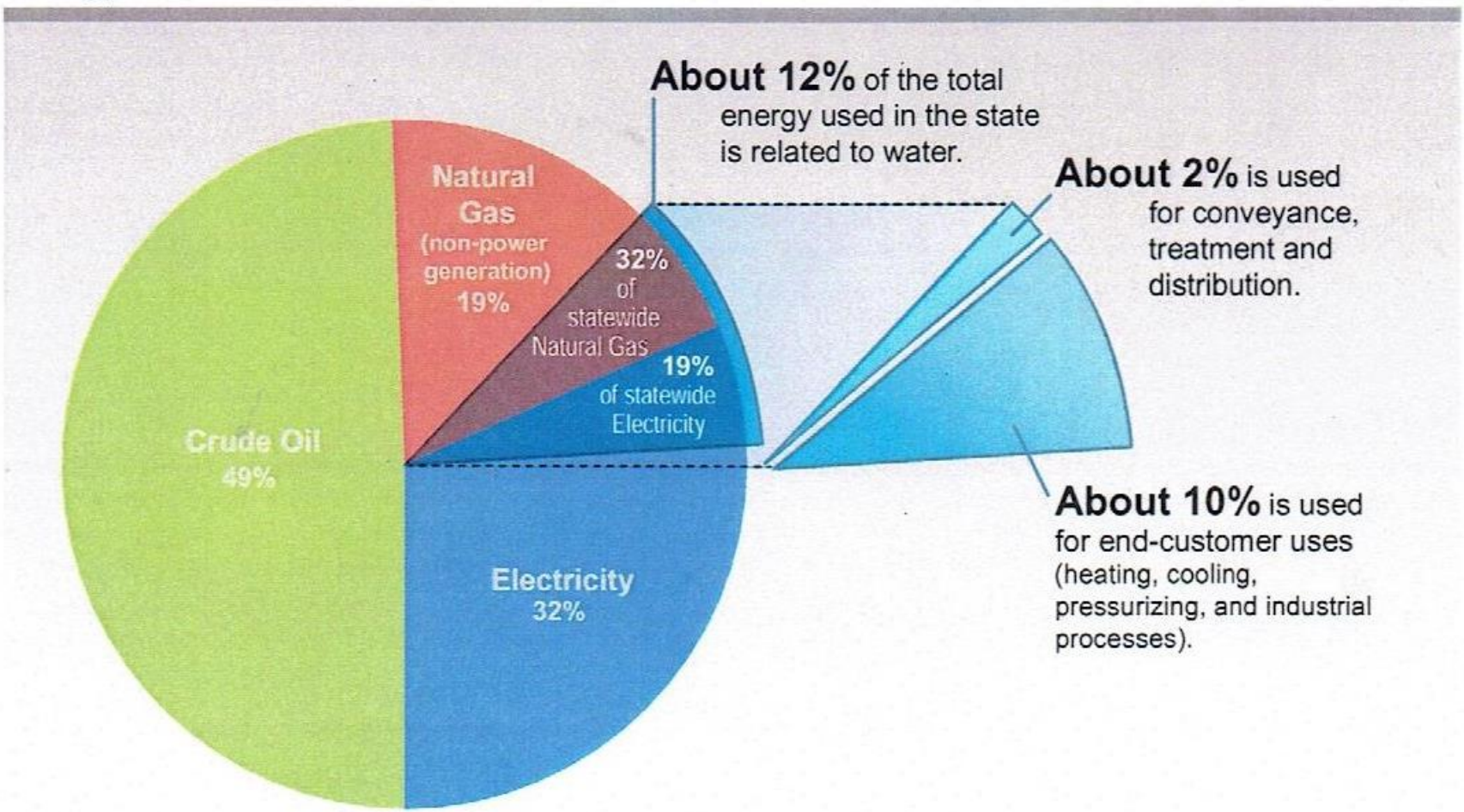
2012 International Energy Agency (IEA) Fig 17.4



Water Requires Energy

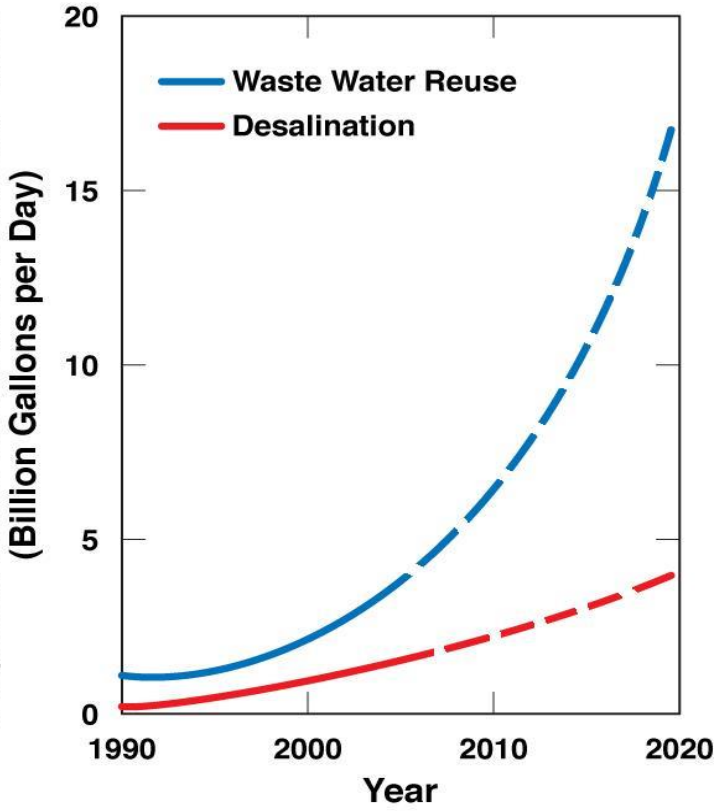
Water Supply Options	Energy Demand (kWhr/kgal)
Fresh Water Transport 100-300 miles	10-18
Seawater Reverse Osmosis Desalination	12-20
Brackish Groundwater Desalination Total	8-10
Reverse Osmosis	7-9
Pumping and concentrate management	1-3
Aquifer Storage and Recovery Total	5-11
Pre-treatment as needed	3-4
Post-treatment as needed	3-4
Pumping	2-3

2005 California Energy Use Related to Water

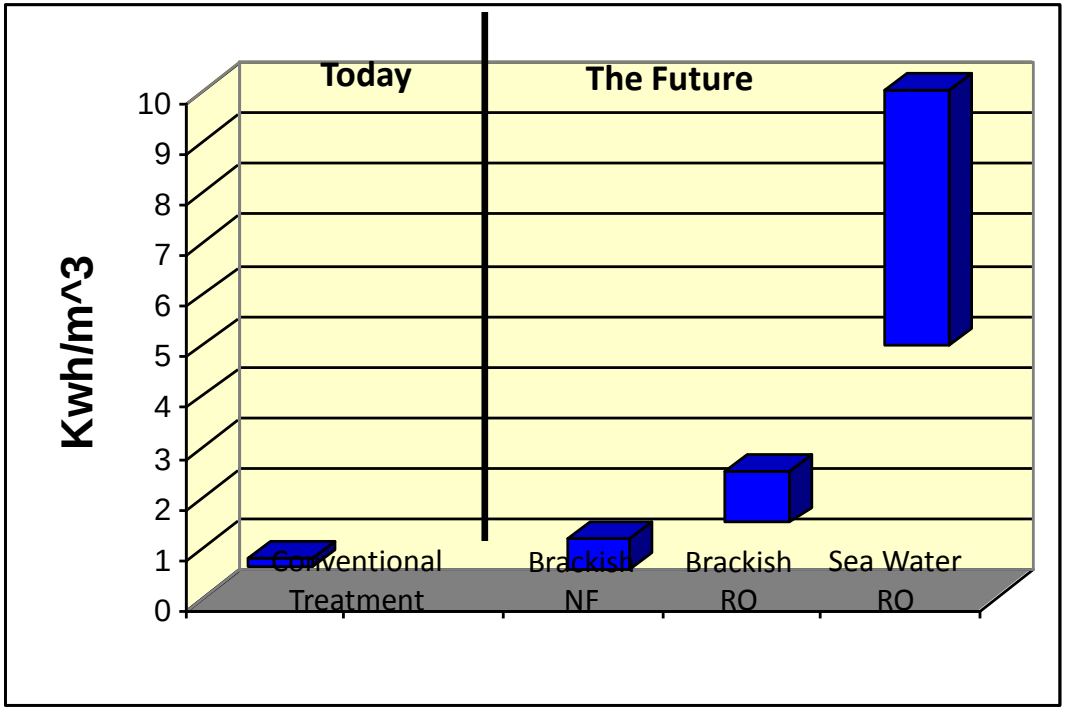


Increasing Non-Traditional Water Use

Projected Non-Traditional Water Use

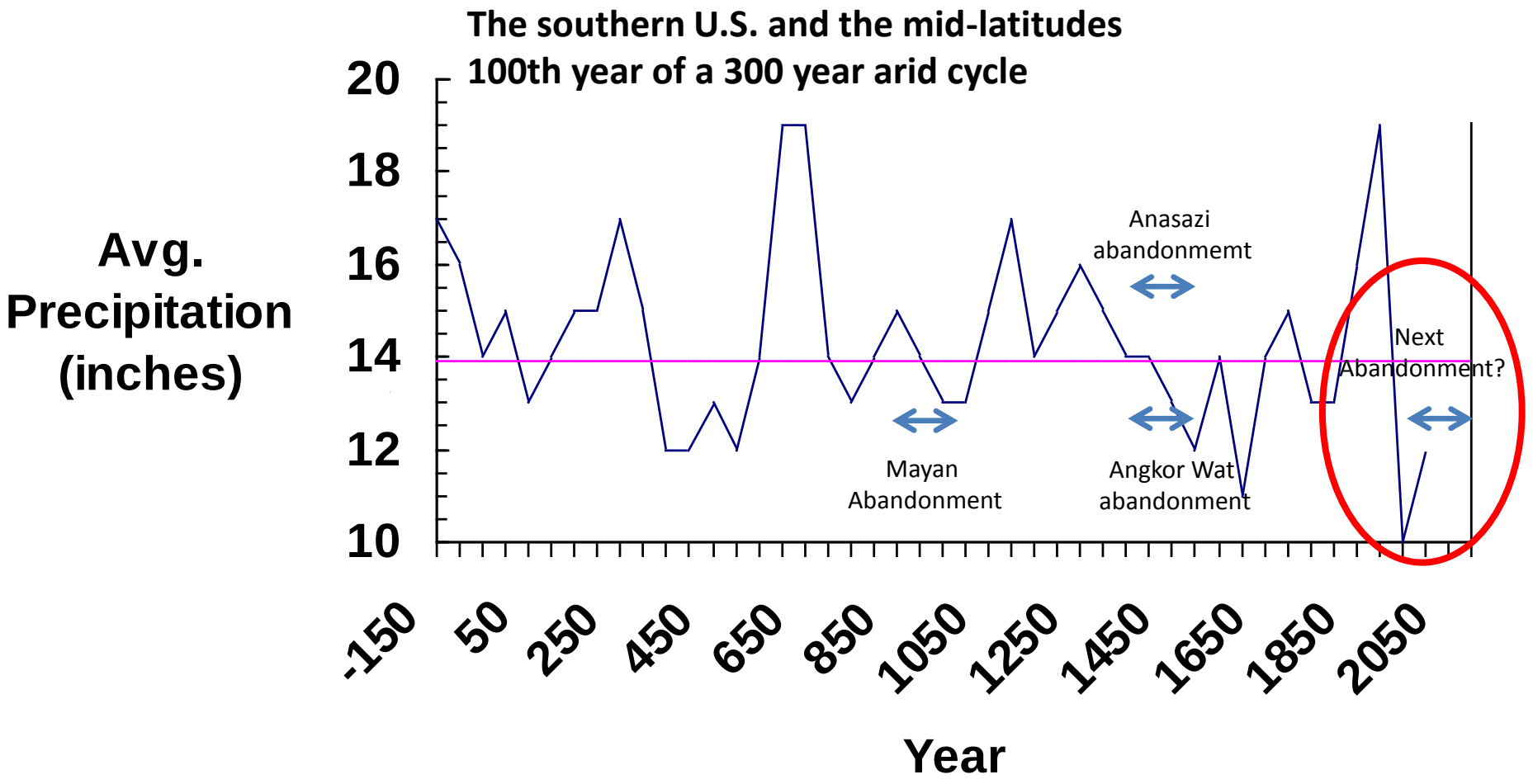


Power Requirements For Treating



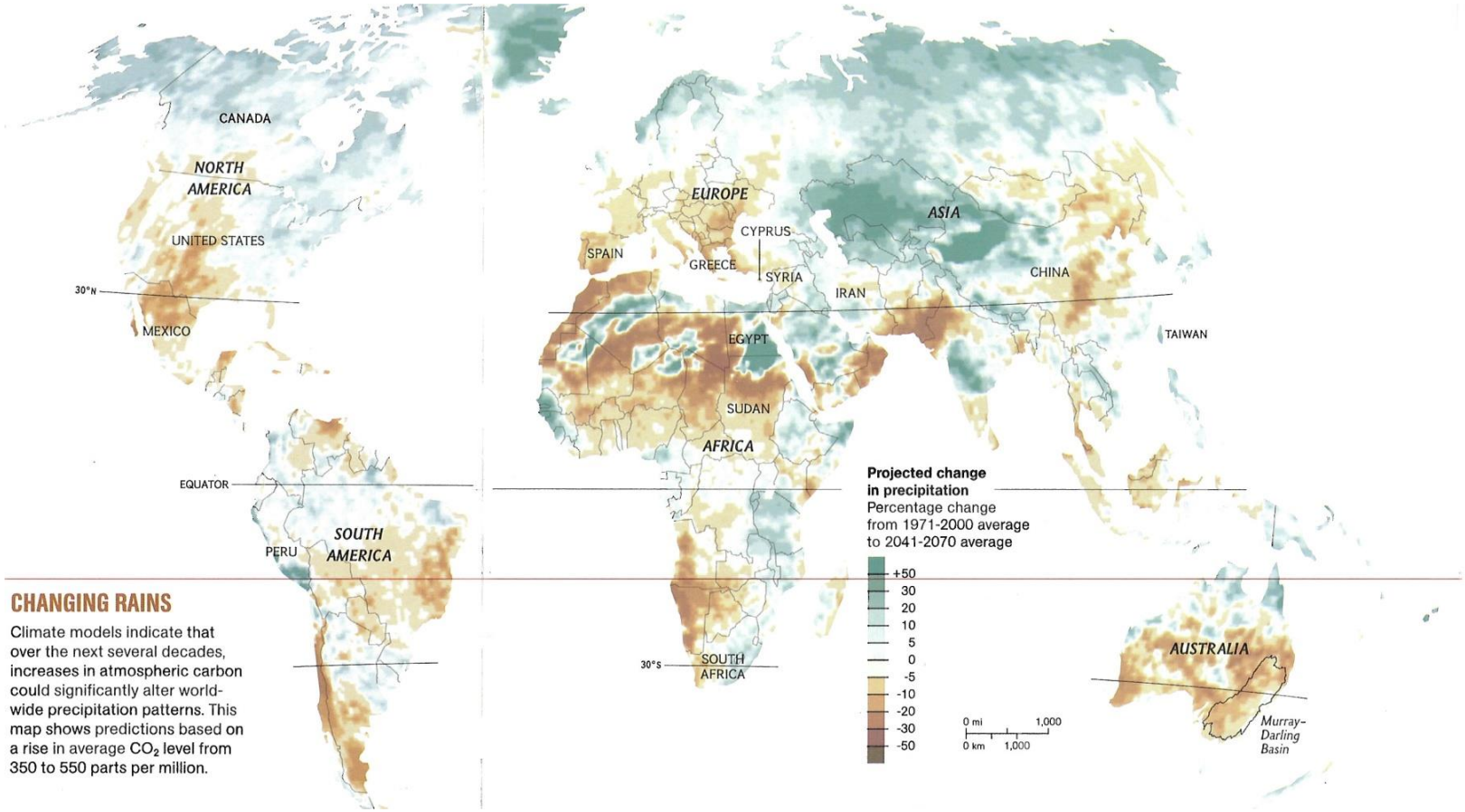
Soruce: EPA 2004, Water Reuse 2007, Mickley 2003, and Einfeld 2007

Tree Ring Data Shows Arid Cycles

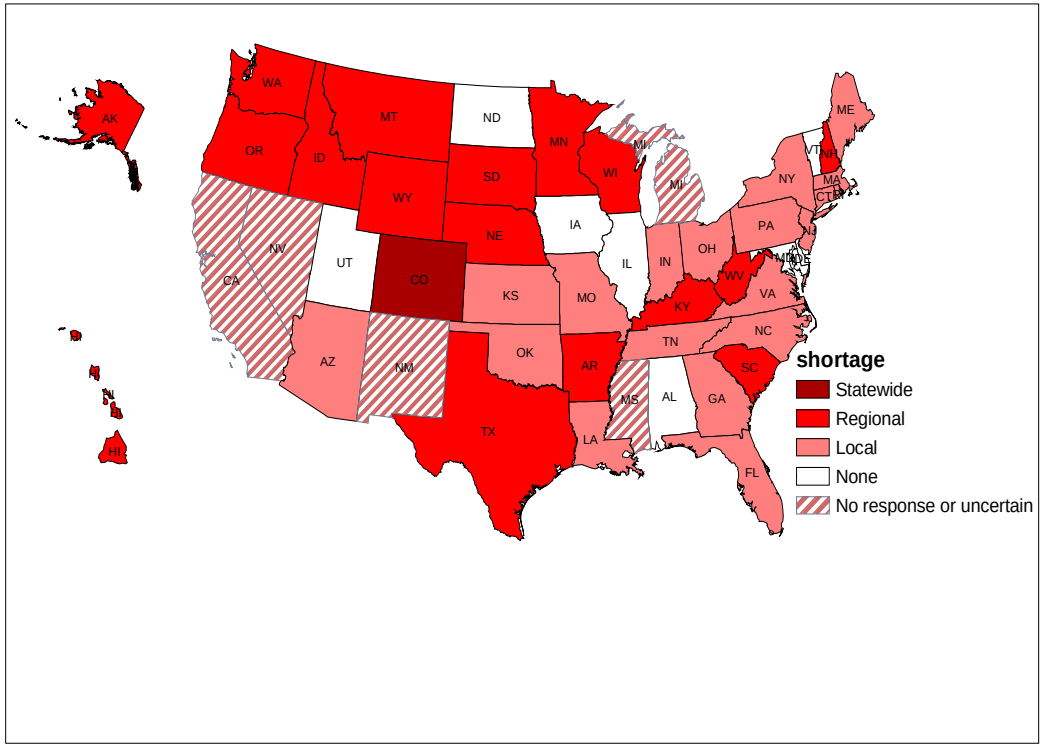


Univ. of Arizona – Tree Ring Research Lab – 50 year averages

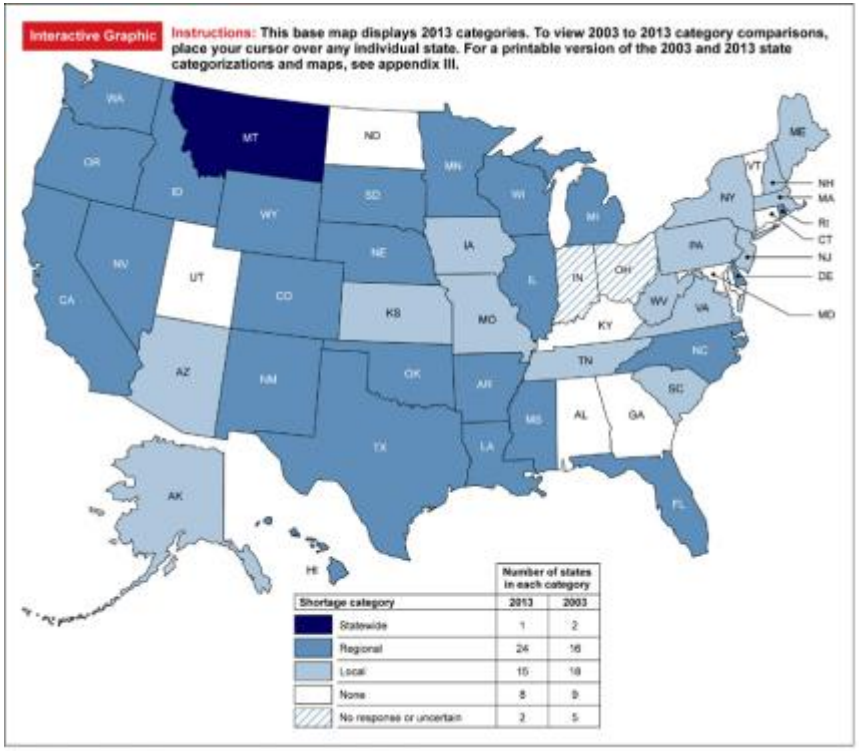
Impact to Mid-Latitude Population



Increasing National Water Stress



GAO 2003



GAO 2013

Water Demand and Supply Trends

- States project economic and population growth which increase demand
- Look to non-traditional water sources to augment regional supplies.
  - Sea water, brackish waters, municipal and industrial reuse, oil & gas produced water, and others can become cost effective
- 300+ Desalination plants operating in the U.S.
  - 10% desalination growth per year projected
  - 15% waste water reuse per year projected
- 40% of Texas drinking water from non-traditional water by 2050 (TWDB)
  - Regional economic and social impacts

Texas Projections

70% Population Growth

- **2020 29.5 million**
- **2070 51.0 million**

17% Increase Water Demand

- **2020 18.4 million acre-feet**
- **2070 21.6 million acre-feet**

Figure 5.6 - Water use category shares of projected annual water demand in 2020

2020

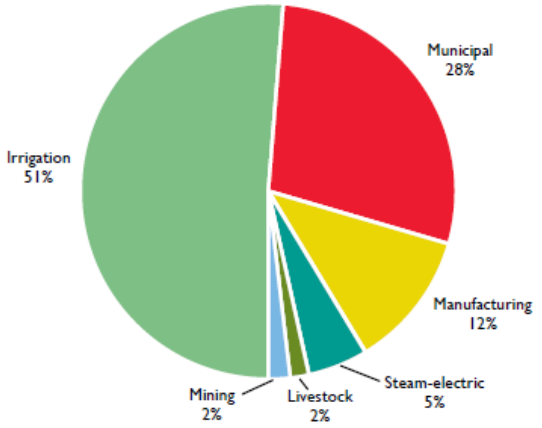
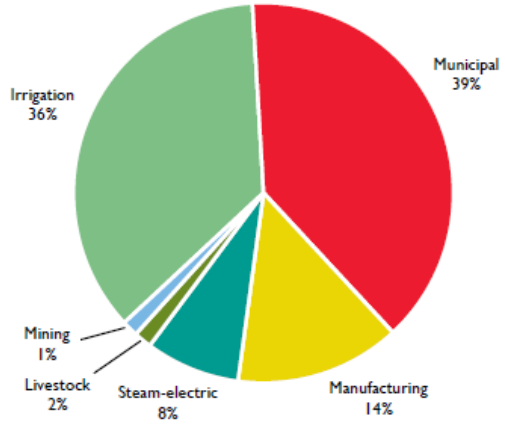


Figure 5.7 - Water use category shares of projected annual water demand in 2070

2070



Texas Annual Existing Water Supply Projection

	2020	2070	△
Total million acre-feet	15.2	13.6	-11%
Surface Water			-1%
Ground Water			-24%
Reuse			+28%

Potential Water Shortage

2020 4.8 million acre-feet

2070 8.9 million acre-feet

1950s drought of record without developing additional supplies

Texas Potential Socio-economic Impacts

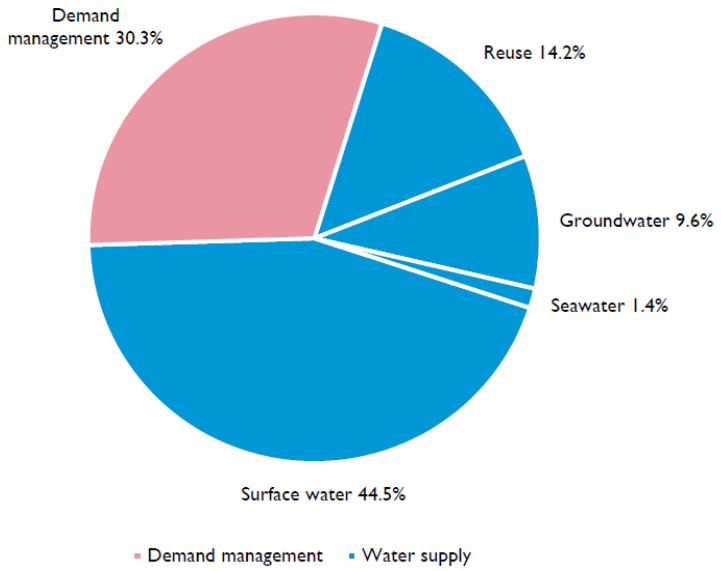
	2020	2070
Income Lost (billions)	$73	$151
Jobs Lost	424,000	924,000
Population Lost	78,000	170,000
School Enrollment Decline	14,000	43,000

Estimated temporary socioeconomic impacts that might occur during a single year or record conditions drought if identified water needs (potential shortages) are not met

Texas Water Plan recommends ~5,500 strategies

- **Add ~3.4 million acre-feet/yr in 2020 and 8.5 in2070**
- **~$63 billion estimated total capital costs (~2,400 projects)**
- **Includes 26 new major reservoirs by 2070**

Figure 8.1 - Share of recommended water management strategies by water resource in 2070



Produced Water – From Oil & Gas Production

- **Produced Water – 5,000 – 200,000 ppm TDS**
  - **25% < 30,000**
  - **25% 30,000 - 60,000**
  - **50% > 60,000**

- **Also Includes naturally occurring**
  - **oils, organic acids, naturally**
  - **radioactive materials (NORM)**
  - **boron, beryllium, lithium, hydrogen sulfide, etc**

- **Frack Water - Fresh to 250,000 ppm TDS**

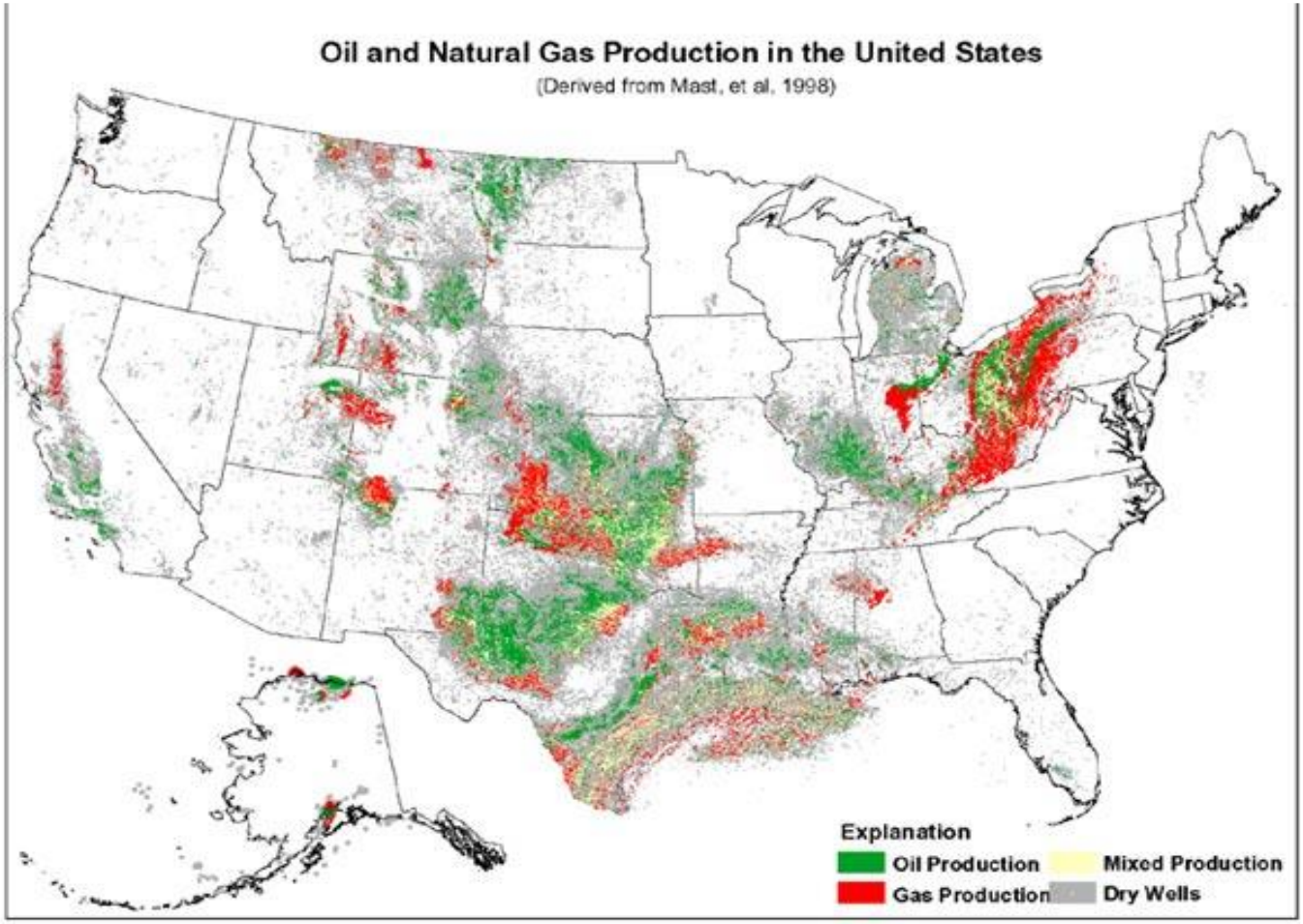
- **Flow back water – 10,000 to - 200,000 ppm TDS**

- **Extracted Water – Deep saline waters > 200,000 ppm TDS**

Western U.S. Produced Water Holding Pond

ppm Total Dissolved Solids (TDS)	
Fresh Water	≤500 ppm
Brackish Water	1,000-10,000
Sea Water	~35,000

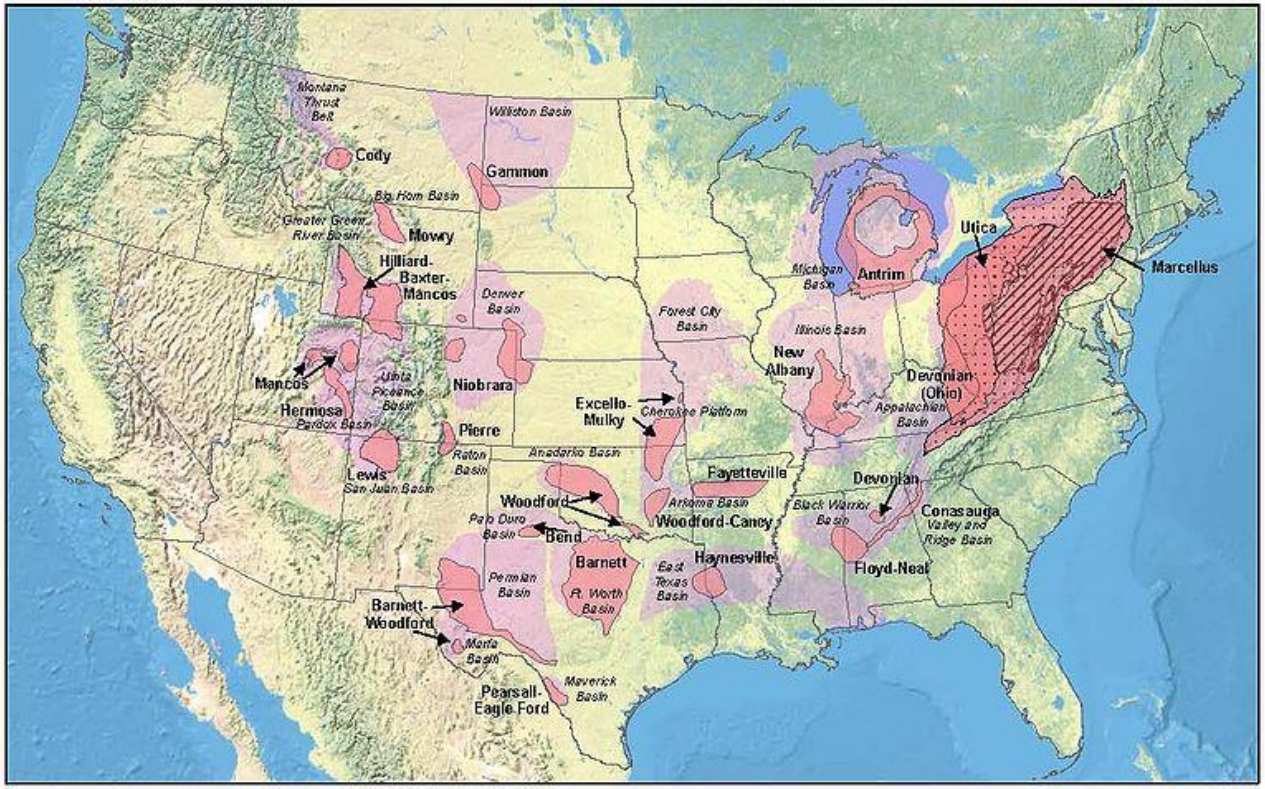
United States Oil & Natural Gas Production



>75% of the Produced Water

- California
- Colorado
- Oklahoma
- Pennsylvania
- Texas
- Wyoming

United States Shale Gas Plays



United States Shale Gas Plays

www.eia.doe.gov
Energy Information Administration
Office of Oil and Gas

Shale Gas Plays
Basins

Stacked Appalachian Plays
Marcellus
Utica
Devonian (OH shale)

November 2008
Miles
0 150 300 600

N

>75% of the Produced Water

- California
- Colorado
- Oklahoma
- Pennsylvania
- Texas
- Wyoming

Produced Water Quantities

States with Largest Quantities	Produced Water Production MGD	Available Water @30% Reuse MGD
Texas	860	258
California	353	106
Oklahoma	264	79
Wyoming	250	75
Kansas	122	37
Louisiana	115	35
New Mexico	88	26
Alaska	71	21
Colorado	37	11

Potential Water Resource Sustainability

Displacing Fresh Water Use

- **Oil and gas production reuse**
  - Hydraulic fracturing up to 250,000 TDS
  - Steamflooding (California) 5,000 TDS
- **Irrigation – after treatment or dilution**
  - Rangeland rehabilitation up to 12,000 TDS
  - Non-food crops - low boron and 3,000 TDS
  - Algal biofuel production up to 20,000 TDS
  - Support wetlands up to 20,000 TDS
- **Injection/hydraulic control** – reduce subsidence and salt-water intrusion
- **Dust/ice control**
- **Industrial applications**
  - Hybrid cooling towers up to 10,000 TDS
  - Pumped hydro – high TDS
  - Solution mining, wash water

Rice Universities' Baker Institute #4

Among world's university-affiliated think tanks

Center for Energy Studies #2

Among world's energy- and resource- policy think tanks

NSF Engineering Research Center

Nanotechnology Enabled Water Treatment (NEWT)
Modular solar-powered desalination

Baker Institute's Energy – Water Forum

- **Policies/practices to improve lifecycle water use, conservation and management** – Emphasis on non-traditional, non-fresh waters

- **Interactive forum platform to accelerate timelines**
  Systems level conversations – Sharing successful practices – Overcome barriers and accelerate technological progress – Policy focus

- **Teaming with industry, government, labs and academia**
  - Baker Energy-Water Forum
  - GWPC, NRWA, and other State organizaitons
  - EWI an Oil and Gas Industry Energy Water Initiative
  - DOE National Labs, and Southwest Regional Partnership
  - Universities

Priority Challenges

Selected by Audience under Chatham House Rule

- **Standardized approaches to verify and test new water analysis and treatment technologies supported by impartial and objective guidelines.**
- **Comprehensive modeling methods**
  - **To calculate and compare relative environmental impact, carbon intensity, risk, costs and other characteristics of using produced water when compared to other fresh and non-fresh water sources.**
  - **Includes need to augment associated data bases.**
- **Clarification of PW ownership and liability as it is treated and put to beneficial use.**

Additional Important Challenges

- **Urge states to consider including a more rigorous accounting of O&G PW in their state water plans and identify the effective volume of PW available for use outside the O&G sector.**
- **Encourage centralized discussions to share local, state, and regional success practices in order to accelerate progress in using PW and other non-fresh water sources.**
- **There is a need to communicate and educate companies on the potential benefits of using non-fresh water sources, including O&G PW, as they look to expand or relocate.**
- **There is a need to communicate and educate the public on the potential benefits of using non-fresh water sources, including O&G PW.**

Oklahoma Produced Water Working Group

- Report *"Oklahoma Water for 2060 Produced Water Reuse and Recycling," April 26, 2017*
- Led by the Oklahoma Water Resources Board
- Study and recommend alternatives to produced water disposal from oil and gas operations in Oklahoma.

The *Report* is stated to:

- Constitute a continuation of the implementation of the 2012 Oklahoma Comprehensive Water Plan
- Support the Oklahoma Governor's initiative to re-use or recycle water produced in oil and gas operations
- Assess the potential alternatives to current practices of injecting produced water from oil and gas wells and disposal wells
- Evaluate the data, issues and opportunities with produced water

Key Findings Include:

- Produced water re-use by the oil and gas industry is the most viable cost-effective alternative due to minimal water treatment needs and low treatment costs.
- A special case of water re-use was evaluated using surplus produced water from the Mississippi Lime play area and was deemed potentially financially competitive (with current disposal methods).
- Evaporation techniques for produced water should be further investigated and developed.
- Water treatment and desalination techniques of produced water should be further investigated and developed if the Group intends to reduce the majority of water produced in the state.

Report Recommendations Include:

- Reduce the challenges to water reuse through targeted regulations and legislation
- Further investigate methods to facilitate the re-use of produced water in oil and gas operations
- Study further the feasibility of transferring Mississippi Lime produced water to the STACK play
- Conduct a more detailed evaluation of evaporation as an alternative to injection
- Identify research needs and potential funding partnerships to further accomplish the Group's goals

Report Recommendations Include:

- Continue the Group or subgroups to identify opportunities to continue cooperative planning and development of new techniques, infrastructure, water users, legislation and regulatory structure
- Support and build upon the Water for 2060 Advisory Council 2015 energy and industry water use
- sector water conservation findings and recommendations to the Governor and Legislature.

Preliminary Legislation related to the topic of produced water:

SB 285 – (Schulz) Oklahoma Brine and Produced Water Development Act, treats produced water as brine under the act. - *Available for consideration and amendments during 2018 legislative session.*

SB 287 (Griffin) clarifying Clean Water Act jurisdiction of state agencies to handle permitting of PW discharges. - *Signed by Governor*

SB 475 – (Schulz) Expands tax collections on skim oil to treat salt water from produced water the same. - *Failed Deadline – April 27, 2017. Available for consideration and amendments during 2018 legislative session.*

SB 743 (Schulz) creates the Oil and Gas Produced Water Recycling and Reuse Act, requires OCC to identify produced water as hazardous waste and develop rules for recycling and reuse of such waste. - *Available for consideration and amendments during 2018 legislative session.*

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