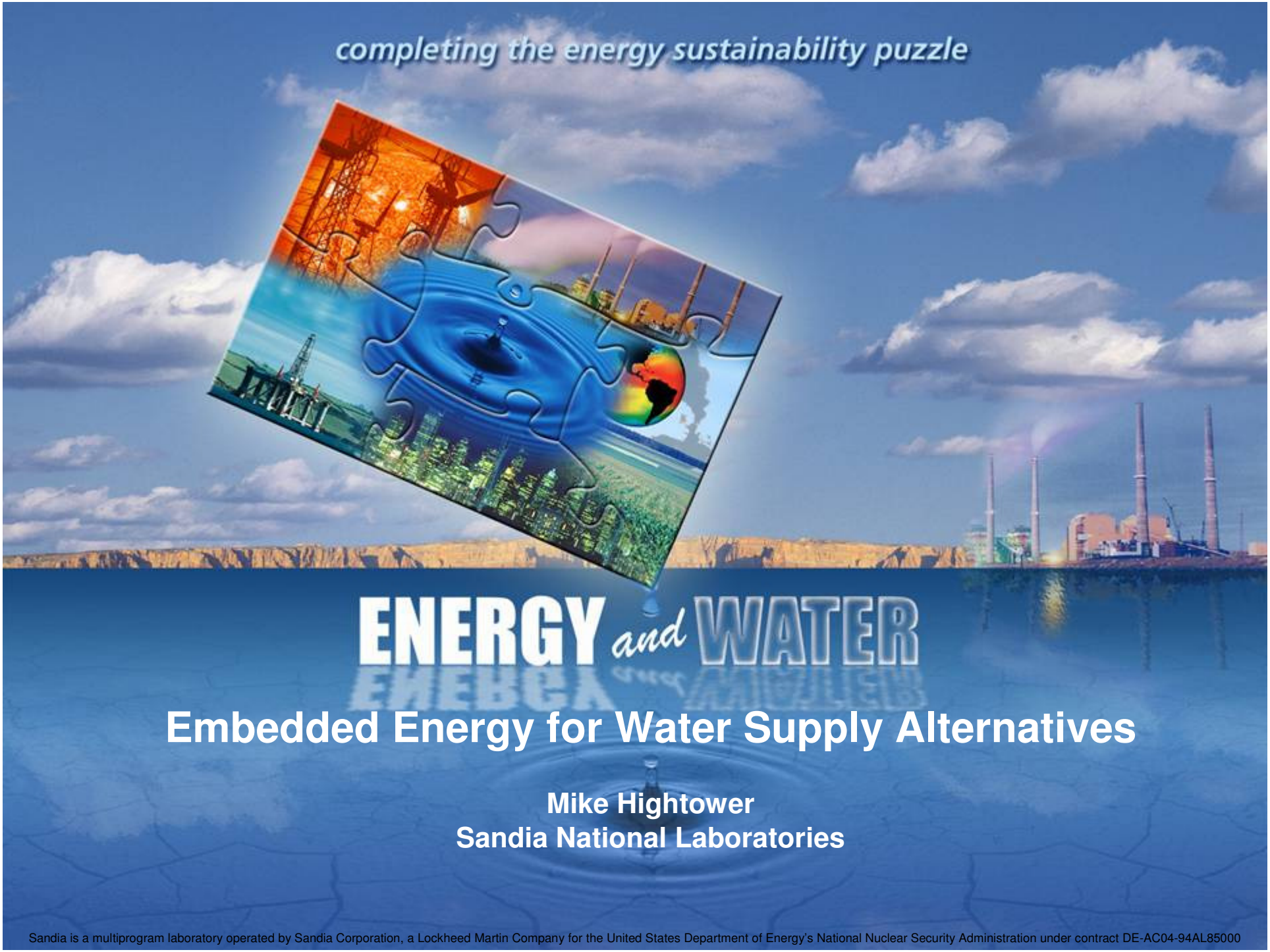


Embedded Energy for Water Supply Alternatives

Mike Hightower
Sandia National Laboratories

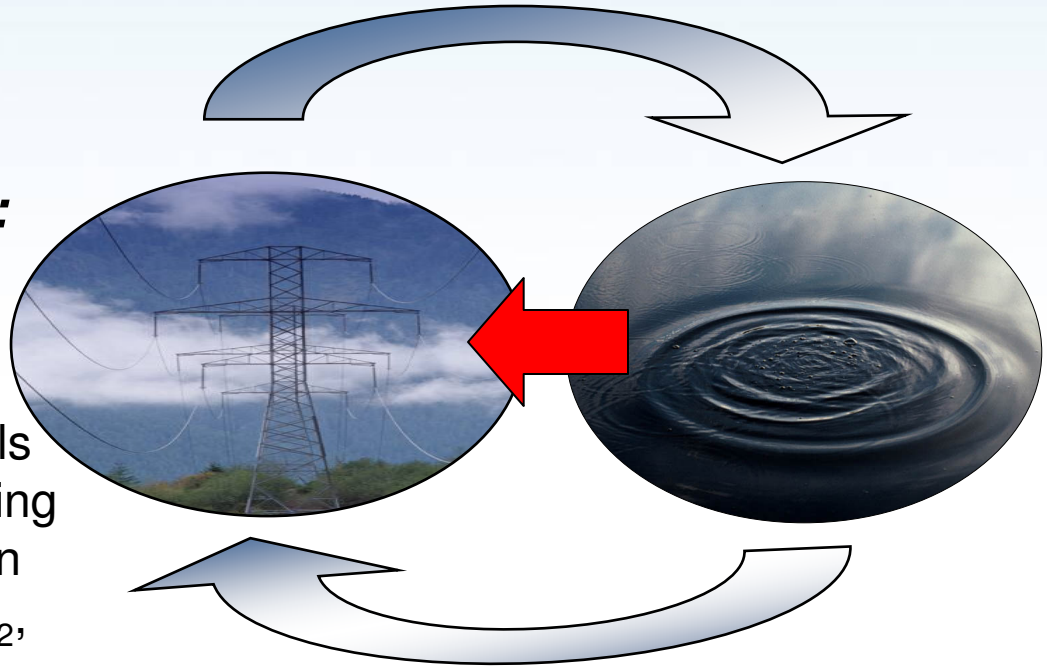
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

Energy and Water are … Interdependent

Water for Energy and ***Energy for Water***

Energy and power production require water:

- Thermoelectric cooling
- Hydropower
- Energy minerals extraction/mining
- Fuel Production (fossil fuels, H_2, biofuels)
- Emission control

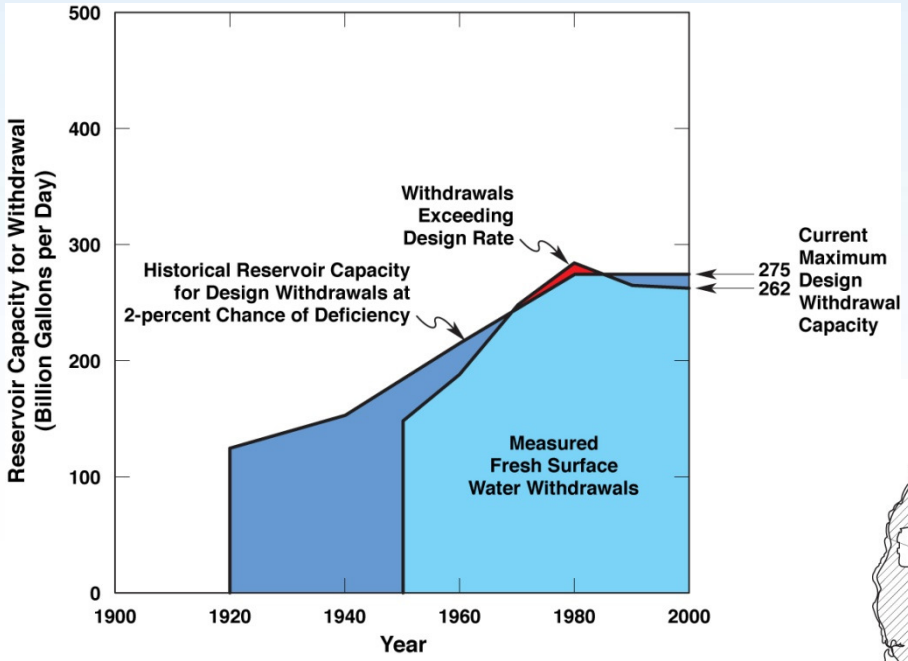


Water production, processing, distribution, and end-use require energy:

- Pumping
- Conveyance and Transport
- Treatment
- Use conditioning
- Surface and Ground water

ENERGY and WATER

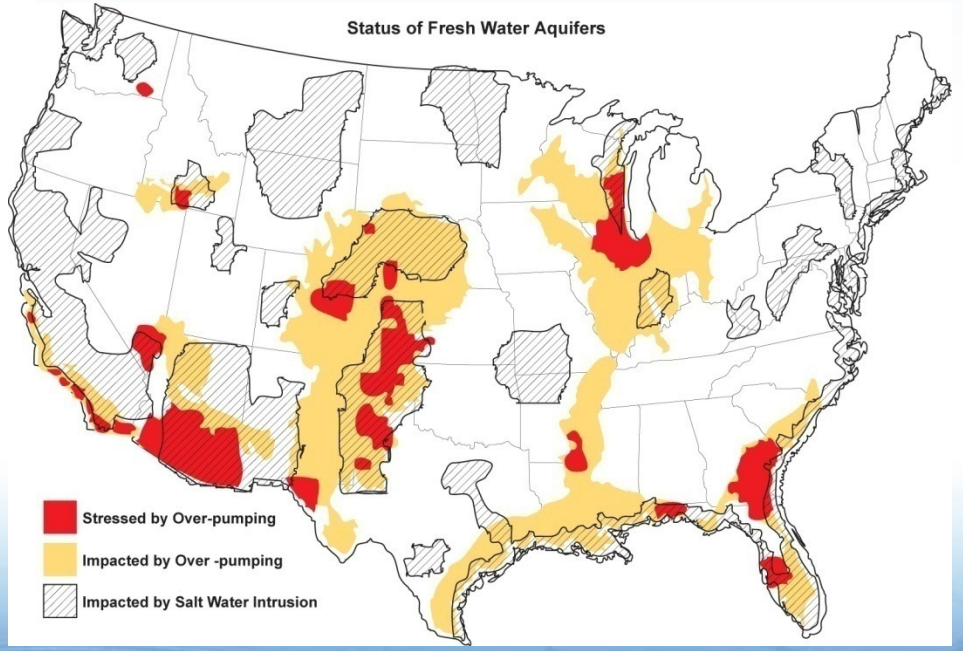
Growing Limitations on Fresh Surface and Ground Water Availability



(Based on USGS WSP-2250 1984 and Alley 2007)

- Little increase in surface water storage capacity since 1980
- Concerns over climate impacts on surface water supplies

- Many major ground water aquifers seeing reductions in water quality and yield



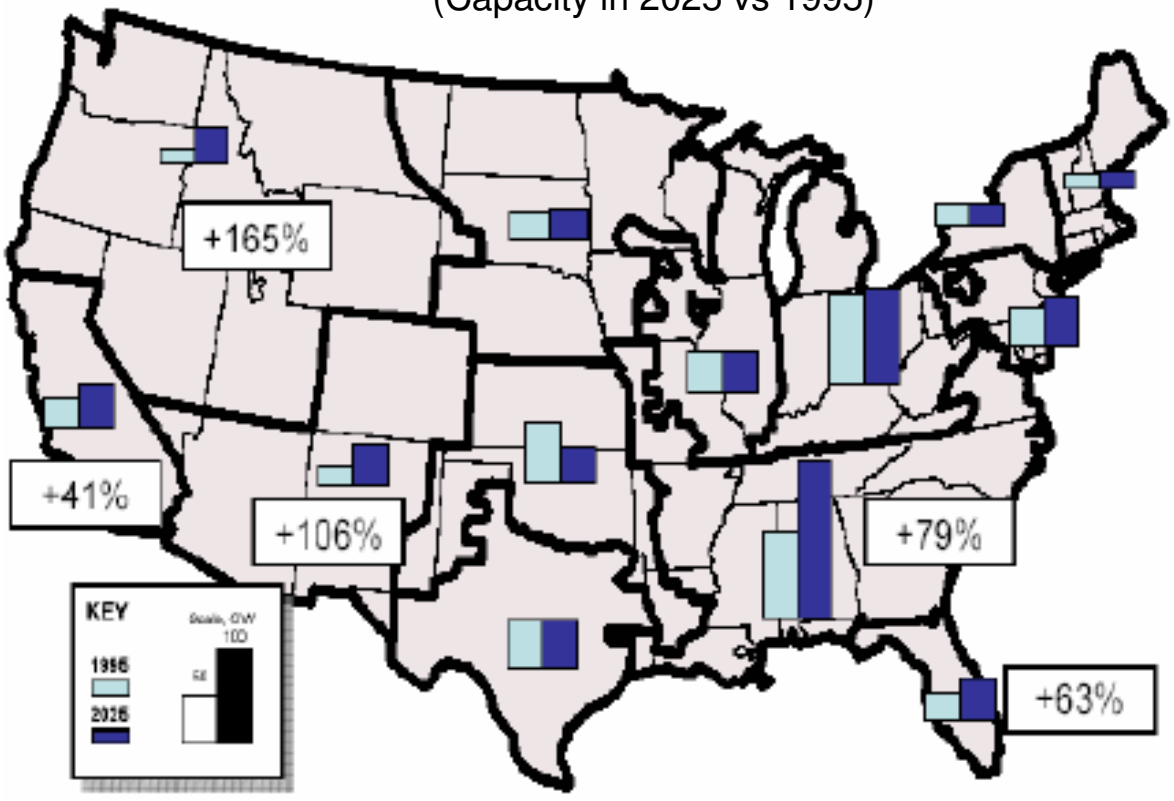
(Shannon 2007)

ENERGY and WATER

Growth in Thermoelectric Power Generation

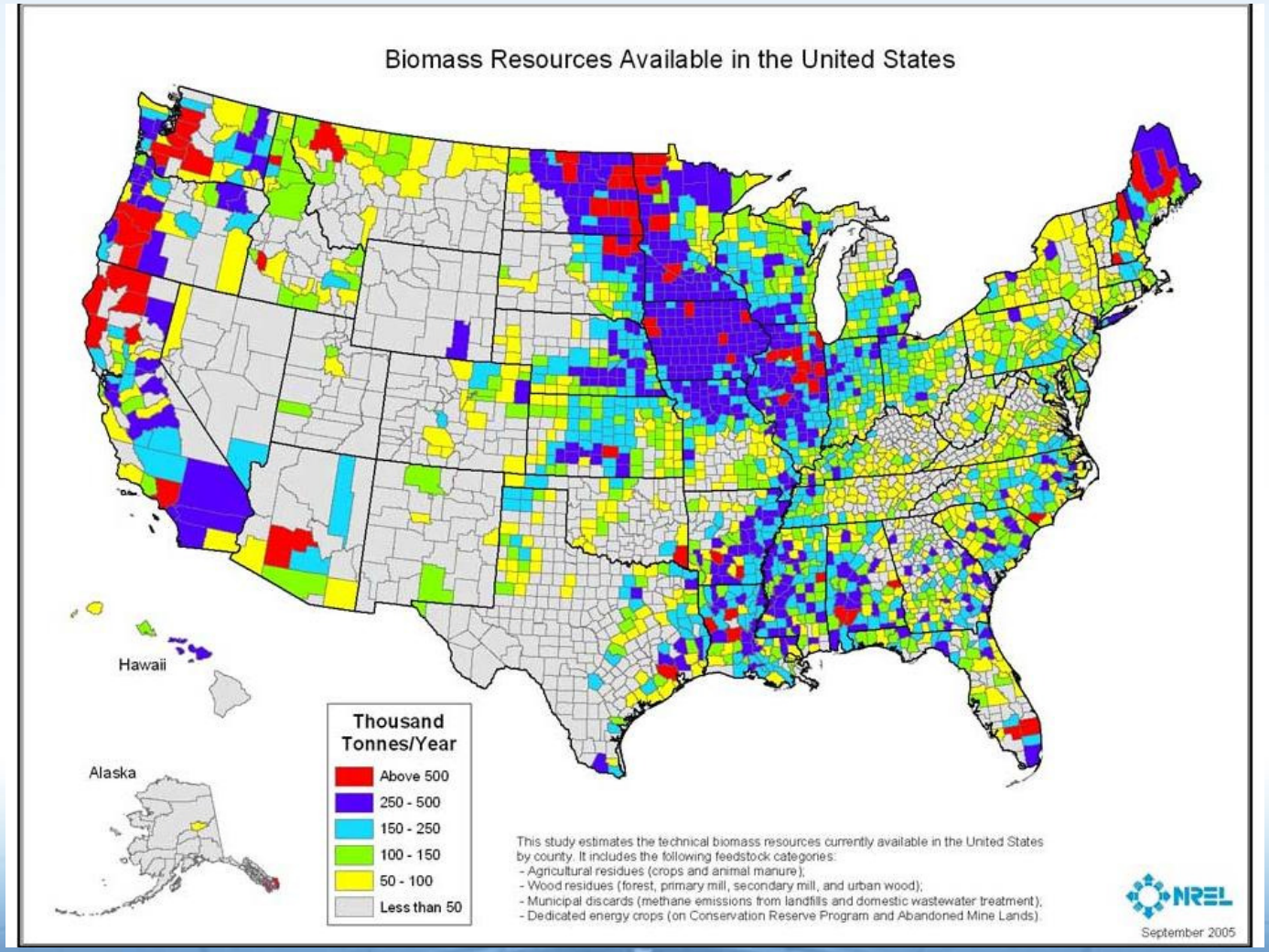
- Most growth in water stressed regions
- Most new plants expected to use evaporative cooling

Projected Thermoelectric Increases
(Capacity in 2025 vs 1995)



Source: NETL, 2004

Biomass and Water Use Impacts Will be Regional



US Energy Sustainability

ENERGY and WATER

Summary of Major National Needs and Issues Identified in Regional Workshops

Better resources planning and management

- Integrated regional energy and water resource planning and decision support tools
- Infrastructure and regulatory and policy changes for improved energy/water efficiency
- Improved water supply and demand characterization, monitoring, and modeling

Improved water and energy use efficiency

- Improved water efficiency in thermoelectric power generation
- Improved biofuels/biomass water use efficiency
- Reduced water intensity for emerging energy resources

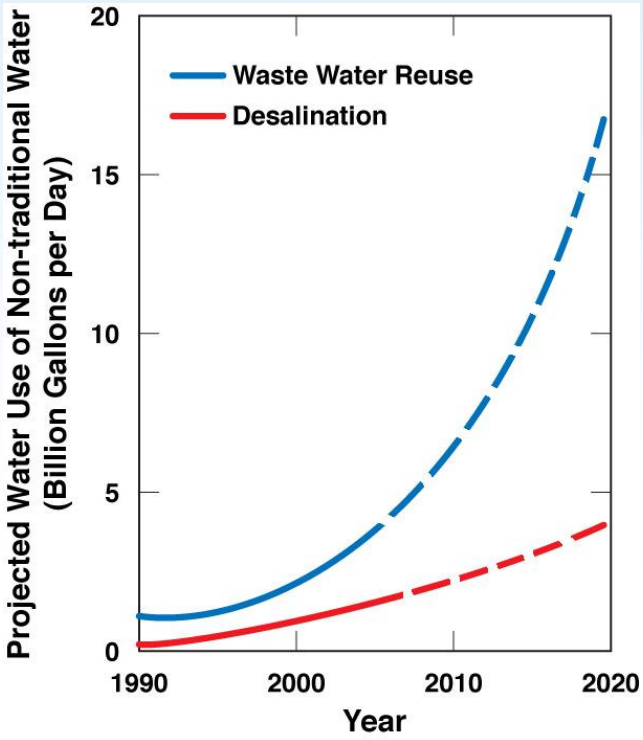
Development of alternative water resources and supplies

- Oil and gas produced water treatment for use
- Energy efficiency and assessment of impaired water treatment and use

www.sandia.gov/energy-water

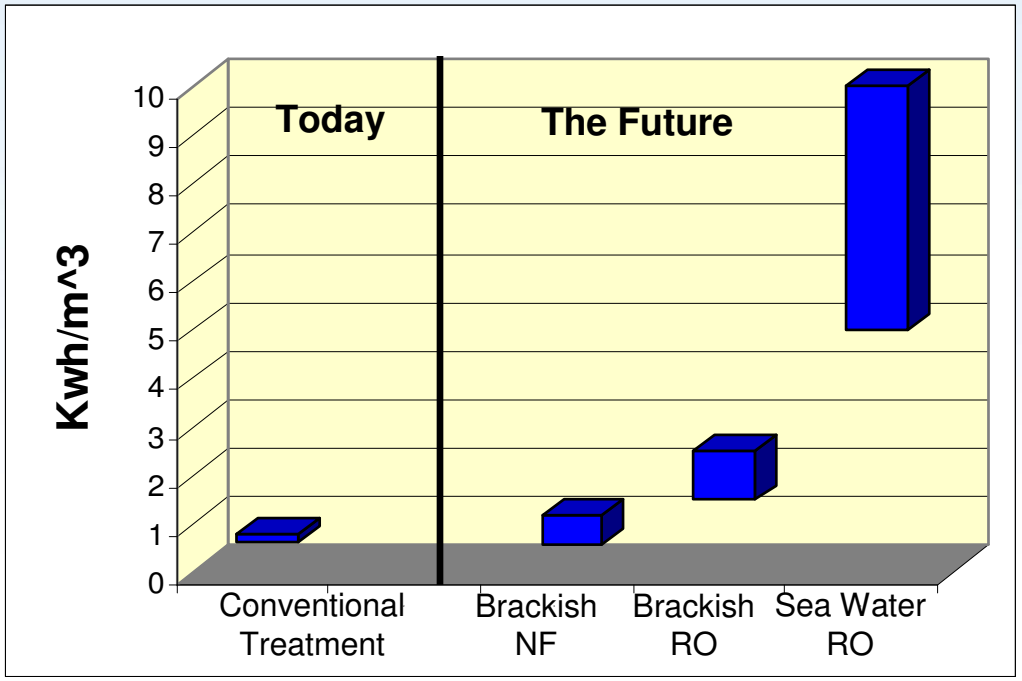
ENERGY and WATER

Growing Use of Non-traditional Water Resources



(From EPA 2004, Water Reuse 2007, Mickley 2003)

Power Requirements For Treating

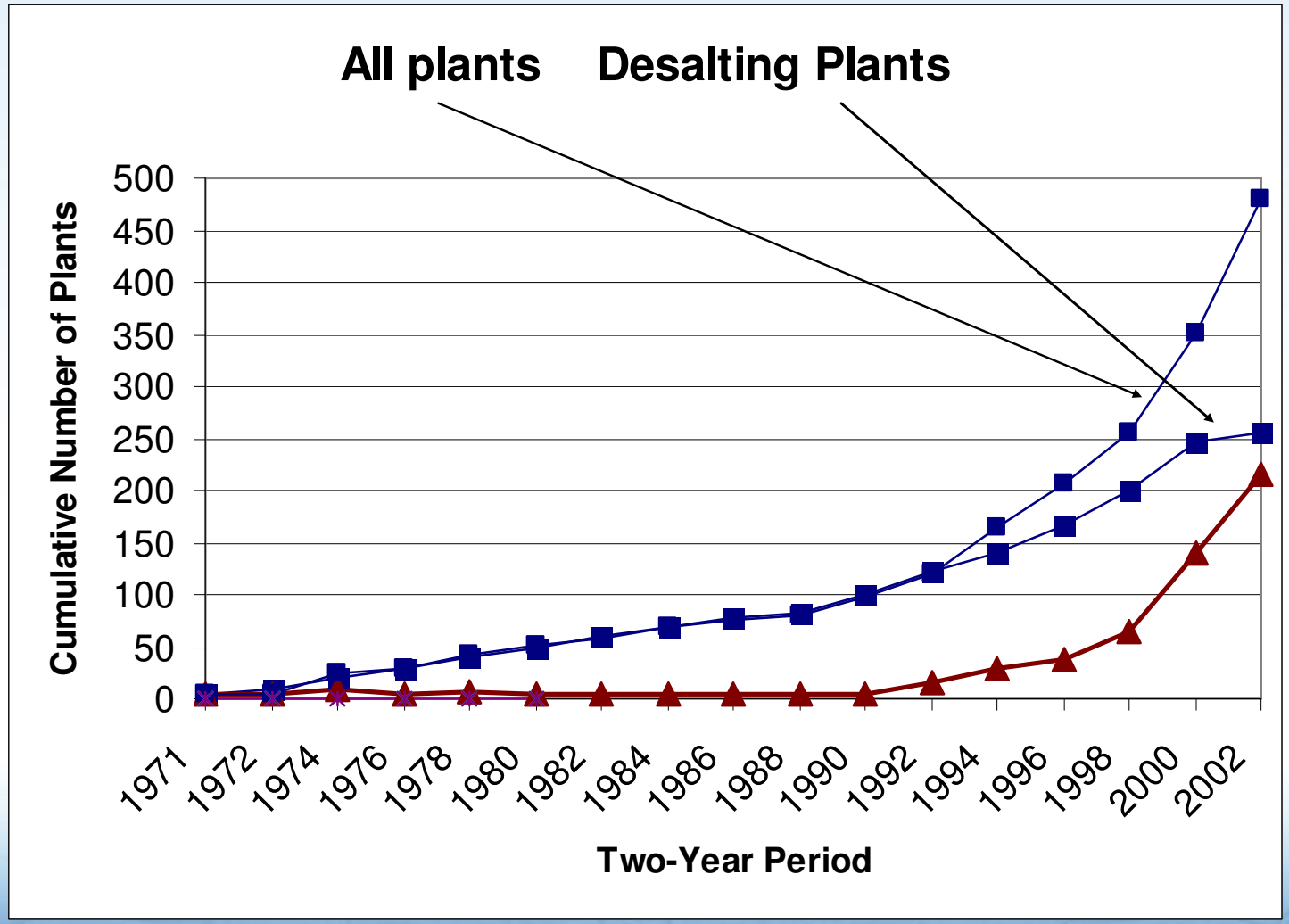


(Einfeld 2007)

- Desal growing at 10% per year, waste water reuse at 15% per year
- Reuse not accounted for in USGS assessments
- Non-traditional water use is energy intensive

ENERGY and WATER

Growth in U.S. Membrane Treatment Plants



(Mickley 2003)

ENERGY and WATER

Emerging Consideration of Waste Water for Energy Production

- **Many municipal and industrial processes have large waste water streams**
  - **Thermoelectric plant blowdown, desalination concentrate streams, oil and gas produced water, manufacturing waste water, etc.**
- **System-level use often neglected**
  - **Embedded nutrients, embedded energy**
  - **Available utilization of byproducts such as biomass, heat, CO2**

Energy Requirements of Various Water Resource Options

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

Water Pumping and Treatment as a Novel Energy Storage Approach

- Water pumping and treatment considered to support renewable energy use
- Detailed matching of wind energy, water demand, and water storage by hour
- Several applications have shown overall savings on water treatment and delivery costs

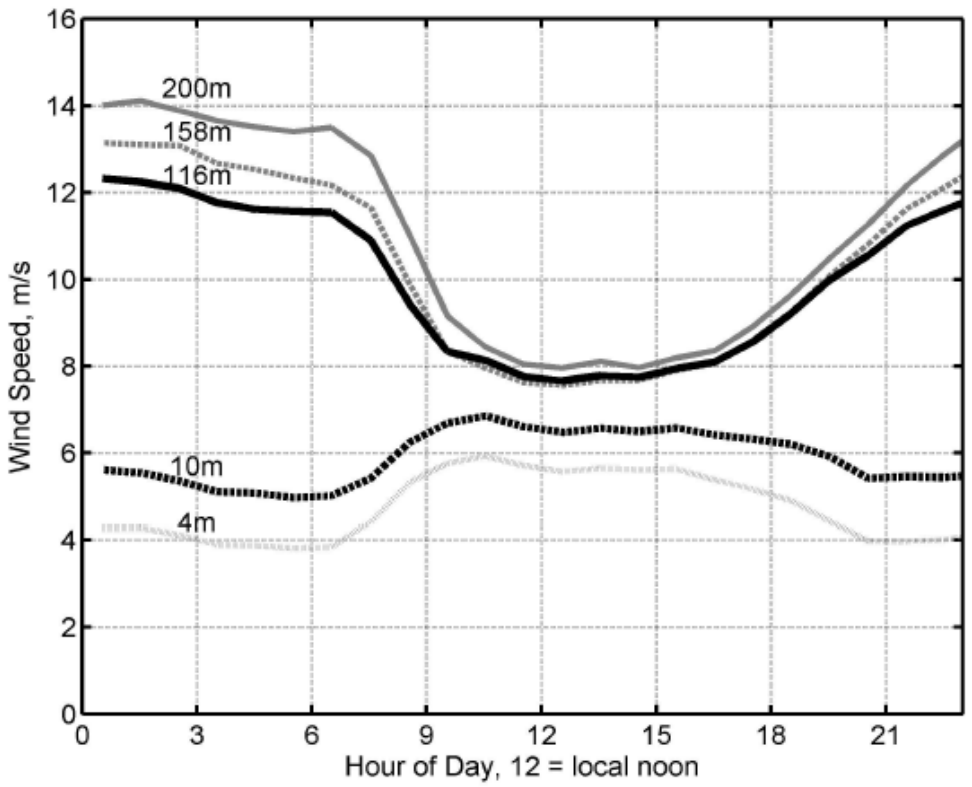


Fig. 78. Average diurnal evolution of the observed wind speed at each height level at Lubbock, Texas.