# Energy Optimized Desalination Technology Development Workshop

**Dr. Mark Johnson**

**Director, Advanced Manufacturing Office**

**U.S. Department of Energy**

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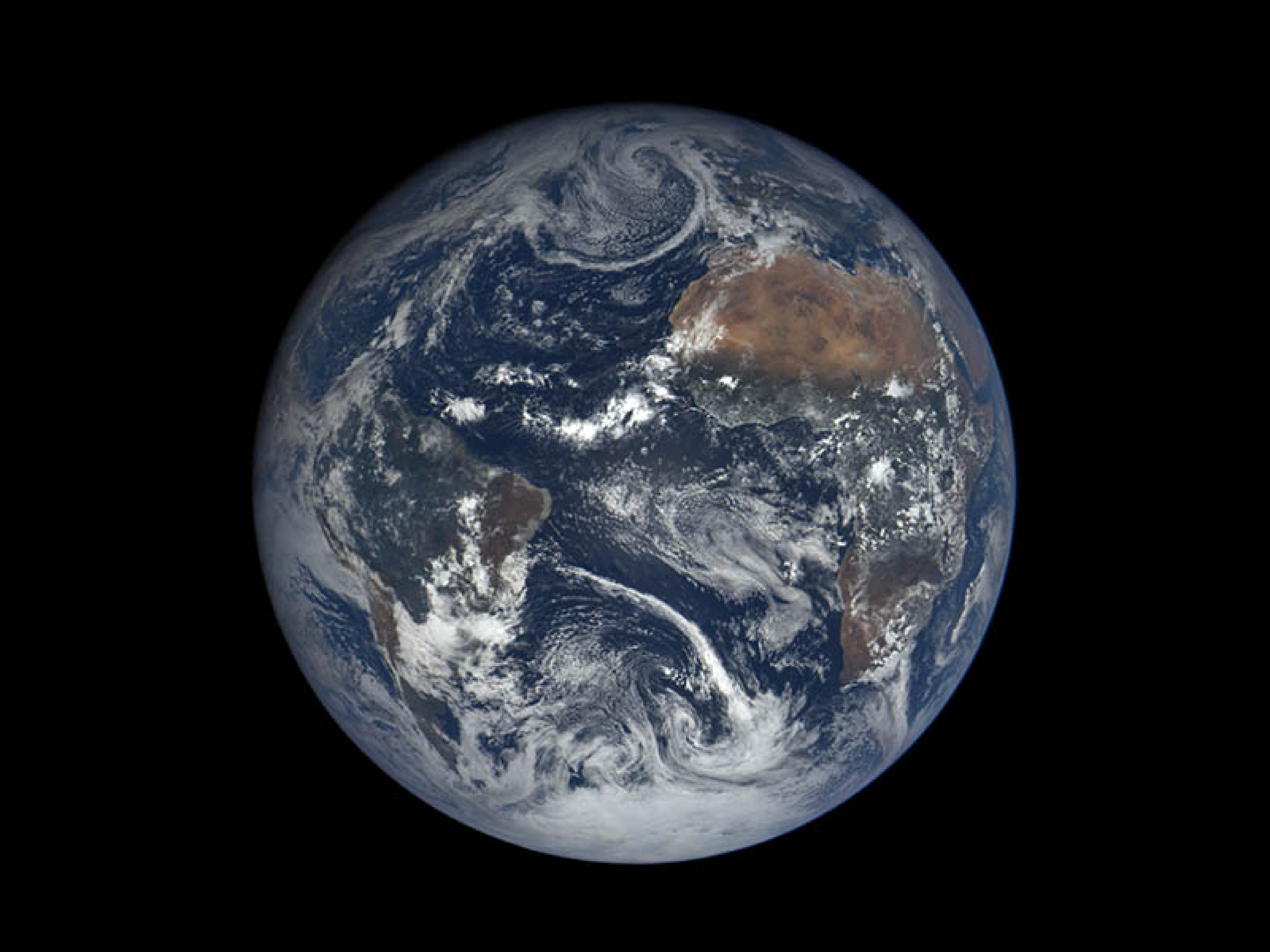
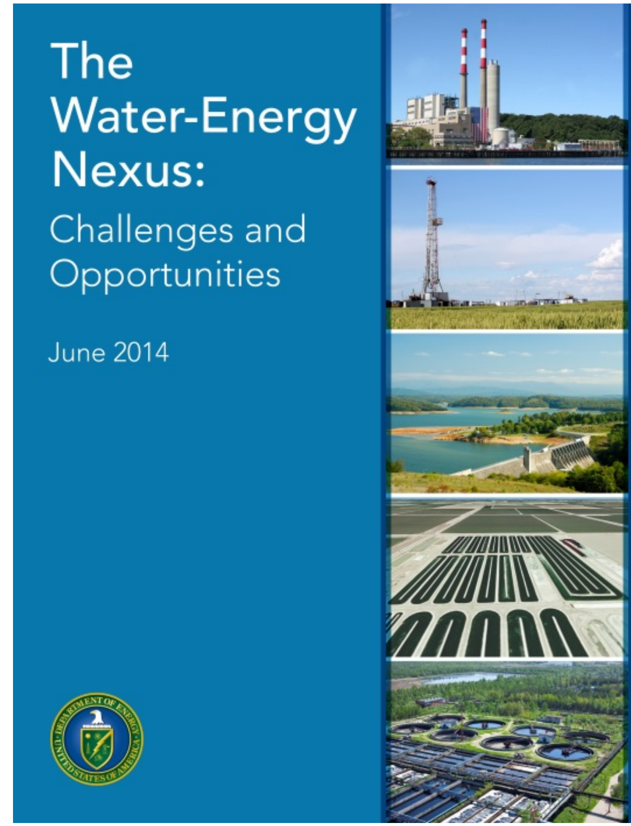
San Francisco



# Energy-Water Nexus: DOE's Role

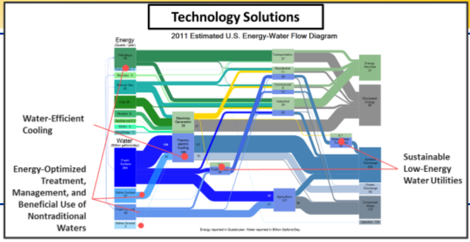
- DOE has strong expertise in technology, modeling, analysis, and data and can contribute to understanding the issues and pursuing solutions across the entire nexus.
- This work has broad and deep implications
  - User-driven analytic tools for national decision-making supporting energy resilience with initial focus on the water-energy nexus
  - Solutions through technology RDD&D, policy analysis, and stakeholder engagement
- We can approach the diffuse water area strongly from the energy side
  - Focus on our technical strengths and mission
  - Leverage strategic interagency connections




Download the full report at [energy.gov](energy.gov)

# Technology RDD&D

## *Three Strategic Thrusts, Pathways, and Drivers*




### Energy-Optimized Treatment, Management, and Beneficial Use of Nontraditional Water

- Projections suggest desalination is most promising current technology with sufficient potential capacity to prevent reservoir depletion in western states over the coming decades
- There are a number of promising treatment technologies that could lead to optimized systems
- Systems level solutions, such as dynamic control, and off-peak optimization, bring increasing opportunities for lower cost and lower carbon footprint.

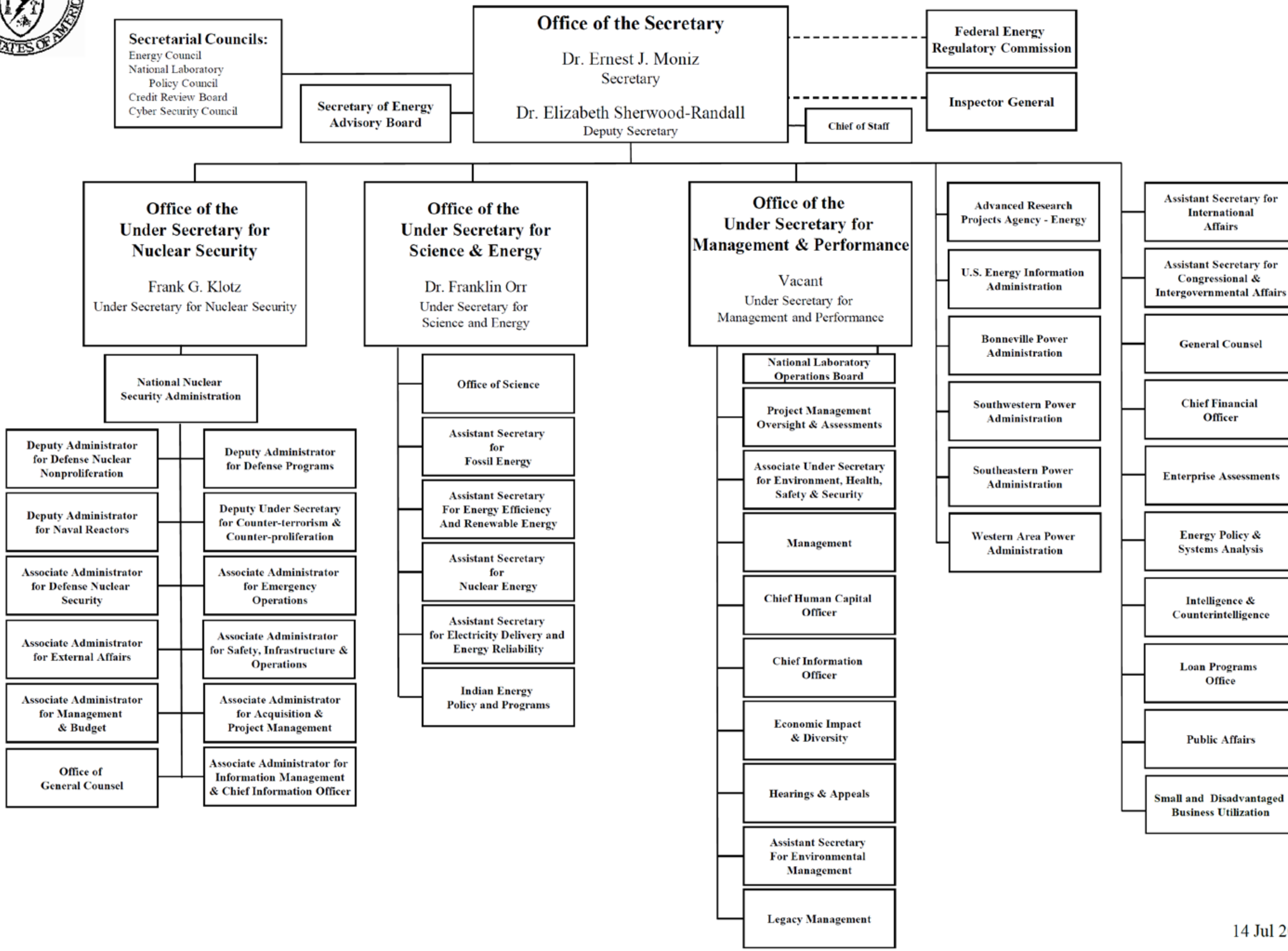
### Sustainable Low-Energy Water Utilities

- Over 3% of US electricity used for water infrastructure (treatment and pumping)
- Water utilities identify energy as largest operating cost
- Energy needs increase with treatment regulatory requirements (e.g. nutrients), growing inter-basin transfers
- Process innovation (e.g. microbial fuel cells), and manufacturing advance (e.g. 3-d printing of pump impellers) enable energy efficiency and energy extraction.

### Water-Efficient Cooling

- About 40% of US water withdrawals and 4% of consumption are for thermoelectric cooling
- Scalable cooling technologies can also reduce water requirements in industry and commercial buildings
- In FY15, there were significant investments by FE, ARPA-E ARID, and in CERC
- In FY17, we will pursue increased efficiency in heat exchangers and cooling systems, while monitoring significant recent tech investment
- In FY18, we will demo promising technology

# DEPARTMENT OF ENERGY

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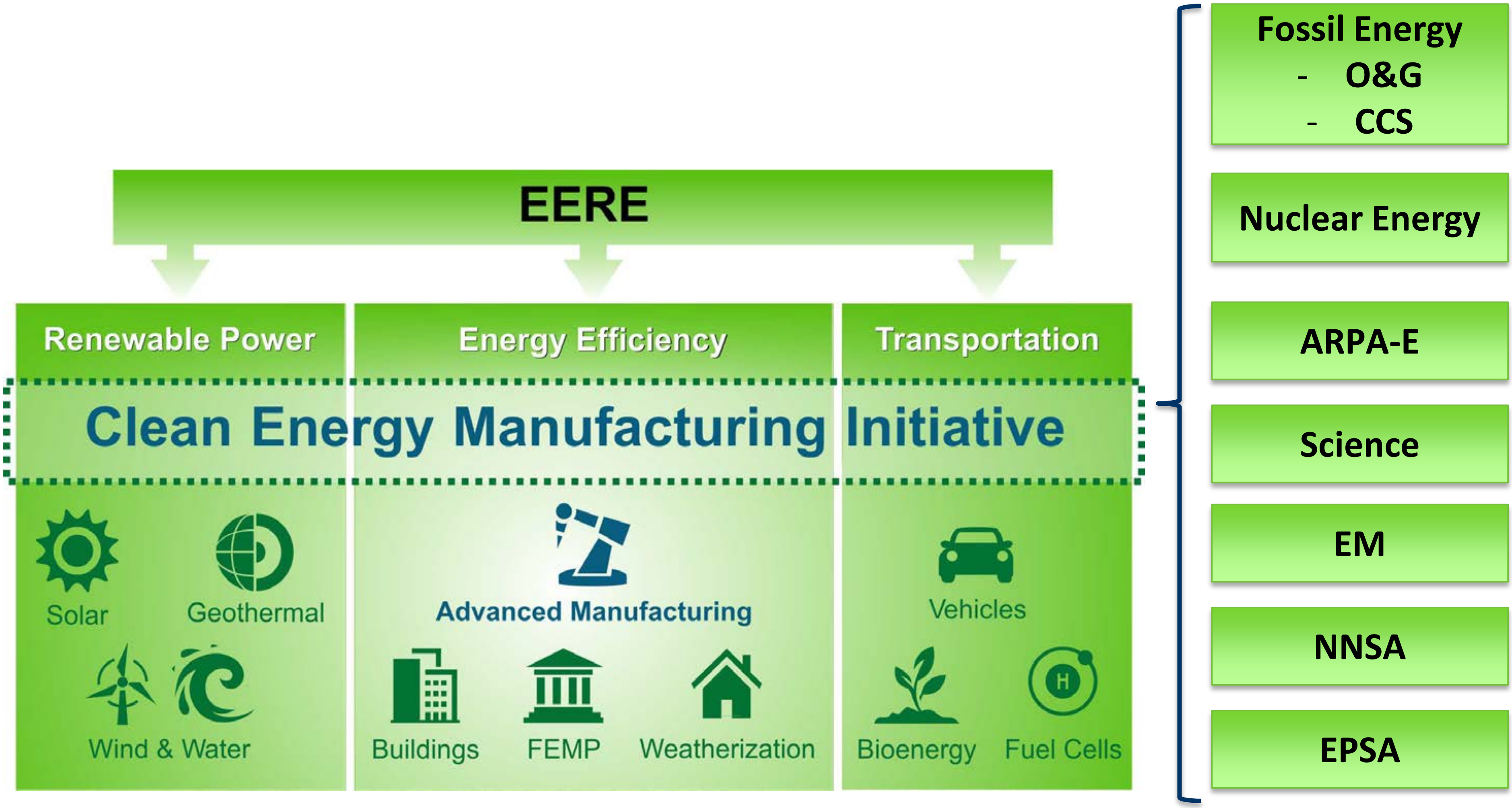
# Clean Energy Manufacturing Initiative – Across DOE



# Energy and Manufacturing: Nexus of Opportunities


- Energy self-reliance
- Stable, diverse energy supply

- Competitiveness in clean energy
- Domestic jobs

- Clean air
- Climate change
- Health

<u>Clean Energy Manufacturing</u>

Making Products which Reduce Impact on Environment

<u>Advanced Manufacturing</u>

Making Products with Technology as Competitive Difference

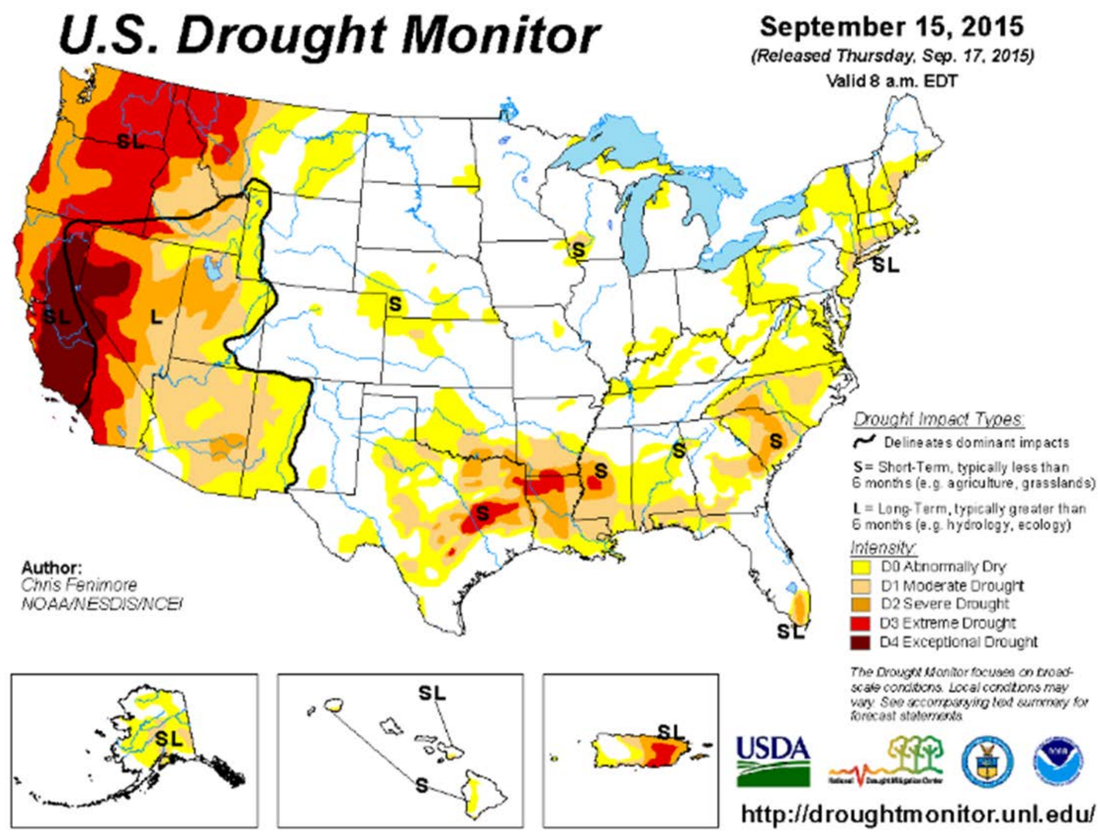
# The Imperative

# Energy-Water Nexus: Critical National Needs

- Energy and water are interdependent.
- Water scarcity, variability, and uncertainty are becoming more prominent.
    - This is leading to vulnerabilities in the U.S. energy system.
- Climate Change and Technology Change: We are already in a Race
- Updating aging infrastructure brings an opportunity.
- The nexus is regional heterogeneous, has dynamically complex systems dynamics, has large uncertainties, and many potential options.
- Energy and water issues are internationally prominent.

# Nature's Timely Reminder!

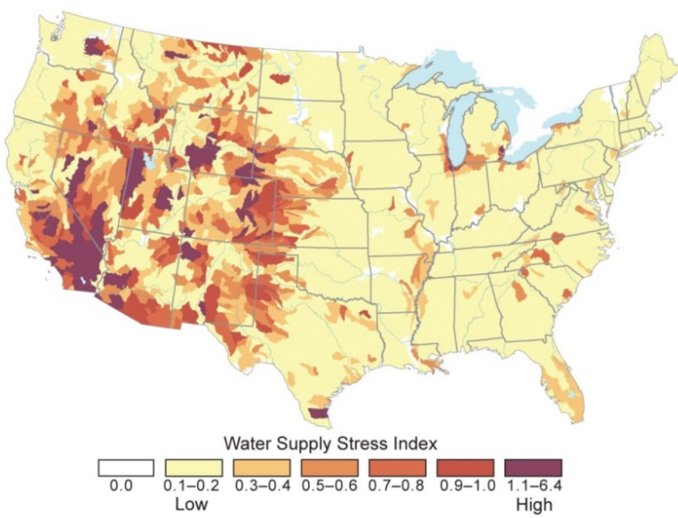
- California drought is cited as the worst recorded in **1200 years***
- California recently passed Italy and the Russian Federation to become the world's 8th-largest economy.



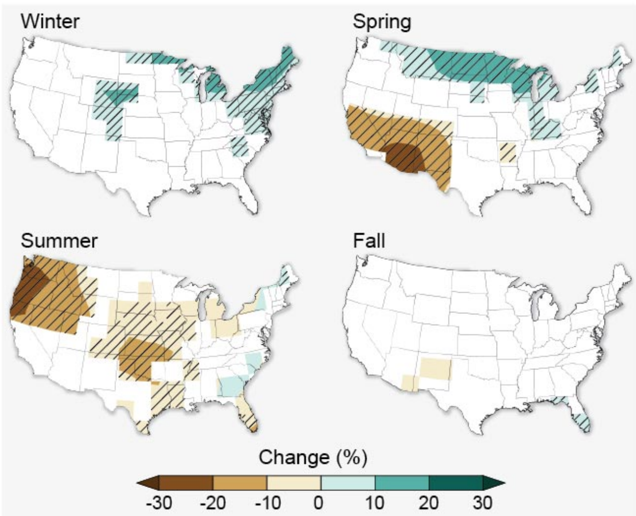

* "How unusual is the 2012–2014 California drought?," Geophysical Research Letters, Daniel Griffin and Kevin J. Anchukaitis, December 2014.

# Context for E-W Dynamics in Water-Stressed Regions

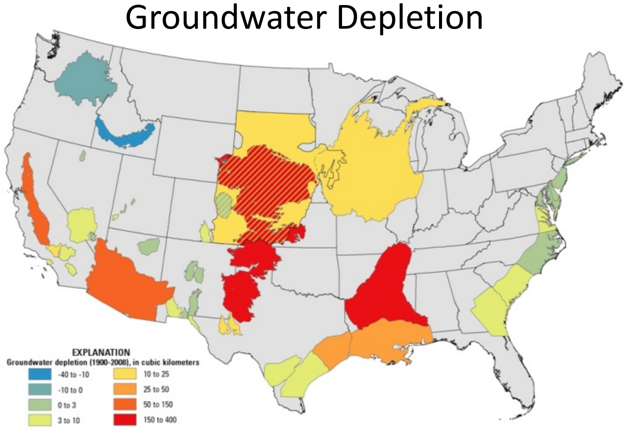
Water Stress in the U.S.




Projected Changes in Seasonal Precipitation




Groundwater Depletion



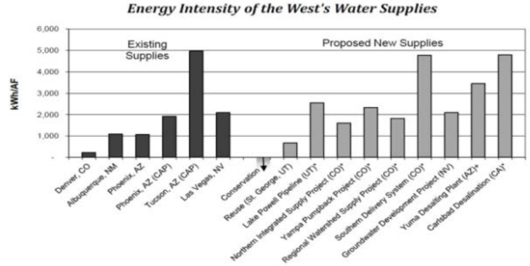

**Present**

**Future**

*Existing and Proposed Water Supply Projects*


| Abbreviation | Project Name |
|---|---|
| Cal. Aqu. | California Aqueduct |
| CAP | Central Arizona Project |
| Carlsbad Desal. | Carlsbad Desalination Plant |
| CUP | Central Utah Project |
| GDP | Groundwater Development Project |
| LPP | Lake Powell Pipeline |
| NISP | Northern Integrated Supply Project |
| RWSP | Regional Watershed Supply Project |
| SDS | Southern Delivery System |
| SJ-Chama | San Juan-Chama Project |
| WG | Windy Gap Firming Project |
| Yampa | Yampa Pumpback Project |
| YDP | Yuma Desalting Project |

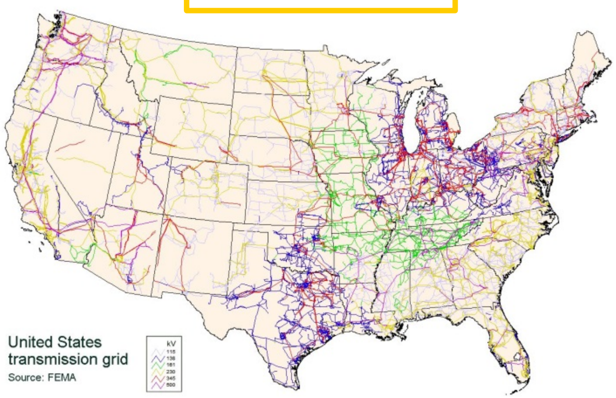
*Energy Intensity of the West's Water Supplies*



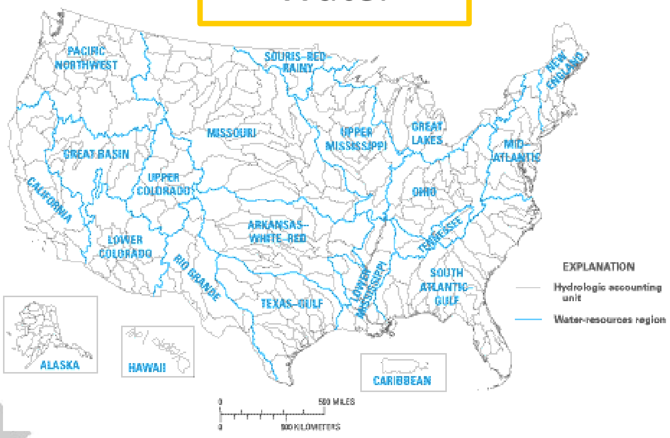

**Example: Energy growth for Inter-basin pumping**

# Context for the Nexus and Connected Infrastructure Vulnerabilities

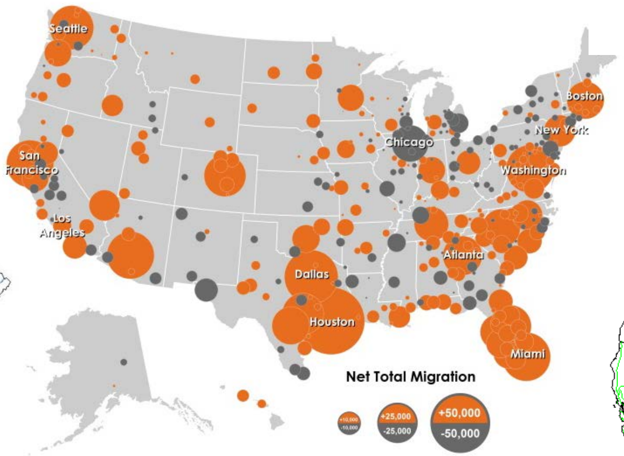
Electricity



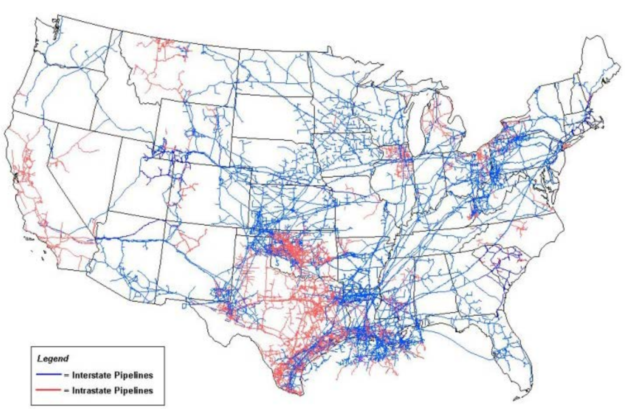

Water




Population



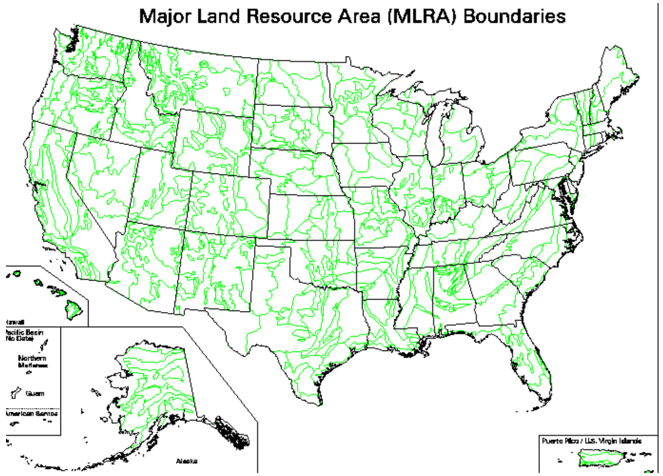

Natural Gas




Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

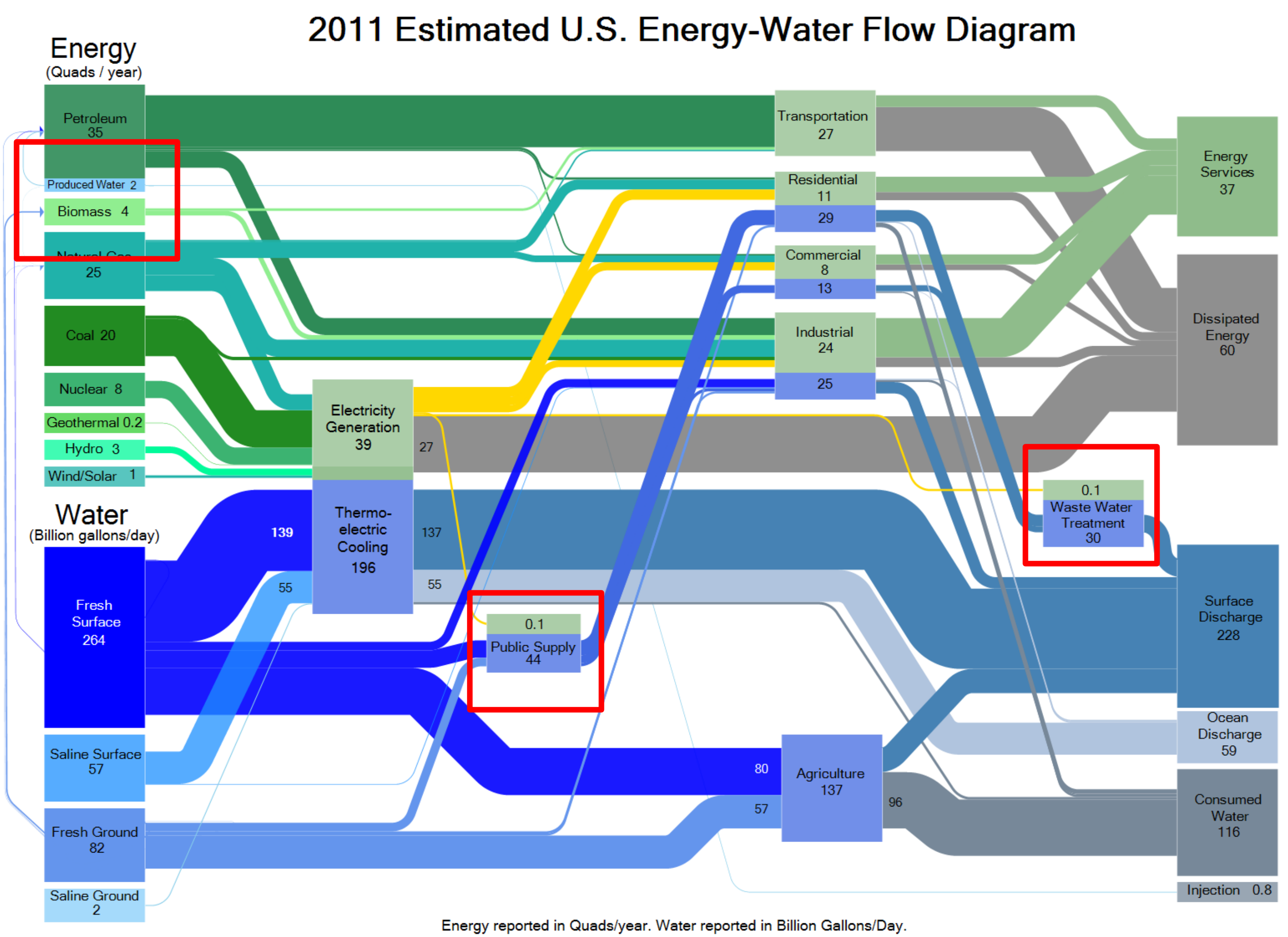
Land

Major Land Resource Area (MLRA) Boundaries



# Water flows in the United States

# A Water problem is an Energy problem



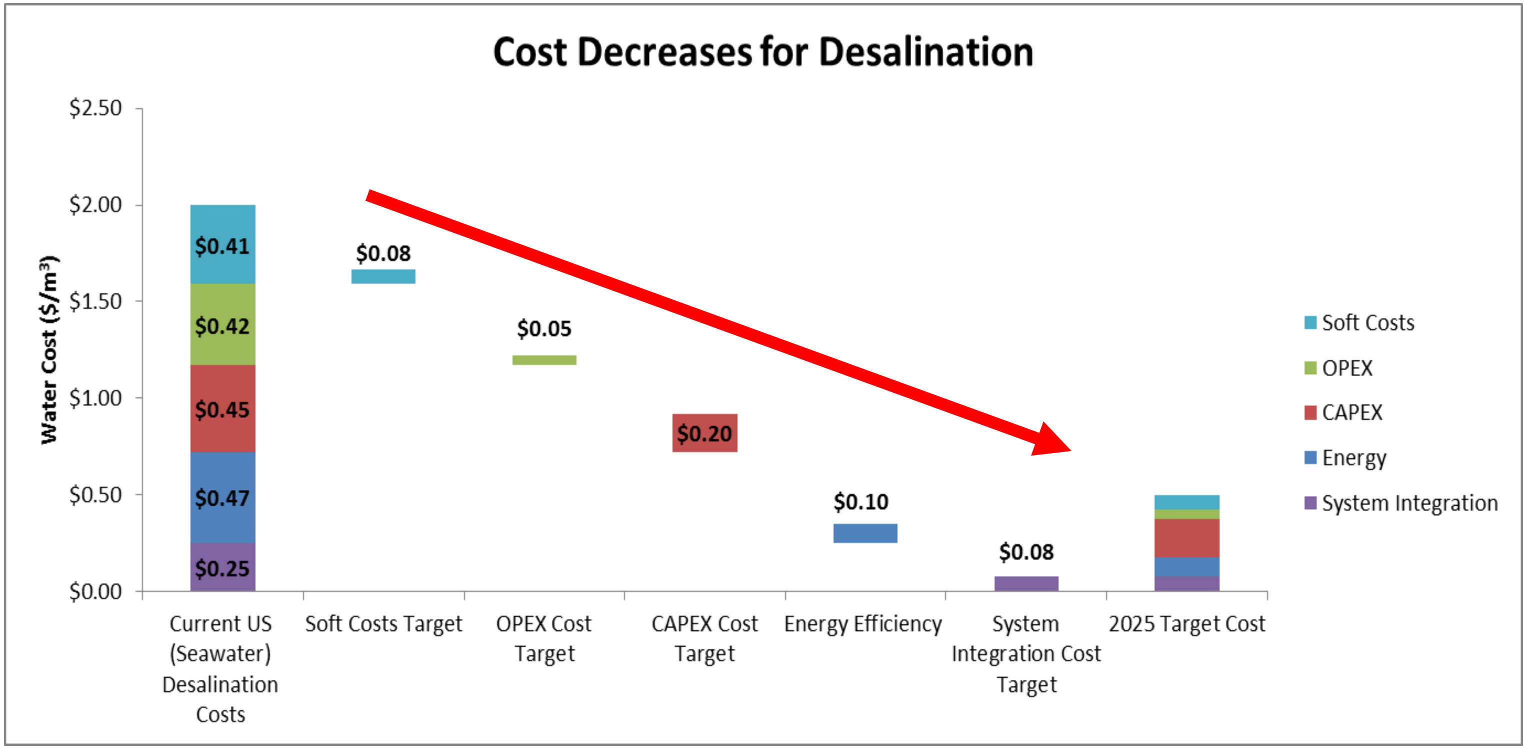

Energy reported in Quads/year. Water reported in Billion Gallons/Day.

# What is 'Pipe Parity' for Water

- Deliver Water with equivalent Economic & Energy / Carbon cost
  - Price: Approximate $0.50 / m3 (tonne)
    - Ranges from $0.10 to $1.00 nationally
  - Energy: Approximate: 1kWh / m3 (tonne)
    - 0.65 kWh (corresponding to 235m elevation change)
  - Carbon: Approximate: 1lb / m3 (tonne)
    - Based on 0.69kg $CO_2$/kWh
  - Quality: 500 ppm TDS
  - Complimentary Cases: Produced Water and Grey Water

# Framework Cost break down for Desalination

## Goal = $0.50/m3




**What are the technology pathways that get us there?**

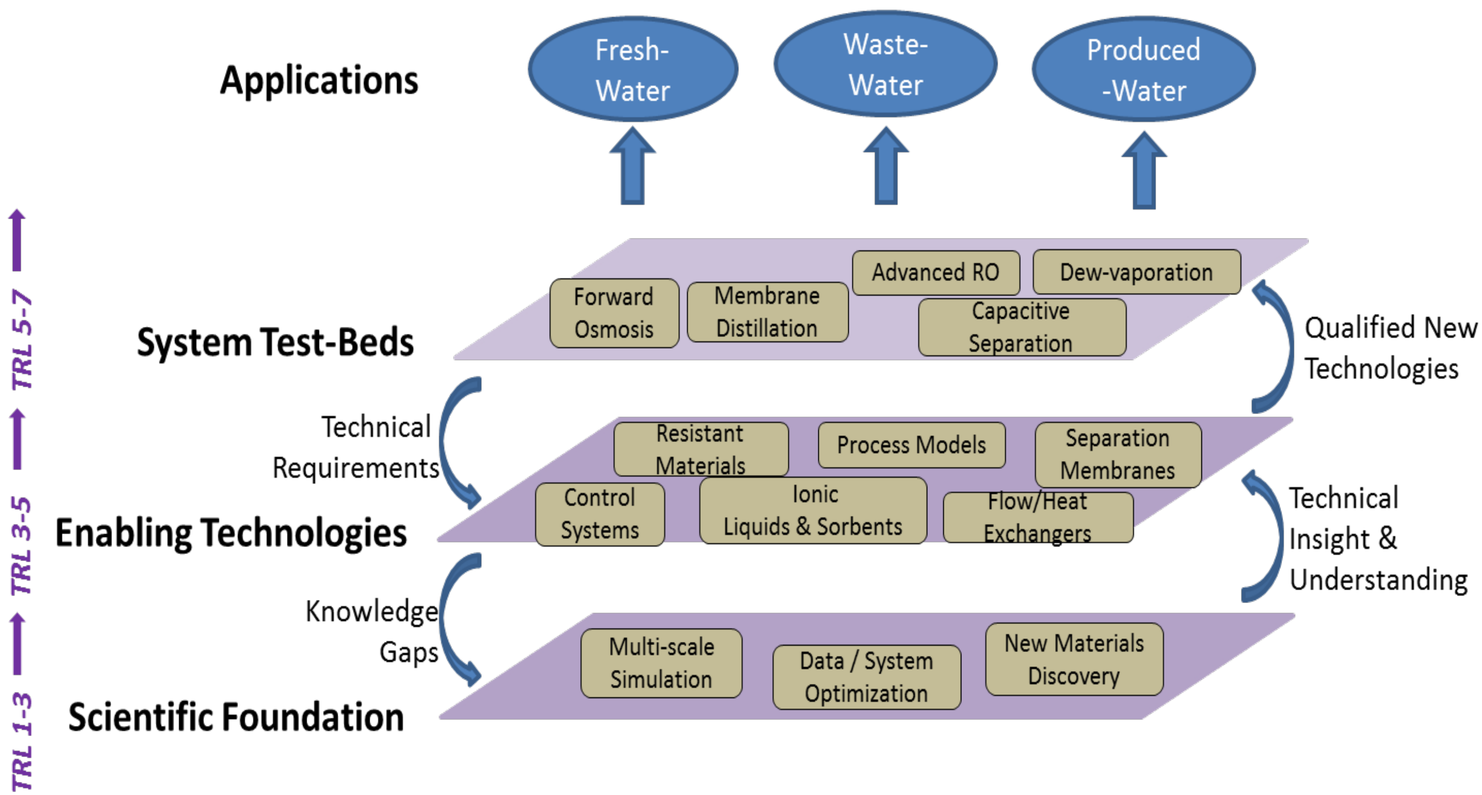
# Some Possible Areas for Opportunity

- Operating Costs:  Chemical additives (anti-bacterial, longer lasting membranes), Disposal / Post-processing of saline brines
- Capital Costs: Low-cost heat exchangers for thermal processes, Cost Effective membranes, Balance of Plant Equipment
- Energy: Improve pressure energy recovery, utilize low-cost thermal energy
- System Integration: Intelligent design of water networks to minimize connection costs, Real-time Control and Sensor Systems
- Soft Costs: Workforce, Supply Chain, Permitting Expertise and Environmental Considerations

# Where are the gaps?

## Technical Challenge Framework

### Multi-disciplinary and Translational



# Goals for workshop

- What are the technology advancements needed to hit our cost target?
- What ancillary and associated technologies (membranes, pumps/valves, etc.) are needed to make desalination pipe-parity competitive?
- Identify the most effective role for DOE in advancing these technologies.
- Discuss pathways to accelerate RD&D of promising desalination approaches for fresh-water at lower energetic, economic, and environmental costs relative to existing technologies

# Thank You!