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Introduction to the Energy Water Nexus

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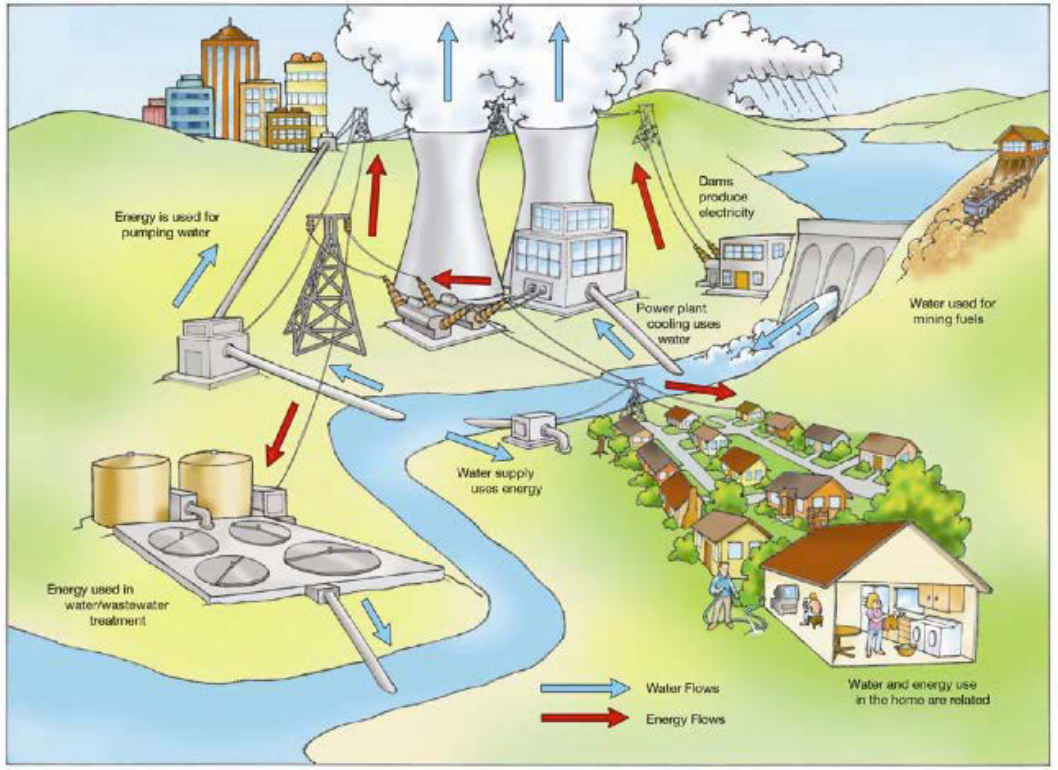
Presentation Overview

- Intro to Energy/Water Nexus
  - Drivers and Pressures
- Water for Energy
- Energy for Water
- Looking to the Future

The Energy Water Nexus

Energy-Water Nexus Defined

- The availability of adequate water supplies has an impact on the availability of energy, and energy production and generation activities affect the availability and quality of water.
- In today's economies, energy and water are linked.
- Each requires the other. As these two resources see increasing demand and growing limitations on supply, energy and water must begin to be managed together to maintain reliable energy and water supplies.



Source: U.S. Department of Energy (DOE). 2006. *Energy Demands on Water Resources: Report to Congress*. http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf

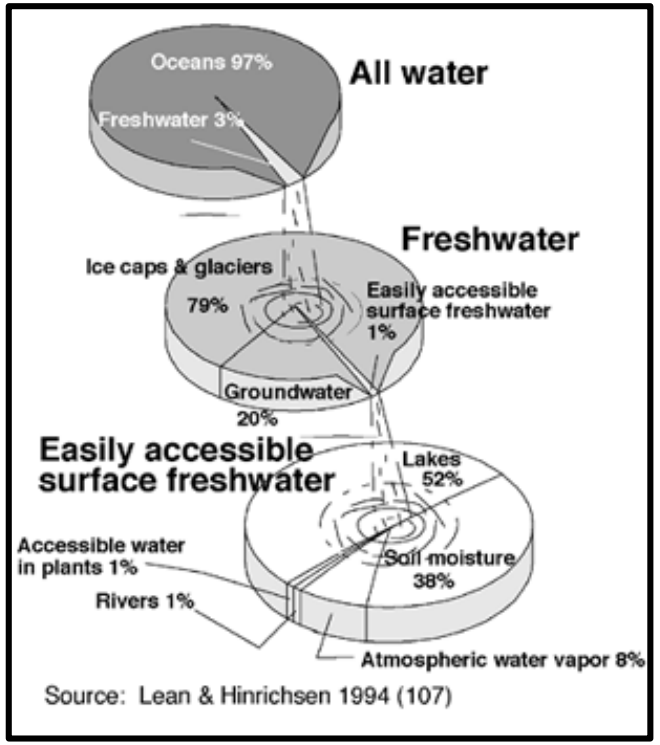
Water Context

Only 1/100th of 1% of the world's total supply of water is considered easily accessible for human use.

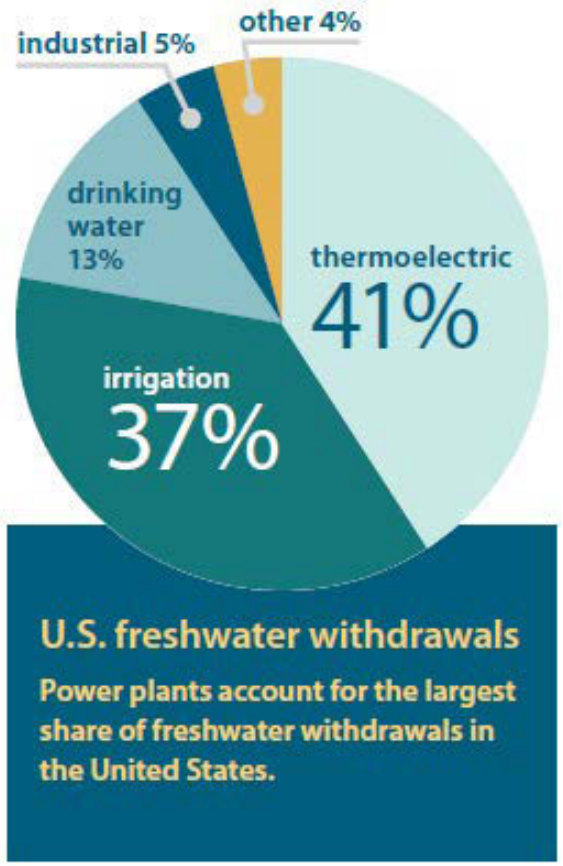
The challenges with water:

- **Spatial distribution**
- **Temporal distribution**
  - Water storage is needed to consistently serve human needs
- **Water quality**
  - Available water is degraded by pathogens, nutrients and industrial

    pollutants, as well as in some cases natural pollutants
- Anticipated climate changes create further uncertainty



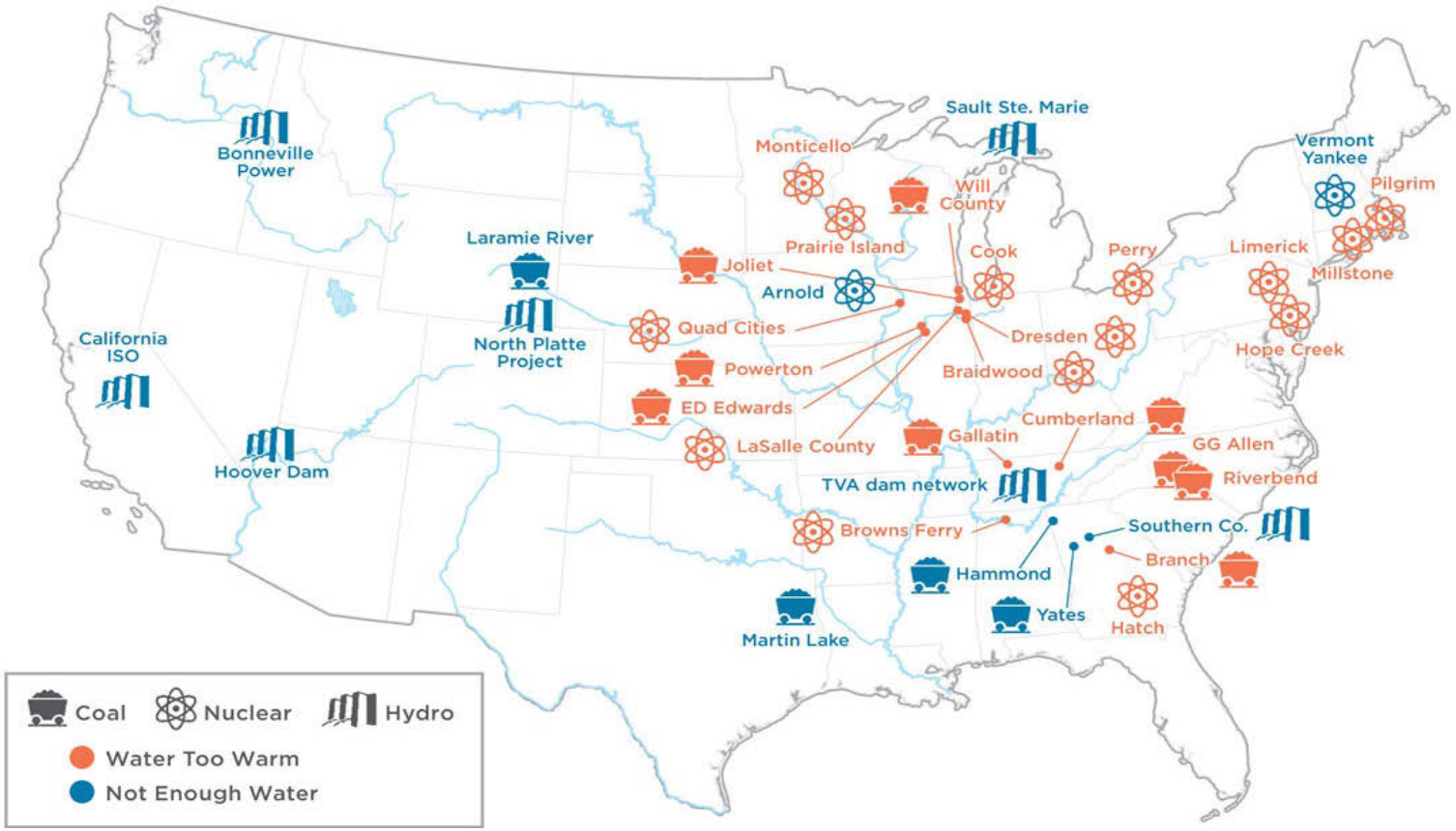
Why Is Water Use for Energy Important?



Source: http://www.ucsusa.org/assets/documents/clean_energy/10-Things.pdf

- In the **U.S. power plants** account for **over 40% of all freshwater withdrawals.**
- In the **SE U.S.**, power plants account for **2/3rds of all freshwater withdrawals.**
- **Water discharged** from a coal or nuclear plant can be up to 17°F **hotter than receiving water.**
- **Water stress can reduce or shut down power plant production**, creating conflicts in water use.

Impact of Water Constraints on Power Generation



Source: Union of Concerned Scientists, 2014

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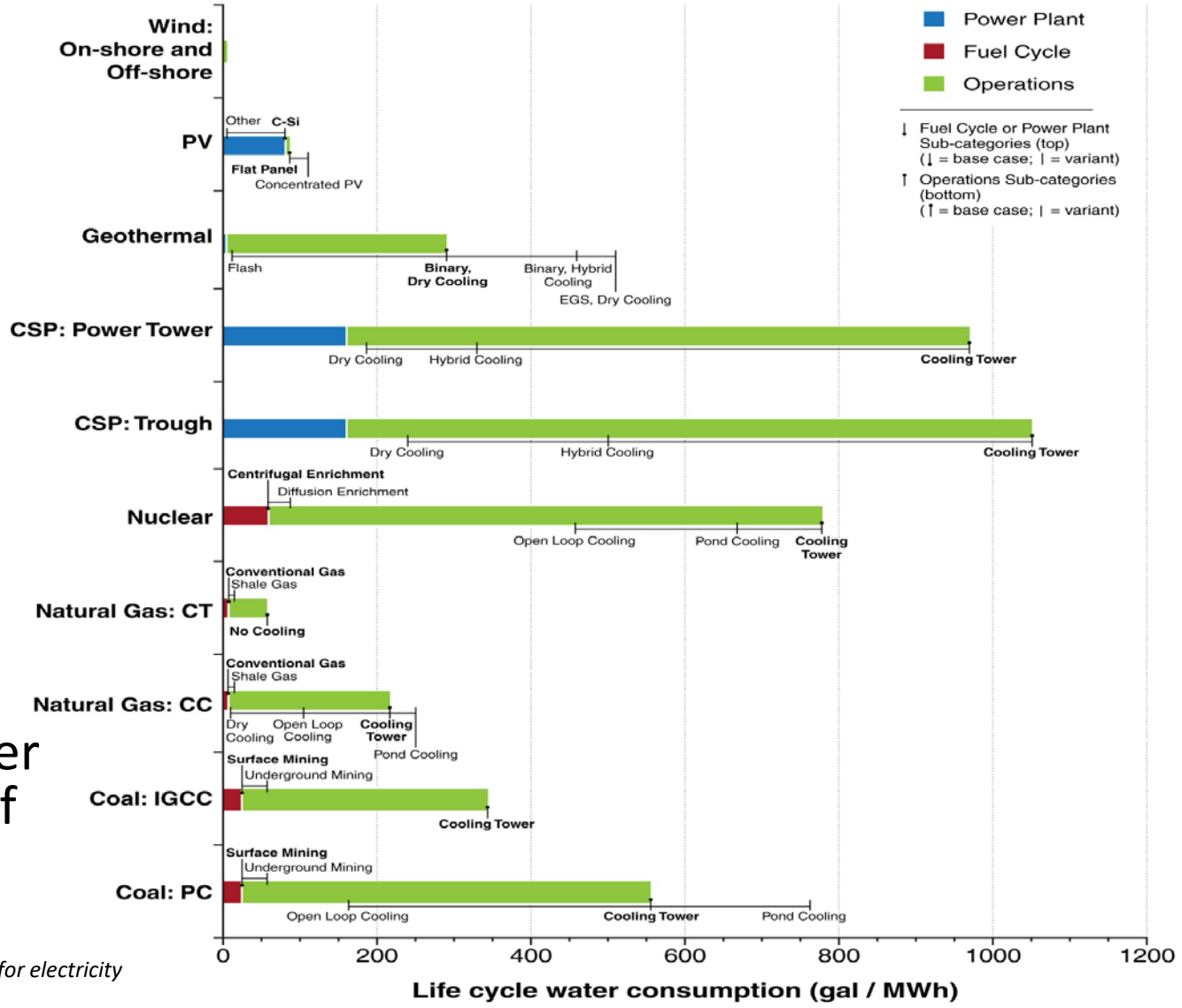
Life-Cycle Water Consumption for Electricity Generating Technologies

- Key determinants of water intensity
  - Fuel type
  - Generation technology
  - Cooling system
- Water requirements for power plant cooling can be orders of magnitude greater than fuel extraction



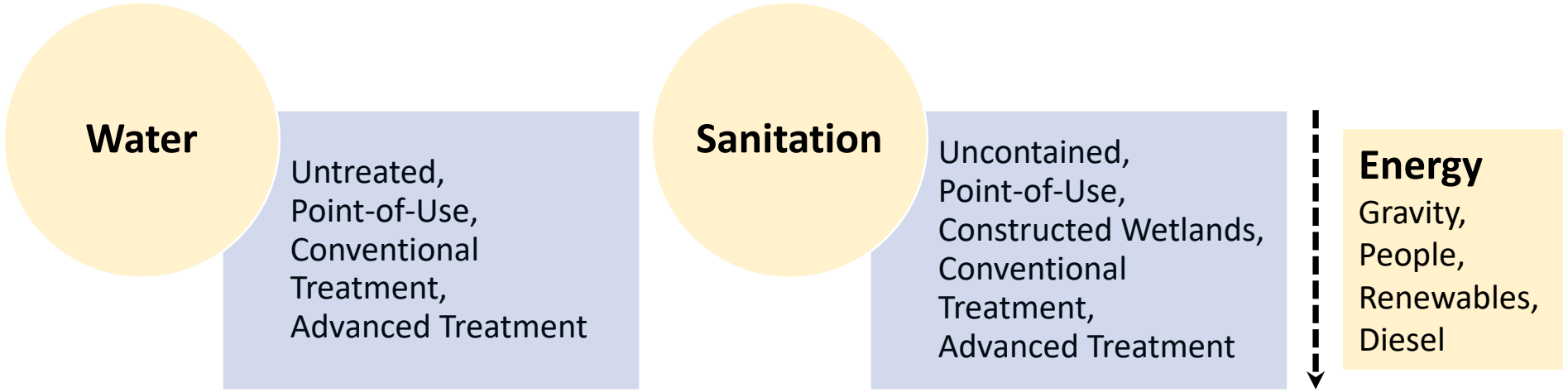
Source: Meldrum, J., Nettles-Anderson, S., Heath, G., and J Macknick. 2013. Life cycle water use for electricity generation: a review and harmonization of literature estimates. Environ. Res. Lett. 8 015031

Why Is Energy Use for Water Important?

- **Drinking water and wastewater plants** are one of the **largest energy consumers** for local governments, accounting for **30-40% of total energy consumed.**[1]
- Energy used by water and wastewater utilities accounts for **35% of typical U.S. municipal energy budgets.**[2]
- **Electricity** accounts for **25–40% of wastewater utility operating budgets** and **80% of drinking water processing and distribution costs.**[2]
- **Drinking water and wastewater systems** account for approximately **3–4% of energy use** (45 million MT of GHGs) in the U.S.[3]
- **15-30% energy savings are "readily achievable" in water and wastewater plants,** with a payback of a few years or less.[4]

1. http://www.epa.gov/statelocalclimate/local/topics/water.html
2. http://www.nyserda.ny.gov/~/media/Files/EERP/Commercial/Sector/Municipal%20Water%20and%20Wastewater%20Facilities/nys-assess-energy-use.ashx?sc_database=web
3. http://www.cwwga.org/documentlibrary/121_EvaluationCHPTechnologiespreliminary[1].pdf
4. http://water.epa.gov/infrastructure/sustain/energyefficiency.cfm

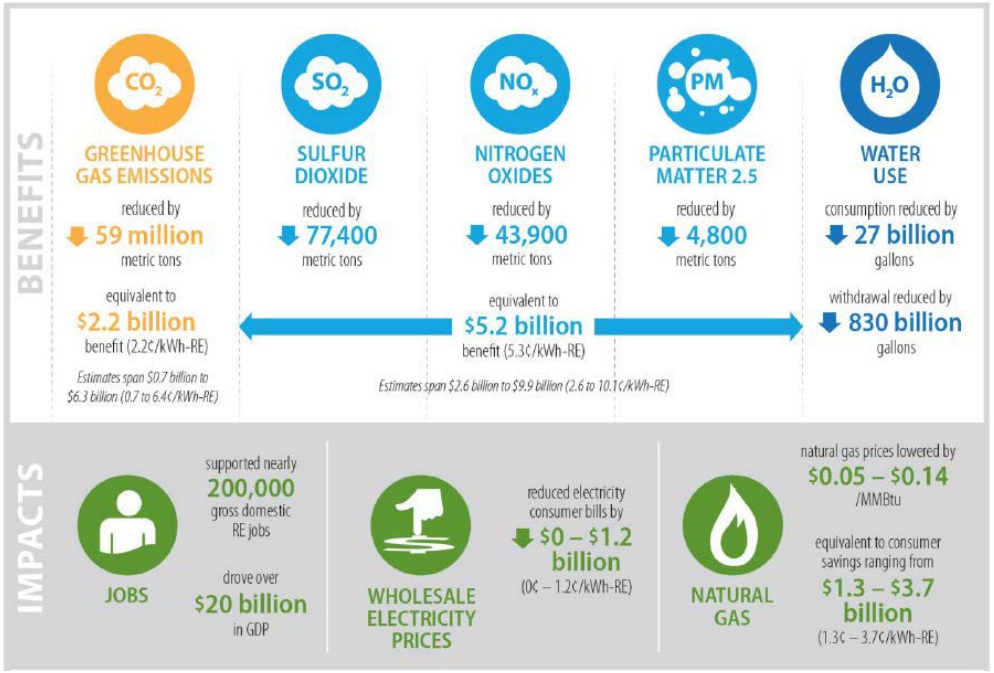
Water and Wastewater Treatment Systems Energy Demands

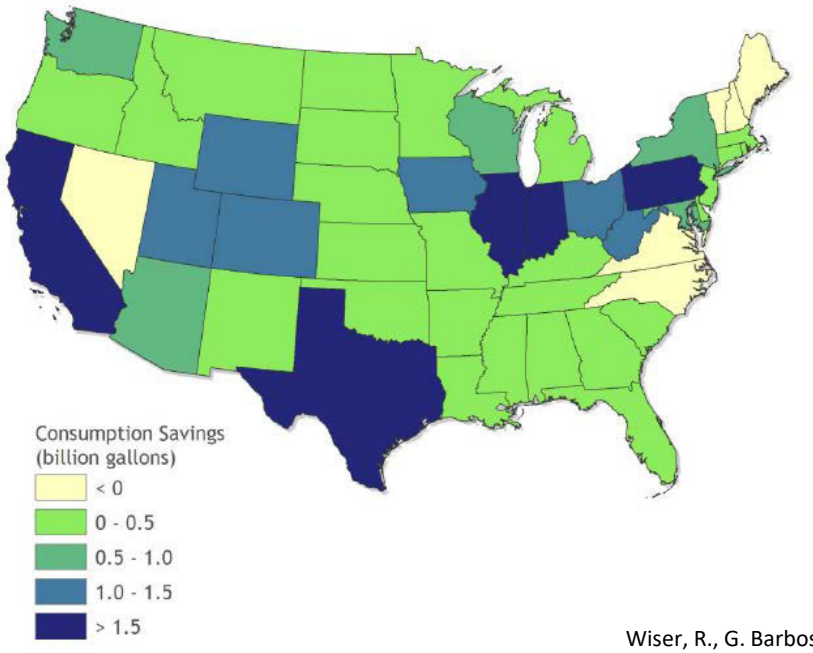


Land/ Environment: Resource demands, technology footprint, waste

Looking Forward

First Looking Back: Historical Water Benefits of Renewable Portfolio Standards (RPS)





2013 snapshot

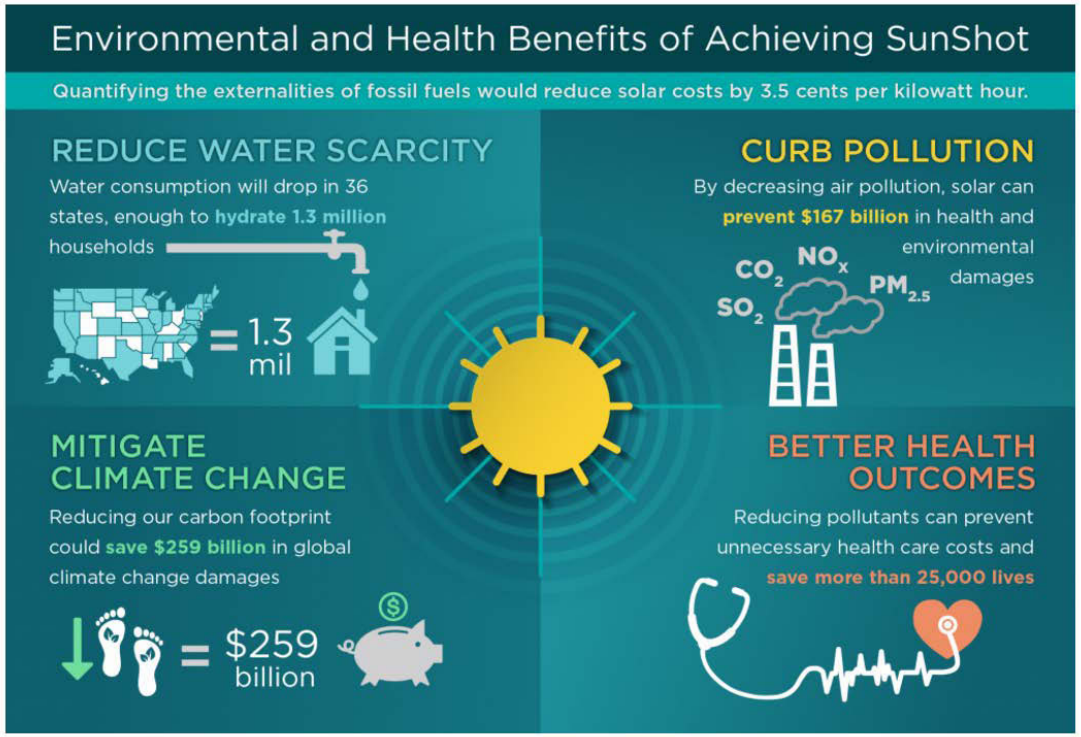
- 98 terawatt-hours of new renewable electricity generation from renewables
- 2.4% of national generation
- 2% reduction in national water withdrawal and consumption

Wiser, R., G. Barbose, J. Heeter, T. Mai, L. Bird, M. Bolinger, A. Carpenter, G. Heath, D. Keyser, J. Macknick, A. Mills, and D. Millstein. 2016. *A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards.* Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory. NREL/TP-6A20-65005. http://www.nrel.gov/docs/fy16osti/65005.pdf.

Looking Forward: High Solar Penetration

- SunShot Vision Study
- 715 GW Solar by 2050
- 27% of Generation
- Mix of Rooftop PV, Utility-Scale PV, and Concentrating Solar Power (CSP)

	Solar Generation in 2030 (TWh)	Solar-Related Water Consumption in 2030 (billion gal)	Solar Generation in 2050 (TWh)	Solar-Related Water Consumption in 2050 (billion gal)
Rooftop PV	164	0–0.8	318	0–1.6
Utility-scale PV	341	0–1.7	718	0–3.6
CSP[a]	137	14–75	412	42–227
Total	**642**	**14–78**	**1,448**	**42–232**



Water consumption reductions in 36 states

DOE (2012). SunShot Vision Study. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. Washington, DC: Report No.: DOE/GO-102012-3037.

Looking Forward: High Wind Penetration

- Wind Vision Study
- 404 GW Wind by 2050
- 35% of Generation
- Onshore and offshore wind technologies

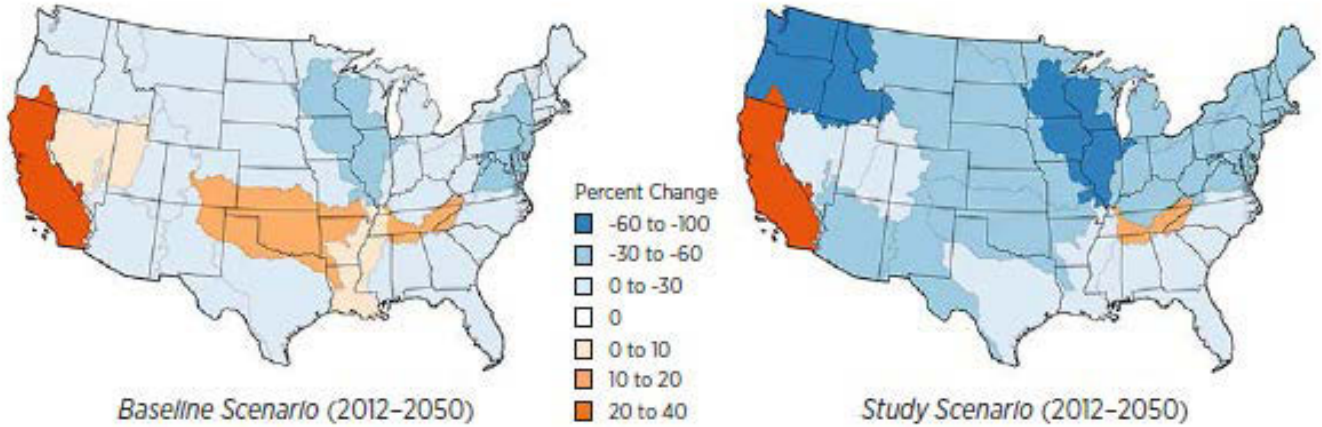


Figure 3-40. Percentage change in water consumption in 2050 compared with 2012 for the *Baseline Scenario* and the *Study Scenario*

System Costs	Benefits		
$	GHG	Air Pollution	H_2O
$149 billion (3%) lower cumulative electric sector expenditures	14% reduction in cumulative GHG emissions (12.3 gigatonnes CO_2-equivalents), saving $400 billion in avoided global damages	$108 billion savings in avoided mortality, morbidity, and economic damages from cumulative reductions in emissions of SO_2, NO_x, and PM 21,700 premature deaths from air pollution avoided	23% less water consumption and 15% less water withdrawals for the electric power sector

23% less water consumption in 2050

DOE/NREL (2015). Wind Vision: A New Era for Wind Power in the United States. U.S. Department of Energy (DOE), NREL (National Renewable Energy Laboratory). United States. http://www.osti.gov/scitech/servlets/purl/1215172

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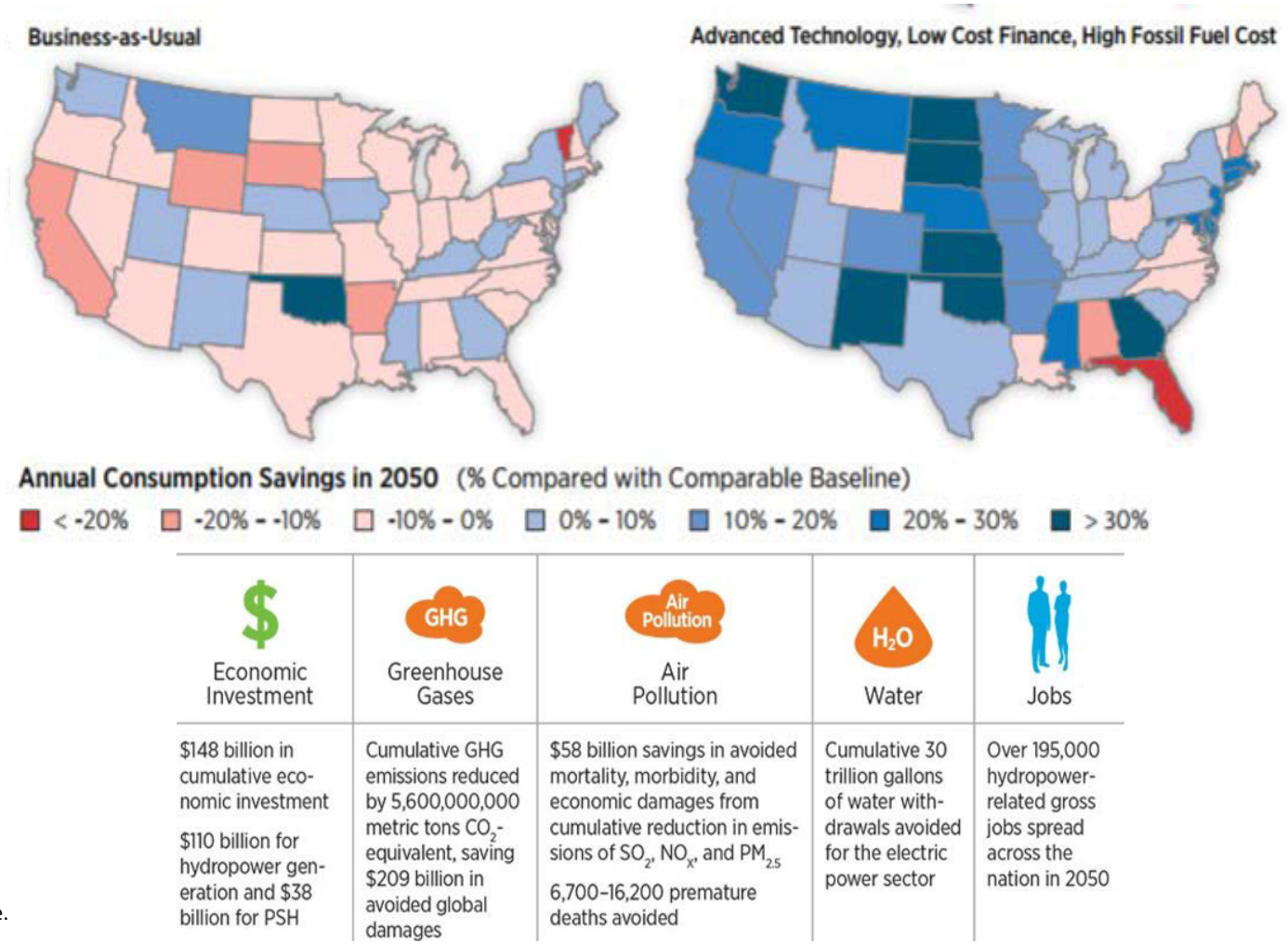
Looking Forward: High Hydropower Penetration

- Hydropower Vision Study
- 150 GW Hydro by 2050
- New run-of-river and pumped storage development
- Hydropower technologies enable other variable renewable energy technologies

30 trillion gallons (cumulative) avoided water withdrawals



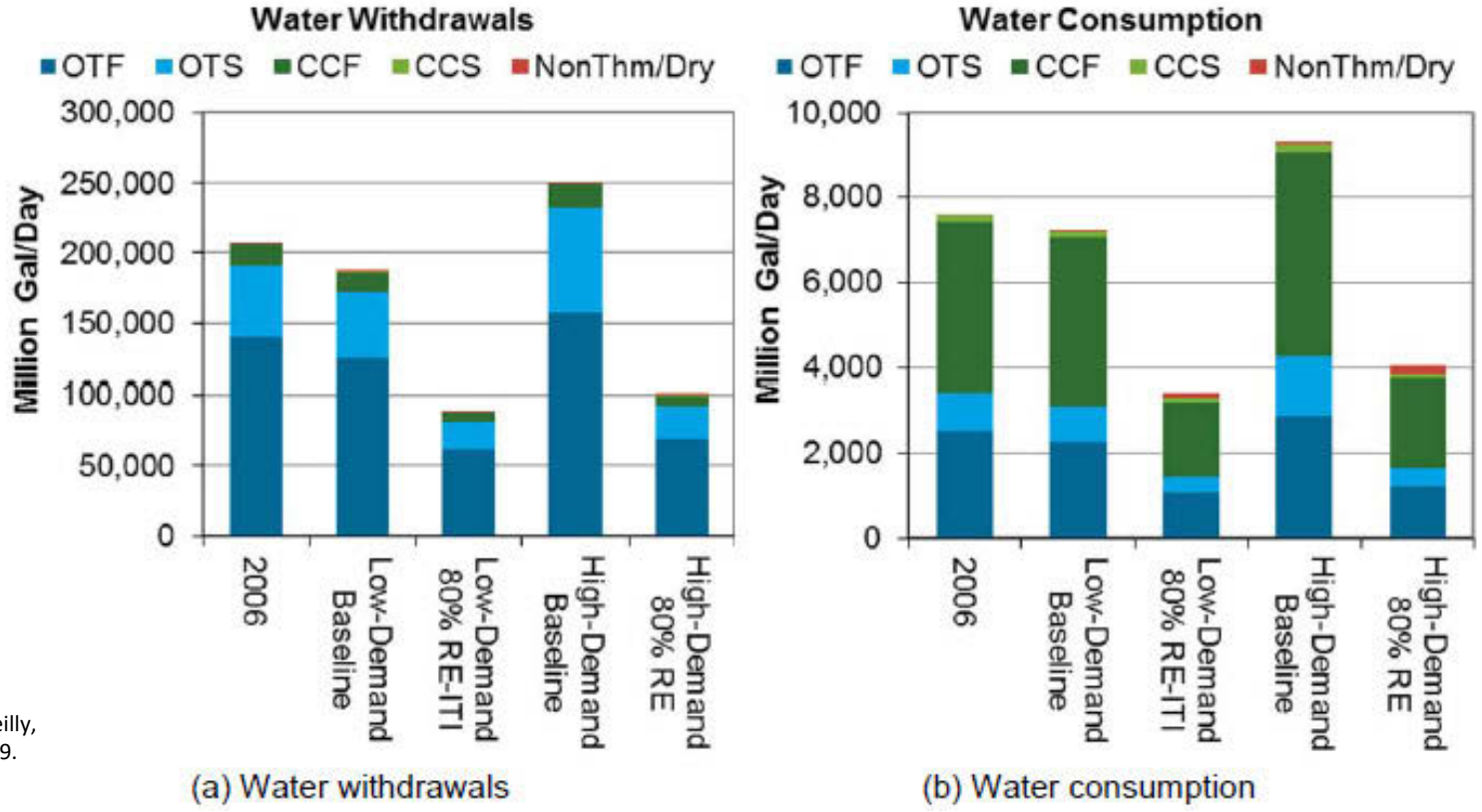
DOE (2016). Hydropower Vision – A New Chapter for America's 1st Renewable Electricity Source.

Looking Forward: Renewable Electricity Futures Study (80% Renewable Electricity Penetration)

- 80% Renewable electricity penetration by 2050
- Detailed transmission infrastructure buildout

Over 50% reduction in water withdrawals and consumption

Key water savings in water stressed regions

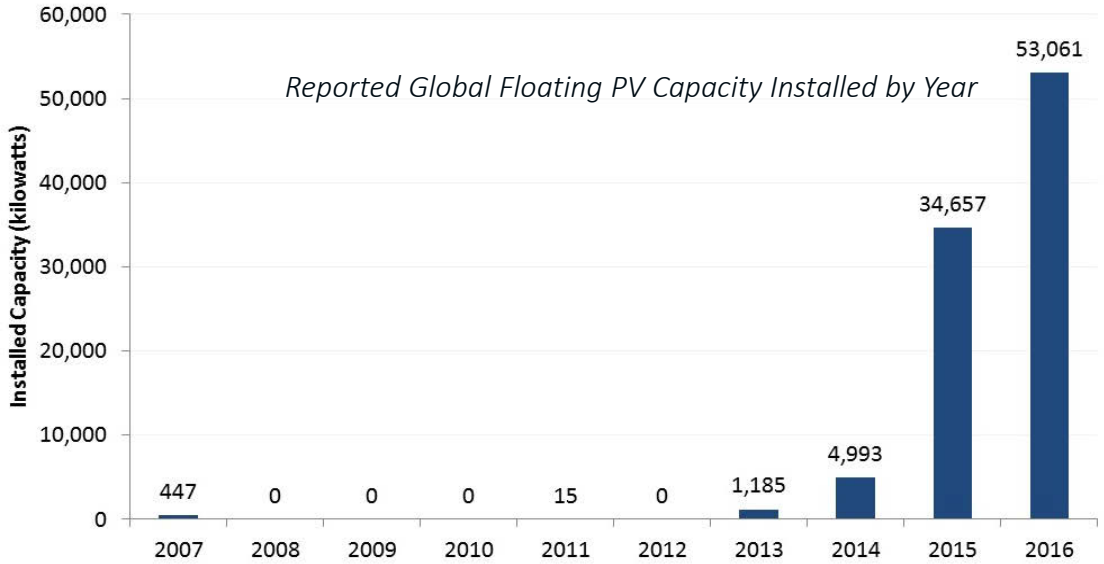


NREL (2012). Renewable Electricity Futures Study. Hand, M.M.; Baldwin, S.; DeMeo, E.; Reilly, J.M.; Mai, T.; Arent, D.; Porro, G.; Meshek, M.; Sandor, D. eds. 4 vols. NREL/TP-6A20-52409. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/re_futures/.

In Closing

Innovative Technologies-Example: Floating Solar PV (FPV)

- In areas where land is a valuable resource
- Not only provide energy, also benefit water (reduce evaporation & algae growth)
- Good integrated option for unused waterbodies



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Energy and Water Are at the Heart of Global Environmental Change

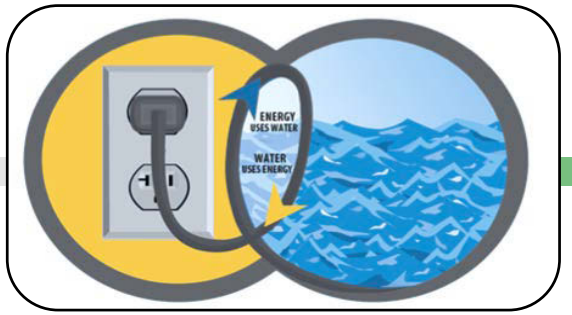
Current energy **infrastructure** and related emissions are **causing global environmental change**

Global environmental change is **exacerbating current water stresses**

These challenges are significant, interrelated and critical to exploring the energy-water nexus

Energy shifts to mitigate dynamic changes also **pose new risks to water**

Declining **water availability** is **reshaping energy and food choices**



Thank You!

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