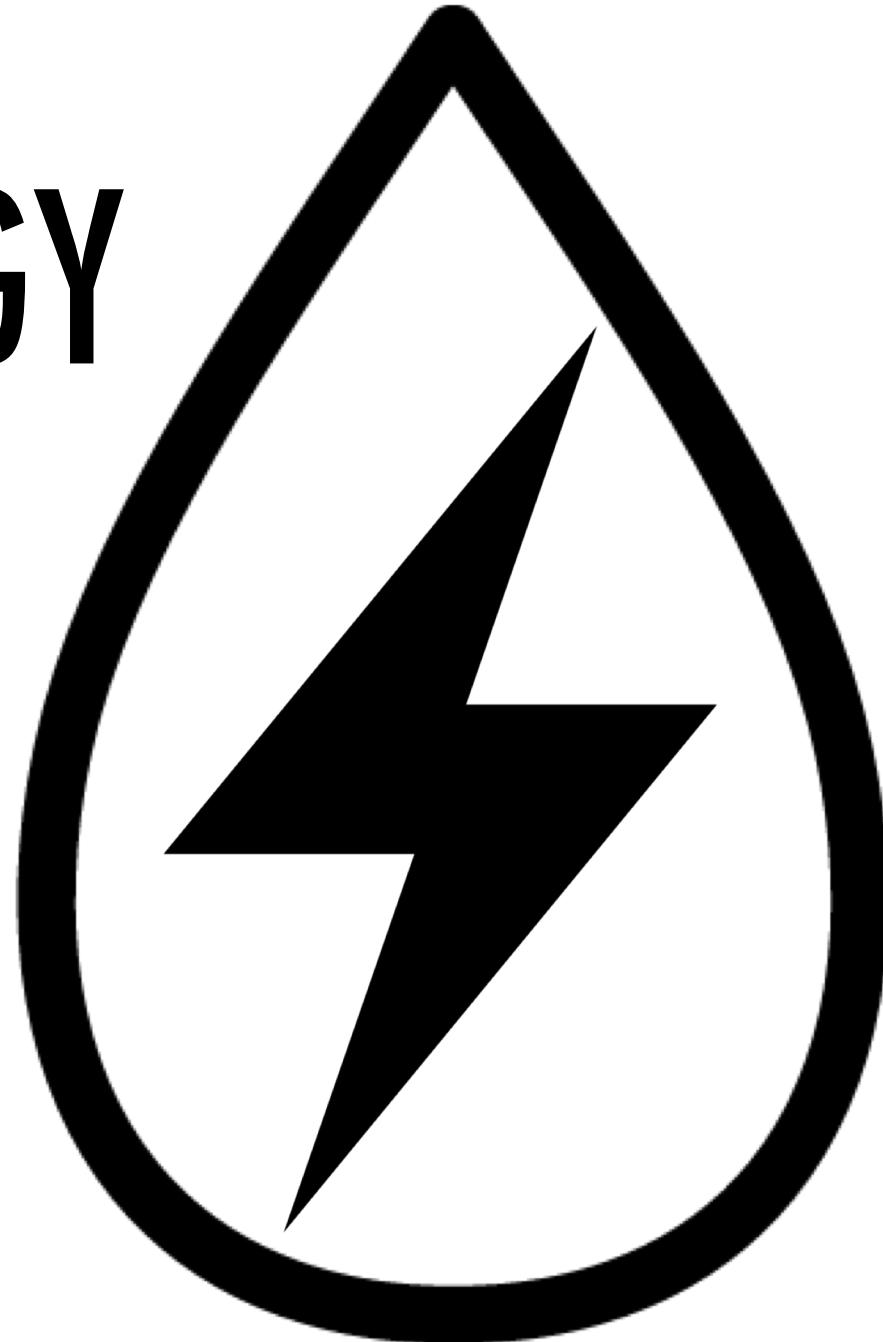


# **WATER-ENERGY NEXUS**



**HEJC, 16<sup>TH</sup> FEBRUARY 2018  
CARLO A. AMADEI**



WATER IS NEEDED  
FOR ENERGY  
PRODUCTION

ENERGY IS NEEDED  
FOR MOVING AND  
TREATING WATER

ENERGY CAN BE  
PRODUCED FROM  
FOOD

ENERGY IS NEEDED  
FOR FOOD  
PRODUCTION



FOOD PRODUCTION AFFECTS WATER  
AVAILABILITY

WATER IS NEEDED FOR FOOD PRODUCTION



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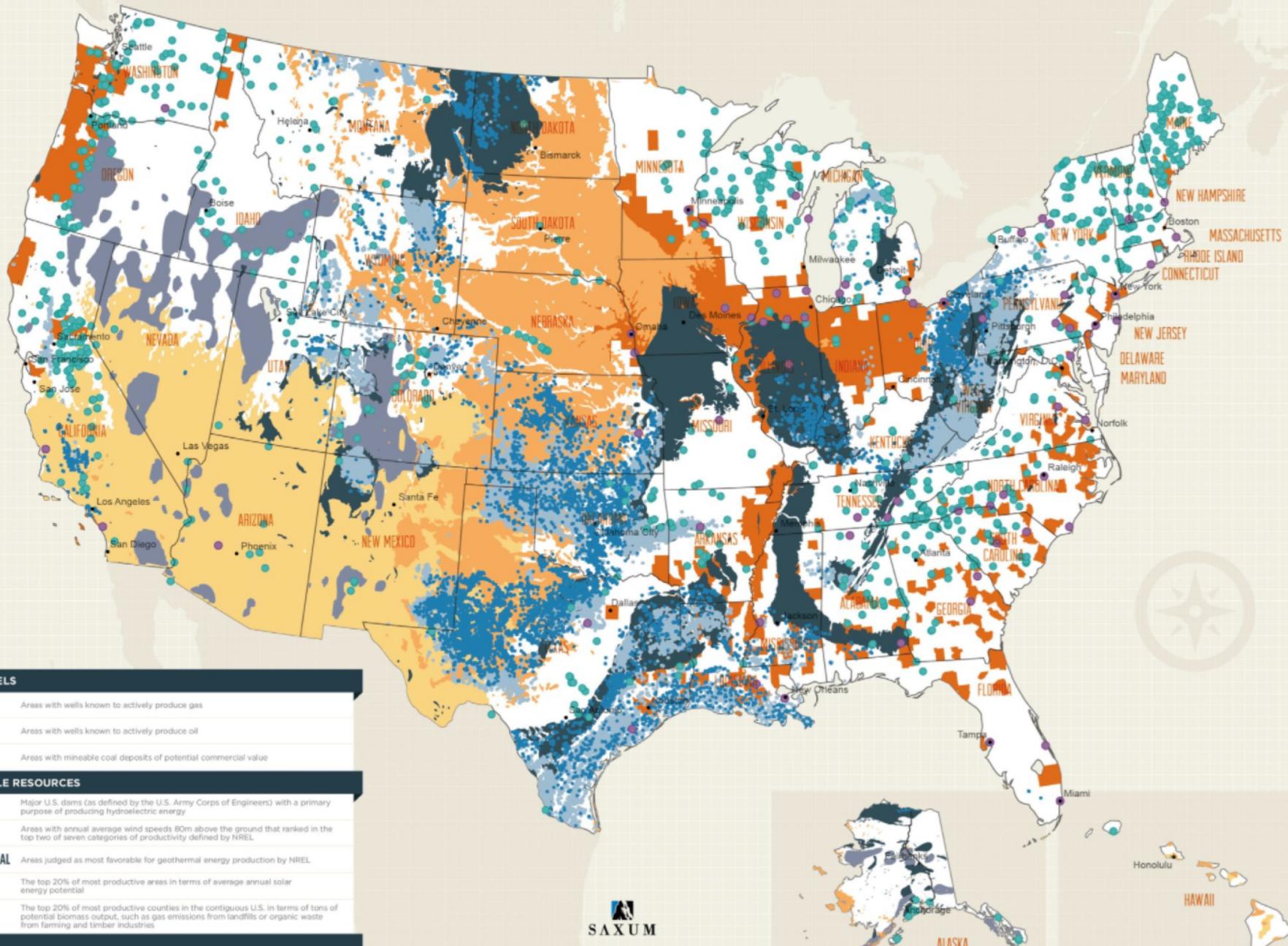
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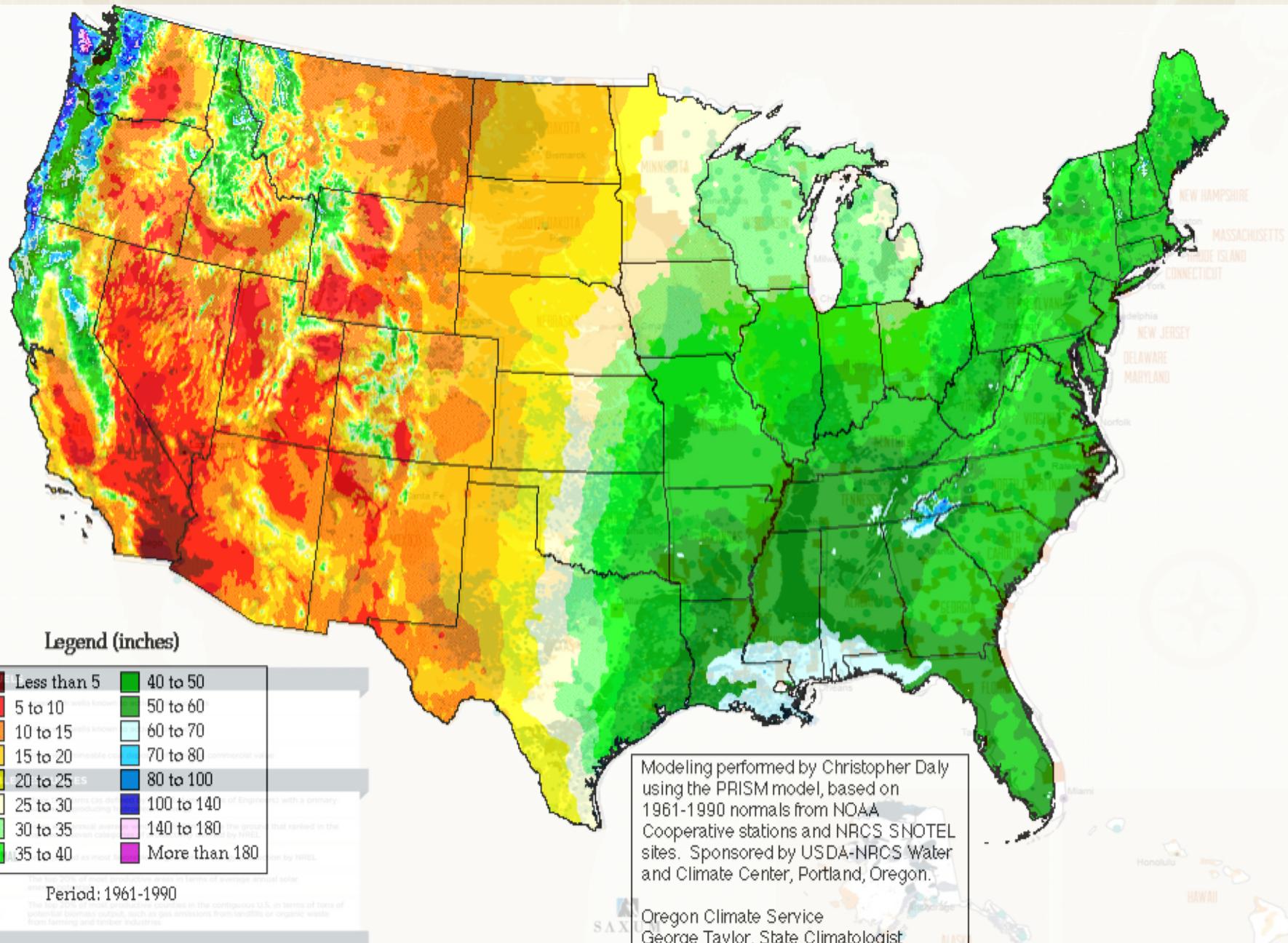
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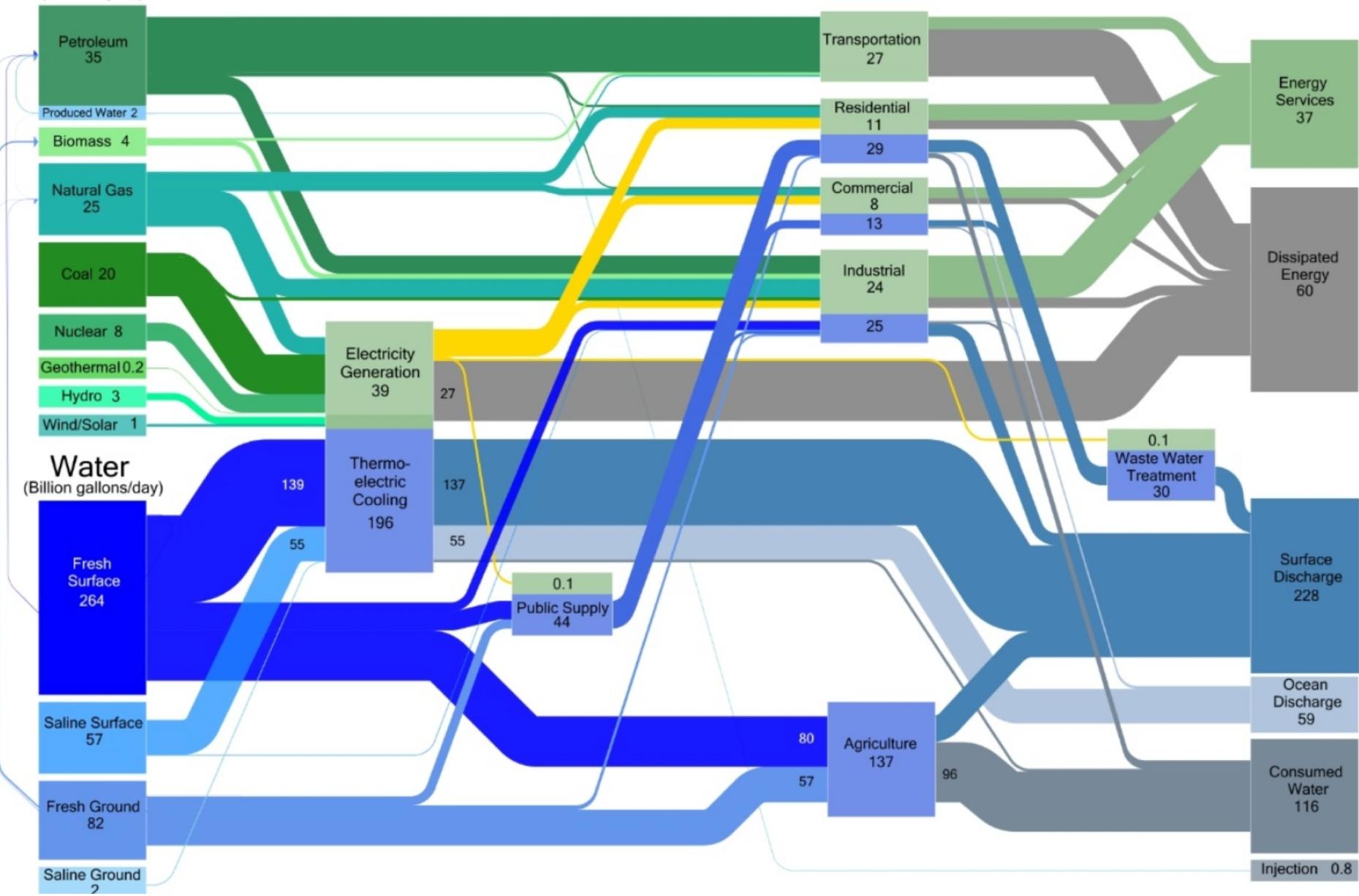
# HIGH SPATIAL VARIABILITY



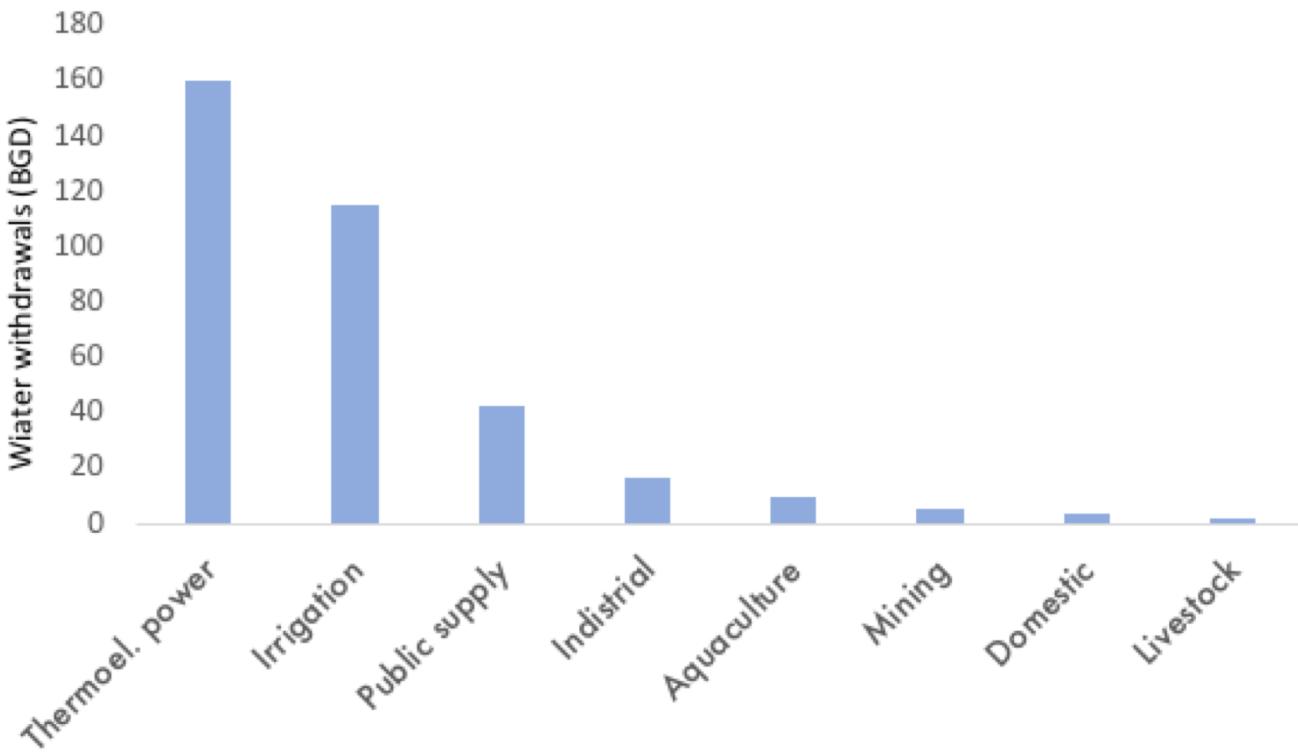
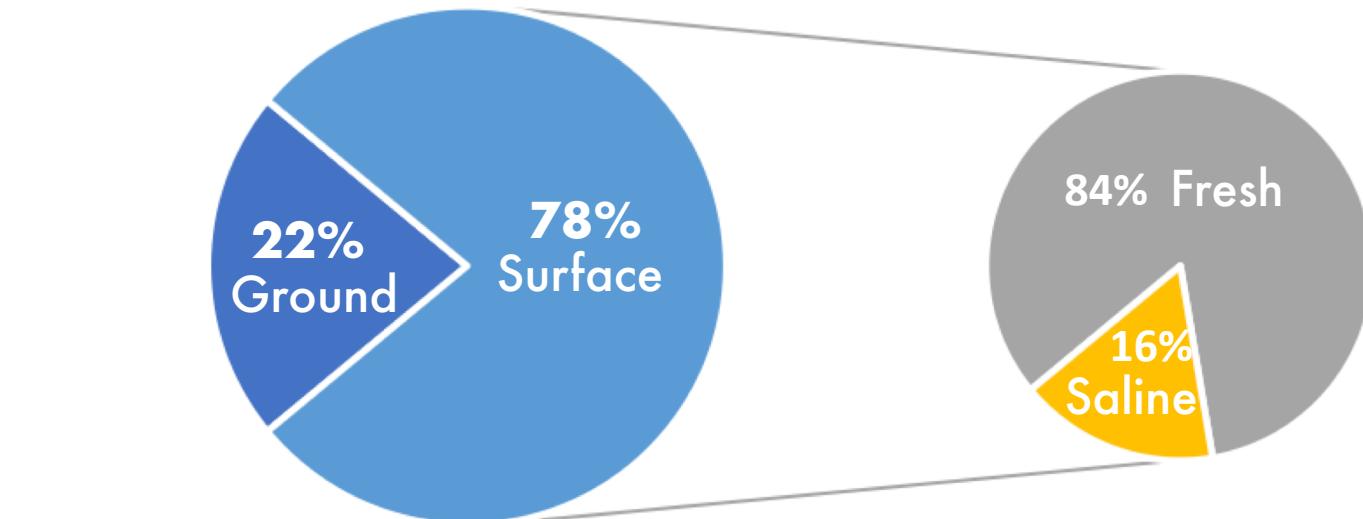
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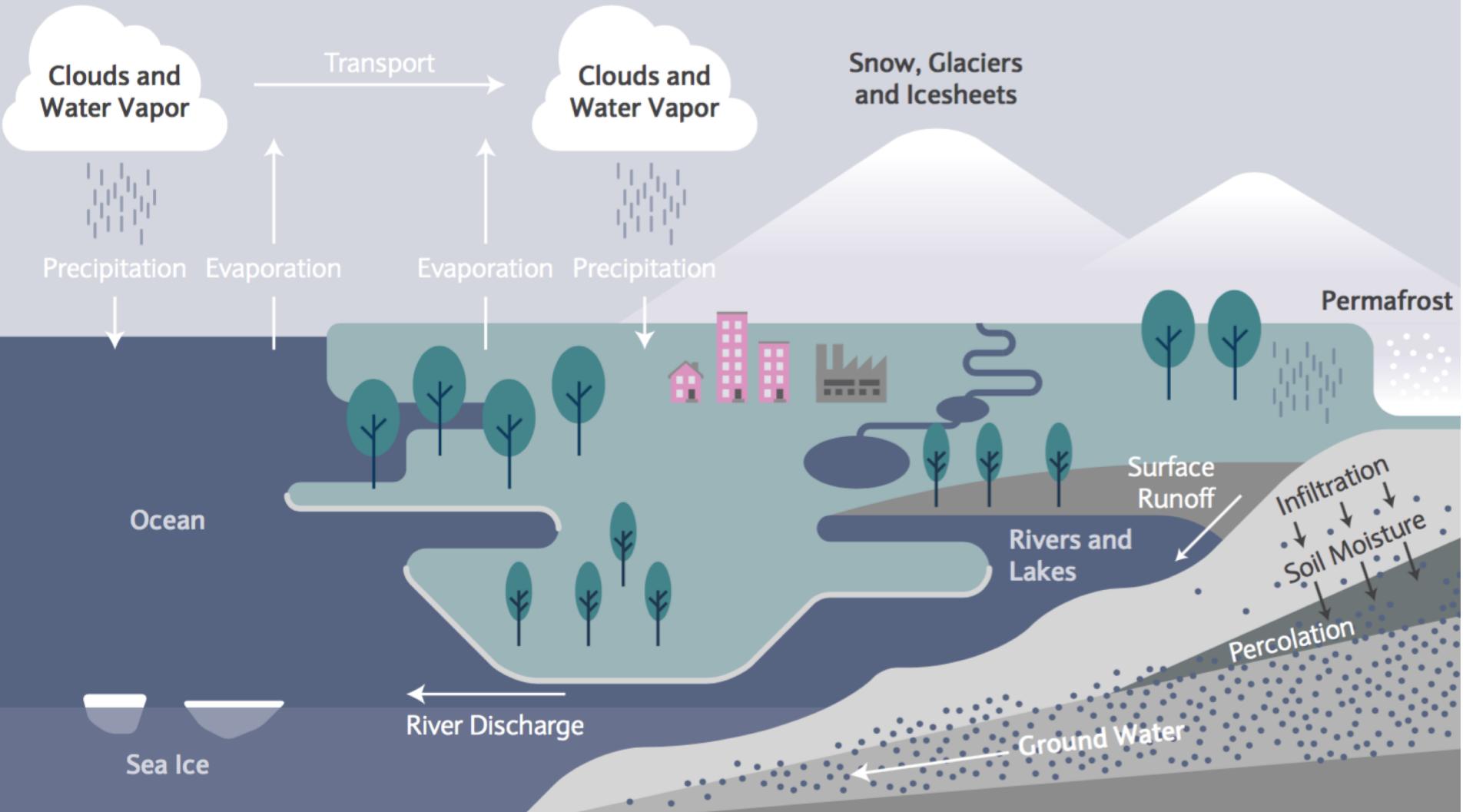


# INTERSECTION



# US WATER WITHDRAWALS: circa 350 BGD

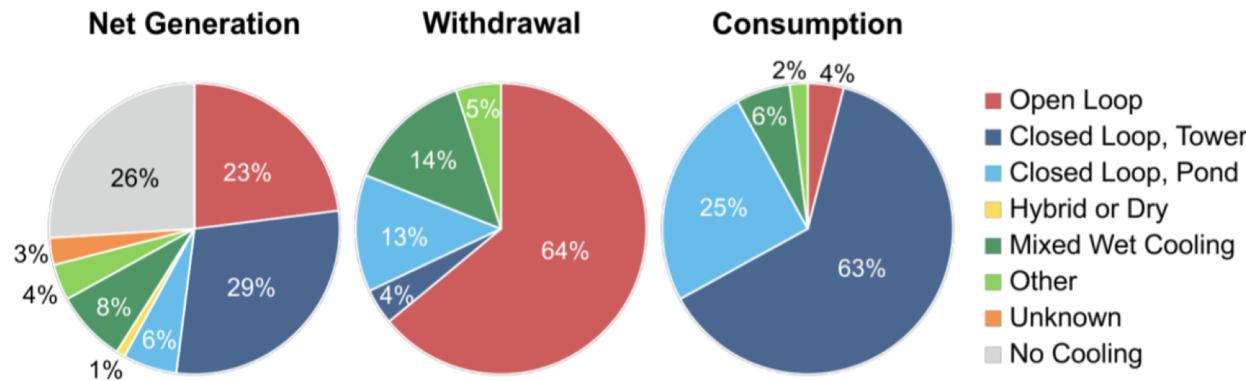




- 
- i) SURFACE WATER and GROUNDWATER
  - ii) OCEAN
  - iii) DRINKING/TREATED WATER (urban)
  - iv) WASTEWATER

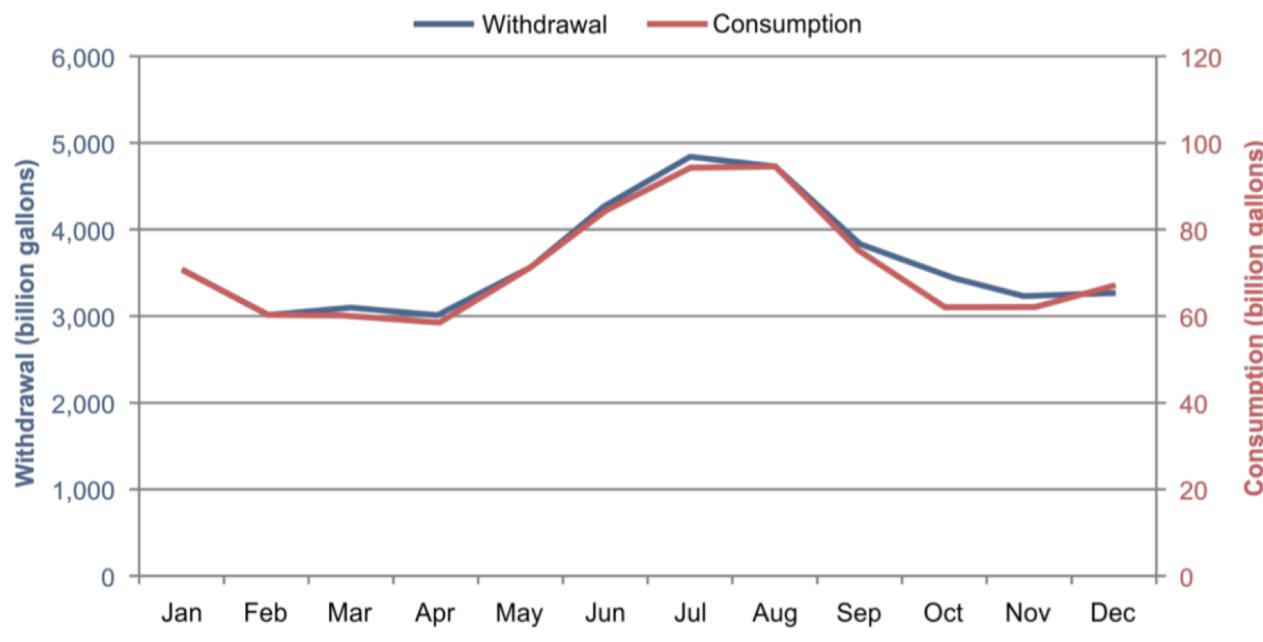
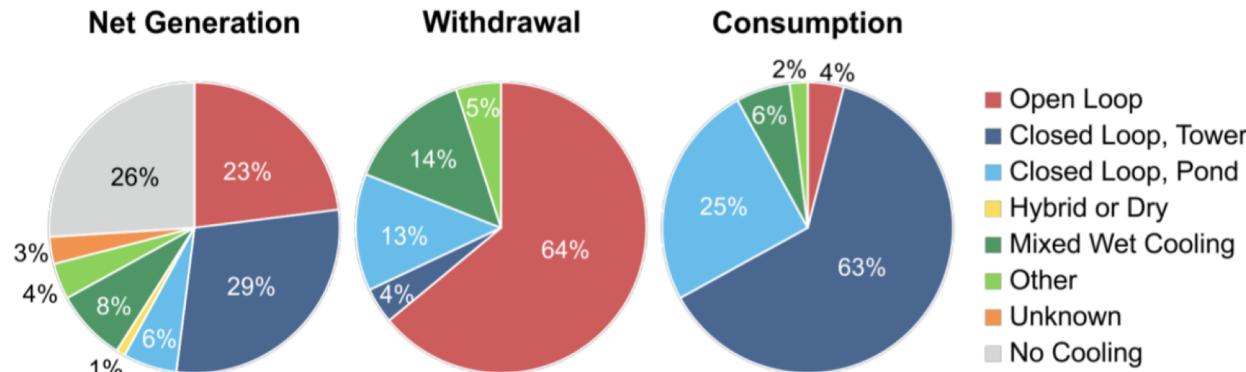
# SURFACE WATER: Withdrawn or consumed to produce energy

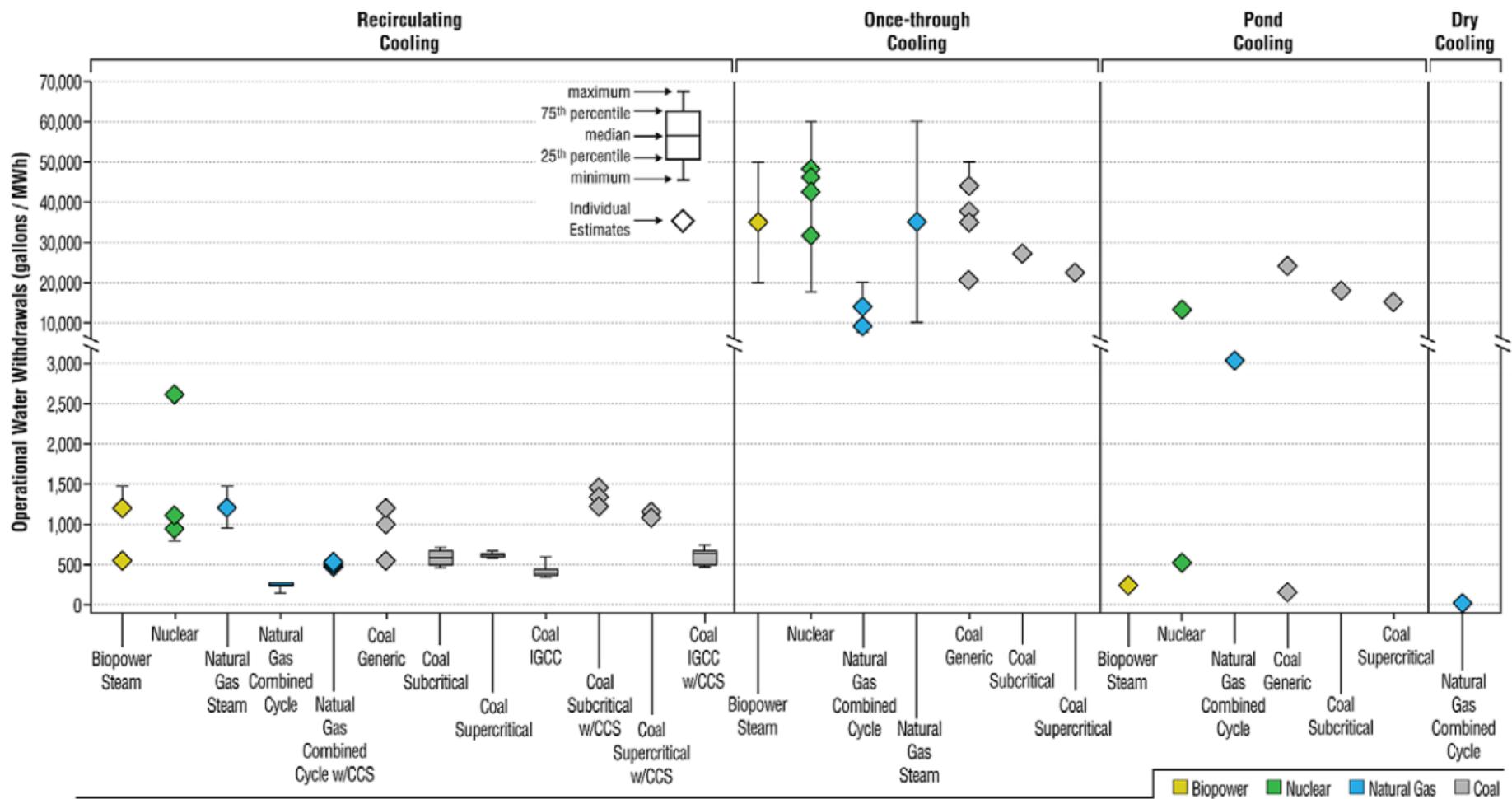
- Withdraw: 140 BGD (40% of the total withdraw)
- Consumption: 4 BGD

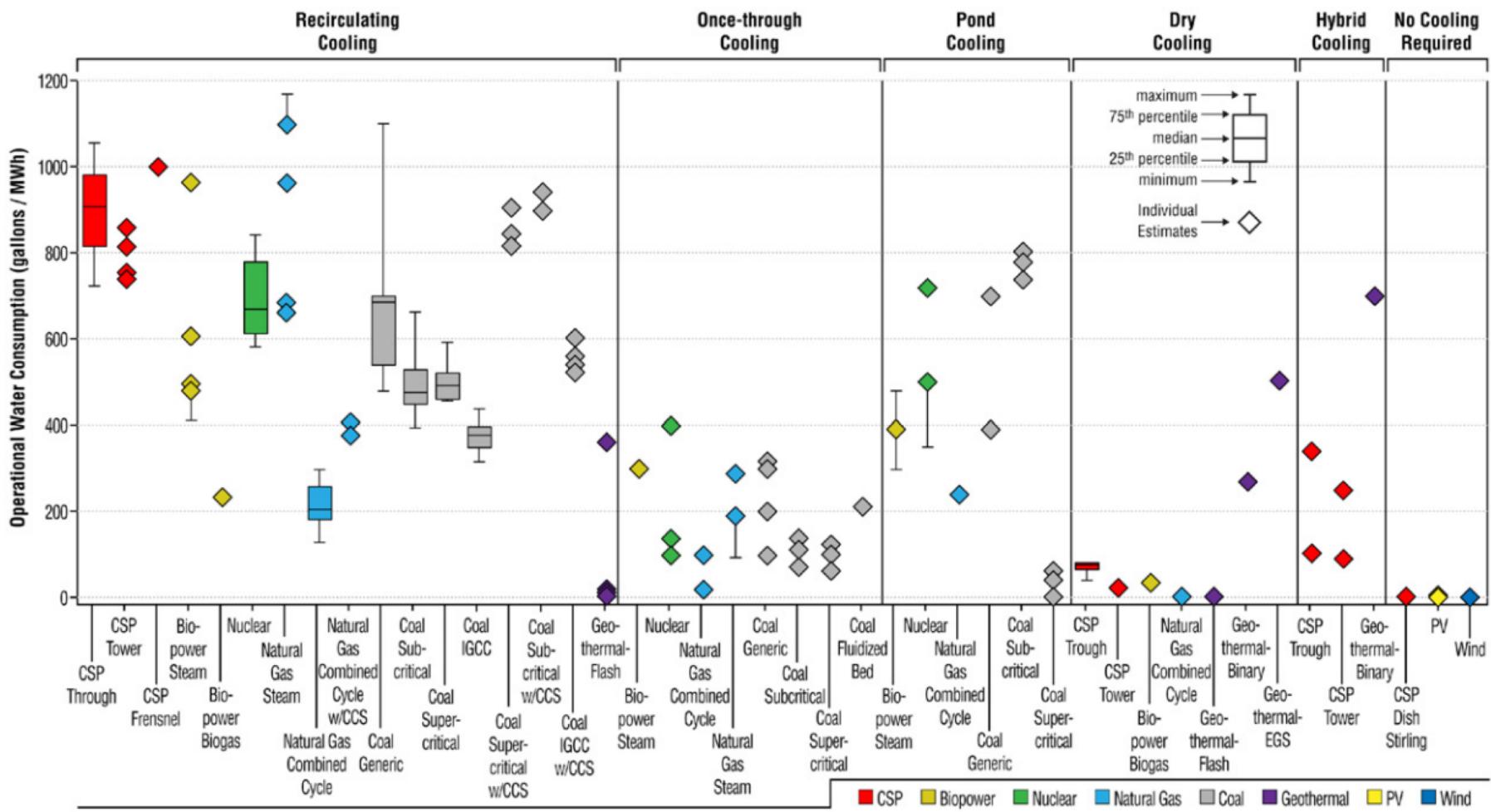


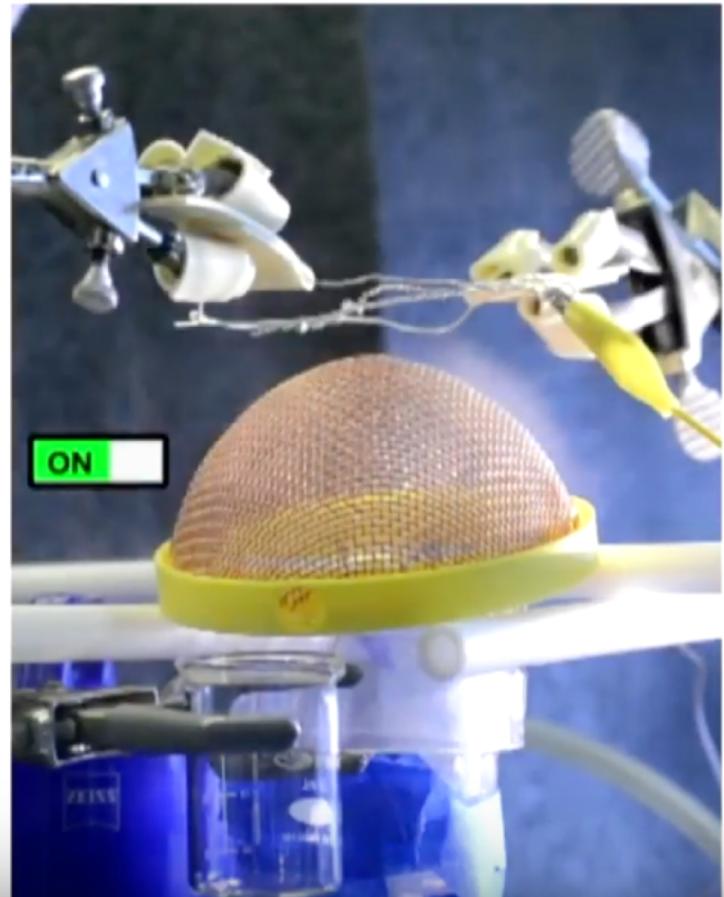
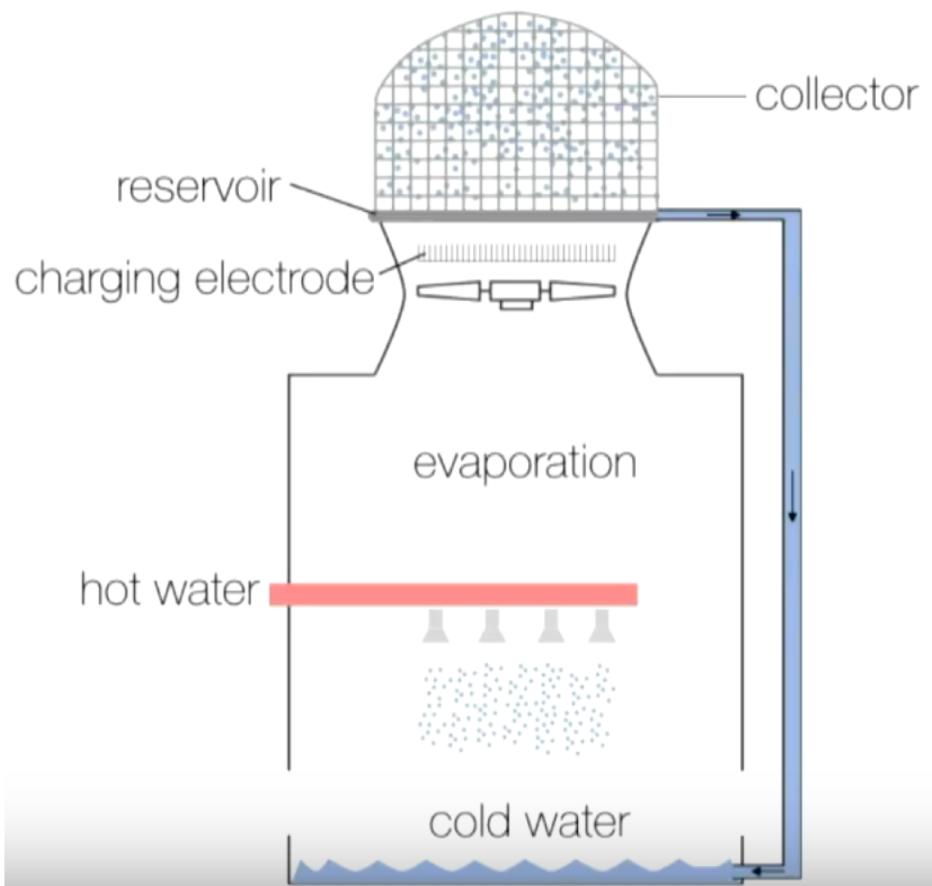
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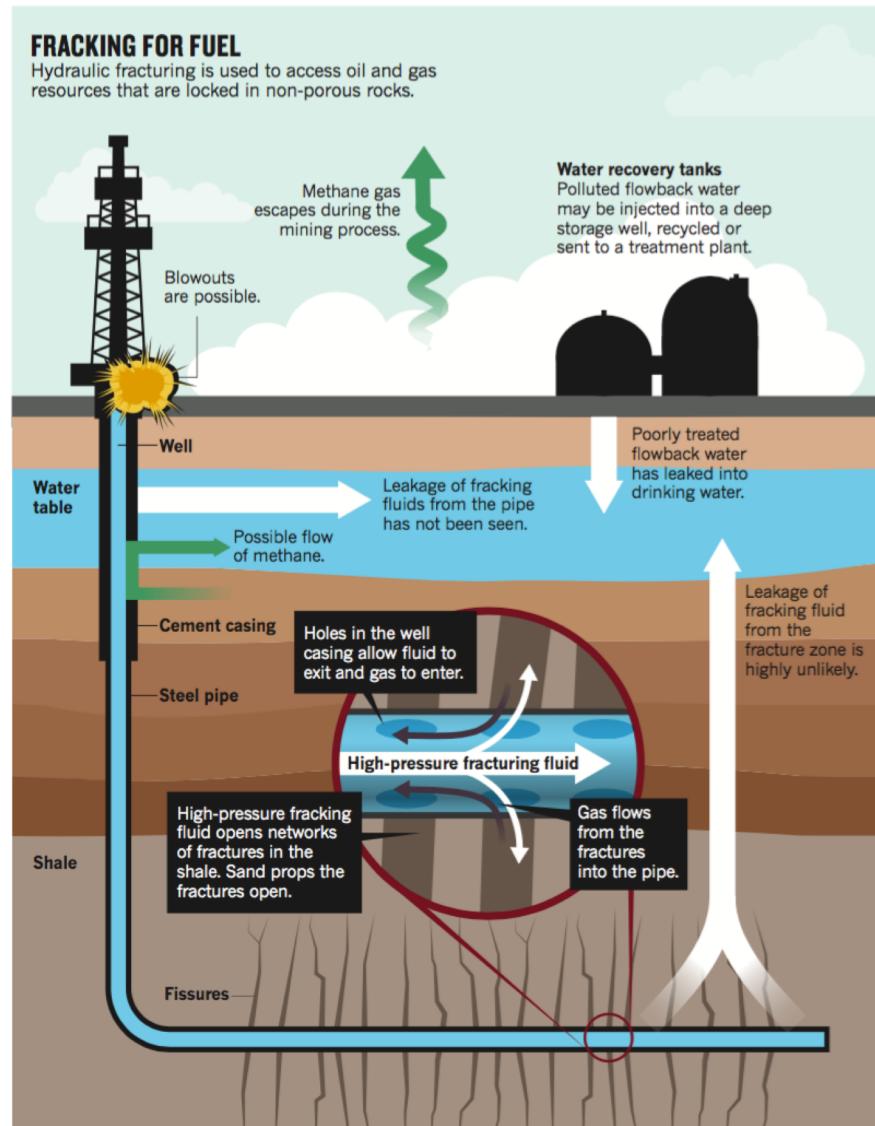


INFINITE COOLING

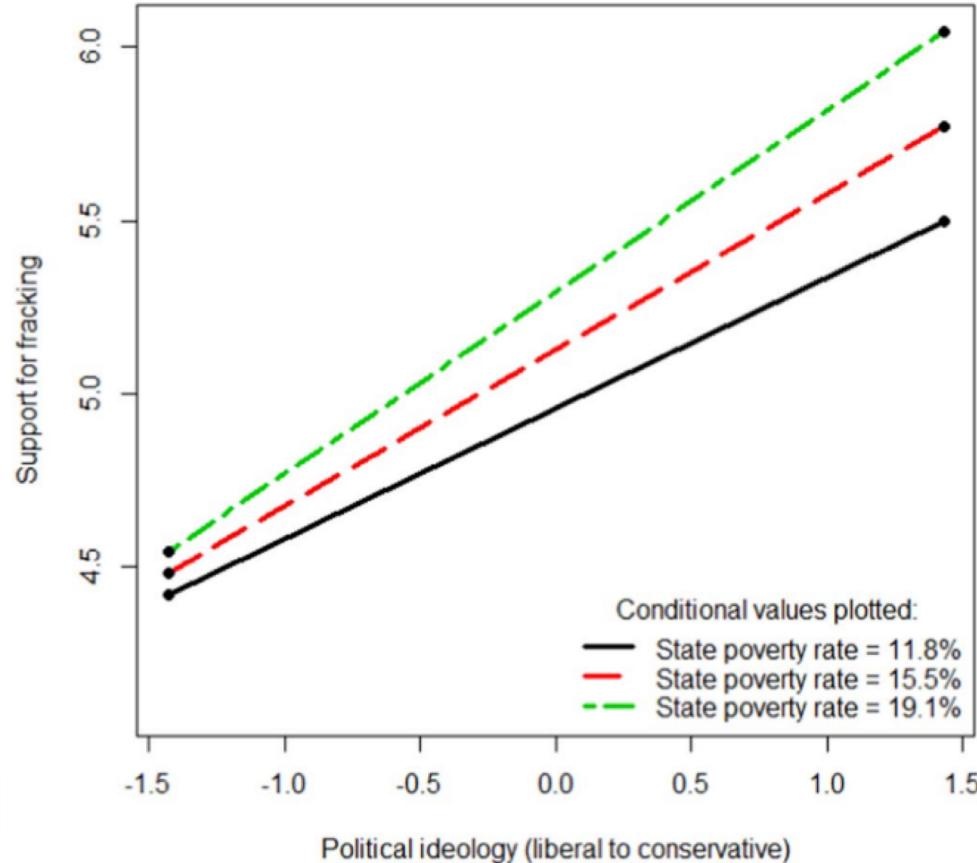
# GROUND WATER: polluted to produce energy?

## FRACKING FOR FUEL

Hydraulic fracturing is used to access oil and gas resources that are locked in non-porous rocks.



ENGELDER, 2011



HOWELL, 2017

## CONCERNs on the FRACKING FLUID

# GROUND WATER: polluted to produce energy?

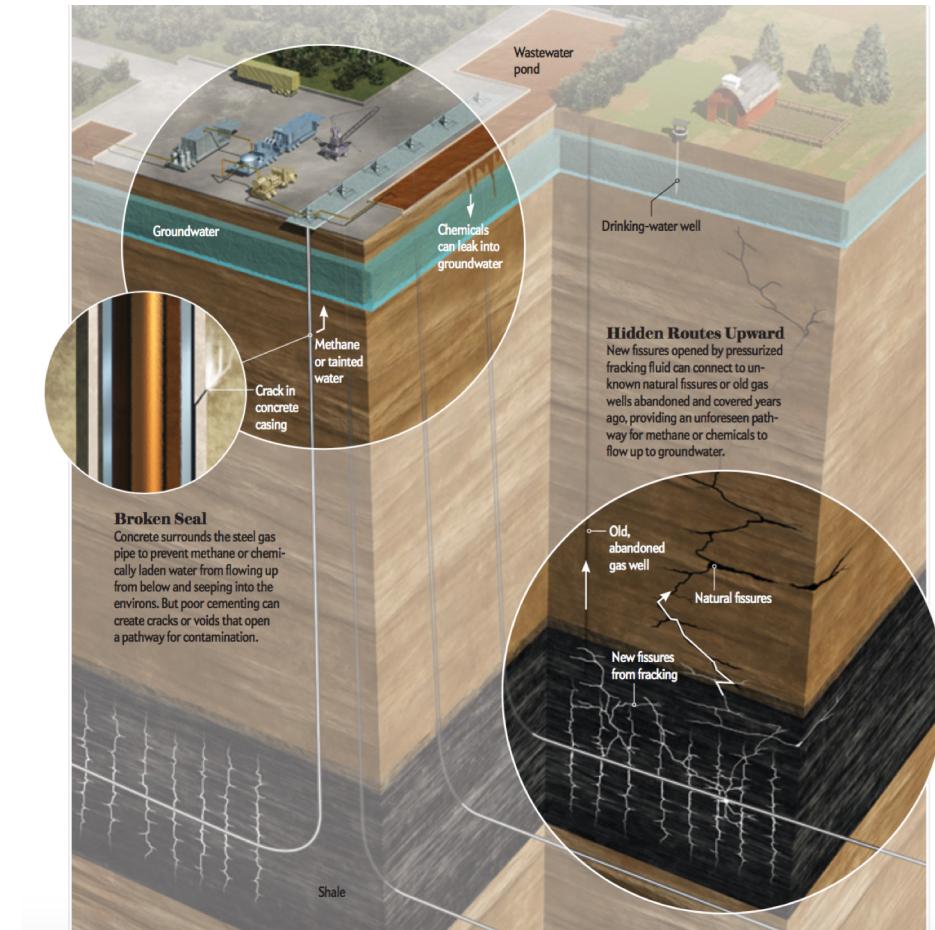
December 2016 Final

## U.S. EPA Releases Final Report on Impacts from Hydraulic Fracturing Activities on Drinking Water Resources

EPA's report concludes that hydraulic fracturing activities can impact drinking water resources under some circumstances and identifies factors that influence these impacts

RISK = toxicity \* exposure:

- POOR WELL CONSTRUCTION
- SPILLS of WASTEWATER
- CONFINEMENT of FRACKING FLUID





i) SURFACE WATER and GROUNDWATER

ii) OCEAN

iii) DRINKING/TREATED WATER (urban)

iv) WASTEWATER

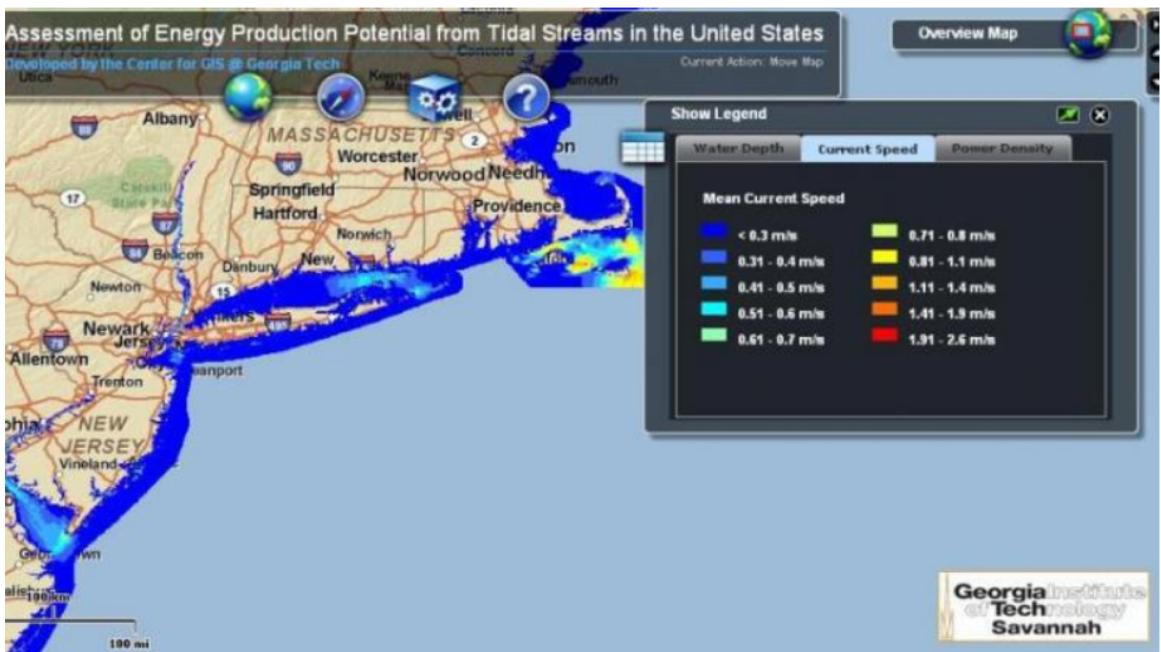
# OCEAN: cooling (today), energy production (future)



POINT SOURCE BUOY

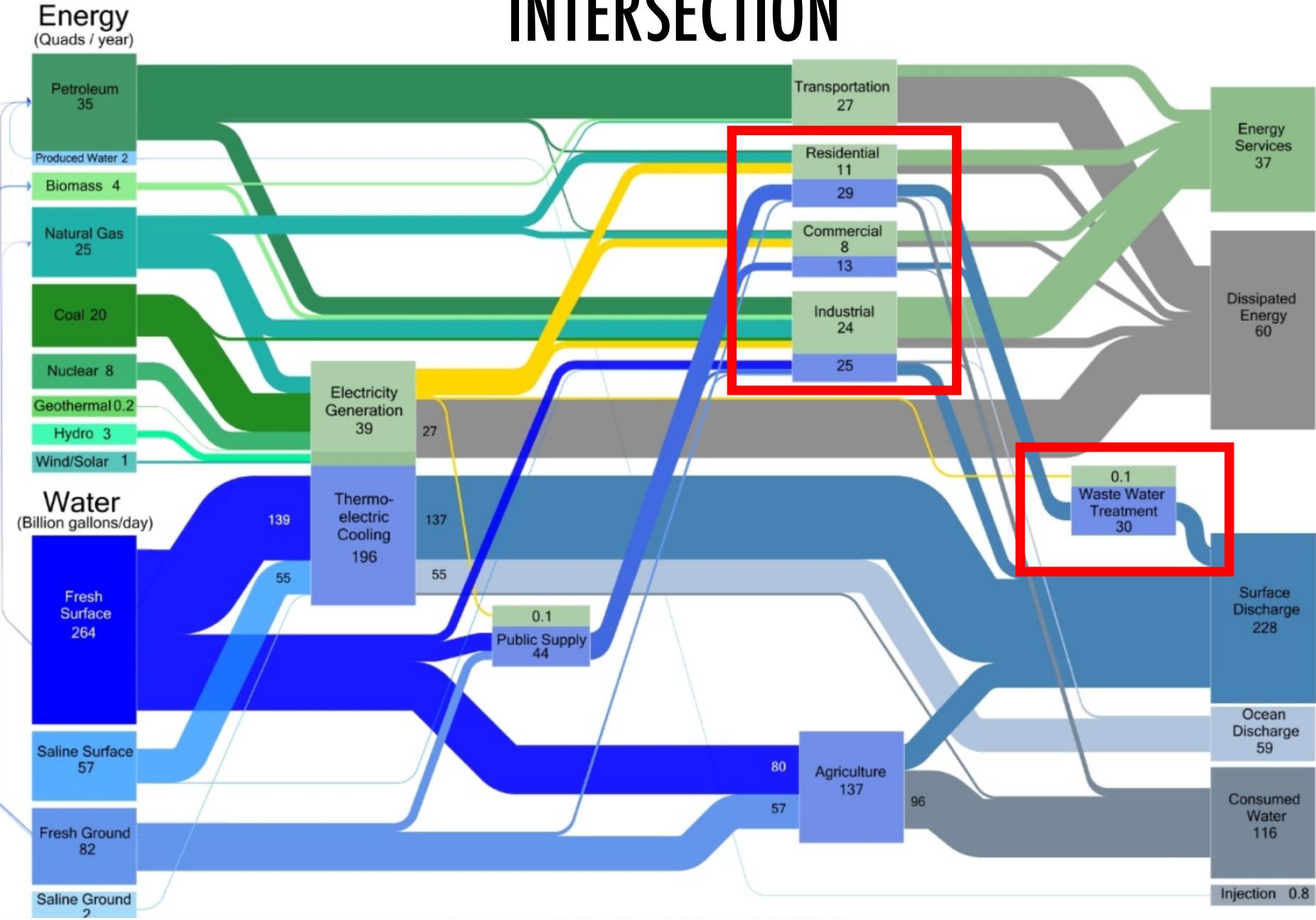


SURFACE ACTUTOR



TIDAL BARRIAGE

# INTERSECTION





i) SURFACE WATER and GROUNDWATER

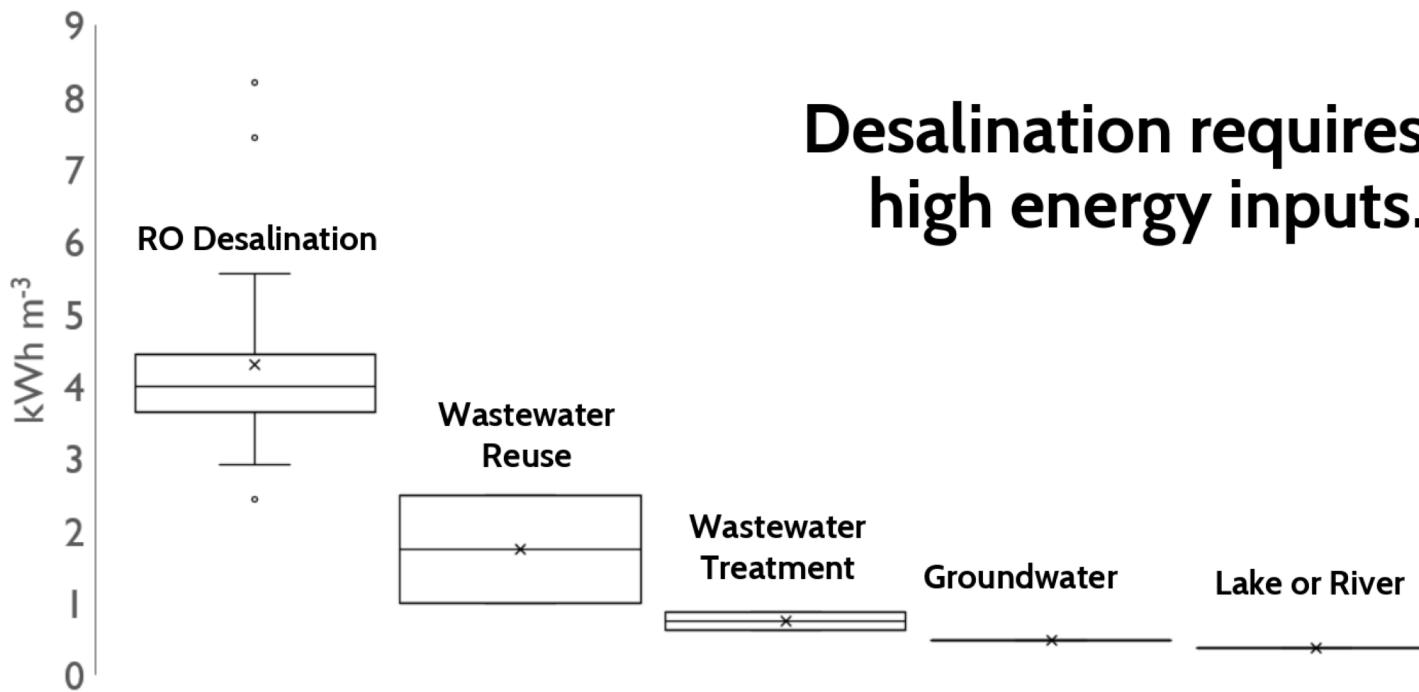
ii) OCEAN

iii) DRINKING/TREATED WATER (urban)

iv) WASTEWATER

# TREATING DRINKING WATER: sink of energy

- i) Pumping groundwater/surface water
- ii) Desalination
- iii) Wastewater reclamation



# i) PUMPING GROUND/SURFACE WATER: 0.25-4 kWh/m<sup>3</sup>

Highly dependent on where the water is coming from:

- Groundwater (rural)/surface water (urban)  
rural/city
- Distance
- 52 billion kWh

## State Water Project (California):

- 3.3 kWh/m<sup>3</sup> S.Cal
- 1 kWh/m<sup>3</sup> N.Cal
- California aqueduct (400 miles, >300 m<sup>3</sup>/s)



## New York

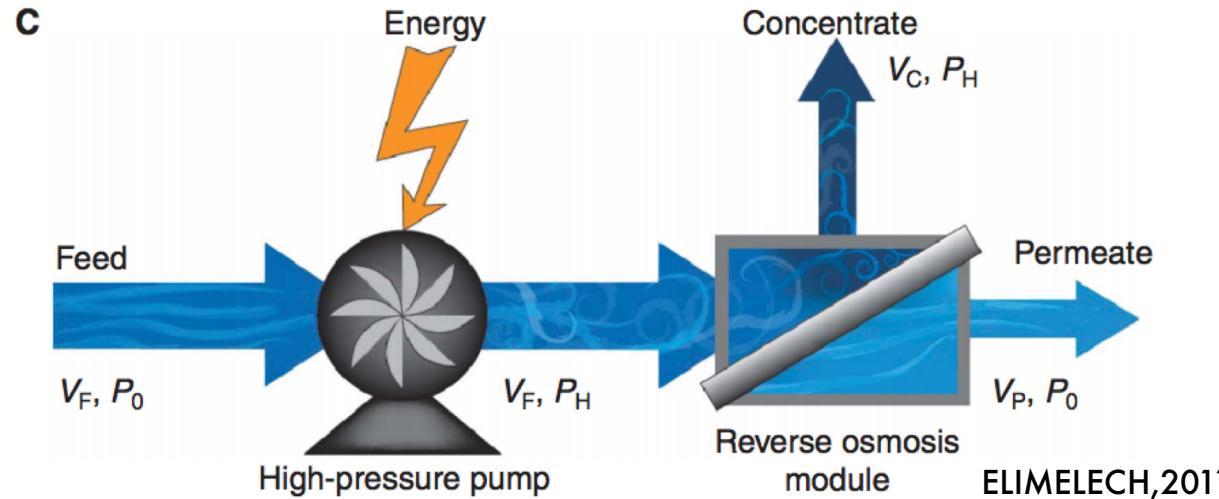
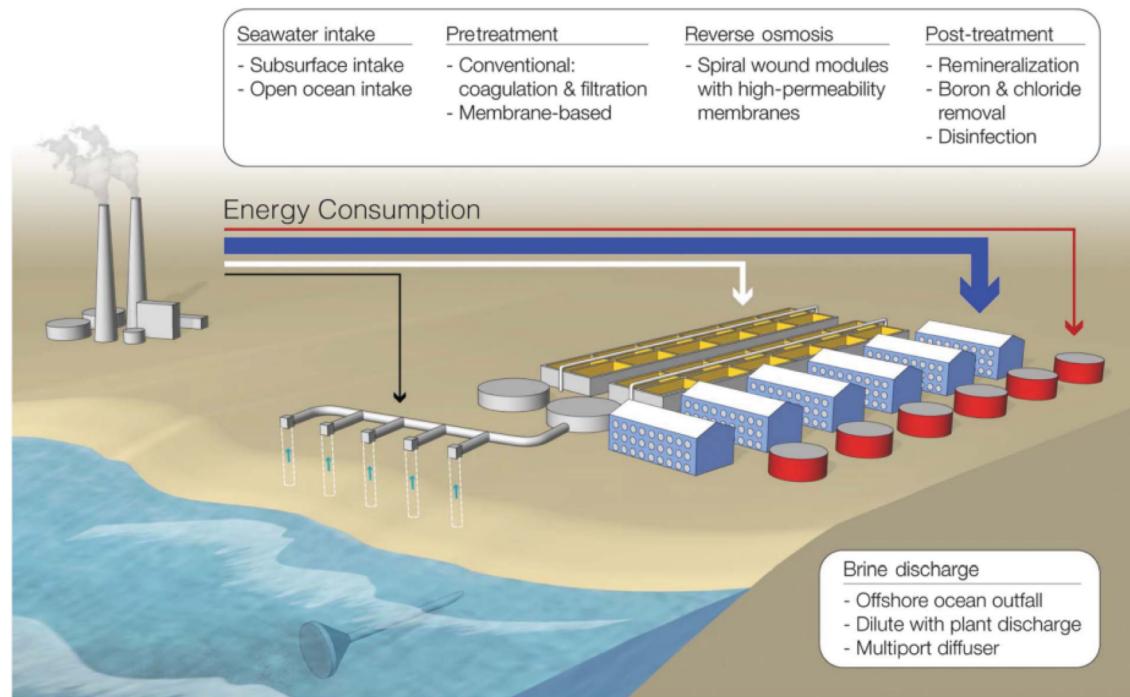
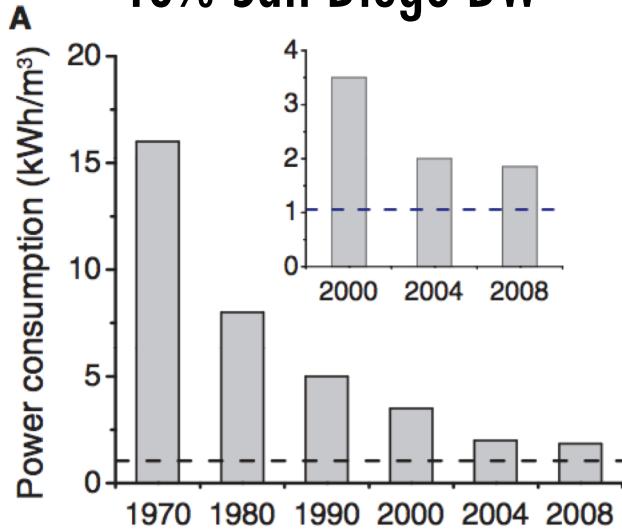
- .5-.7 kWh/m<sup>3</sup> due to gravity-fed distribution

ESMAP,2012

# ii) DESALINATION: 3-5 kWh/m<sup>3</sup>

## Carlsbad Desalination plant

- State of the art
- Largest in the western hemisphere
- Baseline design: 3.9kWh/m<sup>3</sup>
- 10% San Diego DW



- 
- i) SURFACE WATER and GROUNDWATER
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### iii) WASTEWATER RECLAMATION: 2-3 kWh/m<sup>3</sup>

- 0.25-1 kWh/m<sup>3</sup> are already used for primary and secondary treatment



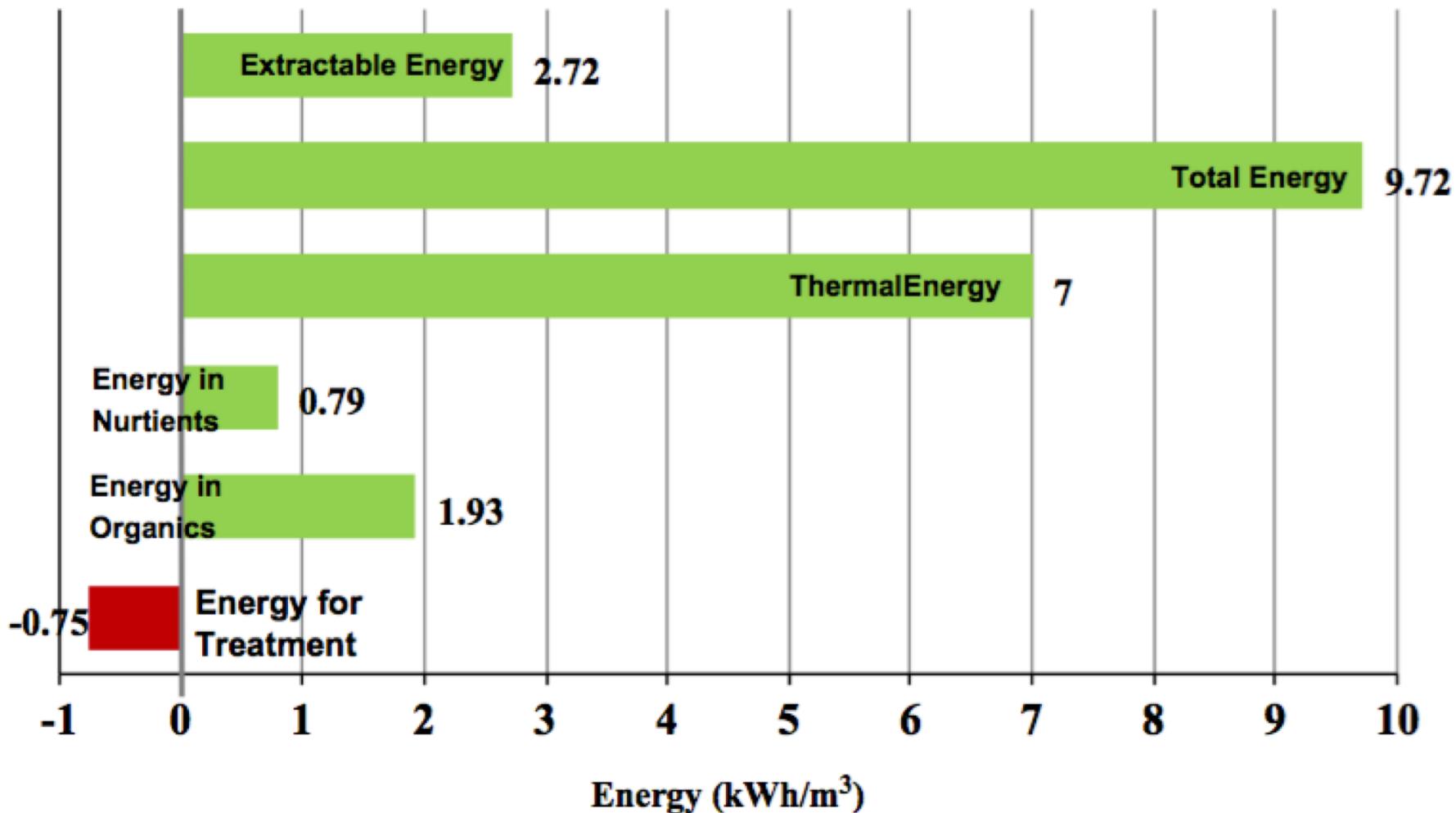
### iii) WASTEWATER RECLAMATION: 2-3 kWh/m<sup>3</sup>

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- WW contains almost 10 times the energy needed to treat it

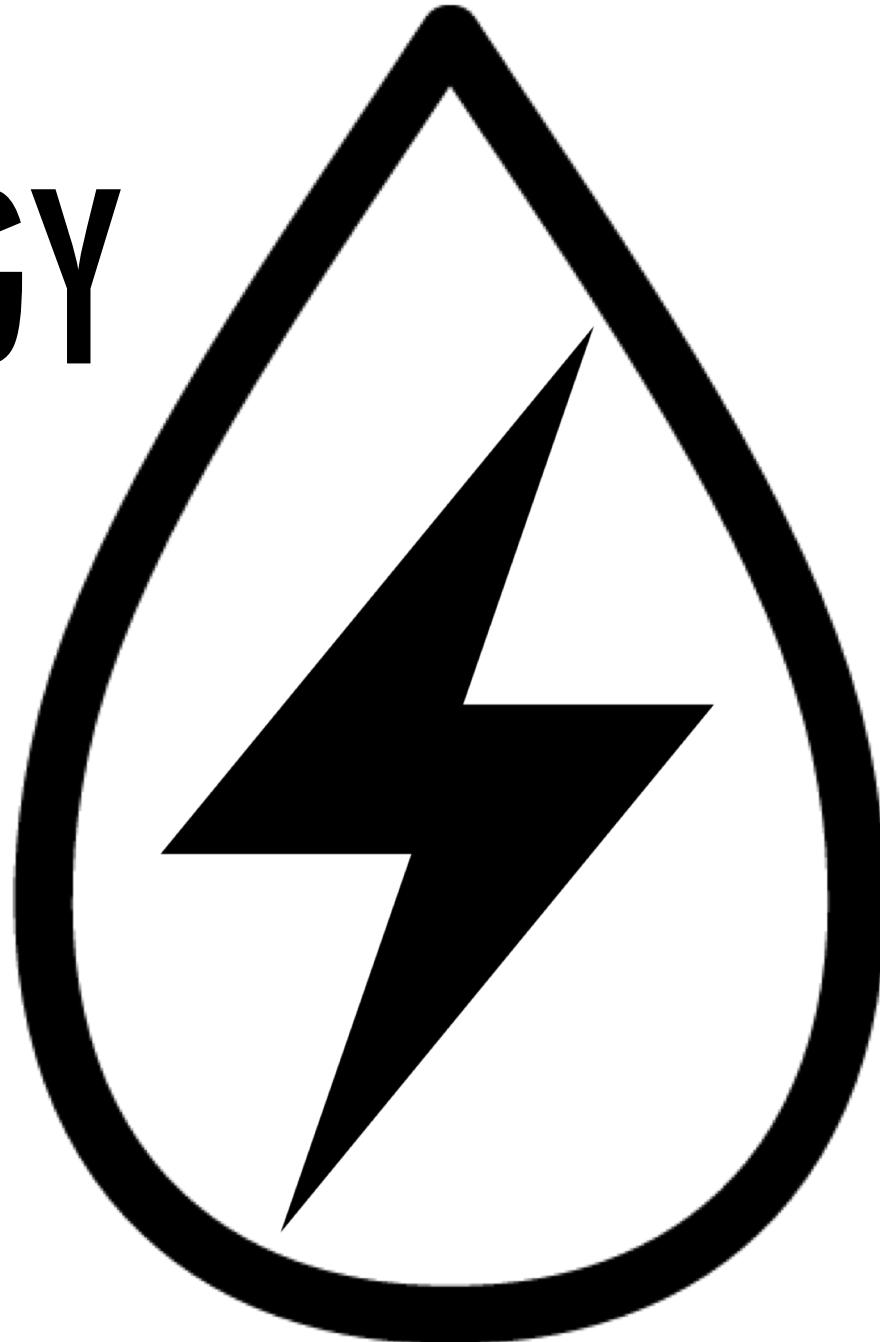
### iii) WASTEWATER RECLAMATION: up to 9 kWh/m<sup>3</sup> in energy recovery (paradigm shift)



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- 1) waste-to-fuel; organics → 70% CH<sub>4</sub> 30% CO<sub>2</sub>;  
0.5 kgCOD m<sup>-3</sup> WW; 0.16 kgTOC m<sup>-3</sup> WW  
**1.9 kWh m<sup>-3</sup> WW**
- 2) nutrient recycling; (N-NH<sub>3</sub>, P-phosphate)  
40 gN & 8 gP m<sup>-3</sup> WW; Haber-Bosch 7% elec.  
**0.8 kWh m<sup>-3</sup> WW**      150,000,000 tons fertilizer
- 3) heat recovery; (6°C)  
**7.0 kWh m<sup>-3</sup> WW**

**WATER-ENERGY  
NEXUS**



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