Economic Feasibility of Corn-based Ethanol Plants in South Dakota and California

James E. McMahon and Larry Dale
Environmental Energy Technologies Division
Energy Analysis Department
(jemcmahon@LBL.gov)

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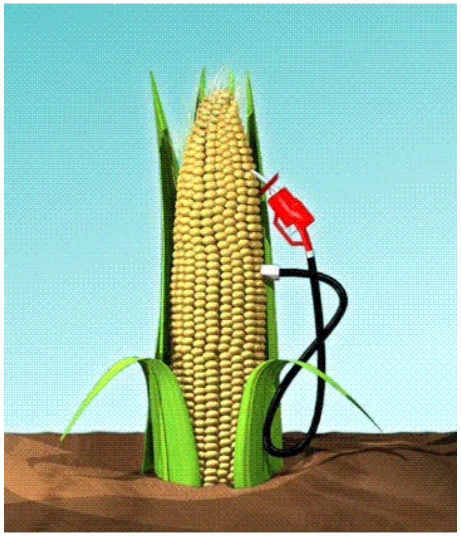
What is Fuel Ethanol?

- Fuel ethanol (ethyl alcohol) is high octane, water-free alcohol
- Produced from fermentation of sugar or converted starch
- Traditionally used as blending ingredient at 5% to 10% of gasoline
  - 85% is possible

- Ethanol production also yields large quantities of distillers grain, a high protein feed stock

Biofuel example: ethanol from corn

- Ethanol is a biofuel for transportation
  - Blend as 5-10% of gasoline (up to 85%)
- US ethanol production is increasing
  - primarily from corn
- Most corn production is in the Midwest
- Large markets exist on the coasts



- California plans to produce at least
  - 20% of its biofuels by 2010
  - 40% by 2020
  - 75% by 2050

Source: Executive Order, April 25, 2006 (S-06-06), Section 1.a

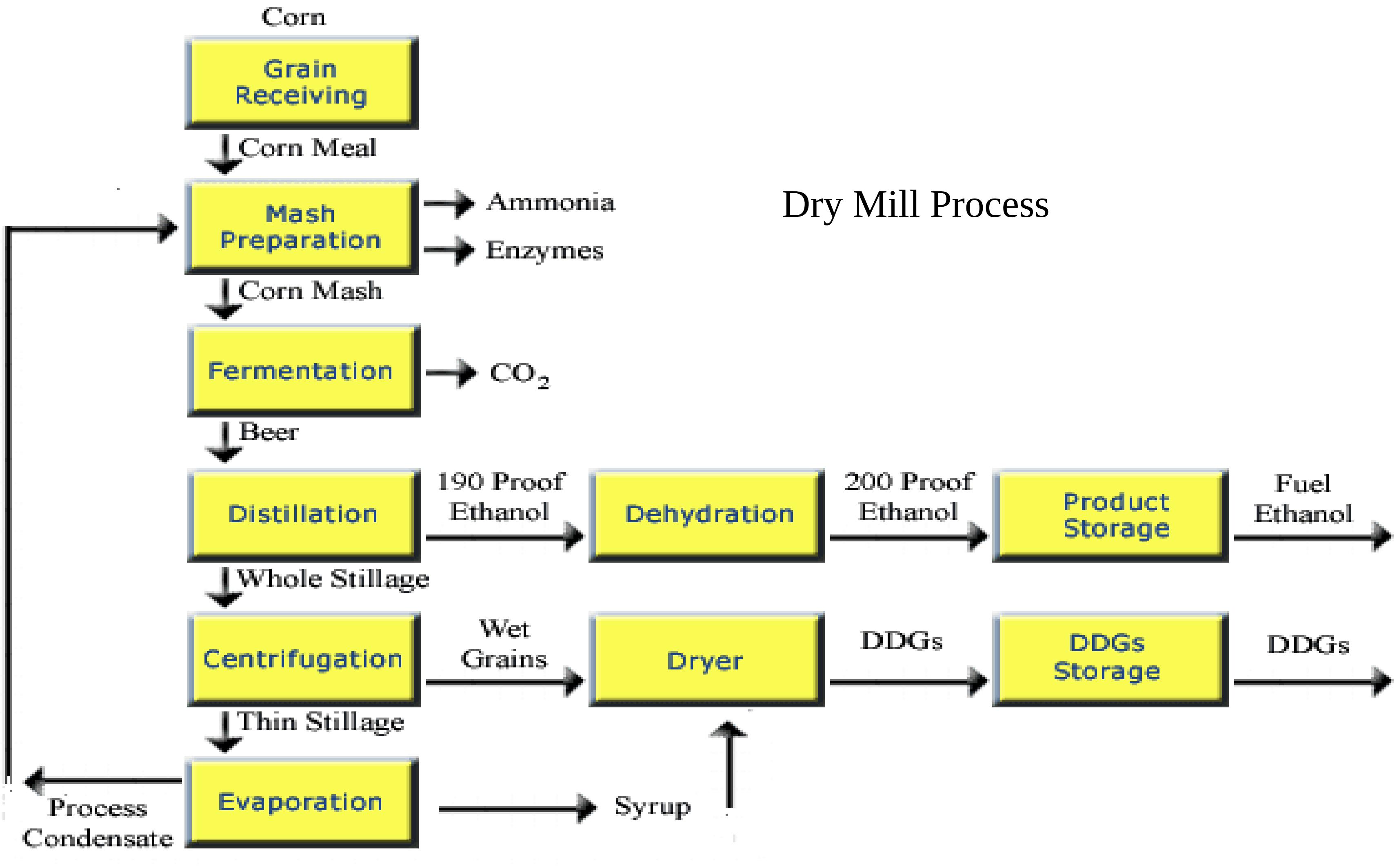
RESEARCH QUESTION:

What key factors will affect the economic feasibility of in-state production of biofuels?

	South Dakota	California
Gasoline consumed (billion gal/y)	0.44	15.9
Ethanol (million gal/y) -Produced -Consumed (est.)	 474 44	 34 960-1500
Corn produced (million bushels, 2004)	26,000	540
Corn price ($/bu, 2005)	$1.70	$2.75

Years of World-Class Science 1931-2006

How is ethanol made?

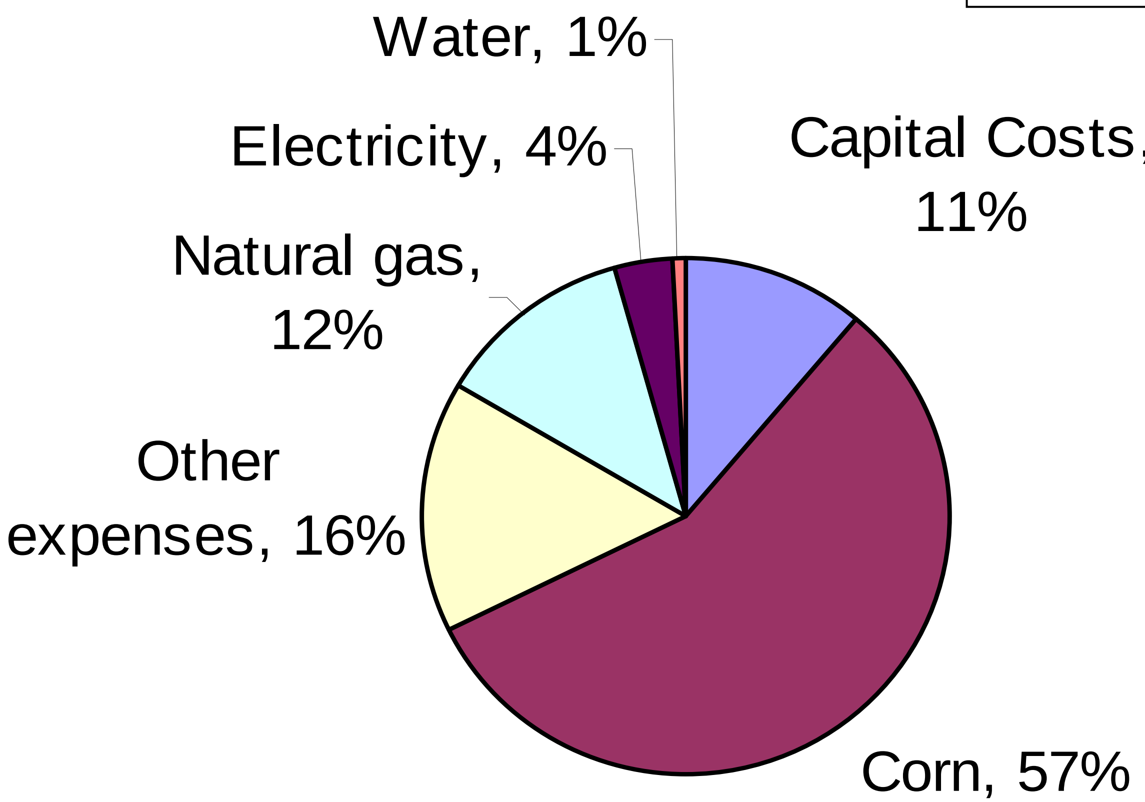


Dry Mill Process

Corn dominates costs of ethanol plant

(US average, 2003)

[Plant capacity: 20 million gal ethanol per year]



*Other = enzymes, yeast, chemicals, antibiotics, denaturant

Source: D.G. Tiffany, Factors Associated with Success of Fuel Ethanol Producers. Staff paper series, University of Minnesota, 2003

Table 1. Corn price ($0.76/gal) dominates break-even cost ($1.33/gal) of ethanol plant (US averages)

	Total	Per Gallon	Percent of total
Capital Costs ($)	30,000,000	0.15	11.1%
Operating Costs ($ per year)	28,466,400	1.19	88.9%
corn	18,240,000	0.76	57.0%
water	144,000	0.01	0.4%
electricity	1,308,000	0.05	4.1%
other operating costs	8,774,400	0.37	27.4%
Revenue ($ per year)	34,052,296	1.42	
ethanol	27,600,000	1.15	
other products	6,452,296	0.27	
Break-even Price($)		**1.33**	

Source: Tiffany, D.G. Factors Associated with Success of Fuel Ethanol Producers. Staff paper series. University of Minnesota. 2003

Ethanol is more costly in California, but still profitable due to higher priced corn, electricity, water and ethanol

	South Dakota	California
Corn price (2005)	$1.70/bu	$2.75/bu (Irrigation contributes $0.70/bu)
Electricity price (industrial)	$0.05/gal 5 cents/kWh	$0.09/gal 8 cents/kWh
Sale price of ethanol ($/gal)	$1.91/gal	$2.32/gal
Breakeven price of ethanol ($/gal)	$1.22 (2006)	$1.67 (2006) (Irrigation contributes $0.26/gal)

California prices are higher than US average or Midwest

	Gasoline($)	Ethanol($)	% of US Average
US	2.23	1.98	100%
Midwest	2.18	1.89	95%
West Coast	2.42	2.35	119%

Source: DOE Clean Cities Alternative Fuel Price Report

Increased demand for ethanol from corn expected to increase corn prices and acreage

Higher demand may lead to increased corn price and acreage

- California
  - Application of Executive Order will increase acreage and price of corn
    - Currently 150,000 acres of corn production
    - If producing 5% of demand, add 22,000 acres (15%)
    - If produce 20% of demand, add 87,000 acres (58%)
- PROJECTIONS FOR 2010: TWO SCENARIOS
  - Midwest corn: $1.77/bushel = $2.78/bu transported to CA
    - Transportation cost is $1.01/bushel
  - California corn meets 20% of state ethanol demand: $3.48/bu
    - Imported corn is much cheaper.

In 2010, ethanol is likely to be profitable – even in California
In 2020, ethanol is unprofitable in California

Location of plant	Midwest	California (producing 20% of demand)		
Corn from: Midwest CA	 100%	 100% 0%	 80% 20%	 60% 40%
Corn price ($/gal)	$1.77	$2.78. Transport $1.01	$3.48	$4.60
Ethanol ($/gal) -production -revenue -plant revenue (all products)	 1.23 1.52 1.78	 1.62 1.65 1.91	 1.90 1.65 1.91	 2.35 1.65 1.91
NET $/gal	0.55	0.85	0.01	-0.44

Risk factors for future ethanol profits

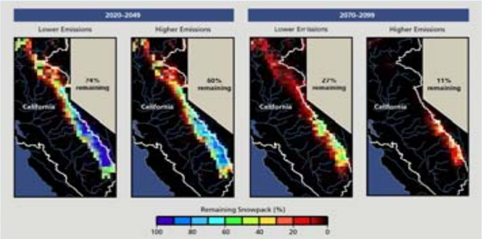
- Decline in price of ethanol would eliminate profits
  - Perhaps due to drop in oil price
  - -33% in SD or -21-36% in CA
- Increase in corn price would eliminate profits
  - +72% in SD or +34-75% in CA
- Ethanol subsidies ($.51 gallon)?
- Sugar subsidies?

- Water availability and cost (in California)
  - Water at ethanol plant costs $0.01/gal ethanol (<1%)
  - Irrigation cost of $0.26/gal ethanol in 2003 (17%)
  - Cost could increase in 2010, depending on whether corn is grown in-state or transported from Midwest
  - Higher demand will increase price of corn and amount of corn acreage
  - Higher demand will increase price of other crops in California

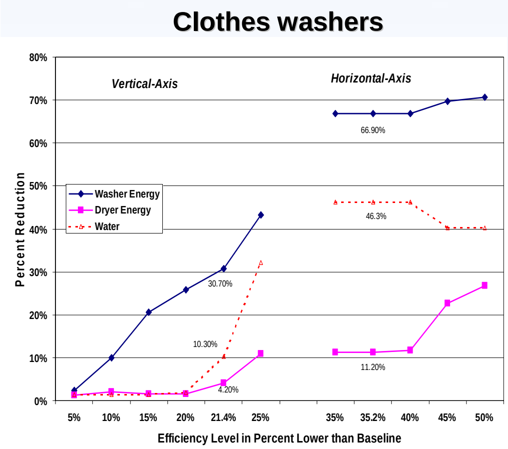
LBNL-WETT

http://water-energy.LBL.gov

Water and Energy Technology Team Missions



- Research the fundamental science, applied technology and economics of how natural processes and human intervention interact in water and energy sectors



- Develop new technologies, practices, and approaches for working with key institutions.

- Analyze technical feasibility and economic efficiency of new technologies, practices and policies compared to existing ones

- Optimize and test new technologies, practices and policies that promote water and energy sustainability.

BEST Wineries

ENERGY and WATER

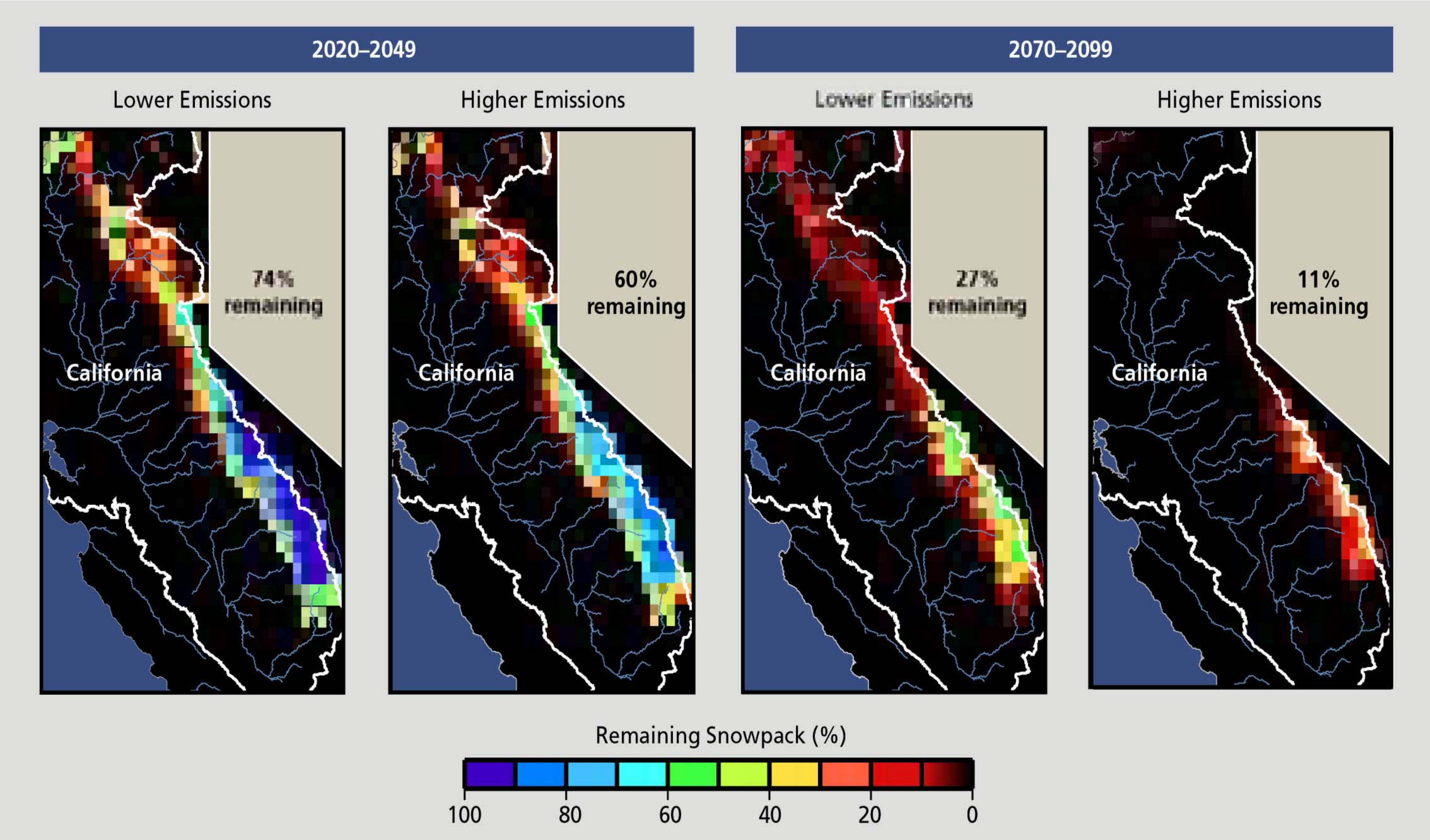
For more information

- **LBNL Websites:**
  - — **Water Energy Technologies Team**
    http://Water-energy.LBL.gov
  - — **esd.lbl.gov (Earth Sciences Division)**
  - — **eetd.lbl.gov (Environmental Energy Technologies Division)**
  - — **Eetd.lbl.gov/EA.html (Energy Analysis)**

- **Contact:**
  - — **Jim McMahon (JEMcMahon@LBL.gov), EETD**
    - **Phone: (1) 510 486 6049**

Diminishing Sierra Snowpack

% Remaining, Relative to 1961-1990

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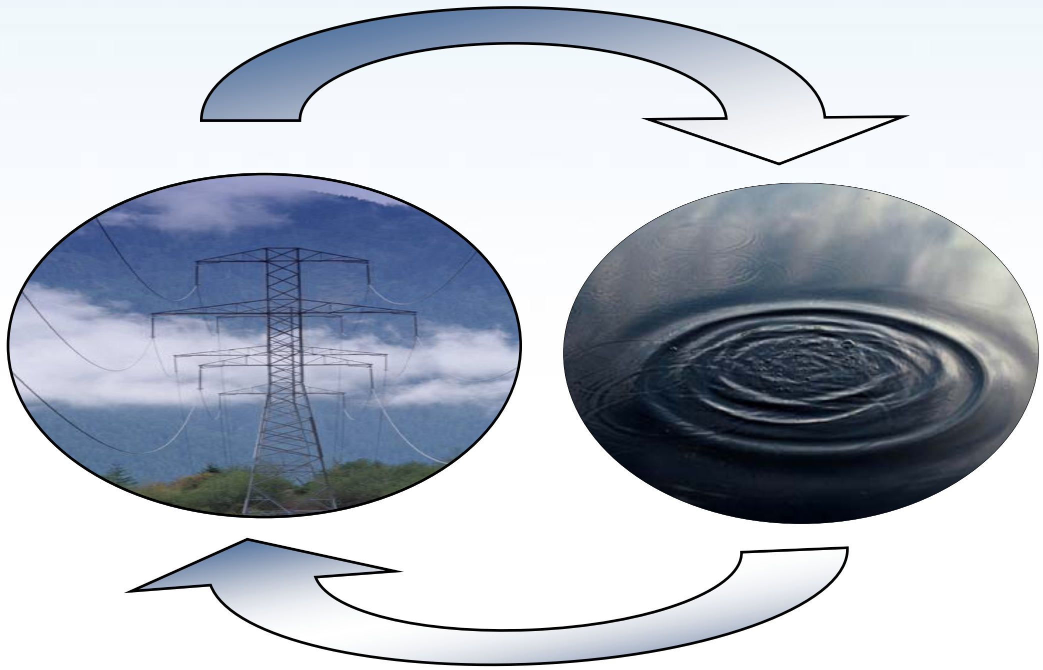
THE ENERGY~WATER NEXUS
a strategy for energy and water security

Energy and Water are linked:

Energy for water and water for energy

Energy production requires water

- Thermoelectric cooling
- Hydropower
- Extraction and mining
- Fuel Production (H_2, ethanol)
- Emission controls

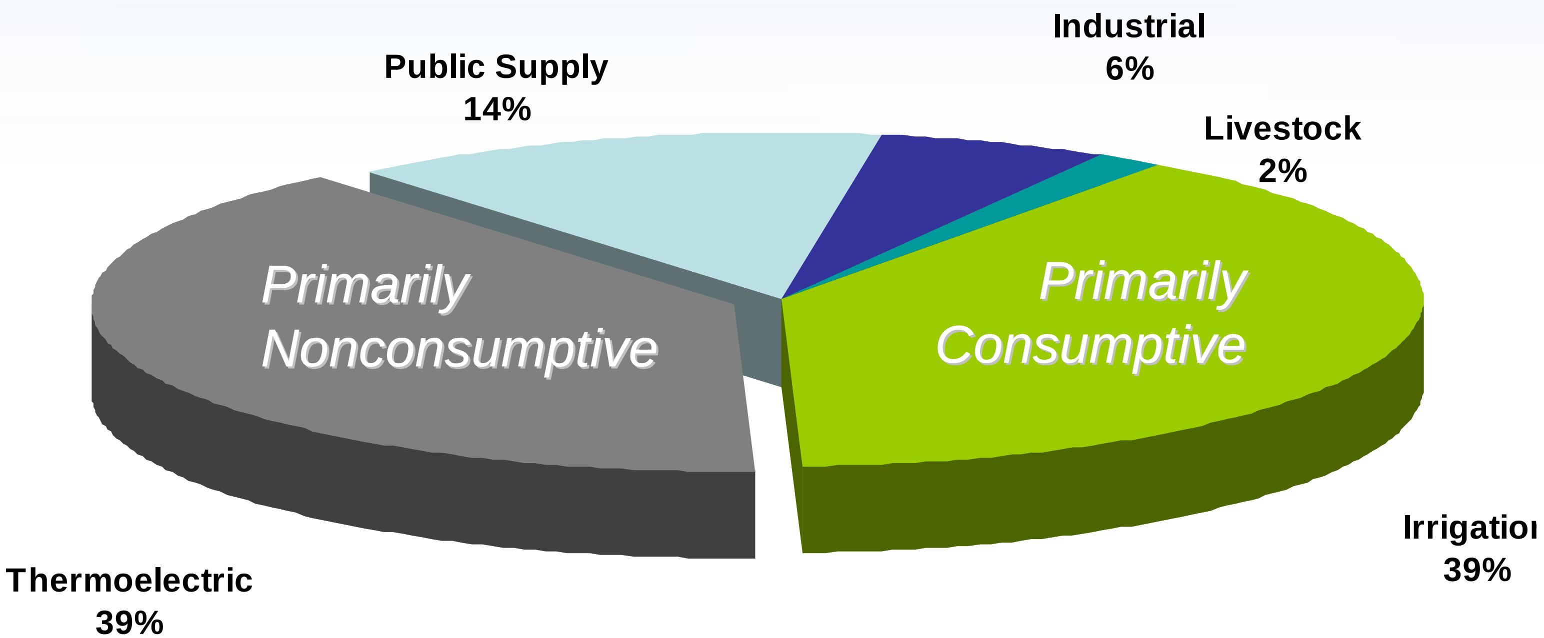


Water production and distribution require energy

- Pumping
- Treatment
- Transport

Energy and agriculture withdraw the most water in the U.S.

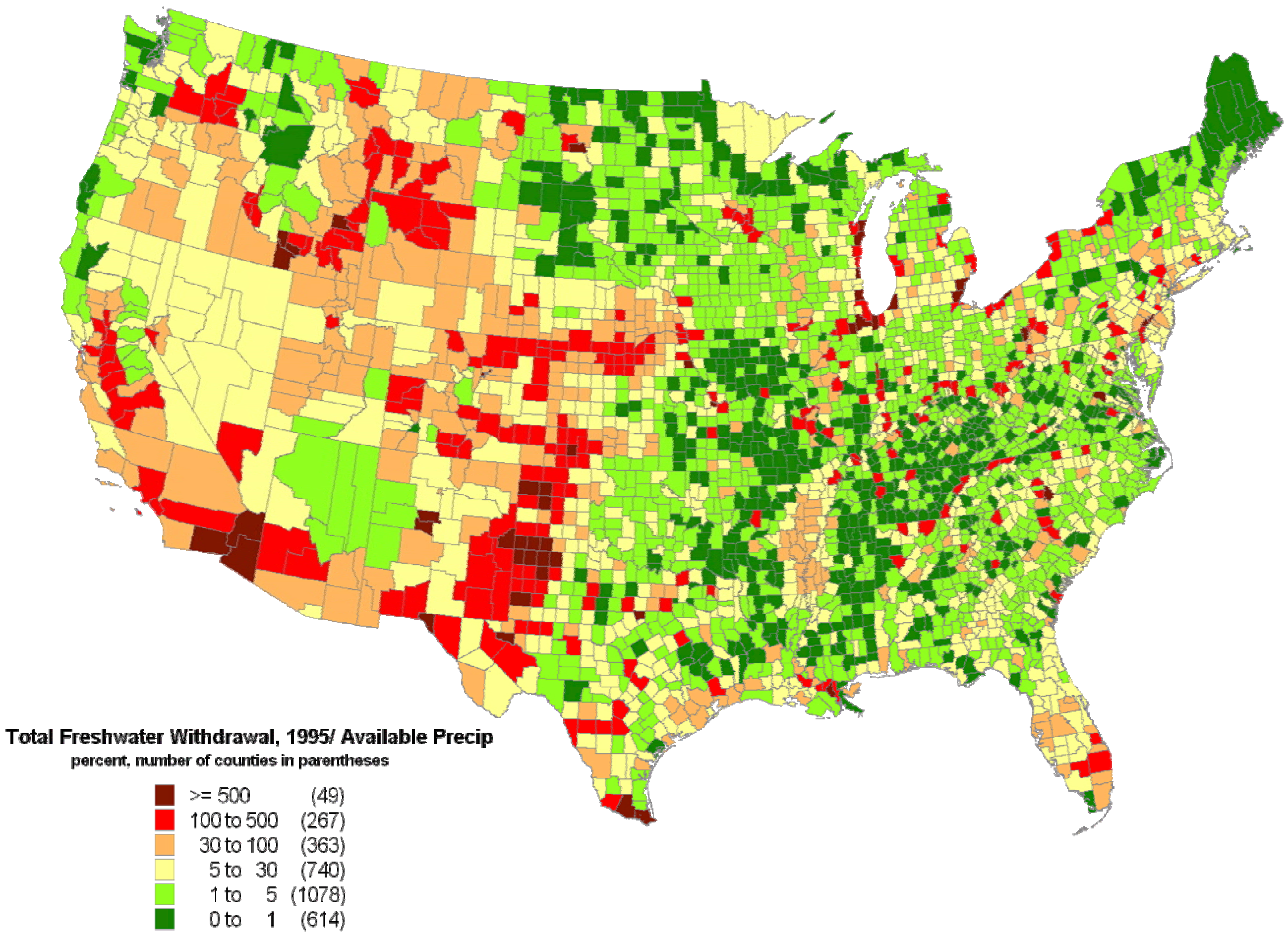
Estimated Freshwater Withdrawals by Sector, 2000



Source: USGS Circular 1268, March, 2004

Note: Hydropower uses are not included here!

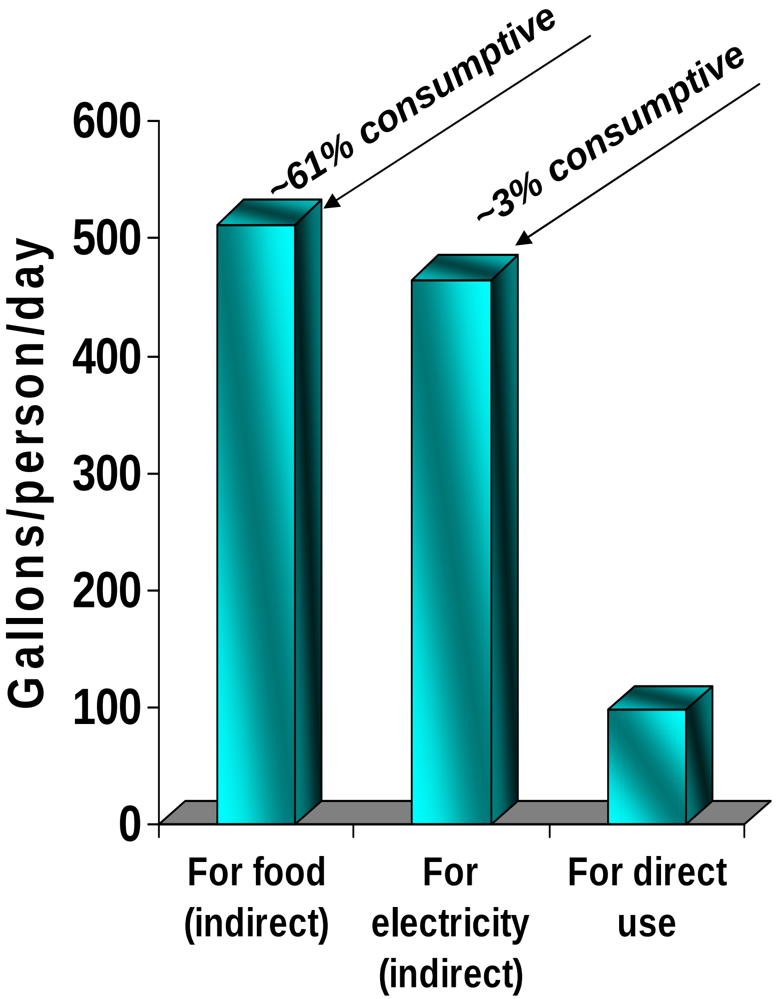
Current withdrawals of freshwater may not be sustainable



In the red regions, more water is withdrawn for human use than is supplied annually by precipitation.

If evaporation and consumptive use are included, the deficit will increase.

Households Use More Energy Indirectly (for Electricity and Food) than Directly



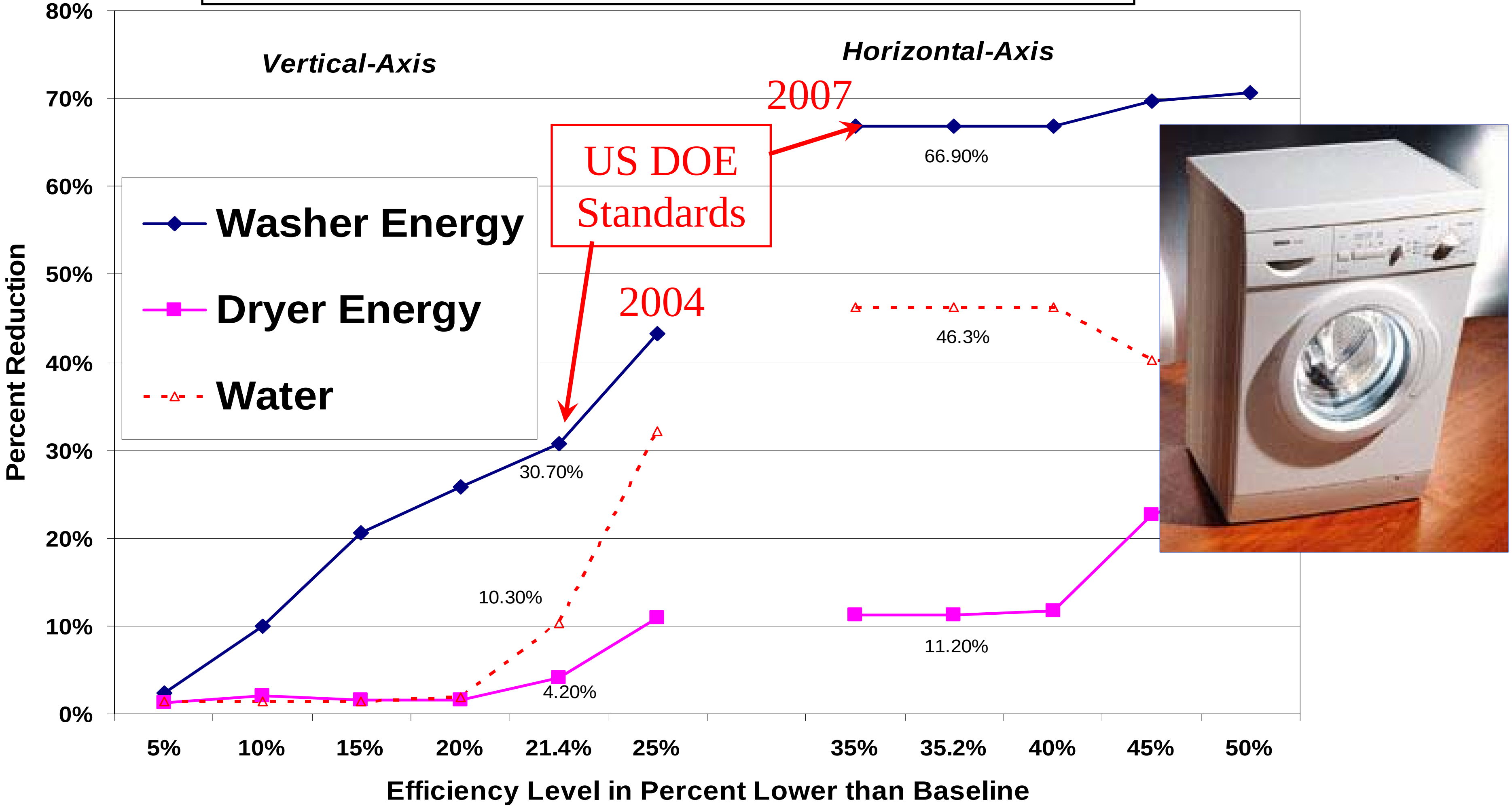
<u>*GALLONS PER PERSON PER DAY*</u>

- **510 for food production**
  - —**irrigation and livestock**
- **465 for electricity**
  - —**Range: 30 to 600 depending on technology**
- **100 for direct household use**
  - —**includes bathing, laundry, lawn watering, etc.**

Source: derived from Gleick, P. (2002), *World's Water 2002-2003*.

Efficient clothes washers save water and energy

- Most energy savings are from saving hot water



Households account for 22% of freshwater withdrawals

- Household use = 8% of all water withdrawn
- Household electricity = 35% of all electricity
  —Corresponds to 14% of all water withdrawn

- *TOTAL = 22% of freshwater withdrawals*

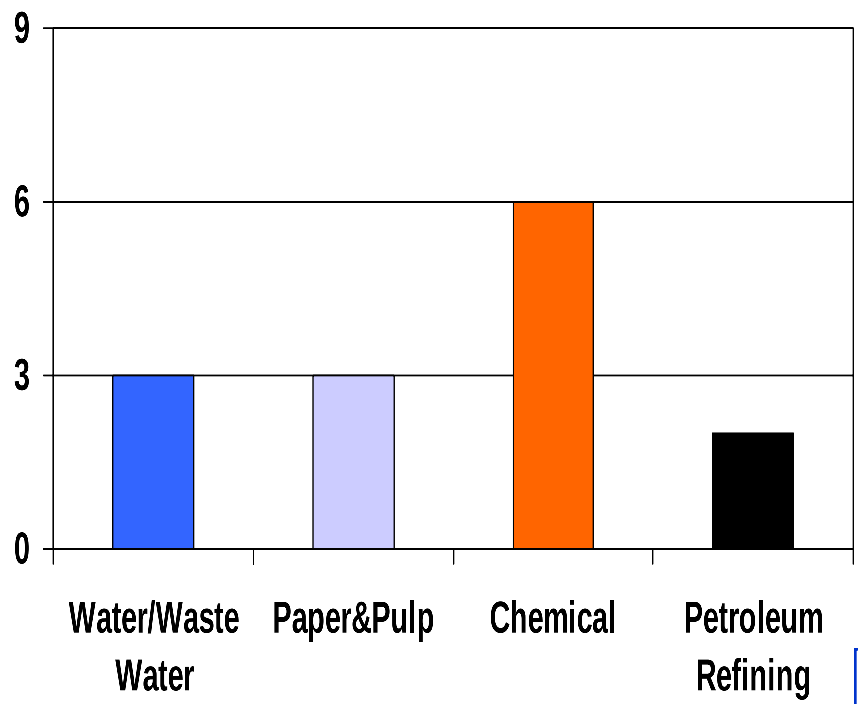
  —and 6% of water consumption

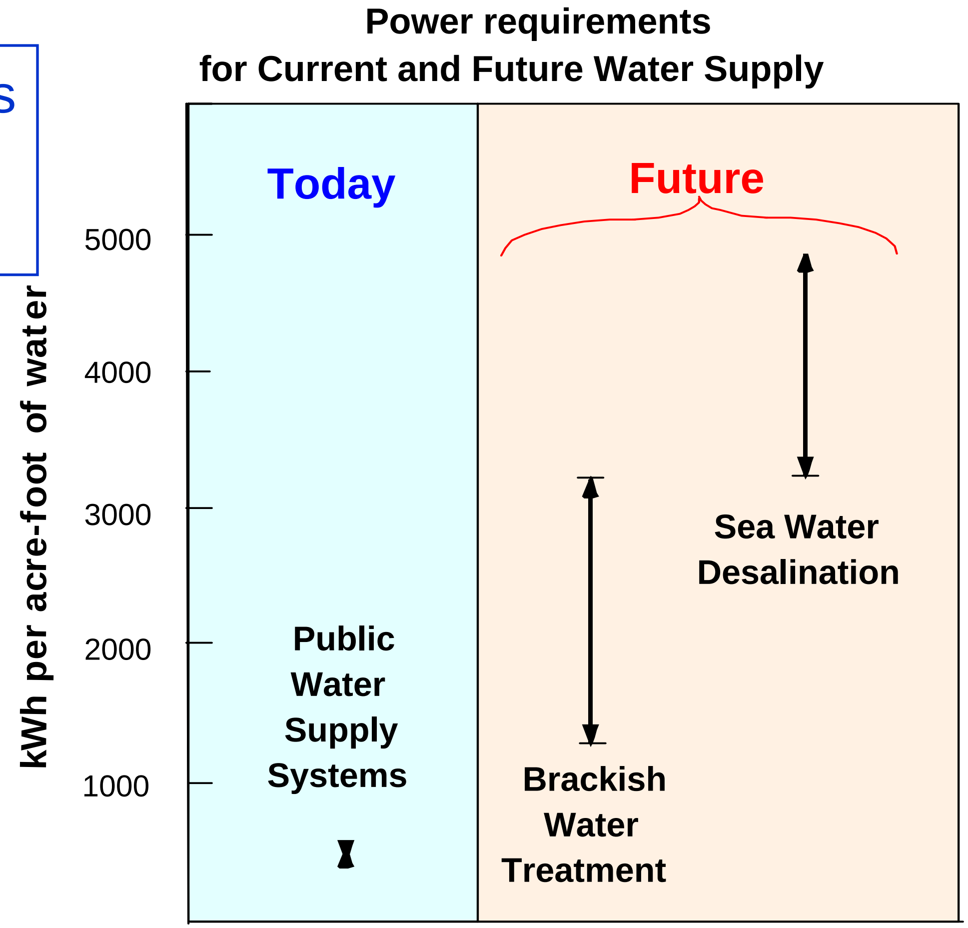
US Energy Sustainability

ENERGY and WATER

Water requires energy for pumping, treating and delivery

Water/Wastewater industry requires 3 Percent of Annual U.S. Electricity Generation



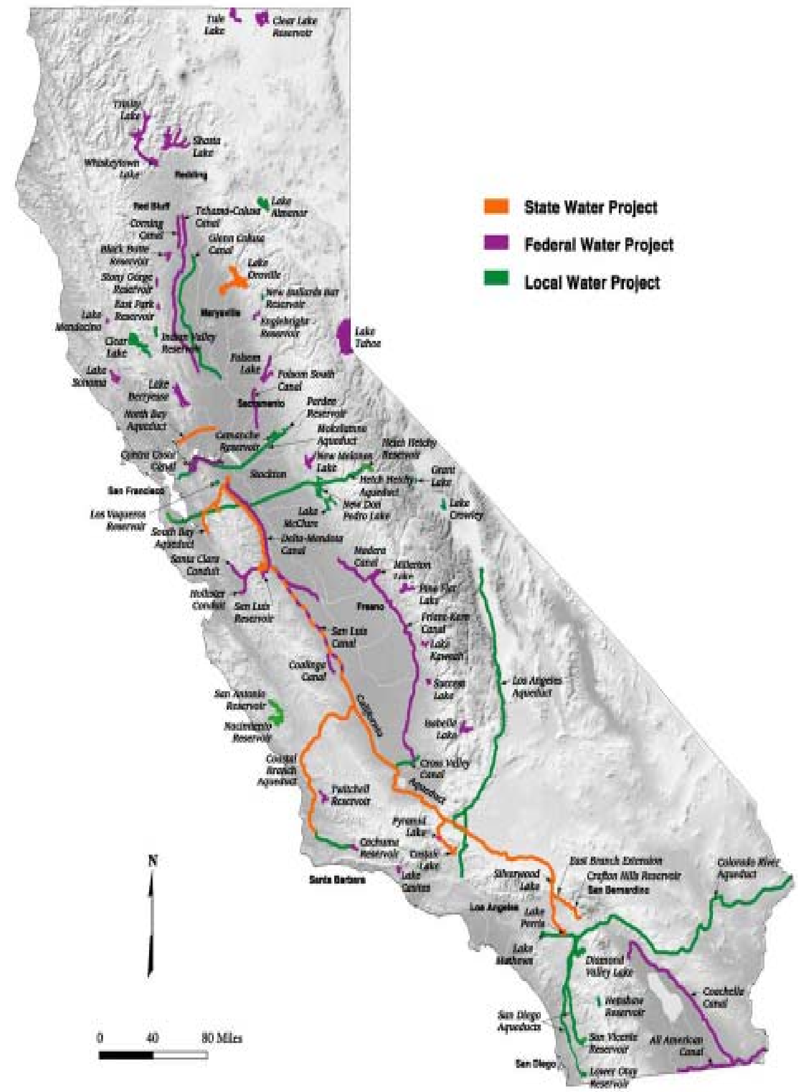


Future water treatment is expected to require more energy than today

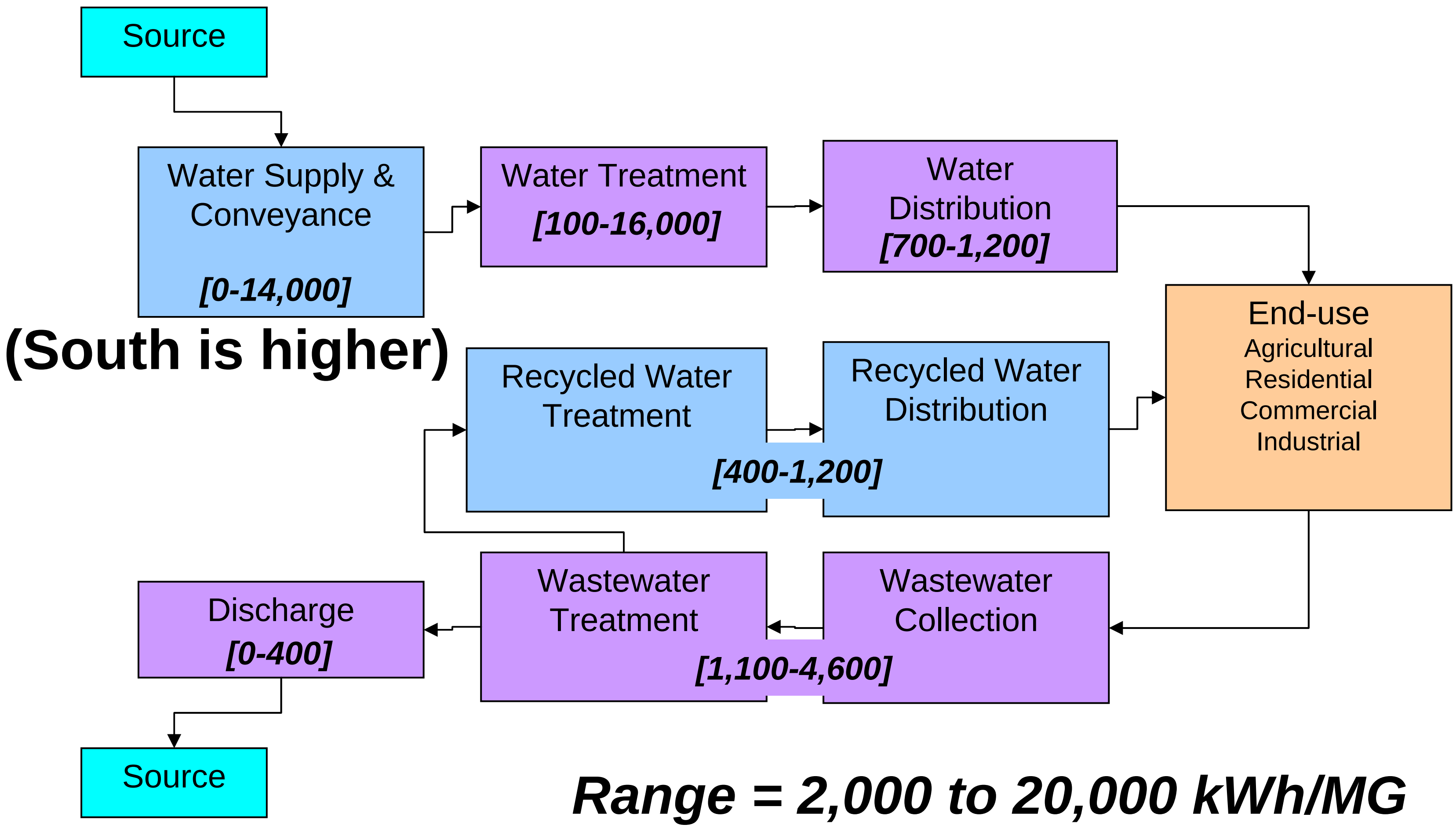
California- Water Overview

- **2/3 of Precipitation in North**
- **2/3 Demand in the South**
- **Water Demand: *43 maf***
  - ***—9 maf Urban***
  - ***—34 maf Agricultural***
- **Energy Use:**

  48,000 GWh; 4,300 MTh
- **Population by 2030: *48 million***
- **2030 Water Demand: *43-50 maf***



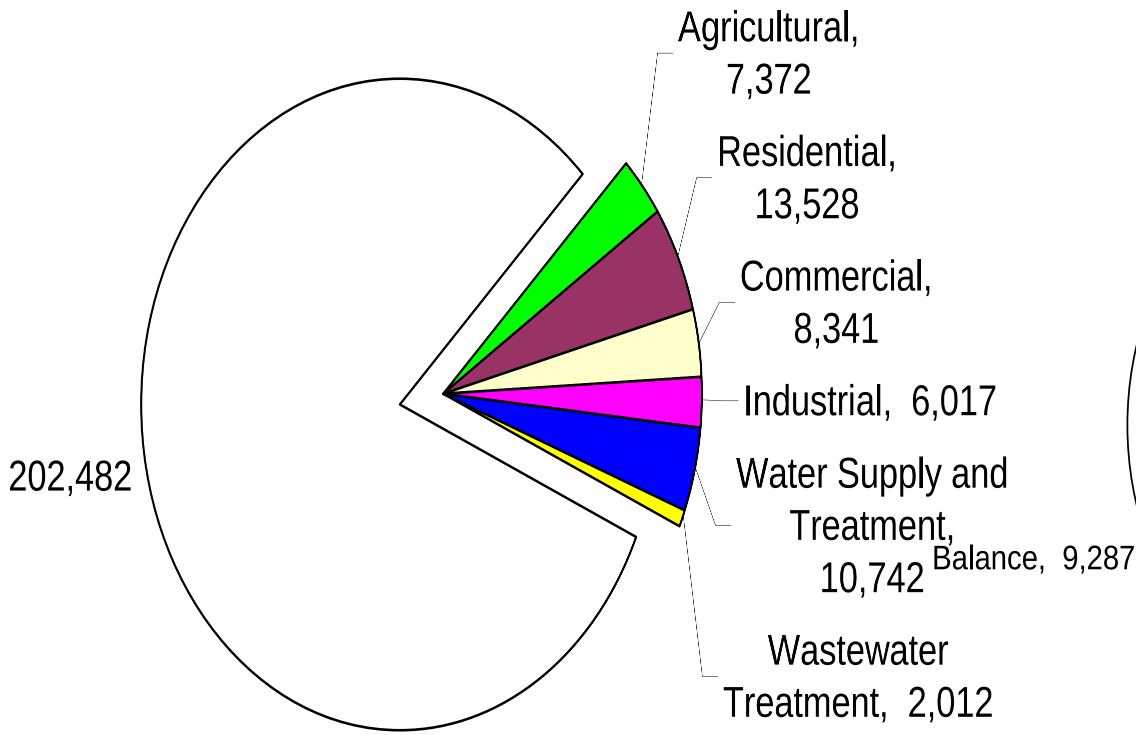
Water Use Cycle Energy Intensities (kWh/MG)

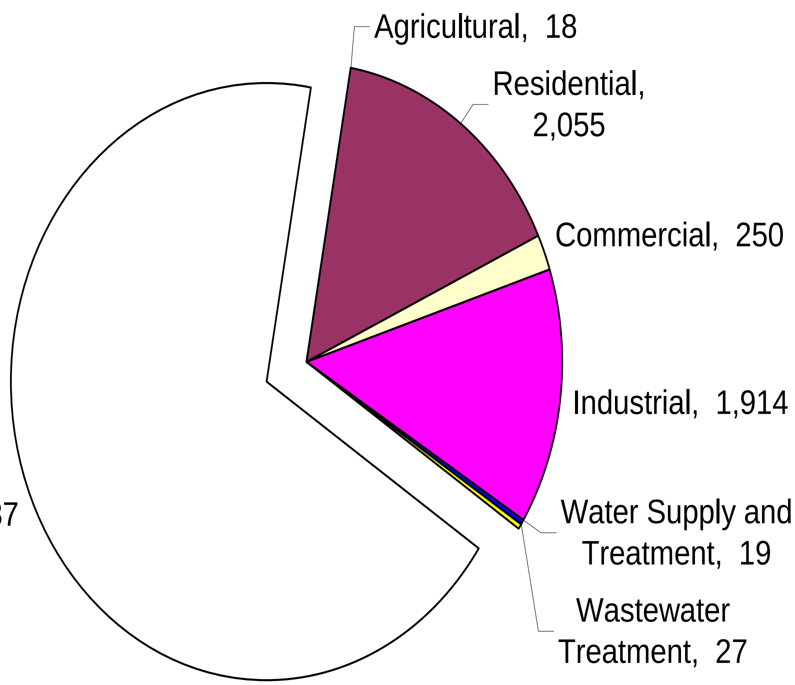


Range = 2,000 to 20,000 kWh/MG

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Energy Demand for California's Water System in 2001





Total Electricity Demand in 2001 = 250,454 GWh; Natural Gas 13,571 therms

Water Related Electricity 19%; Natural Gas 32%

LBNL Water Energy Technology Team

(Earth Sciences, Environmental Energy Technologies, Computational Research)

- **Hydrology, Ecology, Hydrochemistry & Hydroclimate**
  - —Hydrologists
  - —Climate & Groundwater Modelers
  - —Water Quality Experts (Chemistry & Microbiology)
  - —Water & Wastewater Treatment Researchers
  - —Well Testing & Watershed Characterization
- **Water and Energy Technology and Analysis**
  - —Economists (Life Cycle Costs, Regional/National Impacts)
  - —Water and Energy Efficiency Technology
  - —Market and Policy Researchers
- **Simulation Modeling**

LBNL Water Research Structure

To achieve sustainability through efficient technologies and integrated management of water and energy resources

- **Water Availability**
  - **Global & Regional Climate Monitoring & Modeling**
- **Water Quality**
  - **Watershed Level Water Quality Management**
- **Water and Energy Conservation & Use Efficiency**
  - **Water & Energy Data, Efficient Technologies, and Analysis**
  - **Technologies + policies + practices make a difference**
- **Air Quality**
  - **Atmospheric processes; Technology, modeling & climate change studies**
- **Water Vulnerability & Security**
  - **Modeling, Impact Assessment & Technology Development**