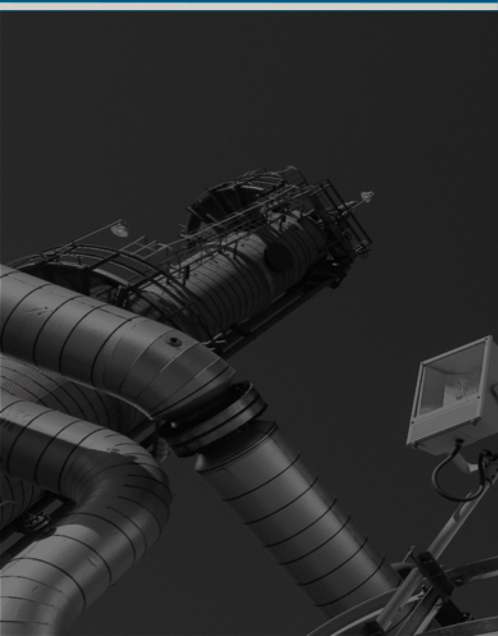



VALERO

Water Reuse/Recycle…What does it mean for Refiners?

Industrial Water Use and Reuse Workshop

April 30 – May 2, 2013




Safe Harbor Statement

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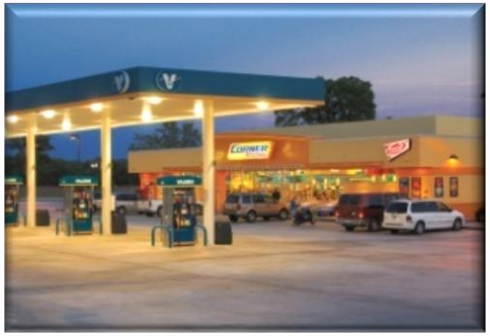
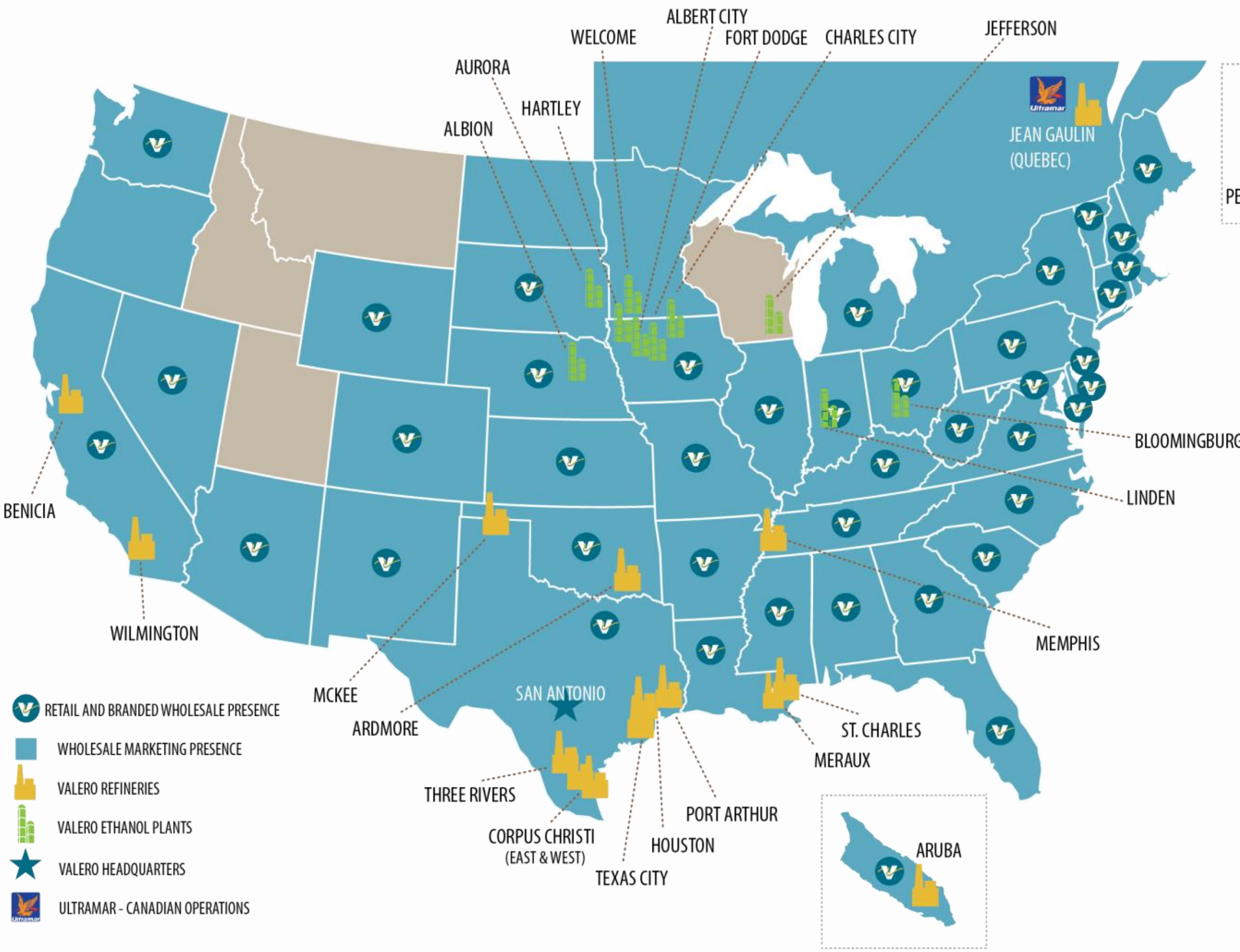
Valero Energy Overview

- **World's largest independent refiner**
  - **16 refineries**
  - **3 million barrels per day (BPD) of capacity, with average capacity of 190,000 BPD (187,000 BPD without Aruba)**
- **Approximately 7,300 branded marketing sites**
- **One of the largest renewable fuels companies**
  - **10 efficient corn ethanol plants with total of 1.2 billion gallons/year (72,000 BPD) of nameplate production capacity**
    - **All plants located in resource-advantaged U.S. corn belt**
  - **50 MW wind farm in Texas**
  - **Diamond Green Diesel JV under construction (renewable diesel from waste cooking oil and animal fat)**
    - **10,000 BPD capacity, 50% to Valero**
  - **Portfolio of investments in next-generation fuels**
- **Approximately 10,500 employees**



Valero's Geographically Diverse Operations



Shutdown in March 2012
235,000 bpd capacity Nelson Index of 8

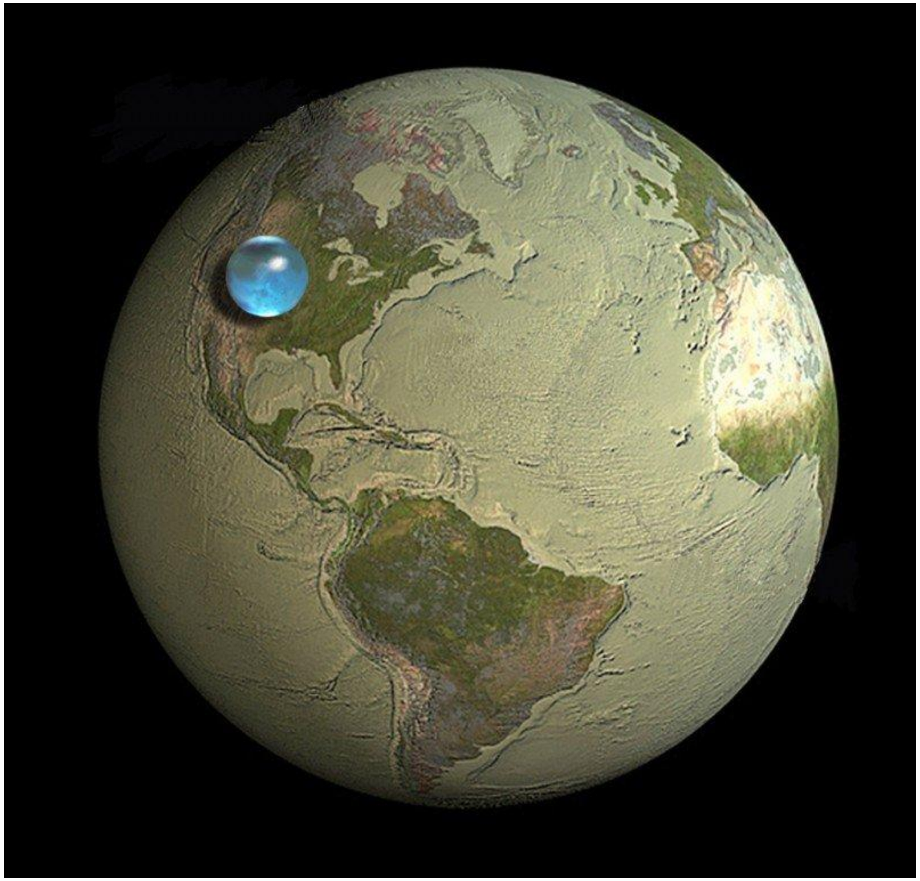
Refinery	Capacities (000 bpd) Total Throug h-put	Crud e Oil	Nelso n Index
Corpus Christi	325	205	20.6
Houston	160	90	15.1
Meraux	135	135	10.2
Port Arthur	310	290	12.7
St. Charles	270	190	15.2
Texas City	245	225	11.1
Three Rivers	100	95	12.4
Gulf Coast	**1,545**	**1,230**	**14.0**
Ardmore	90	86	12.0
McKee	170	168	9.5
Memphis	195	180	7.5
Mid-Con	**455**	**434**	**9.2**
Pembroke	270	220	11.8
Quebec City	235	230	7.7
North Atlantic	**505**	**450**	**9.7**
Benicia	170	145	15.0
Wilmington	135	85	15.8
West Coast	**305**	**230**	**15.3**
Total or Avg.	**2,810**	**2,344**	**12.4**

Demand on Limited Water Resources is Growing

So, How Much Water is on Earth? Here is How We Think of Water on Earth

Demand on Limited Water Resources is Growing

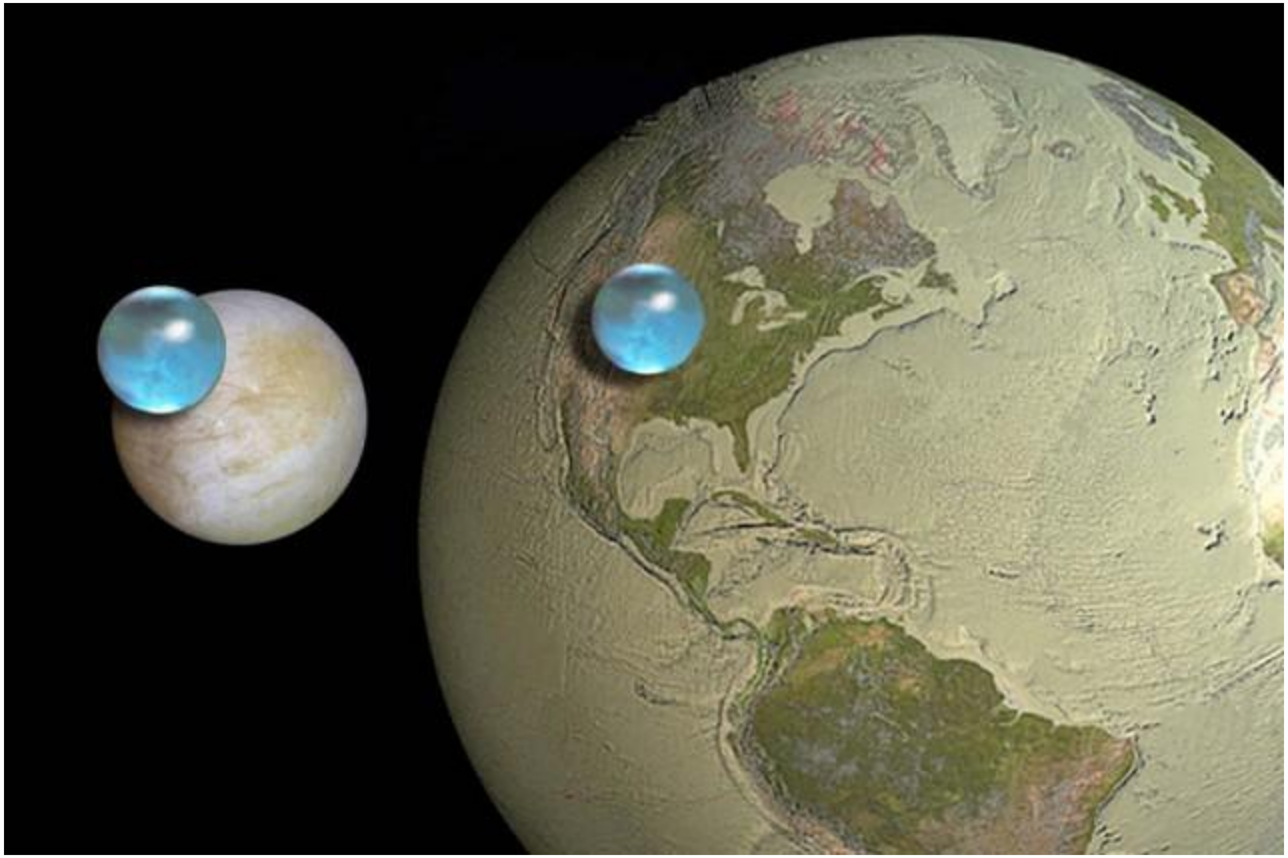
Here is a Different View of the Water on Earth?



- The blue sphere sitting on the United States, reaching from Salt Lake City, UT to Topeka, KS has a diameter of about 860 miles, with a volume of about 332,500,000 cubic miles

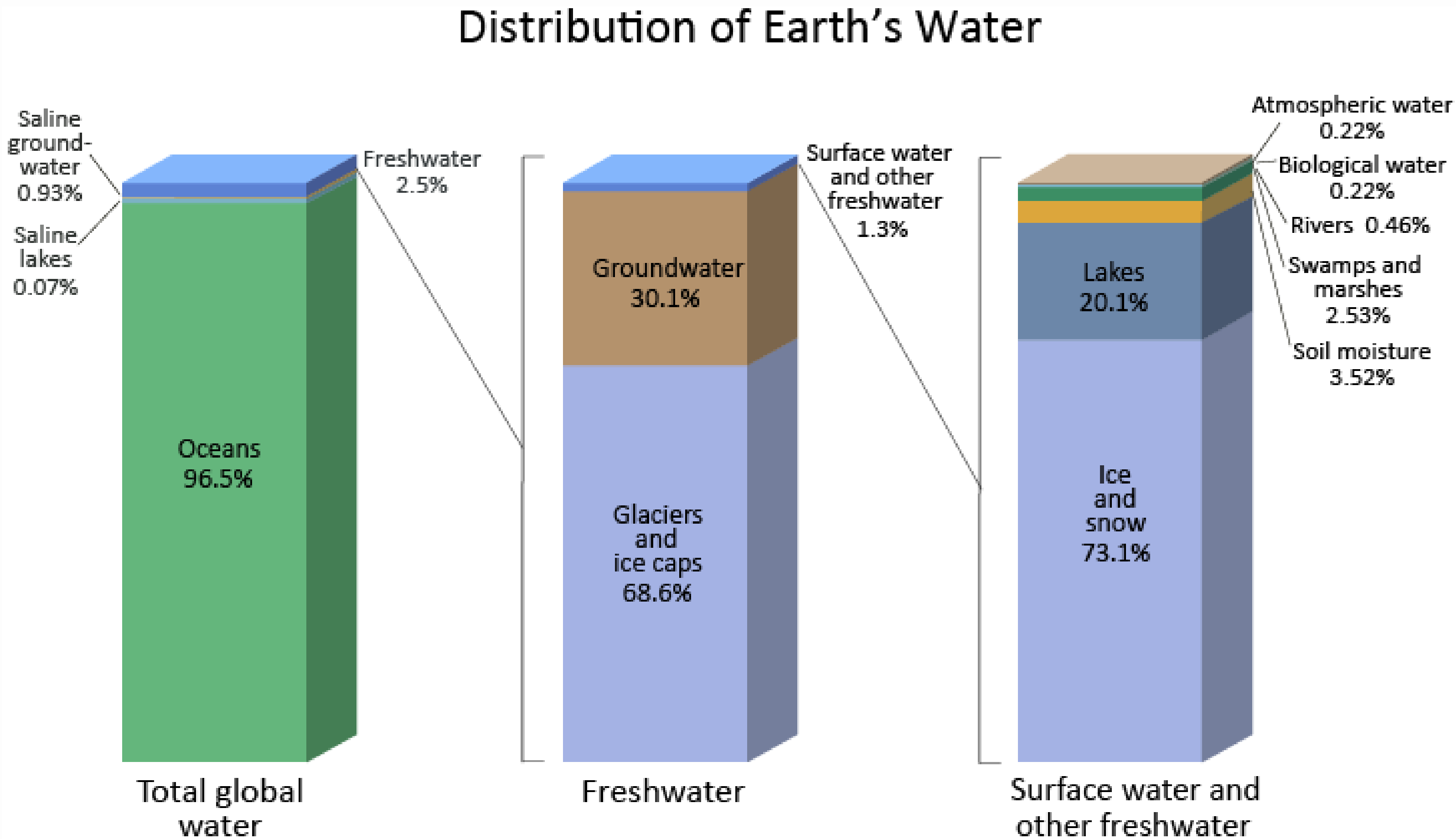
Demand on Limited Water Resources is Growing

How Much Water is this in Context of our Solar System?



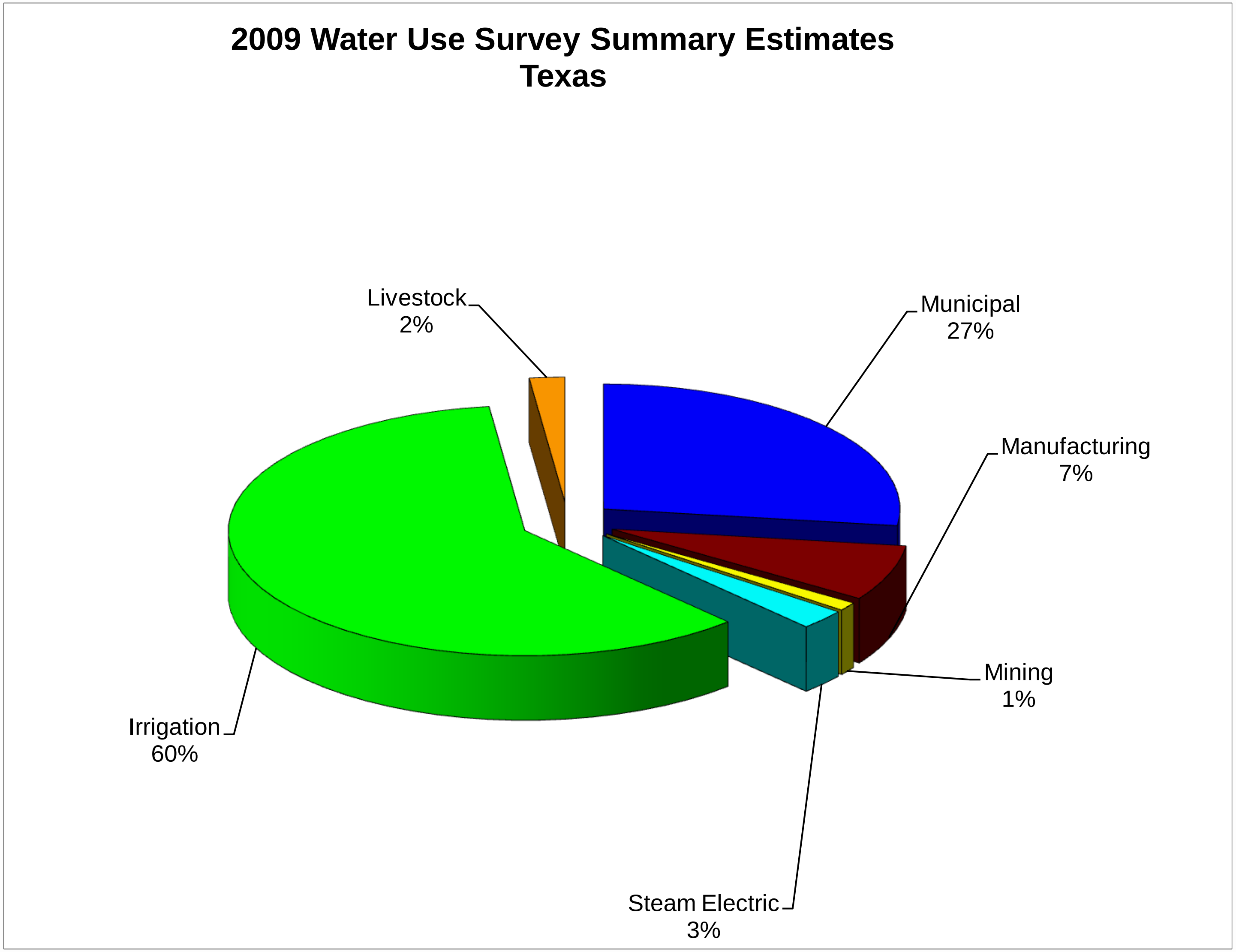
- This is a comparison of the water on Jupiter's moon Europa vs. the water on Earth – a very striking comparison.

Distribution of Earth's Water



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

Texas Water Use Survey Estimates



Refinery Water Use

- Depending on size and complexity, refinery water use varies from 1,400 gpm to 12,000 gpm
  - Majority of water from surface water supplies (reservoirs and rivers)
  - About a third of our refineries purchase clarified water from municipalities
  - Two refineries obtain water from wells that we own and operate
- Water efficiency varies from 0.4 bbl water per bbl of crude to 1.2 bbl of water per bbl of crude
  - Depends on refinery complexity and on-site hydrogen generation from steam methane reformers (water required for Rx)
  - Refineries in water rich areas consume more due to more use of steam drivers and cooling water circuits
  - Refineries in arid regions consume less with more electric drives and use of air fin fan cooling
- 30%-50% of the water is treated to make BFW make up with the remainder used for cooling tower make up and utility/wash down needs

Refinery Water Reuse and Conservation

- Good, detailed water balance is critical to any water conservation strategy
- Typical water reuse and conservation in place today includes:
  - Condensate recovery
  - Stripped sour water used for desalter make up and process wash water
  - RO reject for scrubber or fire water system make up
  - Waste water effluent for fire water system make up
  - Maximize cooling tower cycles
  - Blowdown control on boilers and cooling towers
- Most significant water loss is from evaporative cooling towers
- Typically 50%-65% of water supply is discharged as treated effluent

Other Water Reuse and Conservation Opportunities

- Opportunities exist to reduce cooling water needs and therefore reduce evaporative losses
  - Replace condensing turbines with electric motor drivers (currently implementing projects at several sites based on energy efficiency benefit)
  - Replace cooling water heat exchangers with fan fan coolers ($$$)
- Improving BFW treatment efficiency is another option
  - 2nd pass on RO reject to recover additional BFW make up
  - Install RO ahead of demin units to reduce regeneration cycles (in place at several refineries)
- Other opportunities are available but are often not cost effective:
  - Replace vacuum steam jets with electric vacuum pumps ($$$)
  - Use effluent for seal water ($$$ piping costs)
  - Tank farm and tracing condensate recovery ($$$ piping costs)

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Alternative Water Supplies

- Treat and reuse effluent
  - At best, you could recover 60%-70% of effluent and return as raw water to the refinery or for cooling tower make up
  - Potentially provide 30%-40% of the total refinery water supply
- For coastal refineries, desalination is an option
- For refineries in urban areas, use of municipal treatment plant effluent is an option
  - Currently done at several US refineries

Water Reuse Challenges

- Economic projects are difficult to justify as long as current supply is available
- Typical cost to purchase and/or make clarified water is $1.50-$3.00 per 1,000 gallons
  - In arid regions, this cost may be as high as $6.00 per 1,000 gallons
- The cost to provide clarified water is typically less than 10% of the purchased energy cost to operate the refinery
- Recent evaluation completed at an arid refinery location (very low water usage) identified 14 potential conservation opportunities
  - Based on 10 year amortization, the recovered water cost ranged from $2 - $300 per 1,000 gallons
  - 4 of the projects were estimated at < $6/Mgal (cost of raw water supply) and are being pursued
    - 175 gpm of water savings represents 6% of total water demand

Alternative Water Supply Challenges

- Use of treated municipal effluent water is feasible if piping costs can be minimized (close location)
- Cost to own and operate either a coastal desalination facility or effluent recovery system sized for a single refinery is estimated at $8.00 - $12.00 per 1,000 gallons
  - Estimate assumes brine may be discharged, deep well injection not required
- To obtain economies of scale, an industrial community based facility is needed
- Who wants to be first in?

Conclusions

- With continued growth, competition will increase for limited fresh water supplies
- Optimizing water usage with operational and low capital improvements can reduce consumption by 5-15%
- Effluent treatment/reuse and desalination of seawater are both very expensive (capital and operating expense)
- An industry-wide approach to optimize water across all the industrial water users is needed
  - Optimize how money is spent to reduce water demands to get the biggest bang for the buck
  - Can’t afford to proactively make the necessary large capital and operating investments if our competition is not doing the same
- The other concern is that eventually a water supply strategy may need to be included as part of the project process for a new unit, plant or expansion
  - So, here also, early movement on reducing water use could put you at a disadvantage