Water Is Key to Sustainability of Energy Production

Argonne Looks at Regional Implications of Life Cycle Water Consumption

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The Issue

With substantial amounts of water needed to produce energy feedstocks and fuels, water management has become a major concern for both agriculture practices and energy production processes. Biofuel feedstocks require water for growth and conversion; petroleum crude oil needs water for drilling, extraction, and processing; electricity generation requires water for cooling. Additionally, projects from multiple energy sectors increase water demand at the regional level.

Argonne's Research

Argonne's work examines the growing issue of water use in energy production by characterizing current water consumption in:

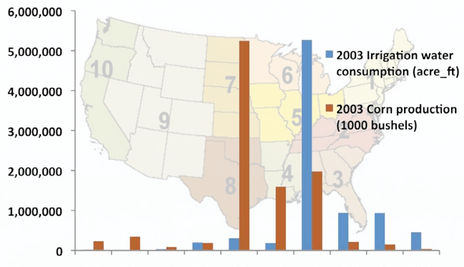
- Corn ethanol
- Switchgrass cellulosic ethanol
- Conventional petroleum gasoline from the U.S. and Saudi Arabia
- Non-conventional petroleum gasoline from Canadian oil sands
- Electricity generation from fossil and renewable sources

Water requirements and consumptions are evaluated for two major steps in energy production life cycle: feedstock production and feedstock conversion.

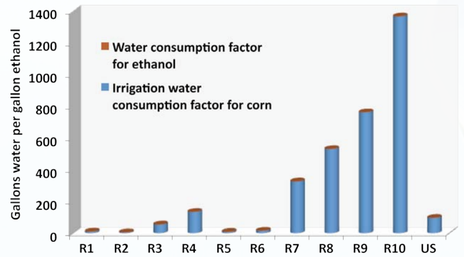
Scope and Approaches

- Estimate net water use (consumption)
  - Irrigation water, process water, produced water, cooling water
- Focus on representative regions that produce
  - 89% of corn and 95% of ethanol in the U.S.
  - 90% of onshore crude and 81% of refinery gasoline output in the U.S.
  - 100% of oil sands production in Canada
  - 52% of oil production in Saudi Arabia
  - 57% of total electric power in U.S.
- Consider technology share
  - Water use factor for each technology is synthesized by technology share to derive a weighted average
- Take into account regional variations and historic trends in water consumption for the selected fuels

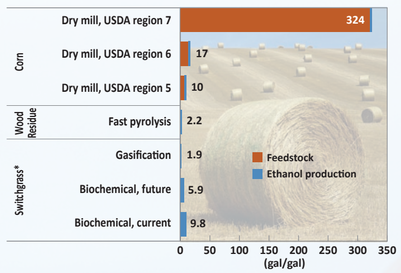
Biofuel – Substantial Regional Variations



Climate, soil, and other environmental conditions drive irrigation demand.



Water consumption factors across the U.S. (assuming corn produced from all regions is used to produce ethanol)

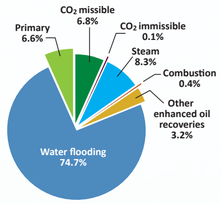


Water consumption factors for cellulosic ethanol varies with the production process

** non-irrigated switchgrass*

Petroleum – Well Geology and Recovery Technology Dependent

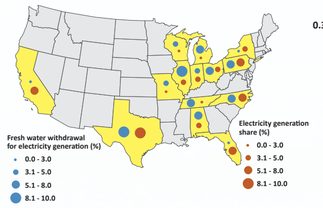
The Petroleum Administration for Defense Districts (PADD) for oil production facilities



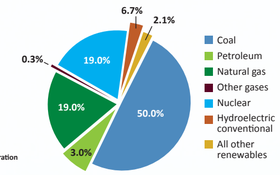
A breakdown of well injection water use for oil recovery technologies

Water consumption for the production of gasoline from conventional sources (U.S. and Saudi Arabia) and oil sands

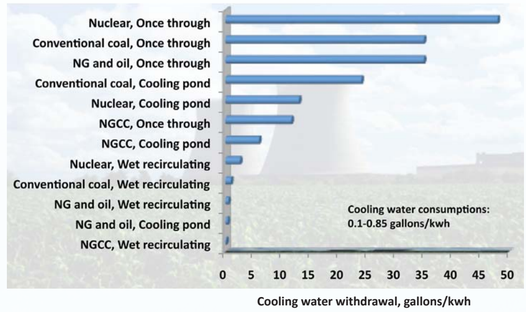
Electricity – Significant Water Withdrawal for Once-Through Cooling



Fourteen states produced 57% of the electricity in U.S. in 2000, using 69% of total fresh water withdrawal for power



A breakdown of electricity sources used in the U.S.



On weighted average, 17-22 gallons of cooling water withdrawn and 0.4-0.6 gallons consumed generate one kilowatt-hour of electricity for 83% of electricity production in the U.S.

Key Findings

- The amount of irrigation water consumed to grow biofuel feedstocks varies significantly from one region to another within the U.S.
- Water consumption for cellulosic biofuel production varies with processing technology, and a low irrigation requirement is one of the benefits of using perennial biomass crops
- Water consumption for the production of gasoline varies from 3-7 gal/gal, which is comparable to that of cellulosic ethanol
- Although the water consumption is small for electricity generation, a majority of the water is held in the cooling systems, and therefore not available for other uses
- Water consumed per mile driven in major life cycle steps (feedstock production and fuel production)
  - Corn ethanol: 0.6-21 gal/mile
  - Switchgrass or forest wood residue based-biofuel: 0.1-0.6 gal/mile
  - Conventional gasoline: 0.1-0.3 gal/mile
  - Oil sands gasoline: 0.1-0.3 gal/mile
- Multiple energy development projects for fuels and electricity in the U.S. will further strain water resources in the Southwest and West Coast where freshwater is scarce.

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