



Wind Energy and Water Resources Sustainability

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Wind Energy

Premise: The use of WIND as an energy source contributes significantly to water resources sustainability. Compared to other energy sources wind electric energy production has a negligible impact or non-impact to water resource uses, including water quantity, quality and the aquatic ecosystem.



Fuel Types for Electricity Generation

- Traditional
 - Coal
 - Oil
 - Nuclear Power
 - Natural Gas
- Renewable
 - Hydro-power
 - Solar
 - Biofuels (Plants)
 - Wind



Energy Jargon

- Energy production generally measured in Megawatt hours
- 1 Megawatt = 1000 Kilowatts=1M watts
- Average home uses about 150 Kilowatt hours /month
- 1 MW powers 600 homes

*National Magnetic Field Laboratory at FSU

<http://www.magnet.fsu.edu/education/tutorials/magnetminute/megawatt-transcript.html>



Power Generation: Sources of Effects/Impacts

- Resource Extraction
- Fuel Transportation
- Facility Construction
- Power Generation
- Transmission and Delivery
- Decommissioning



Water Resources Impacts

- Water Quantity
 - Consumptive/Non-Consumptive (related to cooling or extraction)
- Water Quality
 - Thermal, Chemical impacts
- Aquatic Ecosystem
- Terrestrial Ecosystem



Traditional Steam Electric Generation

- Half of all steam electric generating stations in the US use “once through” cooling systems that condense steam generated to drive turbines
- In NY State alone, 17 Billion Gal/day are used to cool steam electric generating facilities
- In Nevada power plants withdrew 14 Billion Gal/day in 2000
- In the US, 50 percent of water withdrawn from rivers and lakes goes to energy production.



Volume

- Flow through a traditional 1000 MW power plant can be 700,000 to 1,000,000 gal/min, with consumptive losses of 11,000 gal/min
- Closed cycle systems-flow is 5-10% of above, and losses are 80% of what is taken in



Impacts to Water Resources: Quality

Traditional:

Heat Dissipation System:

Biocidal Chemicals (fouling)

Thermal

Impacts to organisms

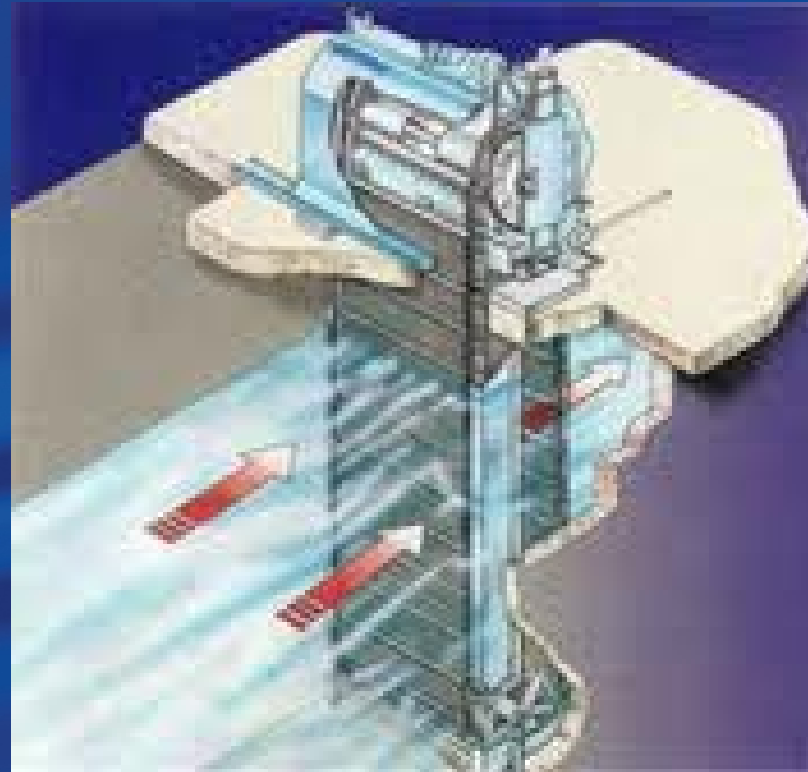
Associated eutrophication

Wastewater/Stormwater



Impacts to Water Resources: Aquatic Ecosystem

Impingement & Entrainment (316b)



Power Generating Source: HYDRO

- Hydroelectric-Quantity
 - Losses: Minimal in generation
 - Non-contact water use
 - Impoundment Creation
 - Evaporative Water Losses
- Hydroelectric-Quality
- Hydroelectric-Ecosystem



Power Generating Source Type: Hydroelectric

- **Hydroelectric** power plants (with impoundments) evaporated 18 gal(68 L) of fresh water per kWh produced.
- The final result for typical **thermoelectric** power plants was 0.47 gal (1.8 L) of fresh water evaporated per kWh of end-use electricity.



SHORELINE IMPACTS-Hydro



BioFuels

- Ethanol-Corn (Starch/Sugar)
- Ethanol –Cellulosic Crops (switchgrass)
- BioDiesel-Soy Beans, Algae



Consumptive Uses: Biofuels

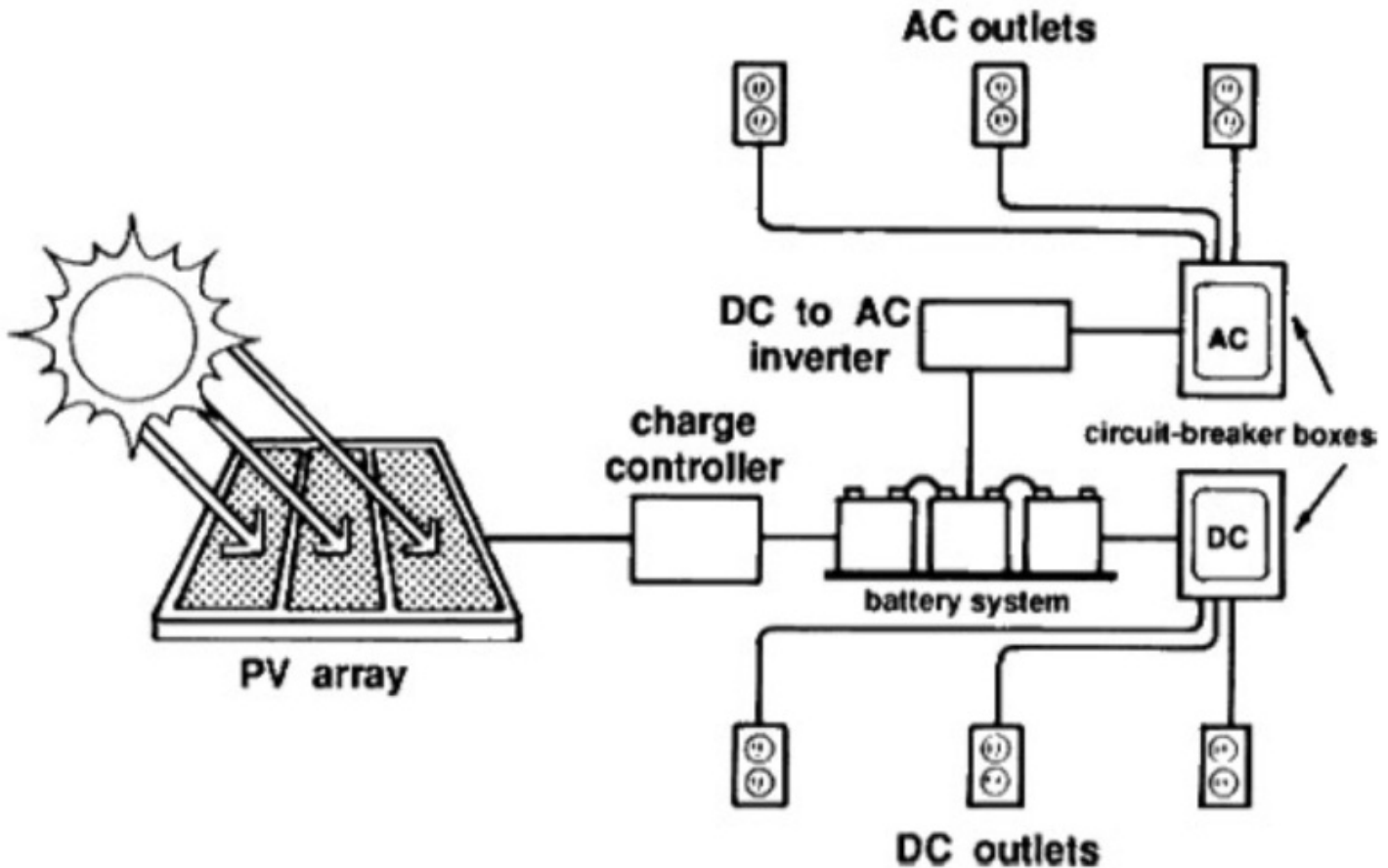
- Irrigation to water crops
 - Water withdrawals
 - Evaporative losses
- Processing (distillation)
- Cooling (evaporation)

2-6 gallons water used/gallon produced*

1 gallon of ethanol = 84,400 BTUs = 24.7 kWh (1 quart/kWh) or 250 gallons/mWh

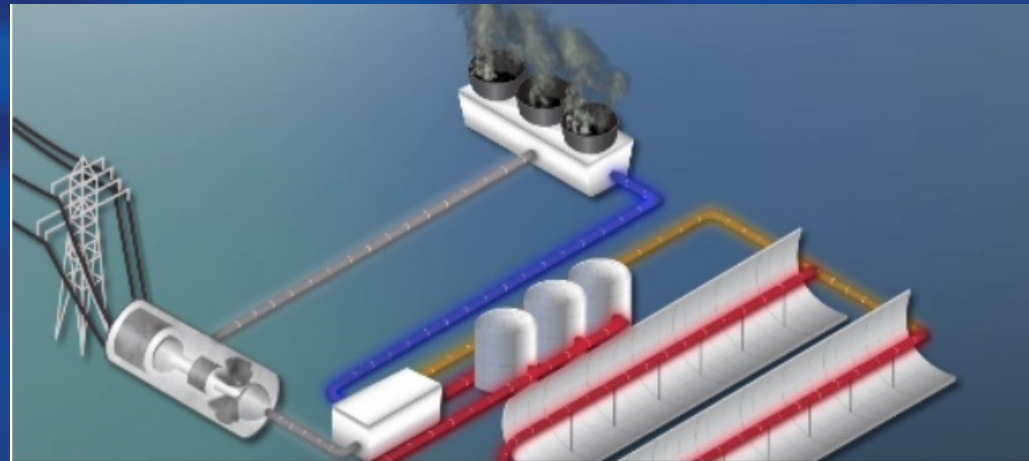


SOLAR PV



Concentrated Solar

- Solar energy to produce steam



And the steam is also cooled, condensed and recycled again and again.

www.nrel.gov



WIND





Rotor

Nacelle
(Turbine housing)

Tower

Foundation

(c)www.solarpowerwindenergy.org

For more information:

<http://www.windmission.dk/workshop/BonusTurbine.pdf>

Energy Production: Wind

- End of 2008, **8500 mW** of Wind Energy produced in the US (2M typical homes*)
- End of 2010, **40,180 mW** of Wind Energy Production in the US
- End of Sept. 2011, **43,261mW****
- US Wind Power 20% of world's
- 1 wind turbine will supply 300-500 homes (depending on where it is)

*According to the Global Wind Energy Association website

** AWEA



WIND ENERGY IN THE UNITED STATES

U.S. Wind Resource Potential,
Onshore (Source: NREL):

10,400,000 MW

U.S. Wind Resource Potential,
Offshore (Source: NREL):

4,150,000 MW

Top 5 States with Wind Power Capacity
Installed, 2010:

- | | |
|---------------|------------------|
| 1. Texas | 10,135 MW |
| 2. Iowa | 3,675 MW |
| 3. California | 3,179 MW |
| 4. Minnesota | 2,432 MW |
| 5. Washington | 2,356 MW |



Wind Impacts

- Birds/Bats
- Management is key
 - Siting and operation
 - Turn wind turbines off during migration/at night
 - Understand wildlife behavior and manage landscape to attract wildlife elsewhere
- Small terrestrial/aquatic impacts from construction
- Aesthetics



Power Generating Source Types

TRADITIONAL STEAM ELECTRIC Closed cycle cooling



Water Withdrawal/ Consumptive Loss	"Non-Contact" water use	Thermal Discharge	Chemical Discharge	Aquatic Ecosystem Impacts	Terrestrial Ecosystem Impacts
Comparative- ly small/ Fairly Large	Small	Limited	YES	Limited impingement /entrainment, thermal	Habitat Loss

Power Generating Source Types

HYDRO-ELECTRIC

Consumptive Water Use	"Non-Contact" water use	Thermal Discharge	Chemical Discharge	Aquatic Ecosystem Impacts	Terrestrial Ecosystem Impacts
Significant?	Impoundment Creation	None	Small	Fish passage, water quality and habitat degradation	Habitat Loss



RENEWABLES

BIOFUELS



Consumptive Water Use	Non-Contact Water Use	Thermal Discharge	Chemical Discharge	Aquatic Ecosystem Impacts	Terrestrial Ecological Impacts
LARGE	NA	NA	YES	Habitat loss and aquatic degradation	Large Loss

RENEWABLES

SOLAR Photo Voltaic



Consumptive Water Use	Non-Contact Water Use	Thermal Discharge	Chemical Discharge	Aquatic Ecosystem Impacts	Terrestrial Ecological Impacts
NONE	NONE	NONE	NONE	Possible habitat loss	Large Loss

RENEWABLES

WIND



Consumptive Water Use	Non-Contact Water Use	Thermal Discharge	Chemical Discharge	Aquatic Ecosystem Impacts	Terrestrial Ecological Impacts
None	None	None	None	Limited	Some

VALUE OF THE GRID

- Wind alone can't sufficiently supply the energy needs of the US
- Wind can contribute to filling in the "gaps" during important aquatic organism life stages
- Multiple energy sources and wise management of the nationwide power grid may be the answer to limiting impacts and maximizing efficiency

and security



www.bp.com



Solar

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From energy diversity comes energy security.

Oil - Natural gas - Wind - Solar - Biofuels - Efficiency



American Wind Energy
Association www.awea.org
National Renewable Energy
Laboratory www.nrel.gov



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