Future projections of water demands for energy

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Subject of today’s discussion

Global Warming
Water resources increasingly stressed

Rise of the middle class
...all wanting to consume like Americans, with resource implications!

Population growth

Between now and 2020, there will be another 1 billion people in the world. If Tom gives each of them a 60W light bulb, it will require about 20 new 500-MW coal-burning power plants, just so they can turn on their light bulb. That requires about 160 billion gallons/day (nearly 500 acre-ft) of water to produce. If I give them each a glass of water, it will require almost another 200 acre-ft*!

* >65 million gallons
Once-through cooling technologies have the highest impact on water withdrawals for electricity generation.

Water Withdrawal Factors (gal/MWh)

- Renewables
- Nuclear
- Natural Gas
- Coal

All possible technology-cooling system combinations

Source: Macknick et al., in development
Water consumption for electricity generation technologies

Differences result from both *generation* and *cooling* technologies

Water Consumption Factors (gal/MWh)

US DOE is supporting research in carbon capture

(Macknick et al, in prep)
Water intensity of transportation fuels is likely to increase

Water intensity of LDVs varies from 0.1 to > 60 gal/mile for consumption

The Regional Energy Deployment System (ReEDS) model offers the high geospatial granularity needed for renewable resource supplies.

356 wind/CSP resource regions
134 Power Control Areas (PCA)
17 annual time slices
23 2-yr time periods 2006-2050
Study assumptions

- Scenarios developed in support of a Programmatic Environmental Impact Statement (PEIS) focused on utility-scale solar energy development\(^1\).

- Current energy policy (currently formulated state RPS goals, no carbon policy, no national RPS)

- Available technologies:
  - Conventional: Coal (pulverized and IGCC), Gas-CC, Gas-CT, nuclear
  - Renewables: utility-PV, CSP, wind (onshore/offshore), bio, geo, hydro
  - Storage: Compressed air energy storage, pumped-hydro, batteries

- Technology costs from Black and Veatch, fuel projections from AEO 2010

- Regional resource limitations, exclusions based on land considerations (resource intensity, slope, protected lands, incompatible land use (e.g., wetlands, urban areas))

\(^1\) Information on the Programmatic Environmental Impact Statement (PEIS) can be found at http://solareis.anl.gov/eis/index.cfm
Scenario results

- ReEDS optimizes electric sector system cost every 2 years, using a 20-yr investment period

- Expands generation capacity and transmission capacity to ensure that regional demand and reliability requirements (planning and operating reserves) are met

- Water consumption factors for individual technologies are applied to results by PCA region

These results, from a single scenario, are illustrative of the potential evolution of the electricity sector.
The current situation: 2006 power sector water intensity

Water intensity in 2006 by PCA

Total water consumption for the power sector in 2006 by PCA

Source: Macknick et al., in development
Power sector water use decreases in scenario by 2050

Nationally, water intensity is reduced by 33%

Total generation has increased 38%; water consumption has declined 7%

Source: Macknick et al., in development
National trends in power sector water intensity: Changes 2006-2050

Water intensity change (%)

Water intensity is reduced by 33% nationally, some areas see increases
(especially in the southwest)

Water consumption change(%)

Water use declines by 7% overall, some areas see increases

Source: Macknick et al., in development
2050 scenario breakdowns by generation technology

**Electricity Generation**
- Wind
- Solar-CSP
- Solar-PV
- Biopower
- Geothermal
- Hydro
- Coal
- Gas
- Co-fire
- Nuclear

Generation is dominated by fossil generation (renewables represent a modest 25% of portfolio)

**Water Consumption**
- Wind
- Solar-CSP
- Solar-PV
- Biopower
- Geothermal
- Hydro
- Coal
- Gas
- Co-fire
- Nuclear

Renewables responsible for only ~10% of water consumption

Source: Macknick et al., in development
Biopower 2050: a local phenomenon, with relatively minor water implications

% Generation

Relatively low impact, except in NE, NW

% Power sector water consumed

Total water consumed

Source: Macknick et al., in development
CSP 2050: deployed primarily in the SW*

*CSP presentation by Jordan Macknick and Craig Turchi, Wednesday morning (Abstract 112)
CSP 2050: Cooling technology can affect water needs

CSP Percent of Total Generation

CSP using dry cooling can result in a relatively minor proportion of power sector water consumption overall

*See CSP presentation by Jordan Macknick and Craig Turchi, Wednesday morning (Abstract 112)

Source: Macknick et al., in development
Wind 2050: strong midwest focus*

Water requirements are negligible; opportunities exist for significant avoided water use, especially in the midwest.

*Note high concentrations over the Ogallala aquifer.

Source: Macknick et al., in development.
If 25% of coal plants implement carbon capture*, water consumption is expected to increase

At a penetration of 25%, carbon capture increases national water consumption by 18%

*using current technologies

Source: Macknick et al., in development
Concluding thoughts

- Scenario analyses such as these indicate how water demands by the power sector may evolve.
  - Refinements and specific studies can provide additional detail

- Technology choices make a difference
  - Examples: wet vs. dry cooling for CSP, CCS impacts

- Regional aspects are important.

- Critical next steps: linking results to water availability.
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