



# ENHANCEMENT OF THE ETSAP E-TECH DATABASE WITH WATER CONSUMPTION AND WITHDRAWAL DATA

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ETSAP WORKSHOP ON MODELLING THE WATER ENERGY NEXUS

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ECN

MINES ParisTech

FCT FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

# Overview of the project

- The ETSAP energy technology repository (ETechDS) had no information on the technologies' water consumption and withdrawal
- Objective: enhancing the ETechsDS with water consumption and withdrawal factors for different electricity generation technologies
- Duration: June 2016 until March 2017
- Deliverables:
  - Repository of water consumption and withdrawal data for electricity generation technologies (including characterisation by cooling technology)
  - Report on methodology and data sources
  - Updated ETechDS data sheets

# LITERATURE REVIEW AND INFORMATION SOURCES

Scientific publications, technical and sustainability reports for several electricity companies

(including European based companies and sources, since most existing published studies refer to data from the USA)

› many published sources cross-reference each other - most focus on work done by

NREL – National Renewable Energy Laboratory (Macknick, Newmark, Heath, & Hallett, 2011, 2012)

Own elaboration based on original data collected from USA companies by the USGS - U.S. Geological Survey and the U.S. Department of Energy's Energy Information Administration (EIA).

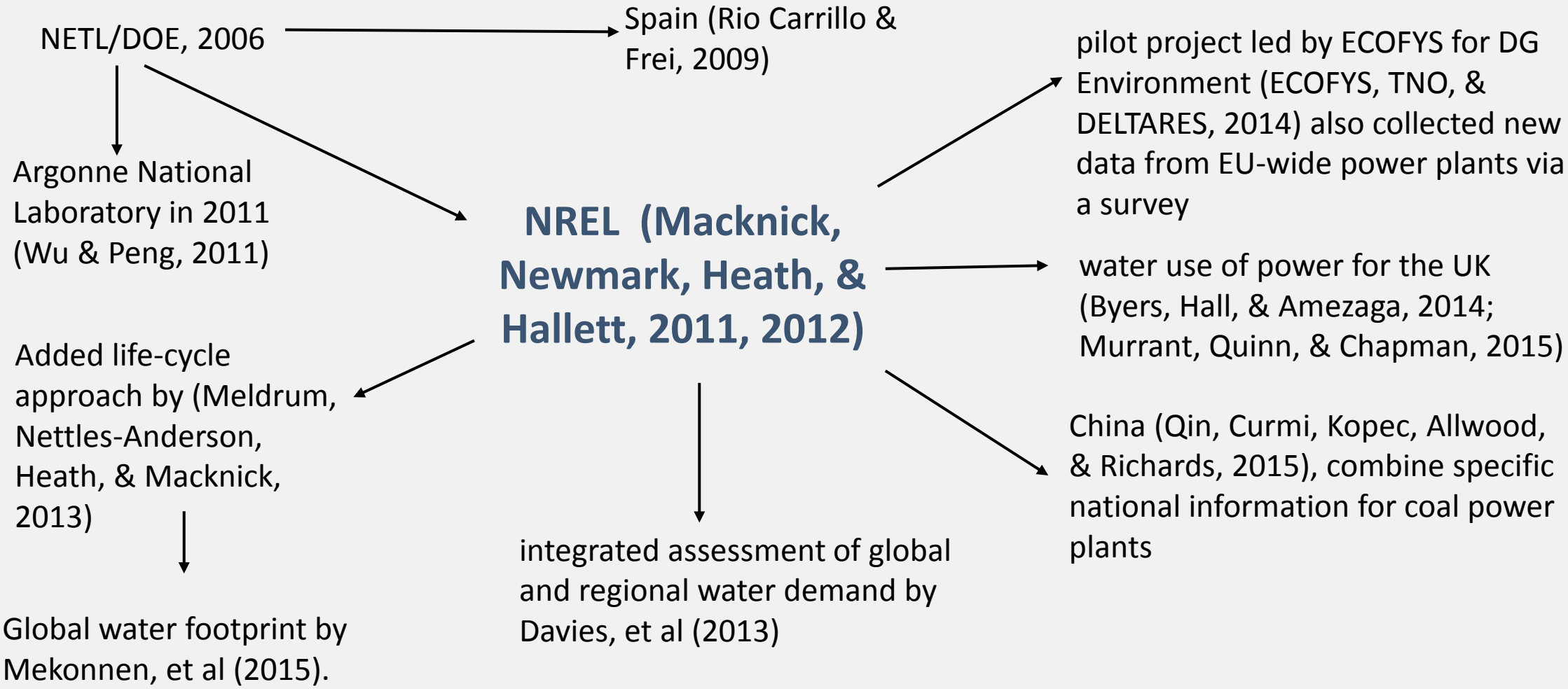
NETL – National Energy Technologies Laboratory starting in 2006 (NETL/DOE, 2006)

Own surveys made to USA power plants

# OTHER SOURCES

| | |
|---|---|
| **IPTS - Joint Research Centre (2016). Best Available Techniques (BAT) Reference Document for Large Combustion Plants** | *only indication on consumption for pollution abatement technologies (e.g. scrubbers)* |
| **WBCSD (2015). Global Water Tool for Power Utilities. World Business Council for Sustainable Development** | *very aggregated information for generic types of plants* |
| **JRC-IET (2014). ETRI 2014 - Energy Technology Reference Indicator projections for 2010-2050** | *not entirely clear what are data sources for all types of plants* |
| **UK Environment Agency (2013). Water use and electricity generation.** | *from study "Water demand for Carbon Capture and Storage (CCS), Parsons Brinkerhoff, November 2012"* |

# All roads lead to Macknick



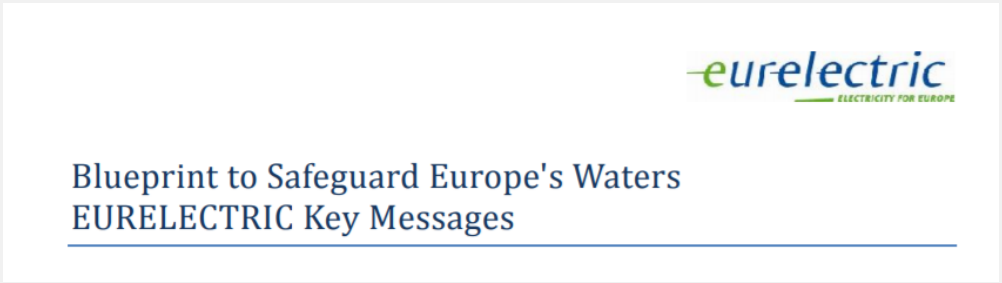
# Direct Information Requests

| Organisation | Contact Person | Outcome |
|---|---|---|
| **EDF power company, France** | Mounir Mecheri, Charles Bourdil, Arnaud Pitard, Mathieu Gennevieve | No data was made available<br>Information on water factors |
| **EDP power company, Portugal** | Patrícia Veloso | Data for Portuguese thermal power plants |
| **EON power company, Germany** | Volker Tuerk | No data was made available |
| **VGB, Germany** | Jean-François Lehougre | No data was made available |
| **ENDESA power company, Spain** | Nuno Ribeiro da Silva | No reply |
| **ENEL power company, Italy** | Generic e-mail | No reply |
| **Vattenfall power company, Sweden** | Frederik Engstrom | Highly detailed data for hydro power plants only |
| **UK Environment Agency** | Stuart Taylor | Supplied some of the support studies made by consultancy firm. |
| **IET of the JRC-EC, EU** | Johan Carlsson | No more updated information than the one available on-line (JRC-IET, 2014) |
| **EURELECTRIC, EU** | Marion Labatut | No data available<br>Contact to VGB in Germany |
| **NREL, USA** | Jordan Macknik | No more updated information than the one available on-line (Meldrum et al., 2013) |
| **IFP Energies Nouvelles, France** | Patrick Duval | No reply |
| **Fondazione Eni Enrico Mattei, Italy** | Michela Bevione | Using (Macknick et al., 2012) |

# Other Relevant data sources

- The EURELECTRIC Initiative - Blueprint for Europe's Waters: The Role of the Power Sector, that took place in 2012 bringing together experts from the power sector and the water policy fields. This resulted in some presentations but not on a systematisation of water consumption and withdrawal

  http://www.eurelectric.org/events/blueprint-for-europes-waters-the-role-of-the-power-sector/proceedings/




- Report of the UK Environment Agency from 2013 and updated in 2015 on “Water use and electricity generation”. The 2015 report was withdrawn from the website on 5th January 2017. However, it made use of several UK-specific sources and studies. Nonetheless, these studies are not available to the general public.

# E-Tech Enhancement

- Techno-economic parameters of the main cooling systems for power plants based on the thermodynamic Rankine cycle (steam-cycle-process):
  - nuclear
  - coal
  - gas
  - Oil (no)
  - biomass
  - concentrated solar power (CSP) systems (and wind and PV)

1. E01 - Coal Fired Power Plants
2. E02 - Gas Fired Power Plants
3. E03 - Nuclear Power
4. E05 - Biomass for Heat & Power
5. E10 - Concentrating Solar Power

- Cooling systems
  - Once-through cooling (O)
  - Cooling-pond (P)
  - Wet-cooling towers (T)
  - Dry cooling systems (D)

[8]

# WATER CONSUMPTION & WITHDRAWAL

**Table 4 – Water consumption and withdrawal factors for coal-fired power plants (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| Supercritical (incl. SCPC) | Tower | 458 – 594 | 582 – 669 |
| | Once-through | 64 – 124 | 22,551 – 22,611 |
| | Pond | 4 – 64 | 14,996 – 15,057 |
| Subcritical | Tower | 394 – 664 | 463 – 678 |
| | Once-through | 71 – 138 | 27,046 – 27,113 |
| | Pond | 737 - 804 | 17,859 – 17,927 |
| IGCC | Tower | 318 - 439 | 358 - 605 |

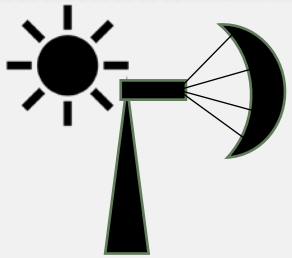


**Table 4–Water consumption and withdrawalfactors for CSP plants (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

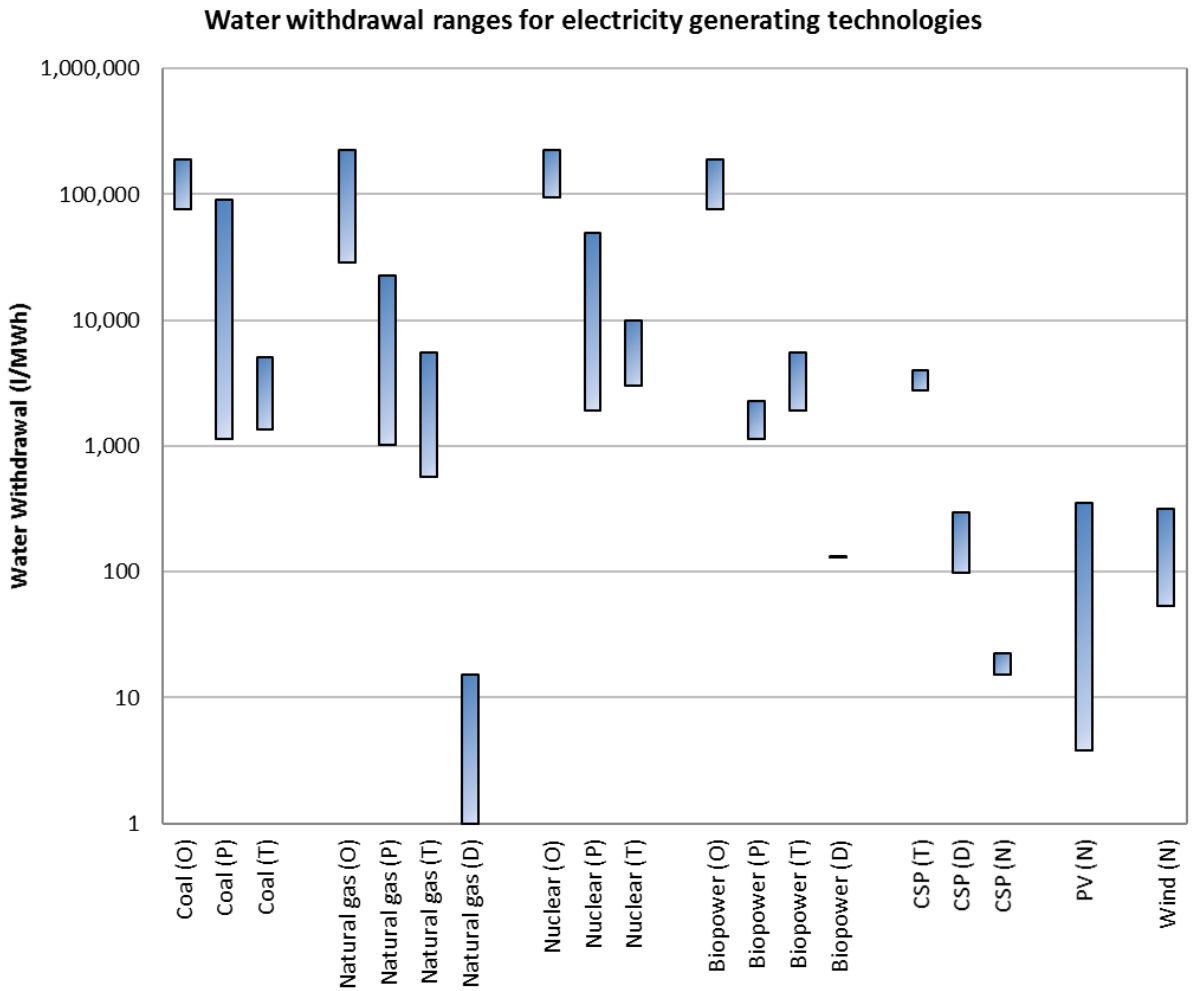
| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| CSP | Tower | 725-1,057 | 725-1,057 |
| | Dry | 26-79 | 26-79 |
| | None | 4-6 | 4-6 |

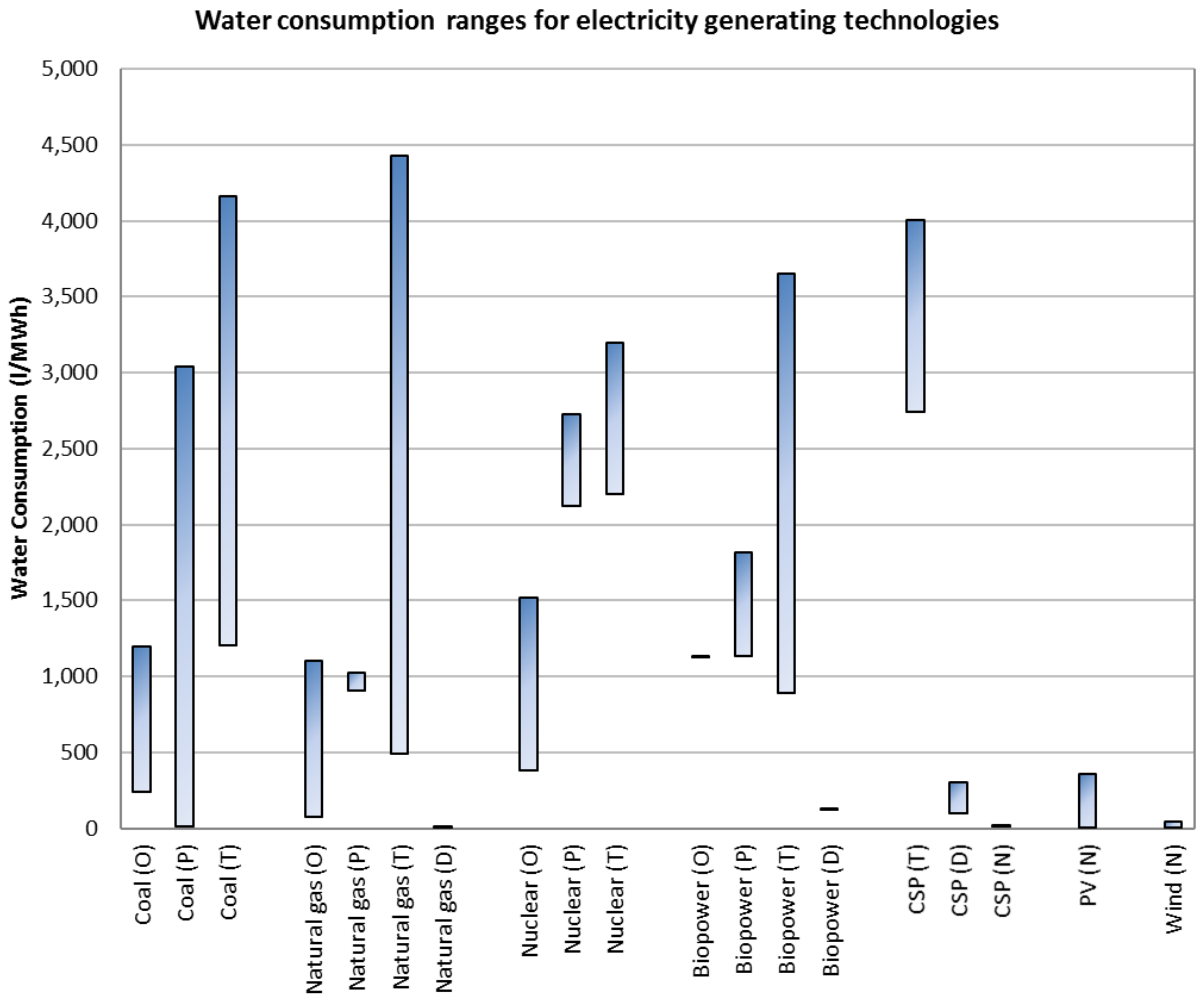
**Table 1 – Water consumption and withdrawal factors for nuclear power plants (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| Nuclear | Tower | 581-845 | 800-2,600 |
| | Pond | 560-720 | 500-13,000 |
| | Once-through | 100-400 | 25,000-60,000 |

[9]

# WATER CONSUMPTION & WITHDRAWAL (II)



# LIMITATIONS

- Limited data sources – mainly from one source (Macknick, 2012)
- Different factors can influence water consumption, apart from the type of cooling technology
  - local weather conditions (temperature of water, air, humidity in the air)
  - imposed environmental constraints (limit to water temperature rise)
  - seasonal constraints (limit to water extraction flow)
  - network constraints (need to vary the load of the power plants)
- Costs of cooling technologies not considered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# WATER CONSUMPTION & WITHDRAWAL

**Table 3 – Water consumption and withdrawal factors for power plants using biomass technologies (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| Biopower | Dry | 35 | - |
| | Pond | 300-480 | 300-600 |
| | Once-through | 300 | 20,000-50,000 |
| | Tower | 235-965 | 500-1460 |

**Table 1 – Water consumption and withdrawal factors for gas-fired power plants (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| OGCT | Tower | 662 – 1,170 | 950 – 1,460 |
| | Once-through | 95 – 291 | 10,000 – 60,000 |
| | Inlet | 80 – 600 | 100 – 750 |
| CCGT | Tower | 130 – 300 | 150 – 283 |
| | Once-through | 20 – 100 | 7,500 - 20,000 |
| | Pond | 240 – 240 | 5,950 – 5,950 |
| | Dry | 0 – 4 | 0 - 4 |

**Table 4 – Water consumption and withdrawal factors for coal-fired power plants (Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)**

| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
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| Supercritical (incl. SCPC) | Tower | 458 – 594 | 582 – 669 |
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| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| Nuclear | Tower | 581-845 | 800-2,600 |
| | Pond | 560-720 | 500-13,000 |
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| Plant type | Cooling system | Water consumption (gallons/MWh) | Water Withdrawal (gallons/MWh) |
|---|---|---|---|
| CSP | Tower | 725-1,057 | 725-1,057 |
| | Dry | 26-79 | 26-79 |
| | None | 4-6 | 4-6 |