



# ***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

Zurich, 14.12.2017



# OVERVIEW OF THE PROJECT

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- › 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

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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)

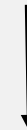
› many published sources cross-reference each other - most focus on work done by

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

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**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**

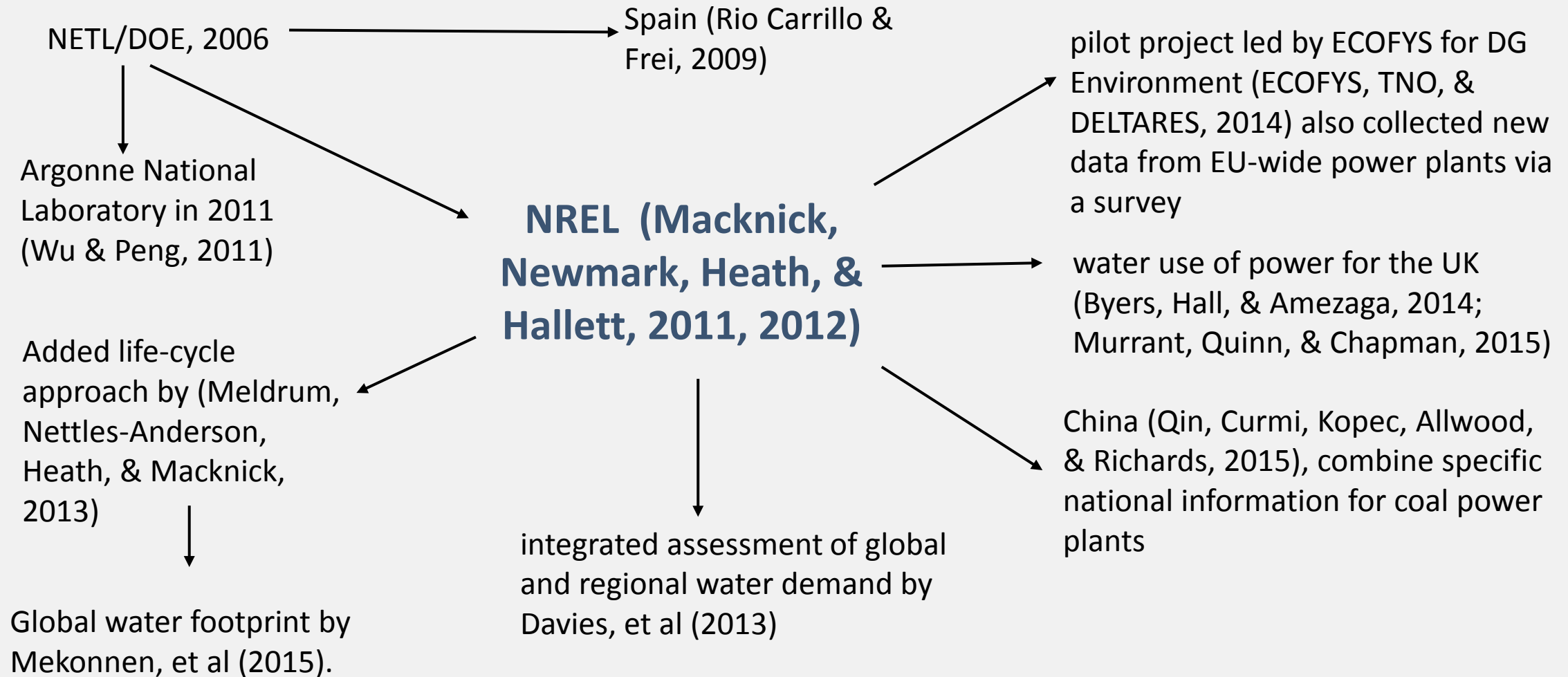
*not entirely clear what are data sources for all types of plants*

**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

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# DIRECT INFORMATION REQUESTS

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

# OTHER RELEVANT DATA SOURCES

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- 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.




Blueprint to Safeguard Europe's Waters  
EURELECTRIC Key Messages

# E-TECH ENHANCEMENT

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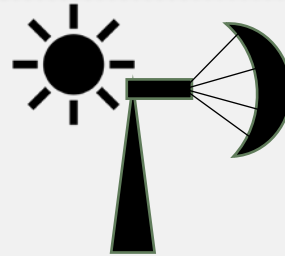
1. E01 - Coal Fired Power Plants
2. E02 - Gas Fired Power Plants
3. E03 - Nuclear Power
4. E05 - Biomass for Heat & Power
5. E10 - Concentrating Solar Power

› Cooling systems

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



# 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 withdrawal factors 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

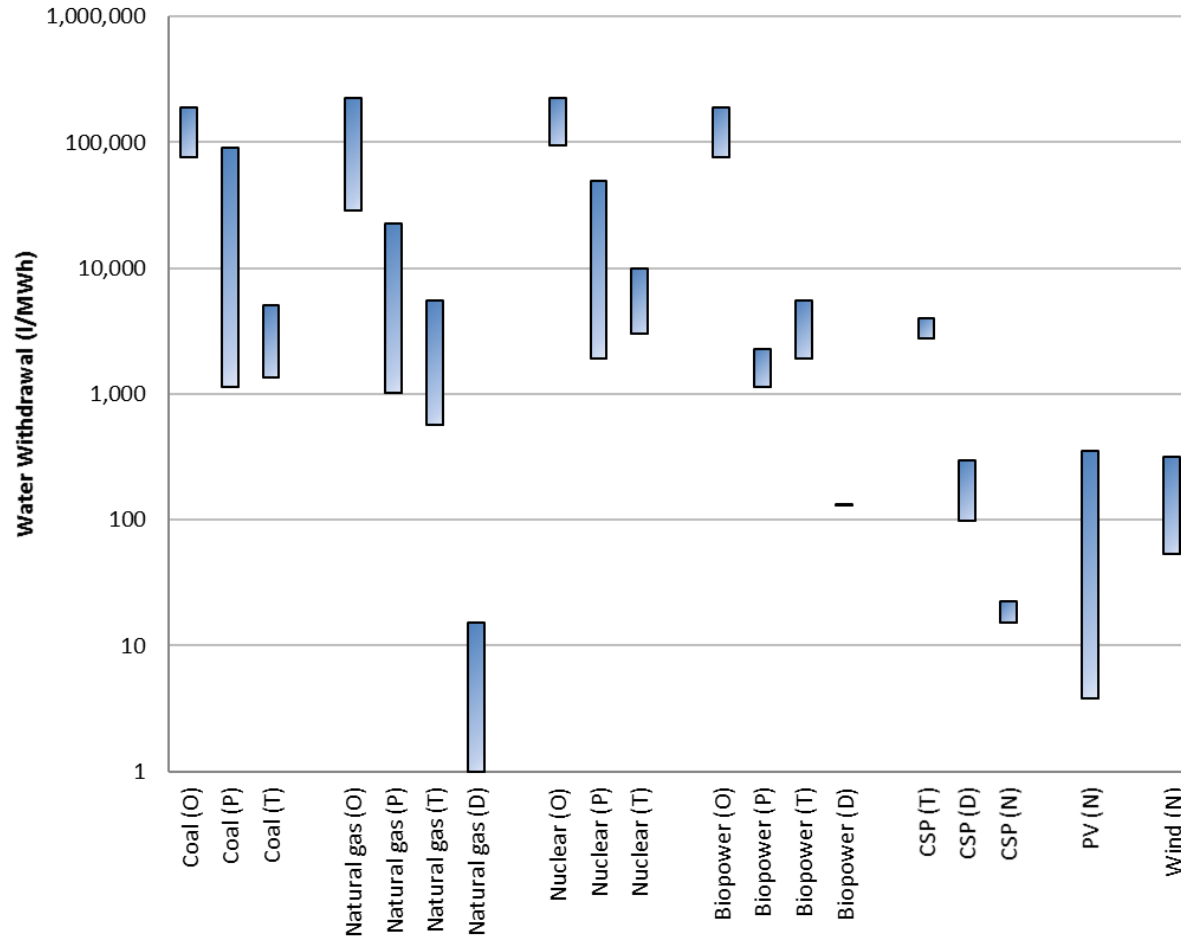
**Table 1 – Water consumption and withdrawal factors for nuclear power plants**  
(Sources: Meldrum et al., 2012; Macknick et al., 2011; Zhai et al., 2011; NETL, 2009; Tzimas, 2011; EPRI, 2011)

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

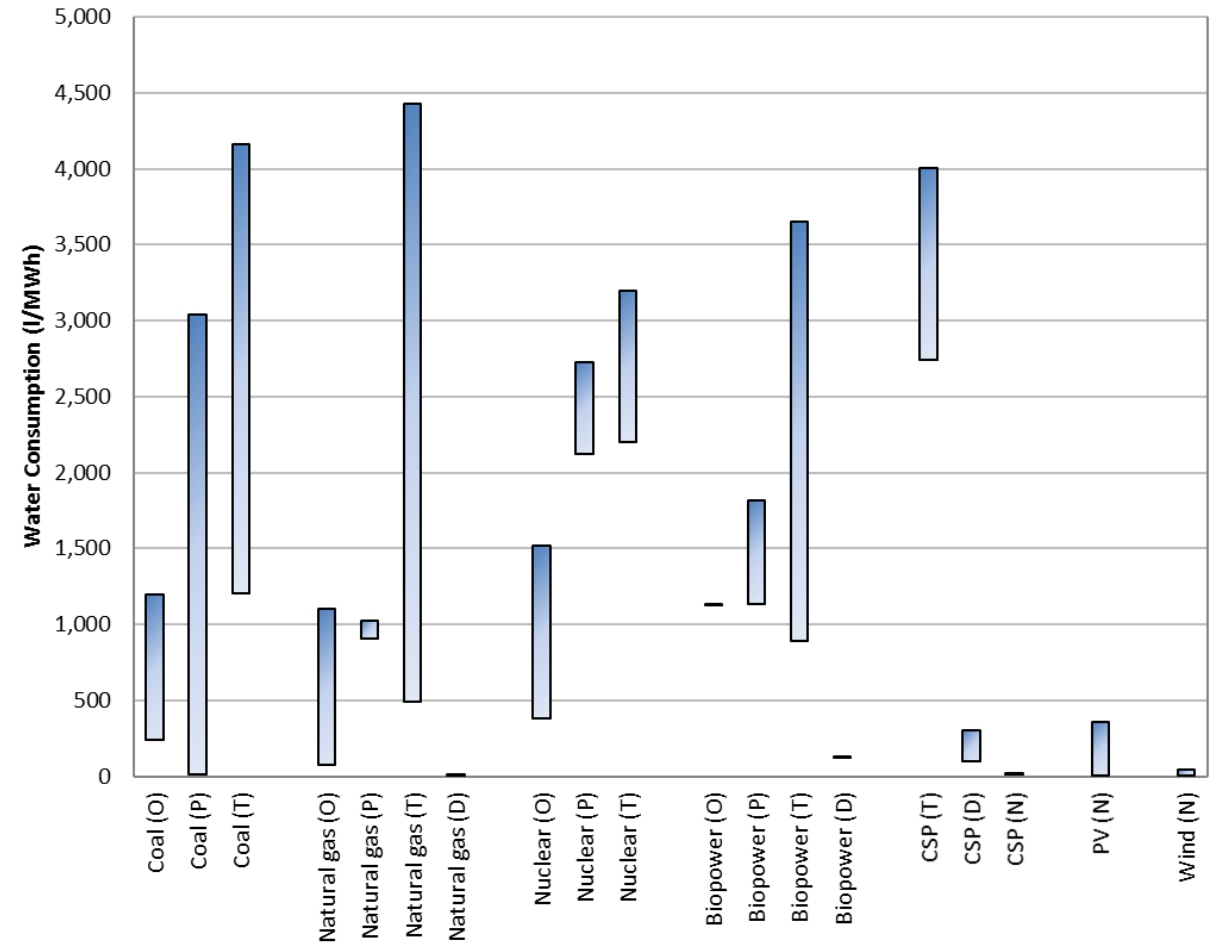


# WATER CONSUMPTION & WITHDRAWAL (II)

Water withdrawal ranges for electricity generating technologies



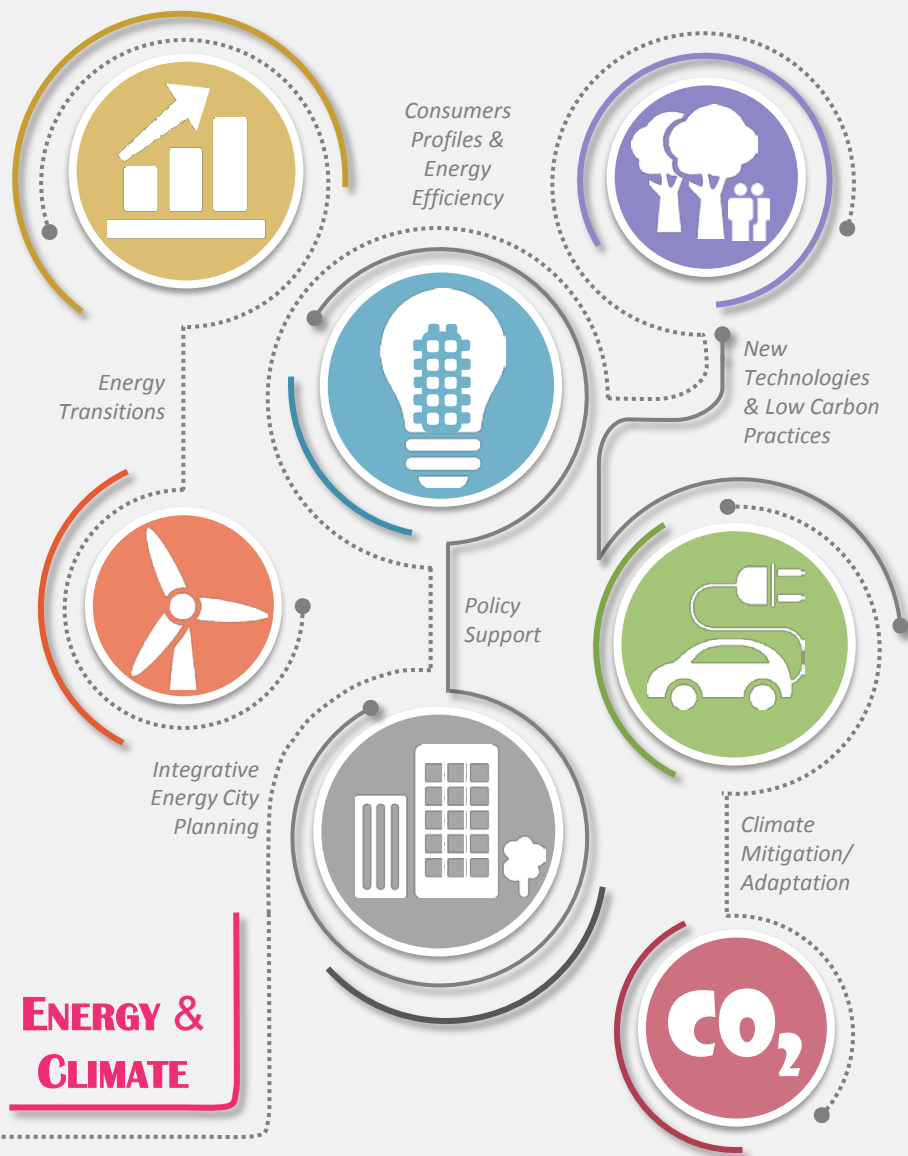
Water consumption ranges for electricity generating technologies



# LIMITATIONS

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- › 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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[www.cense.fct.unl.pt](http://www.cense.fct.unl.pt)  
[www. sites.fct.unl.pt/times-](http://www.sites.fct.unl.pt/times-)  
[sgcs@fct.unl.pt](mailto:sgcs@fct.unl.pt)



# 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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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

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CSP	Tower	725-1,057	725-1,057
	Dry	26-79	26-79
	None	4-6	4-6