Comparison of Fuels Used for Electric Generation in the U.S, 2016 Update – Study Details

ENVIRONMENTAL FACTORS

Natural Gas, Combined Cycle

Typical Plant Capacity	429 MW
Emissions	Typically, a gas fired combined cycle plant must control and measure NOx, CO, ammonia, PM, and sometimes opacity.
Waste Products	Wastewater
Land Use per 1k households	0.18 acres
Water Use per 1k households/year	2,121,125 gallons
Land Use per 1k MWH/year	0.03 acres
Water Use per 1k MWH/year	310,433 gallons
Land Use - Plant Foot-print	20-40 acres
Water Use - Plant Only	2,000 gallons per minute (gpm) (2,209 including Shale gas production water use)

Note: see additional land/water use data for shale gas production at end of document

Coal – APC

Typical Plant Capacity	650 MW
Emissions	The key air pollutant emissions during operations include oxides of nitrogen ("NOX"), sulfur dioxide ("SO2"), PM, carbon monoxide ("CO"), and VOCs.
Waste Products	The primary solid waste products are bottom ash from the bottom of the boiler, fly ash (FA) from the baghouse and/or gypsum from the wet scrubber (Total BA and FA: 15 to 75 tons per hour)
Land Use per 1k households	0.37 acres
Water Use per 1k households/year	6,054,912 gallons
Land Use per 1k MWH/year	0.04 acres
Water Use per 1k MWH/year	720,000 gallons
Land Use - Plant Foot-print	200-250 acres
Water Use - Plant Only	7,800 gpm

Coal – APC with CCS

Typical Plant Capacity	650 MW
Emissions	SO2 emissions can be controlled to 99% to 99.9% removal depending on the type of acid gas removal technology. PM emissions are similar to a coal-fired, combined-cycle plant. CO emissions are similar to a natural gas combined-cycle plant.
Waste Products	Major solid wastes include spent COS hydrolysis catalyst, spent Claus sulfur plant catalyst, spent activated carbon and wastewater
Land Use per 1k households	0.74 acres
Water Use per 1k households/year	6,054,912 gallons
Land Use per 1k MWH/year	0.09 acres
Water Use per 1k MWH/year	720,000
Land Use - Plant Foot-print	400 acres
Water Use - Plant Only	7,800 gpm

Advanced Nuclear

Typical Plant Capacity	2,234 MW
Emissions	Typically thought in the industry to be emissions "free", as related to the specific emissions associated with actual energy production.
Waste Products	Irradiated waste products
Land Use per 1k households	0.64 acres
Water Use per 1k households/year	varies
Land Use per 1k MWH/year	0.07 acres
Water Use per 1k MWH/year	varies
Land Use - Plant Foot-print	1-5 square miles
Water Use - Plant Only	Highly variable, depending on the cooling system

Hydro

Typical Plant Capacity	500 MW
Emissions	Typically thought in the industry to be emissions "free", as related to the specific emissions associated with actual energy production.
Waste Products	none
Land Use per 1k households	varies
Water Use per 1k households/year	n/a
Land Use per 1k MWH/year	varies
Water Use per 1k MWH/year	n/a
Land Use - Plant Foot-print	Varies considerably, depending on the specific hydro technology employed.
Water Use - Plant Only	n/a

Geothermal

Typical Plant Capacity	50 MW
Emissions	Typically thought in the industry to be emissions "free", as related to the specific emissions associated with actual energy production.
Waste Products	none
Land Use per 1k households	varies
Water Use per 1k households/year	5,361,120 gallons
Land Use per 1k MWH/year	varies
Water Use per 1k MWH/year	600,000
Land Use - Plant Foot-print	Varies considerably, depending on the specific reservoir.
Water Use - Plant Only	500 gpm with wet cooling

Biomass – MSW

Typical Plant Capacity	50 MW
Emissions	The key air pollutant emissions during operations include NOX, CO, PM, SO2, hydrogen chloride ("HCl"), certain heavy metals such as mercury ("Hg"), and NH3 slip.
Waste Products	Non-processible wastes, fly ash & bottom ash (monofill-typical)
Land Use per 1k households	0.48 acres
Water Use per 1k households/year	7,064,064 gallons
Land Use per 1k MWH/year	0.06 acres
Water Use per 1k MWH/year	840,000 gallons
Land Use - Plant Foot-print	15 – 25 acres (assuming no evaporation ponds)
Water Use - Plant Only	Depends on technology and location, ~1 million gallons per day

Bimass – BFB

Typical Plant Capacity	50 MW
Emissions	The key air pollutant emissions during operations include NOX, CO, PM, and ammonia ("NH3") slip.
Waste Products	Fly Ash & Bottom Ash (For beneficial use or landfill)
Land Use per 1k households	0.84 acres
Water Use per 1k households/year	5,676,480 gallons
Land Use per 1k MWH/year	0.11 acres
Water Use per 1k MWH/year	720,000 gallons
Land Use - Plant Foot-print	30 – 40 acres (for typical 50 MW project)
Water Use - Plant Only	600 gpm

Solar – PV

Typical Plant Capacity	20 MW
Emissions	none
Waste Products	none
Land Use per 1k households	8.40 acres
Water Use per 1k households/year	n/a
Land Use per 1k MWH/year	4.0 acres
Water Use per 1k MWH/year	n/a
Land Use - Plant Foot-print	7 acres/MW
Water Use - Plant Only	n/a

Solar – Tracker PV

Typical Plant Capacity	150 MW
Emissions	none
Waste Products	none
Land Use per 1k households	10.80 acres
Water Use per 1k households/year	n/a
Land Use per 1k MWH/year	3.42 acres
Water Use per 1k MWH/year	n/a
Land Use - Plant Foot-print	9 acres/MW
Water Use - Plant Only	n/a

Wind – Onshore

Typical Plant Capacity	100 MW
Emissions	None
Waste Products	None
Land Use per 1k households	6.00 acres
Water Use per 1k households/year	n/a
Land Use per 1k MWH/year	1.43
Water Use per 1k MWH/year	n/a
Land Use - Plant Foot-print	Average is 50 acres under lease for each MW of installed capacity*
Water Use - Plant Only	None

*Actual footprint of towers, roads & crane pads is much less but varies by project. Typically about five acres are purchased for the collection station, maintenance building and switchyard.

Shale Gas Production Water Use

High Est. Total Vol Water per Shale Well *	3,900,000 gallons
Typical Gas Production per Horizontal Well**	800,000 MMBtu
Water Use per MMBtu	4.9 gallons
MMbtu/hour (standard gas fired power plant	2,702.7
MMbtu/minute (standard gas fired power plant	45.0
Water Use	219.6 gpm

*based on EPA report on water needs for hydraulic fracturing in Marcellus (highest play in terms of water use)

** based on study of actual shale gas production rates in the Barnett shale for well performance over lifetime (likely conservative as newer plays may have higher total gas recovery than Barnett wells)

Shale Gas Production Land Use

High Est. Total Land Use per Shale Well *	1.9 acres
Typical Gas Production per Horizontal Well**	800,000 MMBtu
Land Use per MMBtu	0.0000023 acres
MMbtu/year (standard gas fired power plant	15,389,174
Land Use	35.6 acres

*based on a 4-horizontal well pad with a disturbance of 7.4 acres

** based on study of actual shale gas production rates in the Barnett shale for well performance over lifetime (likely conservative as newer plays may have higher total gas recovery than Barnett wells)

Legend

Coal APC - standard coal burning operations using advanced pollution control (APC) technology; currently in wide use

Coal CCS - coal plant using carbon capture & sequestration (CCS) technology; several demo projects underway, but not yet commercially viable

Biomass MSW (waste) - burns municipal solid waste

Biomass BFB (wood) - utilizes bubbling fluidized bed technology - typical biomass consists of wood chips, construction and demolition wood, bark, residual logging debris, saw dust, paper rejects, and paper and/or sewage sludge

Source:

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Leidos