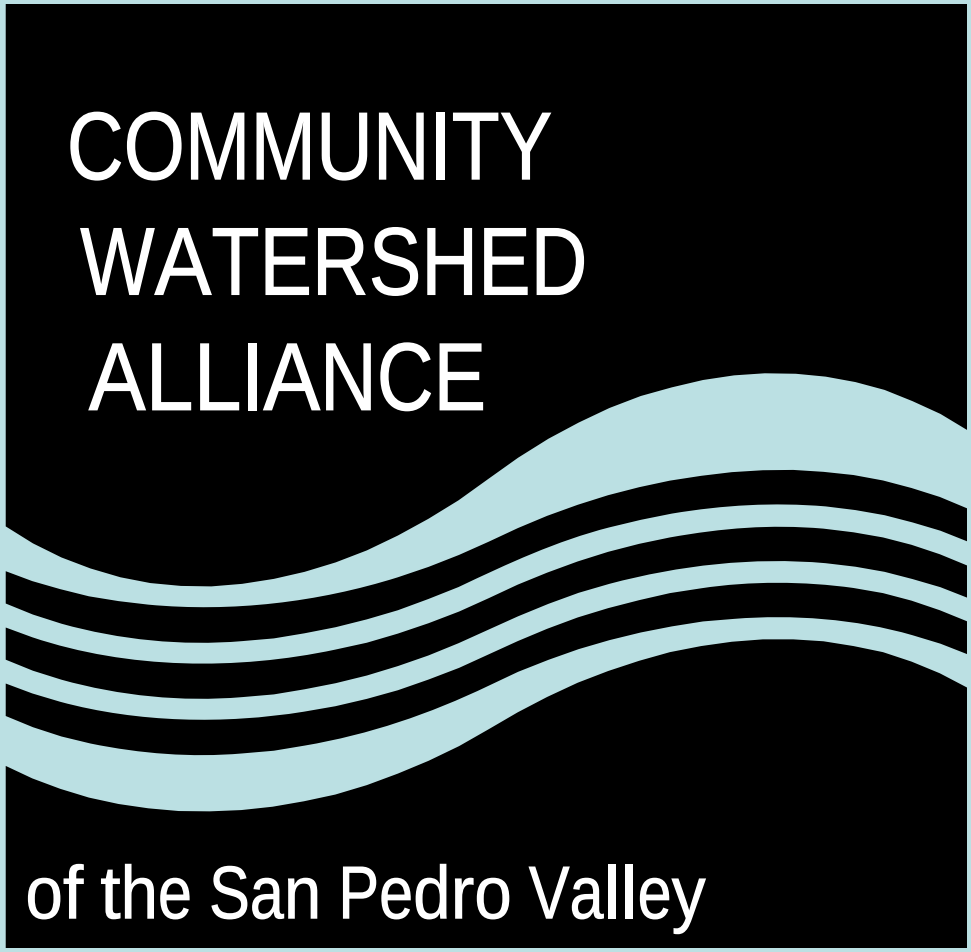


PROMOTING

COLLABORATION RESEARCH AND EDUCATION

WITHIN THE BENSON SUBWATERSHED

WHEREAS our watershed is in an area primed for solar energy production at an industrial level,

WHEREAS our watershed has a finite supply of water,

WHERE as the value of natural resources are woven within our cultural, social, and economic endeavors,

WHEREAS the City of Benson has a major role in managing our local natural resources and water supply,

CWA has, therefore, prepared the following brief summary and list of questions to provide a basis from which to promote dialogue amongst watershed stakeholders and decision makers.

INITIAL RESEARCH ON

PHOTOVOLTAIC / CONCENTRATING SOLAR POWER PLANTS

AND

WATER CONSUMPTION

WATER CONSUMPTION – a necessary topic:

SOLAR PLANTS ARE MOST COST EFFECTIVE IN LOCATIONS WHERE THE SUN IS MOST INTENSE,

WHICH IN TURN OFTEN CORRESPONDS TO AREAS WHERE

THERE IS LITTLE

FOCUS OF PRESENTATION:

What are the most common commercial level solar farms . . . .

What demands are made on local water resources . . . .

What water use restrictions are being placed on solar plants . . . .

MAJOR INCENTIVES FOR SOLAR RESOURCES

1. **The Federal Government is encouraging the development of CSP plants through a 30% investment tax credit.**

2. **Peak power demands in Calif. and AZ. are approaching system capacity.**

3. **In Fall 2006, ACC voted to require regulated electric utilities to generate 15 percent of their total megawatts sold from renewable resources by 2025.**

   In addition, the renewable energy standard establishes minimum requirements for distributed energy. The requirement started at 5 percent of the total portfolio in 2007 and reaches 30 percent of the total renewable mix after 2011.

4. **Twenty-nine states now have Renewable Portfolio Standards.**

ALL SOLAR POWER TECHNOLOGIES USE WATER – SOME MORE MODESTLY THAN OTHERS.

ALL SOLAR POWER TECHNOLOGIES USE WATER – SOME MORE MODESTLY THAN OTHERS.

AT THE MINIMUM, WATER IS USED FOR CLEANING SOLAR COLLECTION AND REFLECTION SURFACES – APPROXIMATELY 20 GALLONS PER MEGAWATT HOUR.

MINIMAL WATER USE

PHOTOVOLTAICS - uses solar cells to convert energy from the sun into electricity. The photovoltaic effect refers to photons of light knocking electrons into a higher state of energy to create electricity. About 5 acres per MW.

Nellis Air Force Base Solar Power Plant

America's Largest Solar Photovoltaic Plant – 48-Megawatt Facility in Boulder City - December 2010 – Copper Mountain Solar Facility

775,000 photovoltaic panels located on a 380-acre site – can generate energy to supply 14,000 homes with electricity. Being sold to Pacific Gas & Electric in Calif. to meet its 33% RPS by 2020.

STIRLING DISH /engine concentrating solar power system uses a mirror in the shape of a dish to collect and concentrate the sun's heat onto a small area where a receiver is located.

The receiver transfers the sun's energy to a Stirling cycle engine that converts the energy into power. Engines are air-cooled, converting 30% of sunlight to electrical energy.

Large capital outlay. Does not lend itself to thermal storage-provides electricity only when the sun is shining.

SRP –TesseraSolar 1.5 MW system in Peoria, AZ (1 acre foot/year)

SIGNIFICANT WATER USE - THERMAL POWER PLANTS

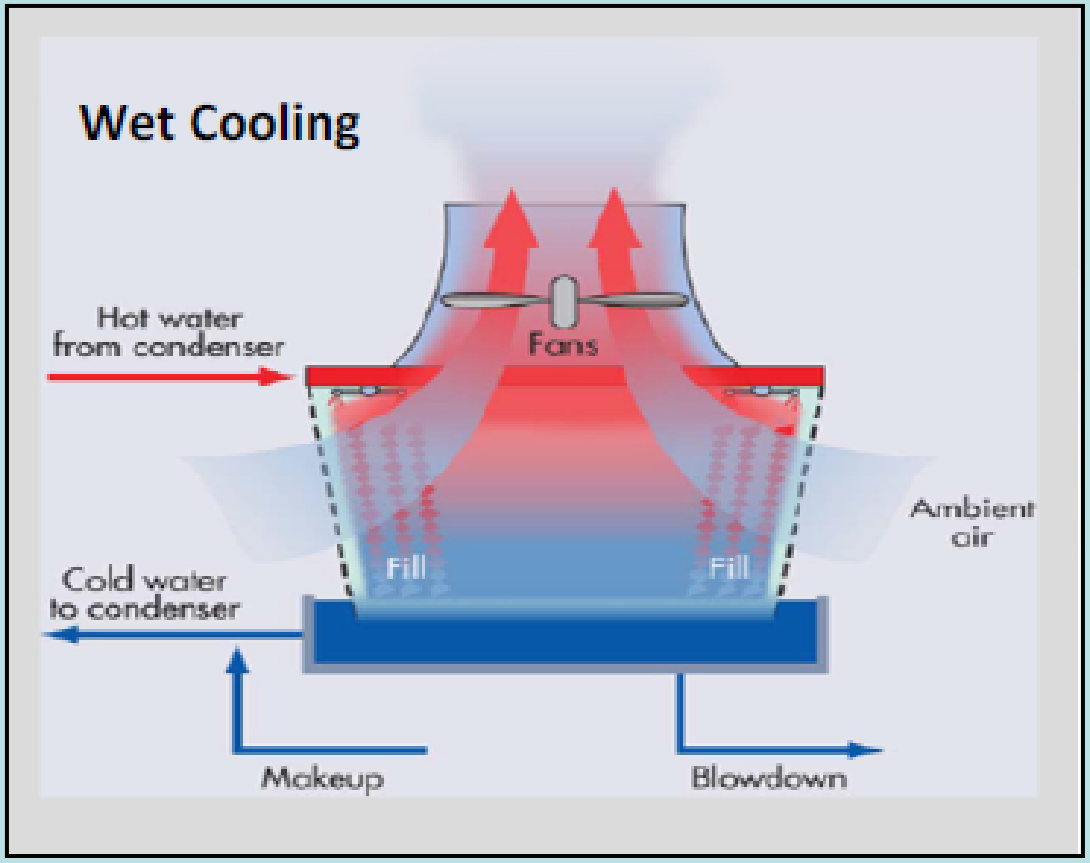
Whether fossil, nuclear, or solar – heat is used to vaporize a fluid which runs a steam turbine to generate electricity. The exhaust steam from the generator must be cooled prior to being heated again and turned back into steam.

Cooling can be done with water (wet cooling) or air (dry cooling), or a combination of both (hybrid cooling). Water Cooling is considered the most efficient.

Comparative Cooling System Performance[2]

COOLING SYSTEM	WATER USE	ANNUAL ENERGY OUTPUT	CAPITAL COSTS
Wet	100%	100%	100%
Hybrid	40%	95.4%	103%
Dry	5%	92.5%	104%

IT'S PRIMARILY IN THE COOLING!



The new Genesis and Mojave solar projects in California are expected to use 536 million gallons and 705 million gallons of water per year, respectively .

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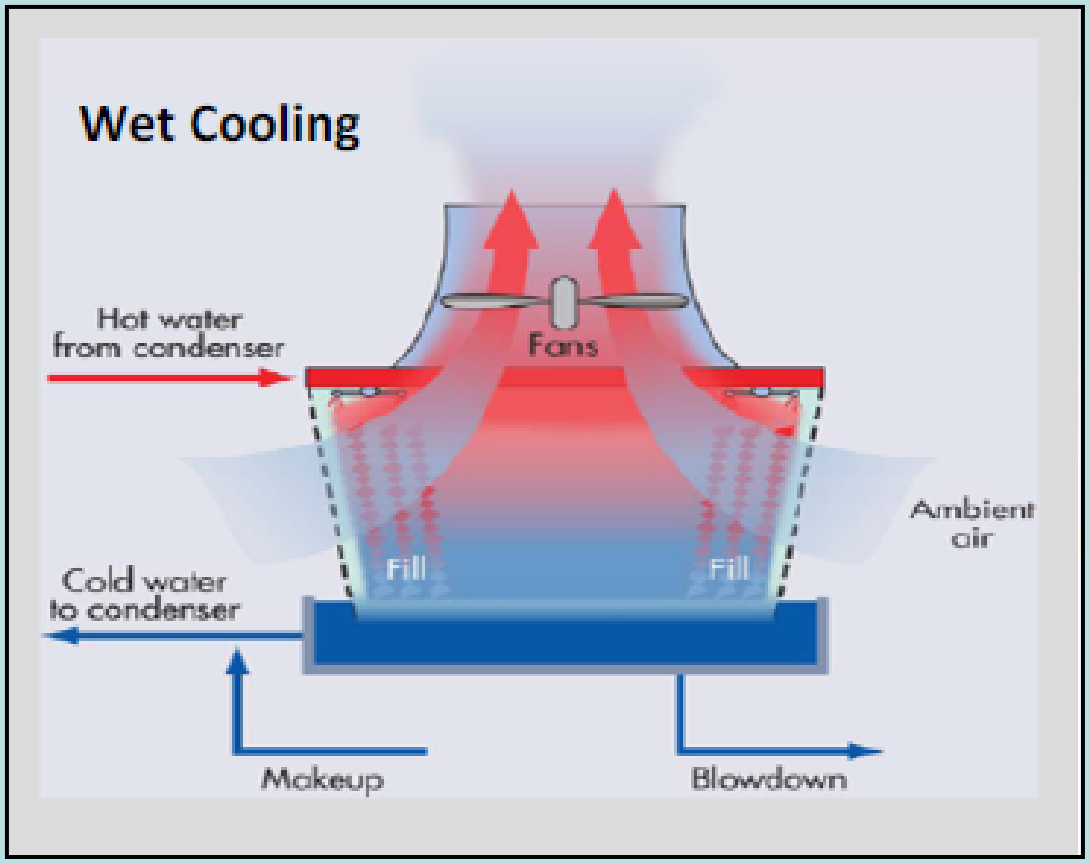

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FACTORS

1. **Type of technology and fluids to be used**
2. **MW to be produced**
3. **Method(s) for cooling**
4. **Efficiency**
5. **Reclamation and Filtration**

Linear Fresnel

Consists of reflectors that track the sun in one axis and focuses the beam radiation onto fluid-carrying receiver tubes elevated above the mirrors.

The optical efficiency is lower than troughs, but promises cost savings and reduced land use, associated with the tight spacing and ground location of the mirrors and a fixed receiver.

Employs water directly in the receiver tubes where it is boiled at about 50 times atmospheric pressure to produce saturated steam which powers a steam cycle.

No commercially operating power-generating systems using this technology at this time – but plans are being developed.

Parabolic trough systems are the most developed and commercially tested technology.

The largest solar power installation in the world is comprised of nine solar thermal power plants in the Mojave Desert built in the 1980's. These plants have a combined capacity of 345 megawatts.

Current commercial plants utilizing parabolic troughs are hybrids; fossil fuels are used during night hours, but the amount of fossil fuel used is limited to a maximum 27% of electricity production, allowing the plant to qualify as a renewable energy source.

Parabolic trough and power tower solar plants consume about the same amount of water as a coal fired or nuclear power plant (500 to 800 gal/MWH).

Nevada Solar One uses this same technology and has is a nominal capacity of 64 MW and maximum capacity of 75 MW. The project required an investment of $266 million USD, and electricity production is estimated to be 134 million kilowatt hours per year. Nevada Solar One went online for commercial use on June 27, 2007. It was constructed over a period of 16 months. The total project site is approximately 400 acres while the solar collectors cover 300 acres.

WATER USE: Nevada Solar One consumes 850 gallons of water per Megawatt hour on a 360-acre site, or about 300,000 gallons per acre per year.

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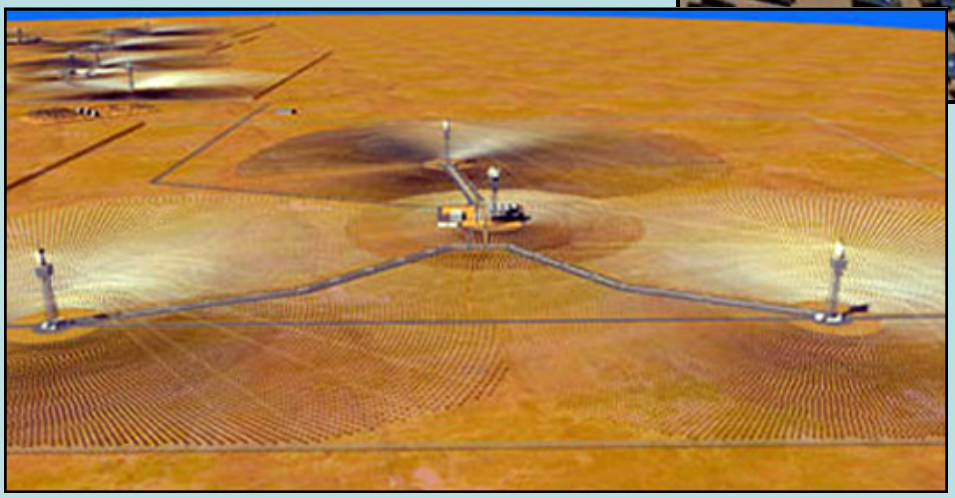
Arizona Public Service's Saguaro Solar Facility opened, in 2006, using similar technology, located 30 miles north of Tucson, and producing 1 MW. Came on line in 2005 as the first solar trough constructed in Arizona. It was also the first in the world to combine solar trough technology with an Organic Rankine Cycle Power Block (technology that uses pentane, an organic fluid, which turns to vapor at a lower temperature). The $6 million, 14-acre plant consists of six rows of parabolic mirrors that track the sun as it moves across the sky.

Power Towers

Uses thousands of tiny, flat movable mirrors called heliostats to focus and concentrate the sun's energy upon a water boiler, heating it more than 1000 degrees. Steam then drives turbine. Plants consist of clusters of these "solar fields" each producing 20MW.



New plant to open in 2011 and should produce 246,000 megawatt hours of renewable electricity per year.

Dry cooled, but will consume an estimated 25 million gallons a year, just to wash the mirrors.

ARIZONA – MOHAVE COUNTY

- County has approved at least six commercial-grade solar plants but none have broken ground.

- Hualapai Valley Solar received approval from the ACC and the others have not applied.

Amount of water proposed to be used to cool turbines was major concern of residents – brought to the attention of the ACC during hearings in January 2010. Discussion led to the approval of a certificate of environmental compatibility for Hualapai Valley from the ACC with the condition that the plant use dry-cooling technology or treated wastewater from the city of Kingman.

The $2.1 billion project will cover more than 4,000 acres of property and use around 1,400 to 3,000 acre-feet of water per year. Will generate approximately 1,500 temporary construction jobs and 100 permanent jobs.

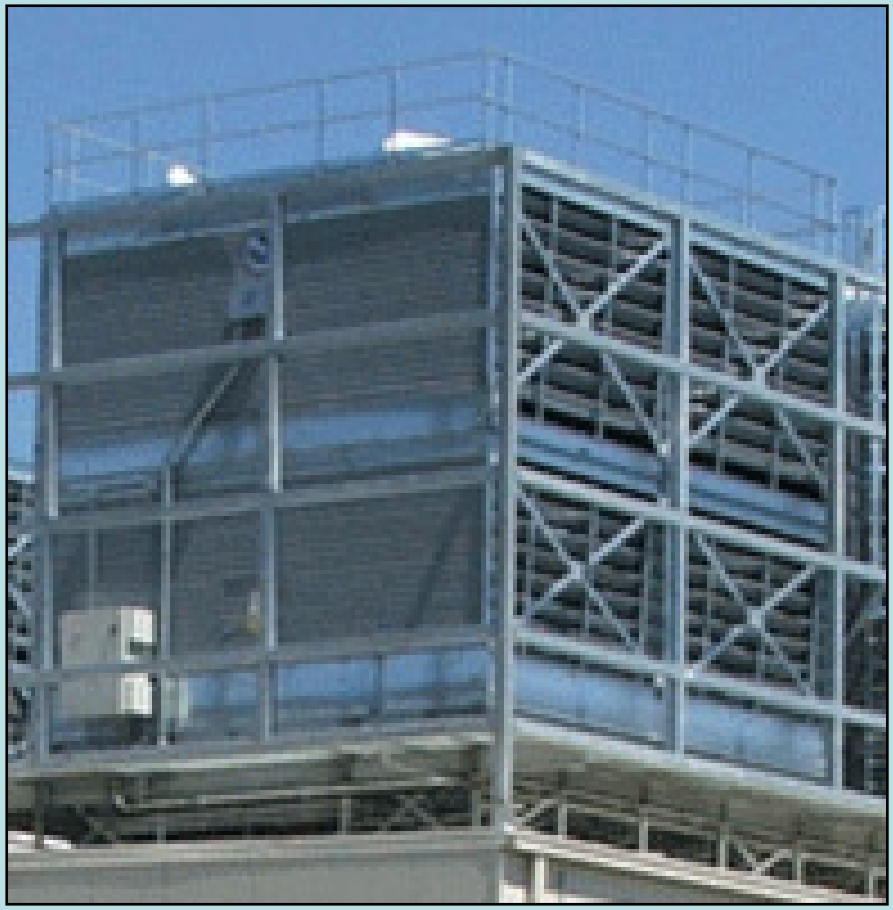
An acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot, = approximately 325,851 gallons.

1,400 acre feet per year = 456,191,400 gallons of water per year.

Other Arizona sites:

Name	Power	Acreage	Technology	Water
Albiasa Power Plant 45 m. south of Kingman $1 billion 2,000 jobs – construct. 100 permanent	200-megawatt	1,400	Trough	2,275 acre-feet per year = **819,000,000 gallons of water**
Needle Mtn. Power Near Topock 75-100 permanent jobs	1,200-megawatt	10,000	Solar dish – stirling type engine	Less than 500 acre-feet per year
Near Dolan Springs	1-megawatt	565 acres	Photovoltaic Panels	Domestic use/cleaning panels
Havasu Solar Electric	1-megawatt	46 acres	Photovoltaic Panels	Domestic use/cleaning panels
Near Hackberry	1.5-megawatt		Photovoltaic Panels	Domestic use/cleaning panels

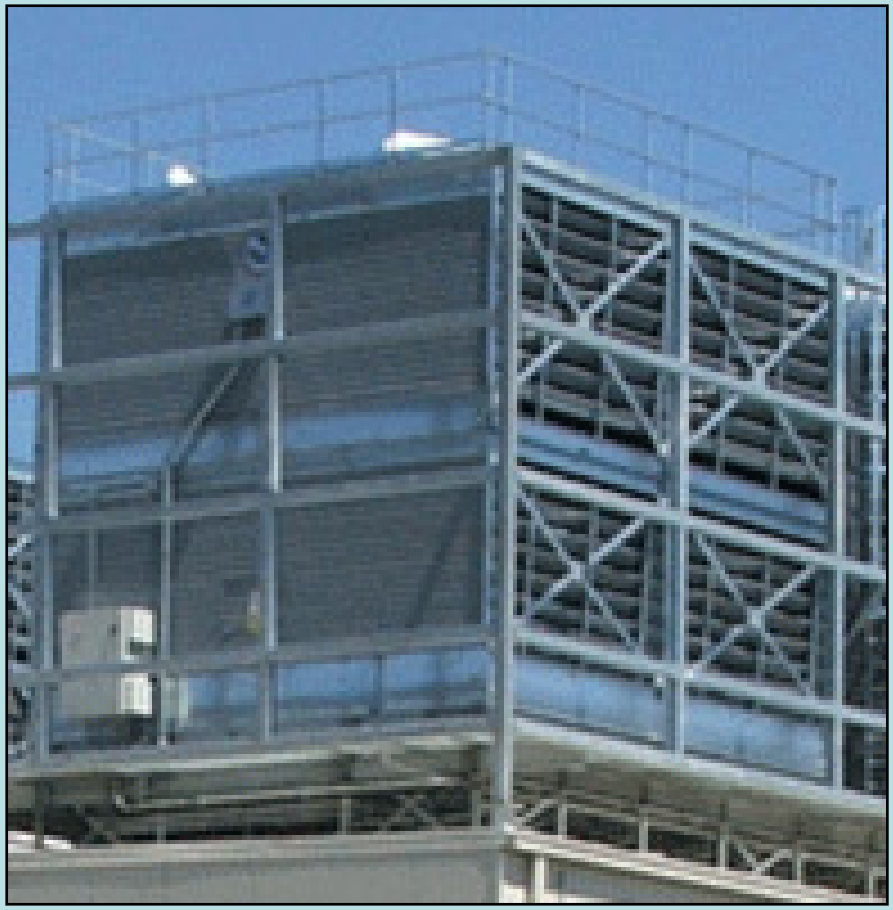
Solar Technology Type	Acres per MW	Estimated Facility Size (MW)	Estimated Land Area Needed (acres)	Estimated Capital Cost ($ 1000)*	Estimated Annual O&M Cost ($ 1000)*	Estimated Annual Water Usage (gallons)
CSP Trough						
No Storage	5	10	50	$45,000 - 60,000	$1,250 - 1,500	20,000,000
No Storage Air Cooled	5	10	50	$65,000 - 70,000	$1,250 - 1,500	2,300,000
With Six-hour Storage	8	10	80	$50,000 - 65,000	$1,300 - 1,600	25 - 30,000,000
Linear-Fresnal Reflector	3	10	30	$30,000 - 35,000	$1,400 - 1,600	20,000,000
PV						
Thin Film (fixed axis)	6 - 8	5	30-40	$25,000 – 30,000	$400 – 600	Negligible
Crystalline Silicon (fixed axis)	4 – 5	5	20-25	$30,000 – 36,000	$450 – 600	Negligible
PV Tracking	8 - 10	5	40-50	$35,000 – 40,000	$900 – 1,100	Negligible



Also applicable to large stores, hospitals, department stores, data centers.

RULE OF THUMB: One ton of cooling for every 425 sq. feet – water use depending upon the system and operation.
Initial Research: estimates from

- **5-6 acre-feet a year for a 100 ton system supporting a data system**
- **as much as 48 acre-feet a year for a 1000 ton system if .03 gallons per minute for each ton of HVAC**
- **one acre-foot a day for larger server farms**



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- **48 acre-feet a year for a 1000 ton system if .03 gallons per minute for each ton of HVAC**
- **one acre-foot a day for larger server farms (15 ½ million gallons)**

A typical family uses about 20,000 gallons of water each year. At current American rates of consumption, on average 1 acre-foot of water is enough to meet the industrial and municipal demands of 4 people for a year.

In an AMA, towers that are 1,000 ton or larger are required to recycle water through the unit before they discharge or “blowdown”.

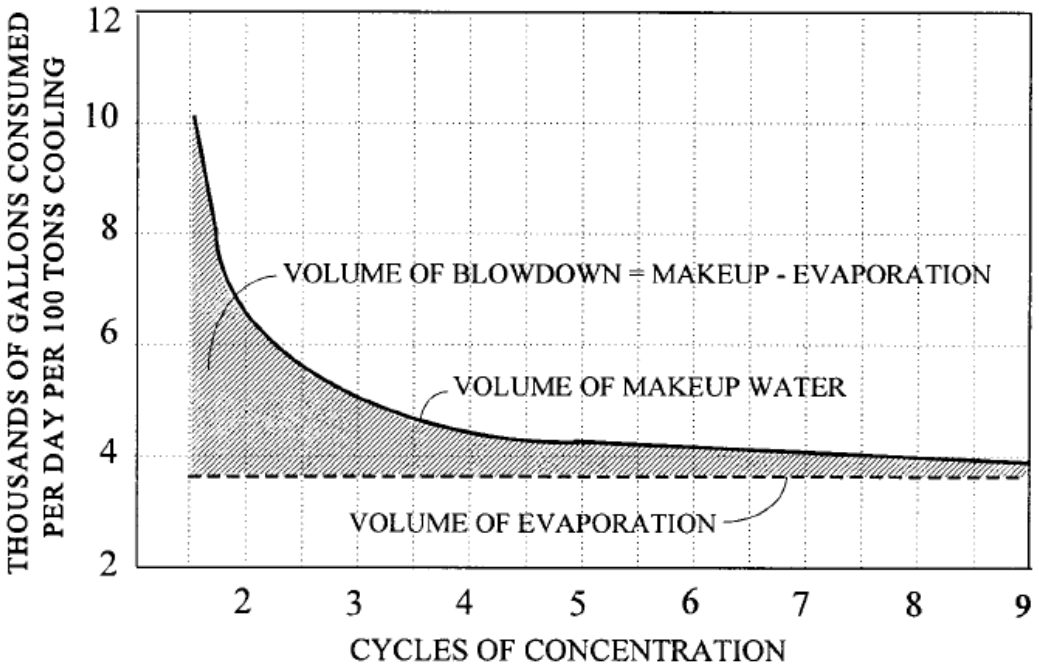
Evaporation causes dissolved and suspended solids in the cooling water to increase in concentration. This concentration factor is termed the cycles of concentration.

Cycles of concentration can be monitored by comparing the ratio of the concentration of a very soluble ion, such as chloride or magnesium, in the makeup and recirculating water. The more cycles of concentration, the less water use.

Another common comparison is the specific conductivity of the two streams, particularly where an automatic control is utilized to bleed off recirculating water when it becomes too concentrated.

(Side note: Blowdown and Drift particulate minimization is very important, as regulations on particulate emissions from cooling towers continue to tighten.)

FIGURE 6-7
RELATIONSHIP BETWEEN THE CYCLES OF CONCENTRATION AND THE AMOUNT OF WATER CONSUMED BY A COOLING TOWER



Can such a standard be worked in to the approval process or an ordinance?

Additional ways to decrease impact on local resources:

- cooling systems to use nonpotable water – grey water, not contaminated with other toxic substances
- use blowdown reclamation systems – water treatment and filtration systems to take solids out of the blowdown
- use hybrid system incorporating air cooling
- encourage technologies that limit water to washing panels and domestic use

Questions:

1. Type of technology – is thermal being considered?
2. MW to be produced – size of facility?
3. Method(s) for cooling – for both farm and data center?
4. What considerations/ parameters for water use/ reclamation/filtration can be incorporated into plan/approval?
5. Possible impacts of ground cover removal, increased erosion, etc.
6. What added support infrastructure is required – additional power lines, etc.
7. What additional natural resources/ fuels are needed for production, operation, storage?
8. Are there significant reflections from panels that need to be considered?
9. Is there a comparable plant in operations for review of track record?
10. Will plant need to go before ACC for a certificate of environmental compatibility before being built?
11. Will operation need to report water use on an annual basis?
12. When is the last opportunity for decision makers to establish guidelines for development of project?