



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

# Parabolic Trough Workshop

## Cooling for Parabolic Trough Power Plants

### Overview

Incline Village, Nevada

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# Water Requirements for Power Generation

(in Gallons per MWh of Plant Output)

<b>Plant Type</b>	<b>Steam Condensing</b>	<b>Auxillary Cooling and Hotel Load</b>	<b>Total</b>
<b>Stand-alone steam plant</b>	720 <sup>(1)</sup>	30 <sup>(2)</sup>	<b>750</b>
<b>Simple-cycle gas turbine</b>	0	150 <sup>(3)</sup>	<b>150</b>
<b>Combined-cycle plant (2/3 CT + 1/3 steam)</b>	240 (1/3 x 720)	110 (2/3 x 150 + 1/3 x 30)	<b>350</b>
<b>Combined-cycle plant with dry cooling</b>	0	110	<b>110</b>
<b>Stand-alone steam plant with dry cooling</b>	0	30	<b>30</b>
<b>Parabolic Trough with wet cooling</b>	920 <sup>(4)</sup>	80 <sup>(5)</sup>	<b>1000</b>
<b>Parabolic Trough with dry cooling</b>	0	80	<b>80</b>

(1) evaporation + blowdown = 12 gpm/MW

(2) estimated at ~5% of evaporation + blowdown

(3) mid-range of 75-200 gal/MWh for turbine cooling, emissions control and hotel load.

(4) based on historical data from SEGS (higher than conventional because of lower net steam cycle efficiency of SEGS, in part due to HTF pumping and night time parasitics .

(5) Includes make-up water requirements for steam cycle (60 gal/MWh) and solar field mirror wash (20 gal/MWh) data from KJCOC.



# NREL Wet/Dry Cooling Analysis

At Kramer Junction Radiation 8.05 kWh/m <sup>2</sup> /day In Service	100 MWe Trough				
	Wet Cooling 2006	Dry Cooling 2006			
		2006			
<b>Solar Field Area (m<sup>2</sup>)</b>	684,717	684,717			
<b>Cooling System</b>					
T <sub>air,d</sub> (°F)	na	87	75	65	54
ITD (T <sub>cond</sub> – T <sub>air,d</sub> ) (°F)	na	22	34	44	55
Capital Cost (\$/kWe)	40 <sup>a</sup>	288	193	152	123
Fan Design Point Parasitics (MWe)	1.9 <sup>b</sup>	5.6	2.8	1.9	1.6
Annual Cooling Parasitics (MWh)	5,297	11,847	7,022	5,205	4,405
Dry Cooling Penalty (MWh)	na	1,912	3,502	5,529	10,878
Total Plant Parasitics (% of gross)	12.4%	14.5%	13.1%	12.6%	12.5%
Annual Net Capacity Factor	29.3%	28.4%	28.8	28.7%	28.3
Plant Capital Cost (\$/kWe)	3080	3328	3233	3192	3164
Operating Costs (k\$/yr) <sup>c</sup>	5292	5201	5201	5201	5201
Insurance	0.5%	0.5%	0.5%	0.5%	0.5%
Levelized Cost of Energy (\$/kWh) <sup>d</sup>	0.119	0.131	0.126	0.125	0.126
	<b>100%</b>	<b>110%</b>	<b>106%</b>	<b>105%</b>	<b>106%</b>
<b>Relative Factors</b>					
Capital Cost	100%	108%	105%	104%	103%
Operating Costs	100%	98%	98%	98%	98%
Annual Performance	100%	97%	98%	98%	97%
Water Use (gal/MWh)	<b>1000</b>	<b>80</b>	<b>80</b>	<b>80</b>	<b>80</b>



**[1] California Energy Commission, 2002, “Comparison of Alternative Cooling Technologies for California Power Plants Economics, Environmental and Other Tradoffs,” CEC 500-02-079F, Feb 2002.**

**[http://www.energy.ca.gov/pier/final\\_project\\_reports/500-02-079f.html](http://www.energy.ca.gov/pier/final_project_reports/500-02-079f.html)**

**[2] KJC Operating Company, 2002, “SEGS Acquaintance & Data Package,” Boron, CA.**

