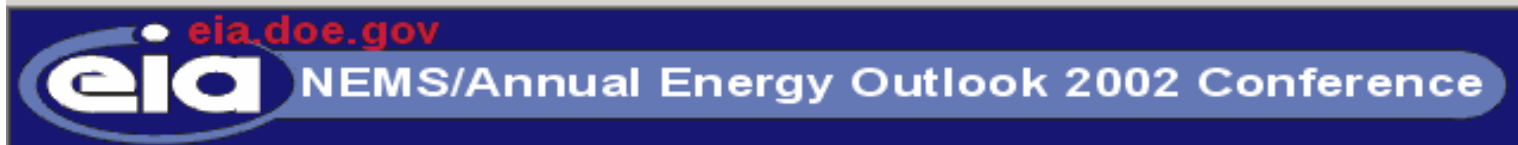




# The Potential of Wind, Solar, Geothermal for the West



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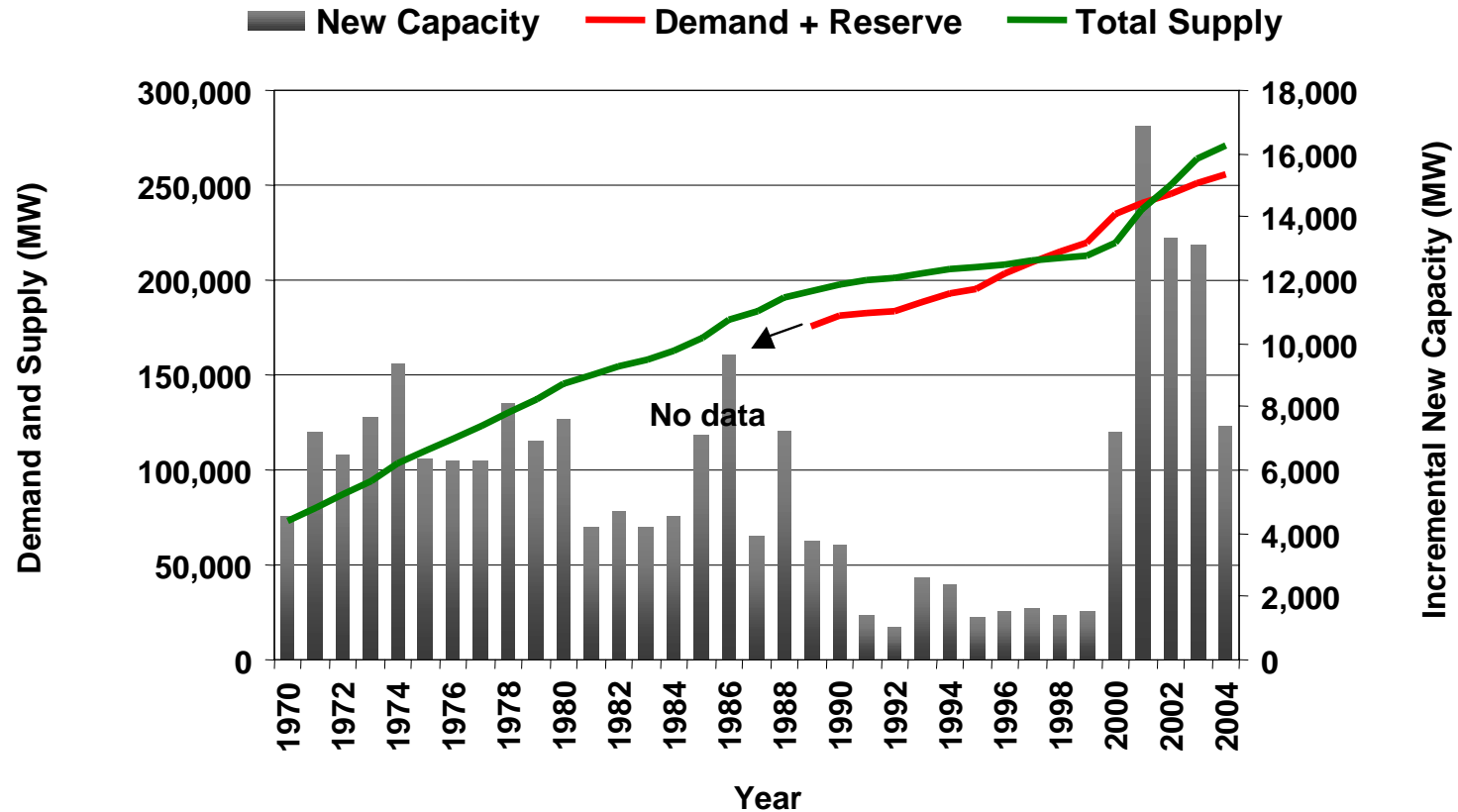


# Regions of the “West”



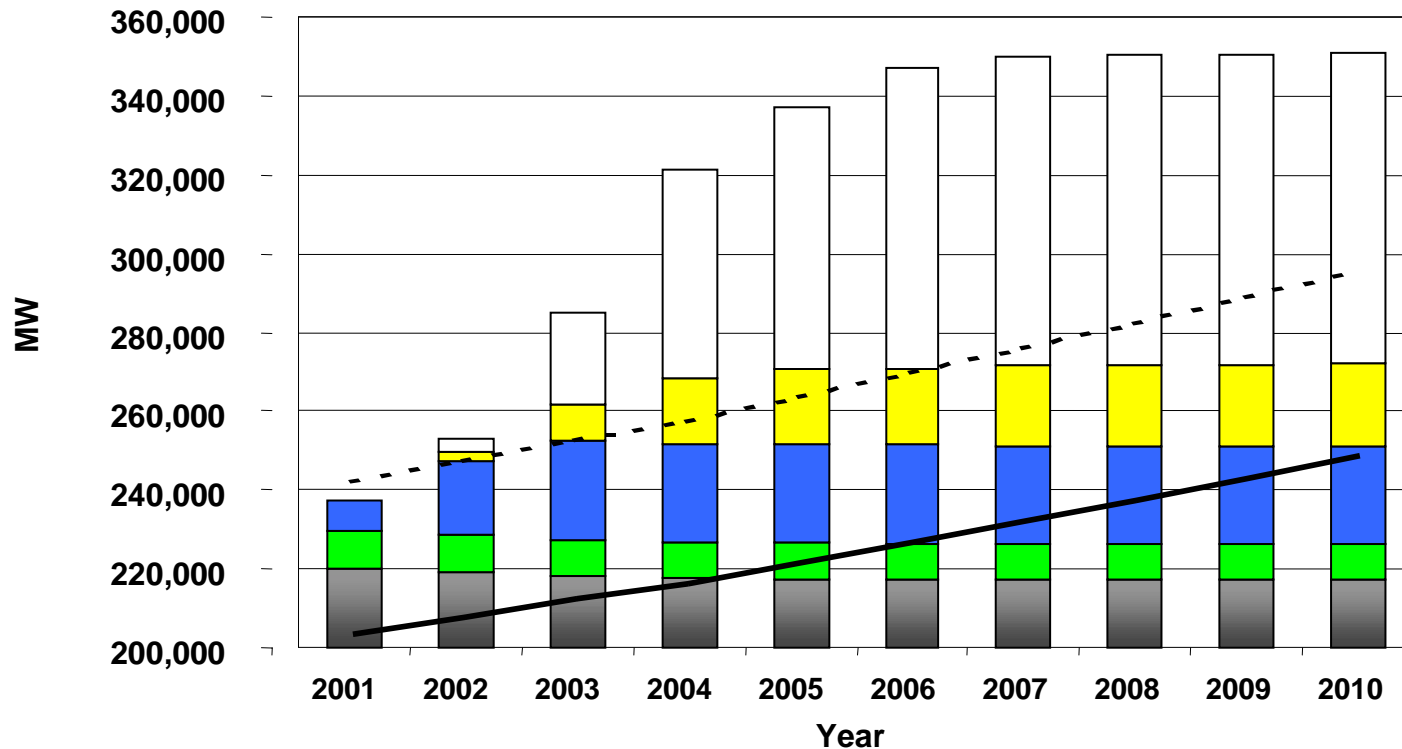
The 16 states of the Western Governors' Association in the Lower 48.

# In 2001 Electricity Supply in the West Remained Tight



- Supply additions in the nineties fell far short of demand growth, and demand eventually outgrew supply.

# Forecast Demand and Supply Balance in the West 2001-2010



- By 2010, an additional 23,000 MW of new capacity (beyond the 55,277 MW expected by RDI Consulting) are needed.

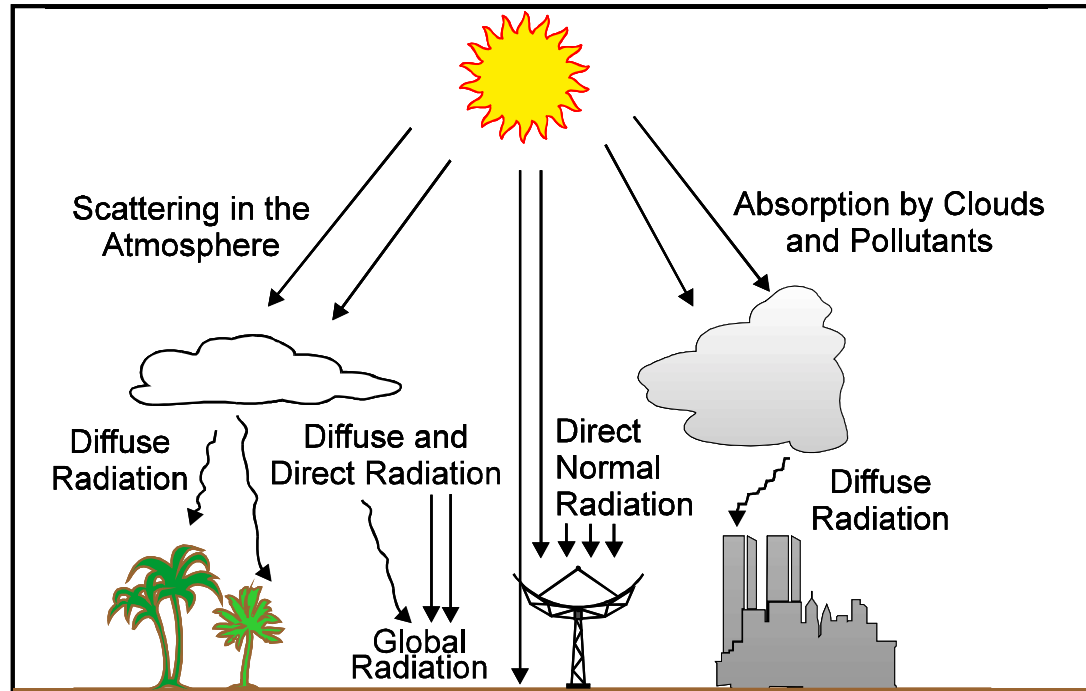
# Western Renewable Energy Options

- **Solar**
  - Large resources, close to load centers, sunshine can be forecast well, concentrating solar power (CSP) can use heat storage or fossil-fuel hybridization for around the clock generation, considerable cost reduction potential for CSP.
- **Wind**
  - Approaching cost competitiveness against conventional generating technologies, intermittent, typically far from load.
- **Geothermal**
  - Where geothermal resources available, good choice.
- **Biomass**
  - Must have agricultural or forestry waste products, “energy crops” need water, generation causes emissions.
- **Hydro**
  - Little hydro potential left, significant environmental impact, highly controversial.

# Solar



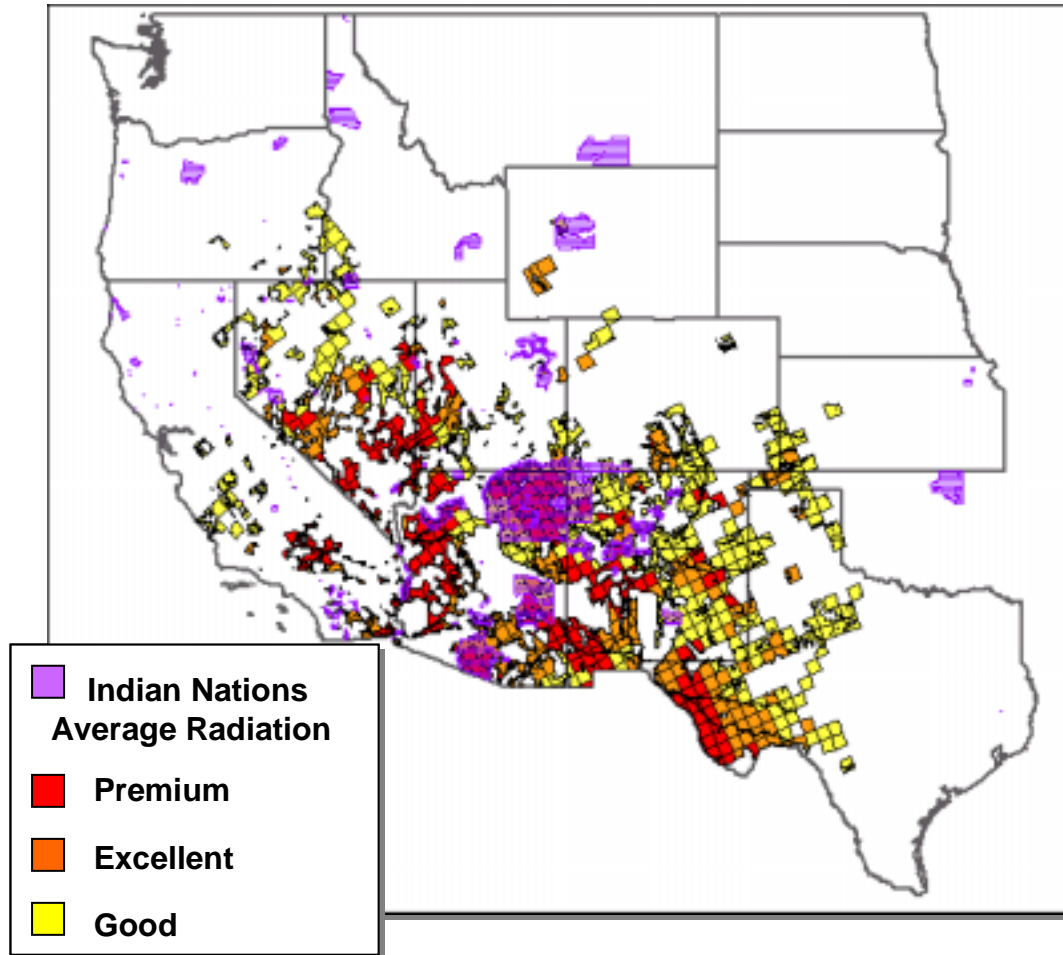
# Concentrating Solar Power (CSP) Uses Direct Normal Radiation



Source: Status Report on Solar Thermal Power Plants , Pilkinton Solar International, 1996. Used by permission.

- The West receives large amounts of direct normal radiation.
- This is not a limiting factor for the deployment of CSP.

# Direct Normal Solar Resources in the West



- Solar resources  $\geq 7.0$  kWh/m<sup>2</sup>/day are considered premium, 6.5–7.0 excellent, and 6.0–6.5 good.



# Solar Resource Methodology

- Geographic information system analysis excludes:
  - Military bases
  - Wilderness areas; Fish & Wildlife Service, National Park Service and National Forest Service land
  - Cropland
  - Major highways, railroads, navigable waterways and lakes;
  - Major urbanized areas
  - Locations of 9,000 ft above sea level (with a 4.5-mile buffer around each point)
- GIS establishes various buffer zones of up to five miles
- Of this potential resources consider only
  - 3% of premium;
  - 2% of excellent; and
  - 1% of good solar resources.

# CSP Performance Figures of Merit

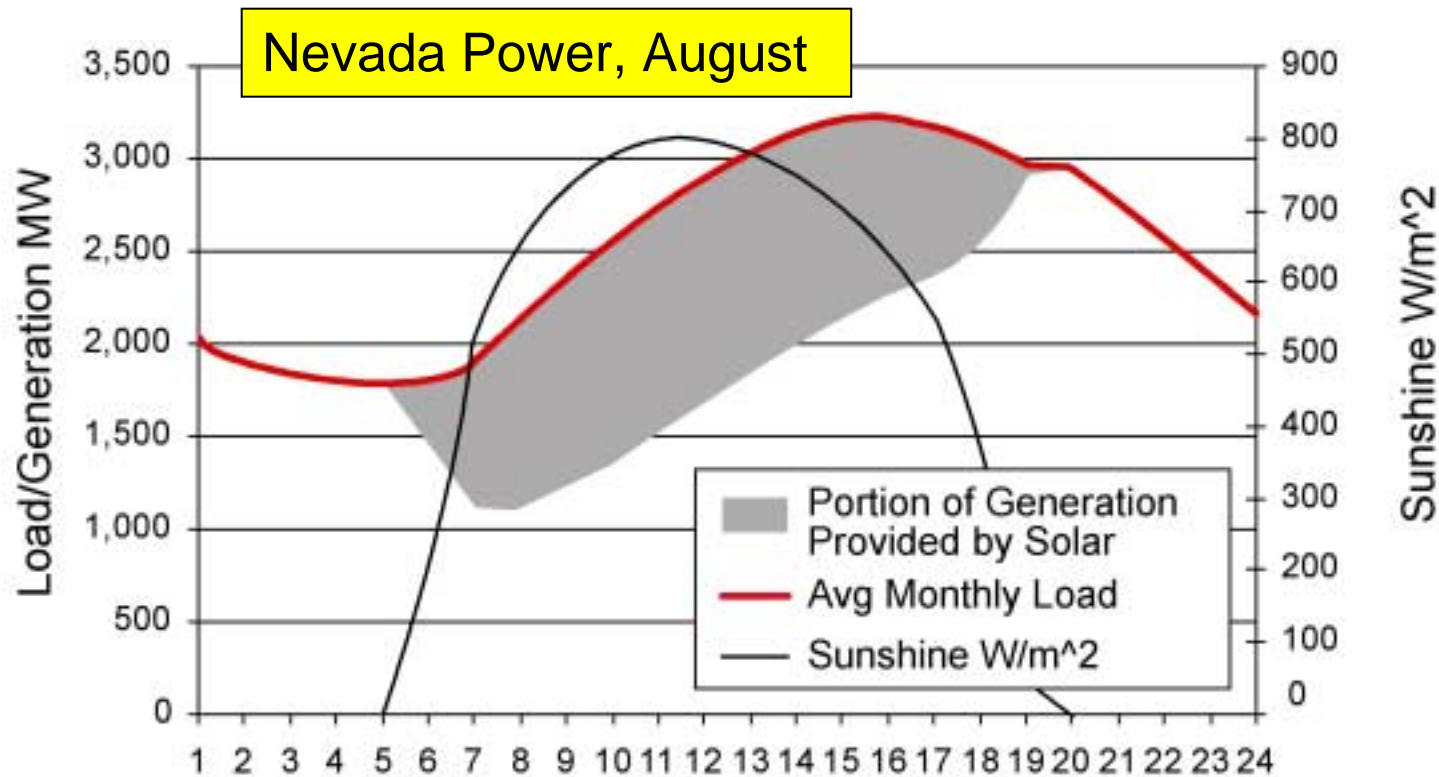
- 1 MW of solar power per 5 acres
- Solar field capacity factors
  - 25% in premium
  - 22.5% in excellent
  - 20% in good

# Western Solar Energy Potential

Region	Solar Resources GWh			Land as % of Region
	Premium	Excellent	Good	
Northwest	-	3,529	26,995	0.03%
CO & WY	5,504	36,313	42,388	0.20%
California	134,942	29,189	38,093	0.50%
Southwest	825,956	417,600	273,536	1.40%
Prairie States	-	4,105	8,288	0.02%
Texas	85,064	99,892	67,039	0.40%
<b>TOTAL</b>	<b>1,051,466</b>	<b>590,627</b>	<b>456,340</b>	<b>0.50%</b>
2001 Demand	1,092,160 GWh			N/A

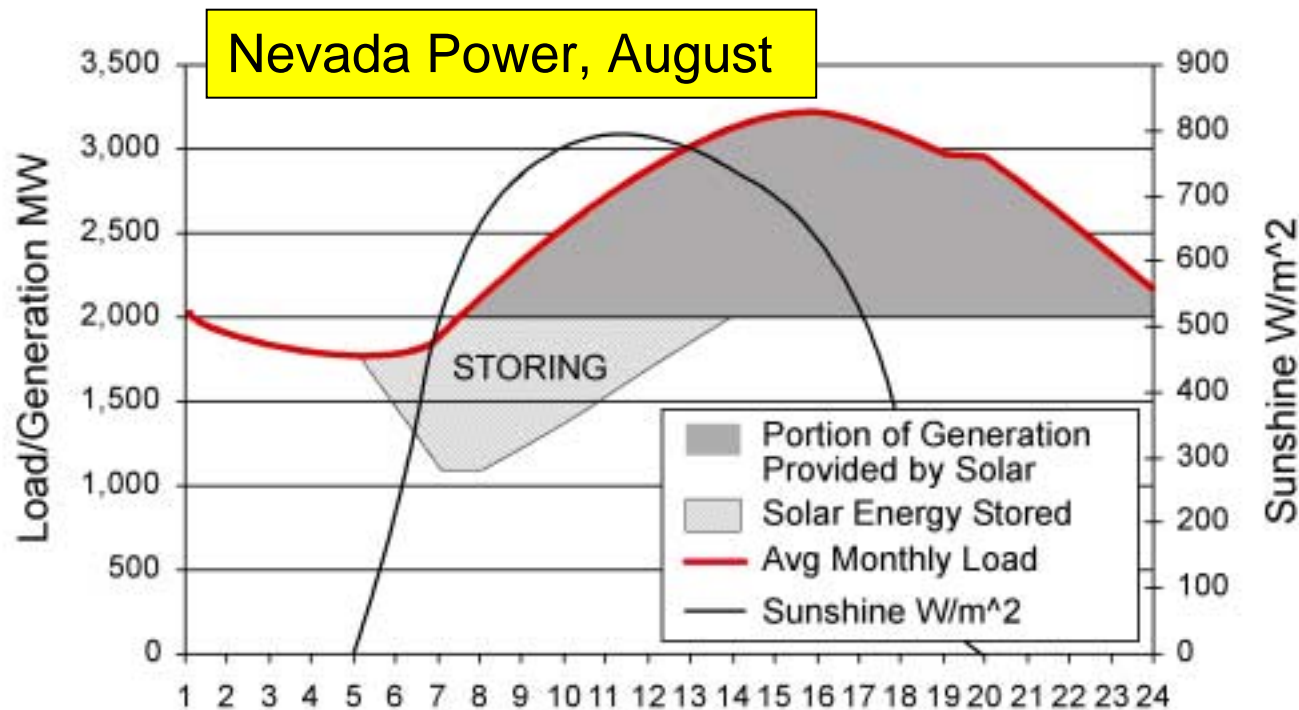
- On only 0.2% of western land, premium solar resources could meet nearly all of Western demand.
- Premium solar capacity equals 480,121 MW, more than twice the western peak demand.

# Dealing with the 'Nightly Outage'



- Assume 1,250 MW of (instantaneous) solar power in Nevada Power's market.
- After dark demand has only dropped by 125 MW from the peak, but solar generation is unavailable.

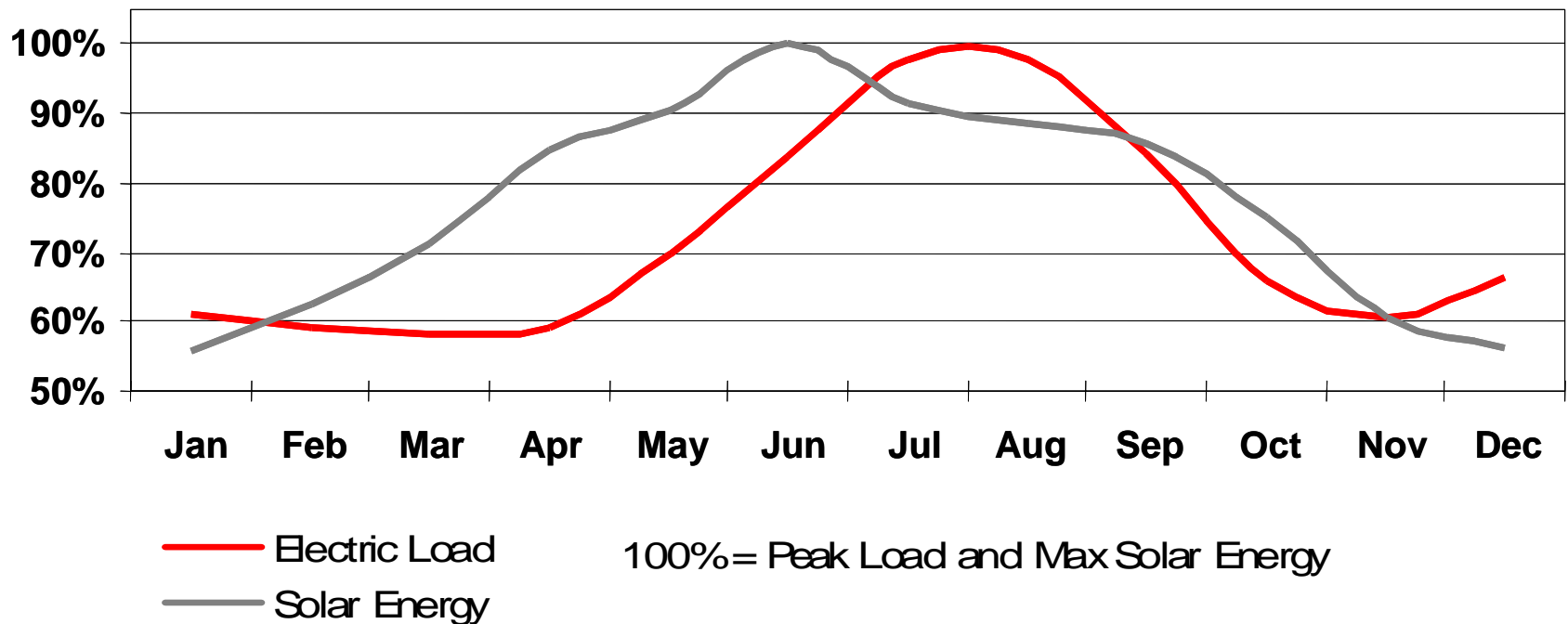
# Heat Storage Allows Generation After Dark



- Generation of 1,250 MW of solar with 3.5 hours of storage can displace 1,000 MW of capacity from Nevada Power's market.

# Seasonality of Load and Solar Energy

## Solar plant located near Las Vegas serving Nevada Power

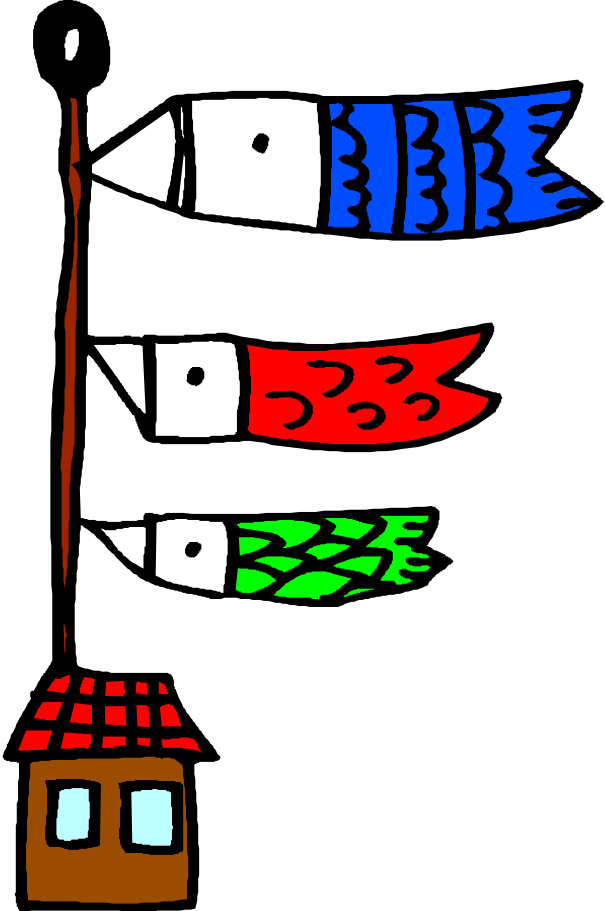


- Solar energy and load generally well matched.

# Solar Power Take Away

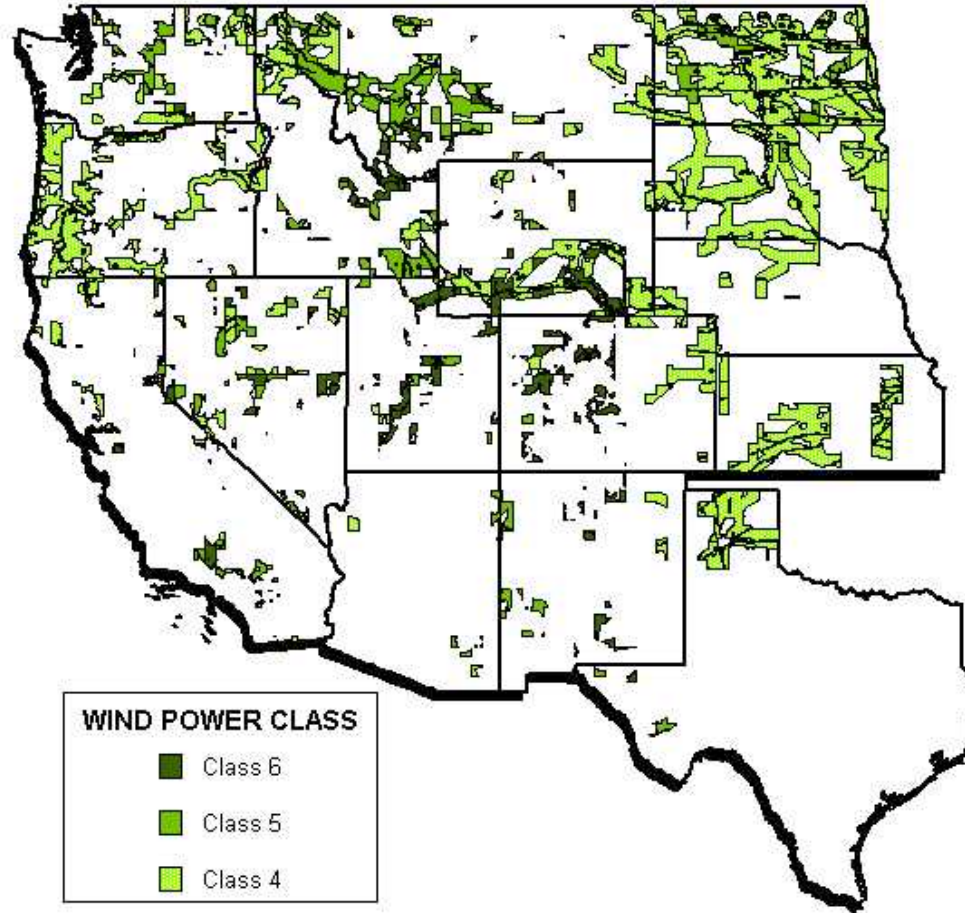
- Large resources, potentially the best in the world.
- Solar resources are close to load centers.
- Solar radiation can be forecast well.
- Heat storage allows around-the-clock generation.
- Concentrating solar power (CSP) is the least expensive form of solar power.
- Needs incubation period to become cost competitive.

# Wind





# Wind Resources in the West



# Wind Resource Methodology

- Made following changes compared to solar resource assessment
  - Only wind resources of Class 4 and 5 and higher were considered.
  - Cropland was included as potential land for wind power development.
  - Only land within a 10-mile corridor adjacent to a transmission line of 100 kV or greater was considered.
  - For Class 4 and 5 wind resources we assume that 5% of the land could be used for wind power and 10% for wind resources of Class 6 and higher.

# Wind Power Figures of Merit

- 20 MW wind power per square mile
- Wind capacity factors
  - 35% in Class 4
  - 38% in Class 5
  - 45% in Class 6

# Western Wind Energy Potential

Region	Wind Resources GWh			Land as % of Region
	Class 6	Class 5	Class 4	
Northwest	43,418	90,805	139,070	1.06%
CO & WY	97,484	3,733	62,179	1.10%
California	12,834	6,970	11,115	0.30%
Southwest	78,163	30,234	20,597	0.40%
States	-	23,104	278,583	1.59%
Texas	1,494	2,533	28,138	0.20%
<b>TOTAL</b>	<b>233,393</b>	<b>157,379</b>	<b>539,682</b>	<b>0.80%</b>
2001 Demand	1,092,160			N/A

- Wind energy resources of 0.8% of Western land are about 85% of Western electric energy needs.

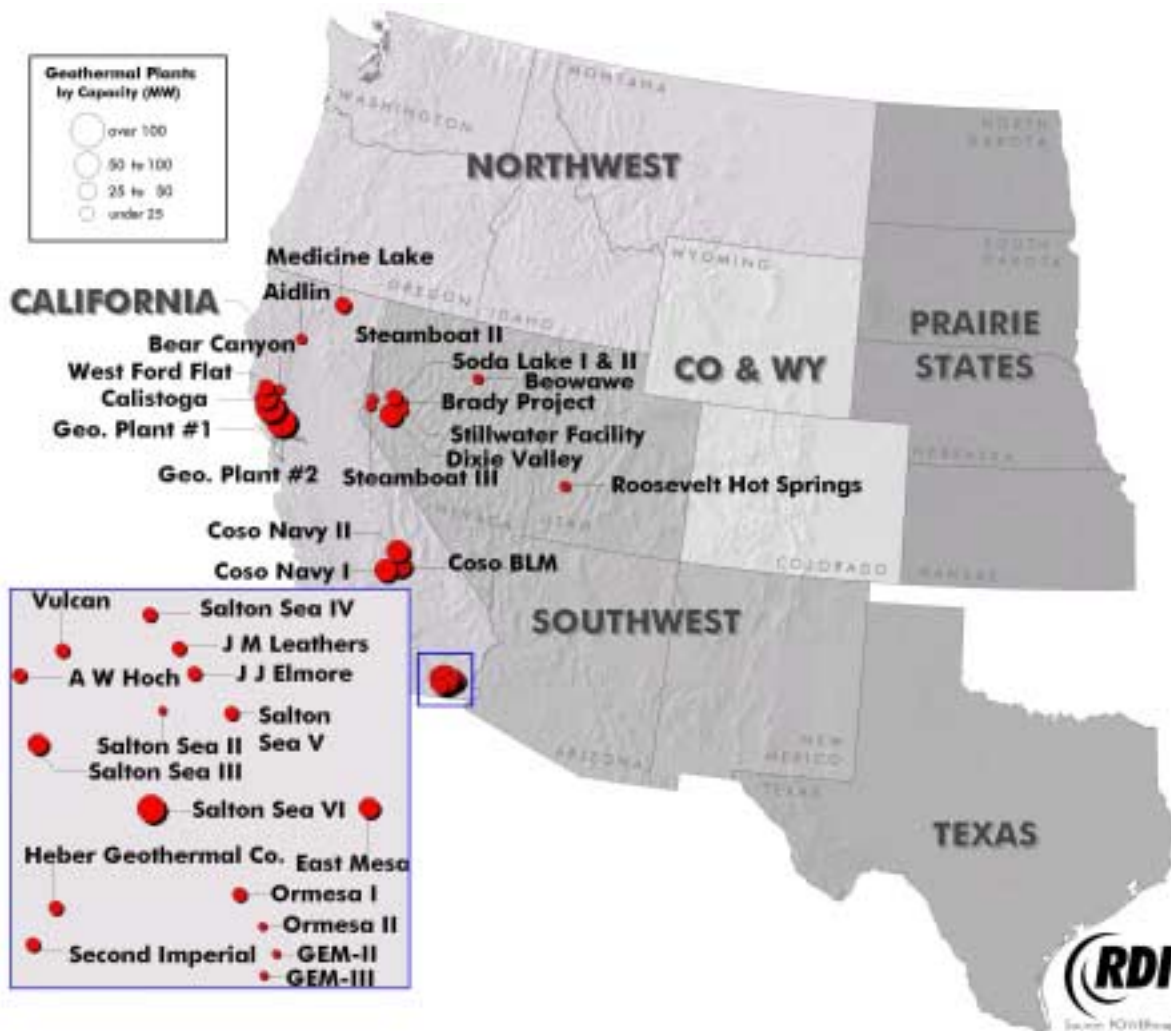
# Wind Power Take Away

- Power cost in 2001 is below \$40/MWh, before the federal production tax credit PTC.
- Capacity factors at top wind sites have reached 48% and are poised to reach 52% in new projects.
- Little impact on land use.
- From GIS analysis, wind resources appear smaller than solar, but are likely underestimated. Example, Texas.
- Intermittent and often far from loads.

# Geothermal



# Geothermal Power in the West



# Geothermal Take Away

- There are 53 geothermal power stations with a combined nominal capacity of 3,276 MW.
- Need geothermal resources.
- With a production tax credit commensurate with wind, geothermal power would be nearly cost competitive today.
- Great uncertainty with regards to resource potential.
- Advanced drilling technology could greatly enhance geothermal resources.
- Geothermal resources are clustered and not always near load centers.



# Summary

- Wind and solar power can make a significant contribution to Western electricity supply.
- Heat storage for thermal solar power can greatly mitigate intermittence issues.
- Search for geothermal resources could be valuable energy policy goal

# Questions and Answers

