National Renewable Energy Laboratory
Innovation for Our Energy Future

Concentrating Photovoltaics

NREL

Sarah Kurtz

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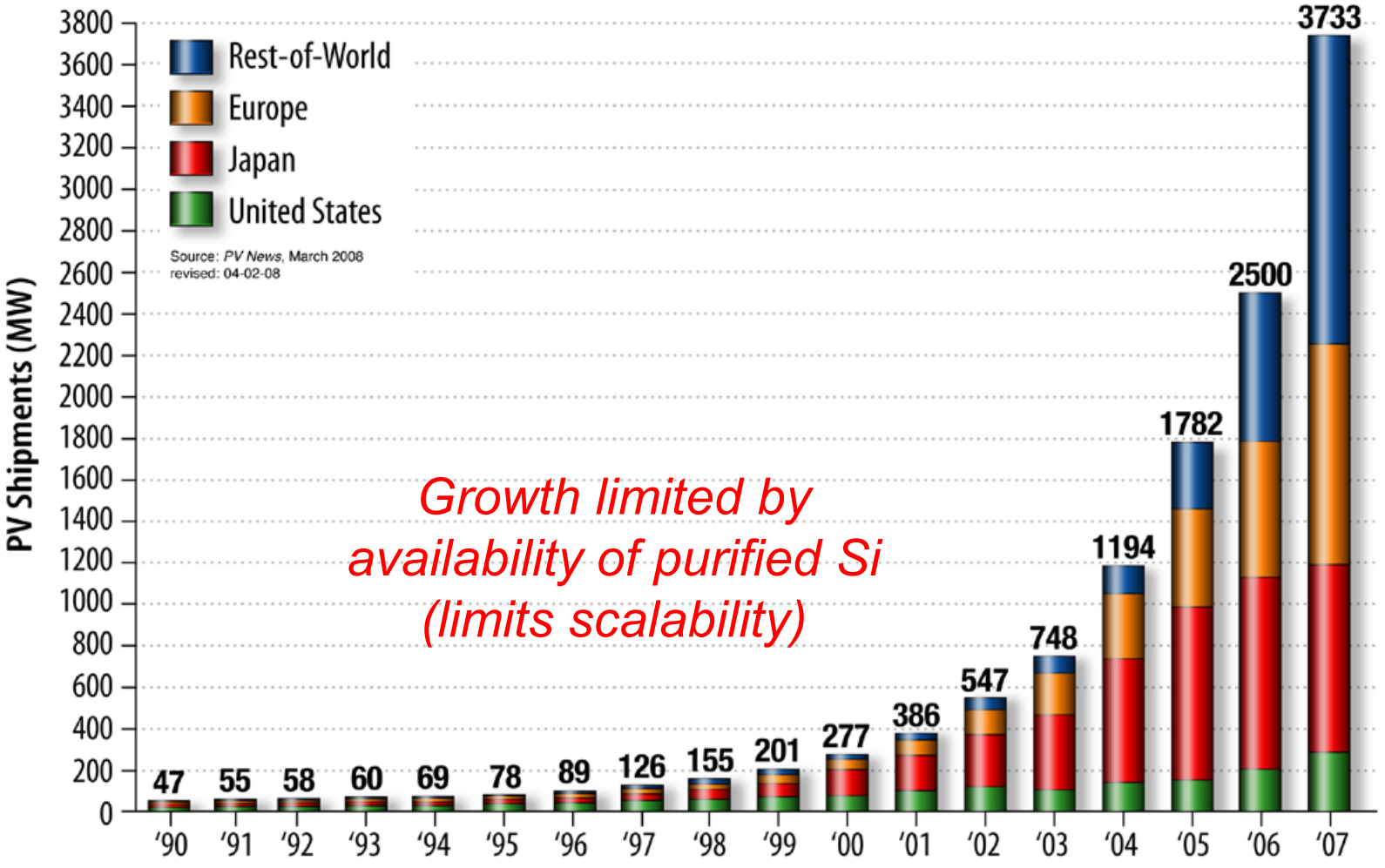
Solar Power Generation

Sponsored by
Green Power Conferences

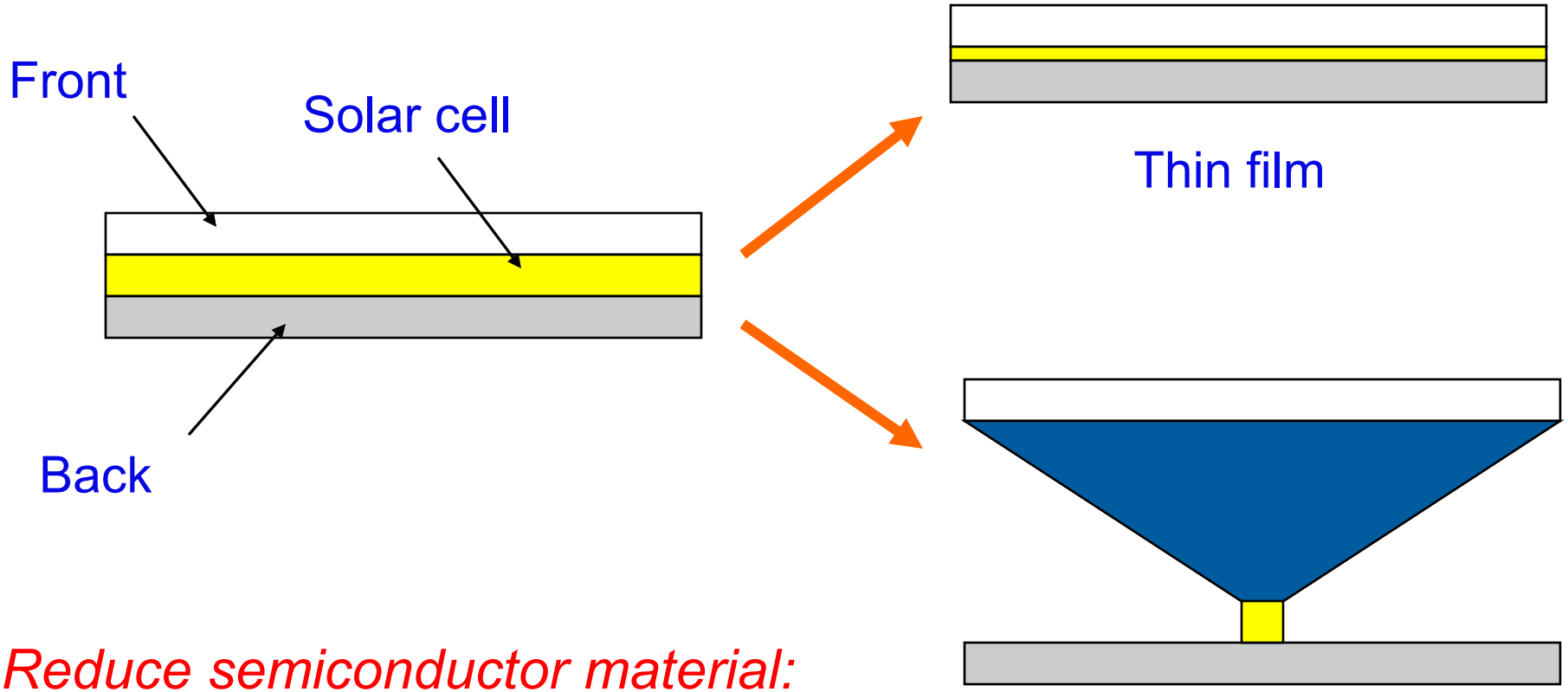
Las Vegas, NV

NREL/PR-520-44884

Solar is growing rapidly



Two strategies to reduce semiconductor material

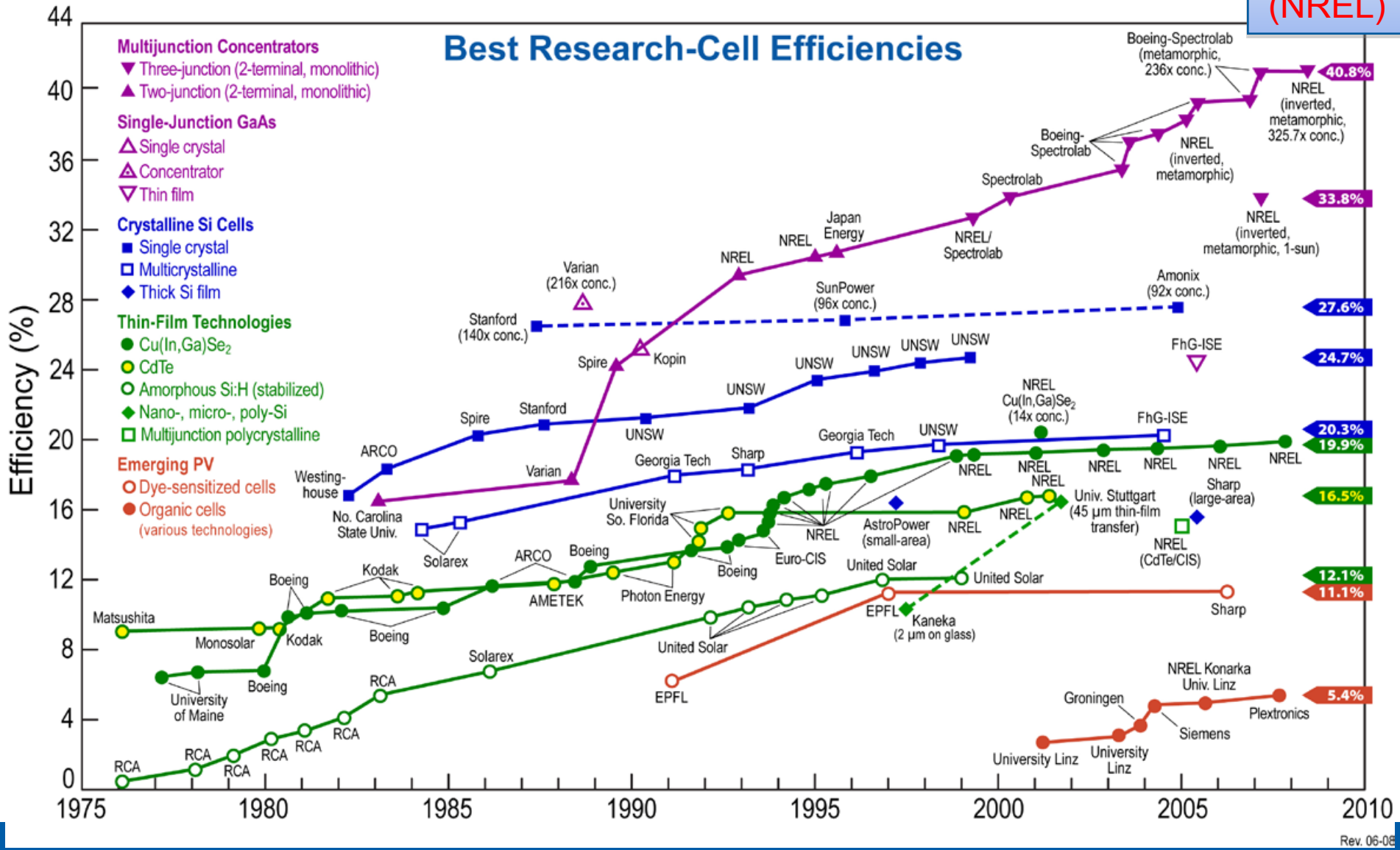


Reduce semiconductor material: reduce cost and improve scalability

~ $1Billion investment

Multijunction cells show highest efficiencies

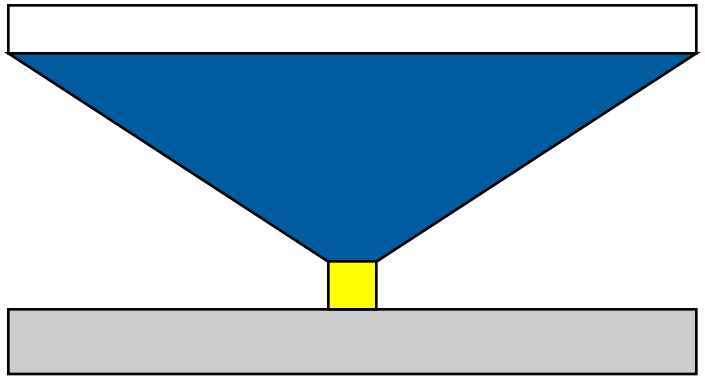
40.8%
Geisz
(NREL)

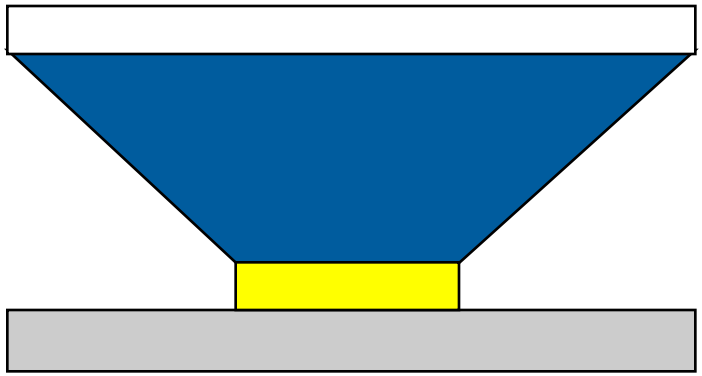


Range of concentrator approaches

Amonix

JX Crystals





High concentration
- 35% - 40% cells
- 400X – 1500 X

Low concentration
- 15% - 25% cells
- 2X – 100 X

High-concentration cell companies

Company Name	Location	Comment
Arima	Taipei, Taiwan	Report having achieved >37% cells
Azur Space	Heilbronn, Germany	Report 36% efficiency; custom designs available
CESI	Milano, Italy	Have been selling space cells since early 1990s.
Cyrium	Ottawa, Canada	Solar cells are available for independent evaluations
Emcore	Albuquerque, NM, USA	Datasheet describes typical 39% cells and receivers at ~500 suns
Epistar	Hsinchu, Taiwan	Multijunction cells in development
IQE	Cardiff, Wales, UK	Have demonstrated state of the art efficiencies with two separate partners
Microlink Devices	Niles, IL, USA	Multijunction cells in development
Quantasol	Kingston upon Thames, Surrey, UK	Multijunction cells with quantum wells
Sharp	Japan	Have demonstrated high efficiencies, but have not indicated plans for full commercialization
Spectrolab	Sylmar, CA, USA	Datasheet describes minimum average 36% cells and cell assemblies at 50 W/cm^2
Spire	Boston, MA, USA	Datasheet describes typical 35% cells at 500 suns
VPEC	Ping-jen city, Taiwan	Multijunction cells in development

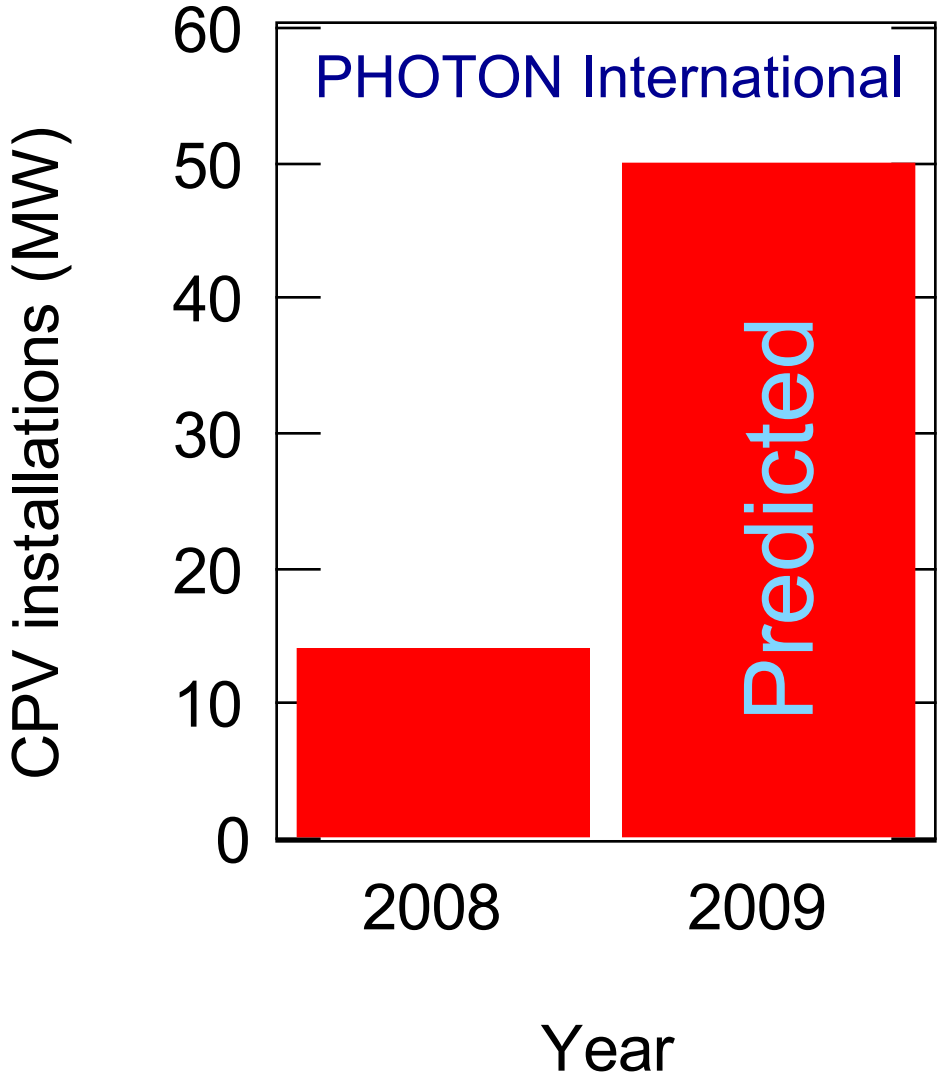
High-concentration companies

Company	Type of System	Location	On Sun in 2007*	On Sun in 2008**	Capacity**
Abengoa Solar	Lens, pedestal	Madrid, Spain, and elsewhere			
American CPV		Orange, CA, USA			
Amonix	Lens, pedestal	Torrance, CA, USA	>100 kW (Si-based)	600 kW (Si-based)	
Arima Ecoenergy	Lens, pedestal	Taipei, Taiwan		50 kW	7 MW/y
Boeing	Mirror, Pedestal	Seal Beach, CA, USA			
Concentracion Solar La Mancha	Lens, pedestal	Ciudad Real, Spain			11 MW/y
Concentrating Technologies	Small mirror, pedestal	Alabama	>1 kW		
Concentrix Solar	Lens, pedestal	Freiburg, Germany	~100 kW	300 kW	25 MW/y
Cool Earth Solar	Inflated mirrors	Livermore, CA, USA	>1 kW		
Daido Steel	Lens, pedestal	Nagoya, Japan		30 kW, planned Dec. 2008	
Delta Electronics	Lens, pedestal	Taiwan		400 kW in progress	> 2MW/y
Emcore	Lens, pedestal	Albuquerque, NM, USA	>10 kW	400 kW	10 MW/y
ENEA	Lens, Si cells, pedestal	Portici, Italy			
Energy Innovations	Lens, each module tracked	Pasadena, CA, USA		UL certification	
Enfocus Engineering	Lens, flat pivot	Sunnyvale, CA, USA			
ENTECH	Lens, pedestal	Keller, TX, USA	>1 kW in 2003		
ESSYSTEM	Lens, pedestal	Gwangju-city, Korea			
EverPhoton	Lens, pedestal	Taipei, Taiwan			
Green and Gold	Lens, pedestal	South Australia			
Greenfield Solar	Reflective; edge-illuminated Si cells	Cleveland, OH, USA			
GreenVolts	Small mirrors, carousel	San Francisco, CA, USA	>1 kW	2 MW in progress (2009 completion)	
Guascor Foton	Lens, pedestal	Ortuella, Spain	~10 MW (Si-based)	10 MW (Si based)	15 MW/y
IBM	Lens	Armonk, NY			
Isofoton	Lens, pedestal	Malaga, Spain		400 kW Puertollano	10 MW/yr
Menova	Modified trough	Ottawa, Ontario, Canada			
OPEL International	Lens, pedestal	Shelton, CT, USA			
Pyron	Lens, carousel	San Diego, CA, USA	>1 kW		
Scaled Solar	Dish	San Francisco, CA, USA			
Sharp	Lens, pedestal	Japan			
Sol3g	Lens, pedestal	Cerdanyola, Spain	>10 kW	1.4 MW	12 MW/y
Solar Systems	Dish, pedestal	Victoria, Australia	>100 kW	1.2 MW	5 MW/y
SolarTech	Lens, pedestal	Phoenix, AZ, USA			
Solar*Tec AG	Lens, pedestal	Munich, Germany			
SolFocus	Small mirror, pedestal	Mountain View, CA, USA	>10 kW	500 kW	50 MW/y
Soliant Energy	Lens, flat pivot	Pasadena, CA, USA			
SUNRGI	Lens	Hollywood, CA, USA			
Xtreme Energetics	Two designs: central station and rooftop	Livermore, CA, USA			

Low-concentration companies

Company	Type of System	Location	On Sun in 2007	On Sun in 2008
Abengoa Solar	Reflective, linear, Si cells	Madrid, Spain		1.2 MW
Archimedes	Reflective, linear, Si	Stuttgart, Germany		
Covalent Solar	Luminescent, multiple types of cells	Boston, MA, USA		
CPower	Reflective, 25X–30X (point focus), Si cells	Ferrara, Italy		> 10 kW
ENTECH	Linear Fresnel lens; Si cells	Fort Worth, TX, USA	> 100 kW in the 1990s	
JX Crystals	Reflective, linear, Si cells	Issaquah, WA, USA	> 100 kW	> 100 kW
Maxxun	Luminescent	Eindhoven, Netherlands		
MegaWatt Solar	Reflective, linear, 20X, pedestal	Hillsborough, NC, USA		50 kW
Netcrystal	Non-tracking; Si cells	San Francisco, CA, USA		
Opel International	Reflective, linear, Si cells	Shelton, CT, USA		
Optony	Thin-film cells	Silicon valley, CA, USA		
Pacific Solar Tech	Dome-shaped lens; Si cells	Fremont, CA, USA		
Prism Solar Technologies	Holographic; Si cells	Lake Katrine, NY, USA		
Pythagoras Solar	Static	Hakfar Hayarok, Israel		
Silicon CPV	Fresnel (point focus) Si cells	Essex, UK		
Skyline Solar	Reflective, 10X; Si cells	Mountain View, CA, USA		
Solaria	2X–3X; small strips of Si cells	Fremont, CA, USA		
Solbeam	Tracking optics in flat configuration	Laguna Niguel, CA, USA		
Stellaris	Static, 3X "see-through"; Si cells	North Billerica, MA, USA		
SV (Silicon Valley) Solar	Flat-plate dimensions	Sunnyvale, CA, USA		
Sunengy	Fresnel (point focus); Si cells in water	Sydney, Australia		
Thales Research	Static, reflective	Severna Park, MD, USA		
Whitfield Solar	Linear Fresnel lens, ~40X; Si cells	Reading, UK		
WS Energia	Reflective, linear, 2X Si modules	Oeiras, Portugal	24 kW	263 kW
Zytech Solar	Reflective, linear, Si modules	Zaragoza, Spain		

Turning point for industry?



Is the CPV industry ready to ramp production?

PHOTON International predicts 50 MW in 2009