CONCENTRATING SOLAR POWER (CSP)
== AN INDUSTRY AND MARKET OVERVIEW ==

CSP Peer Review
Albuquerque, NM
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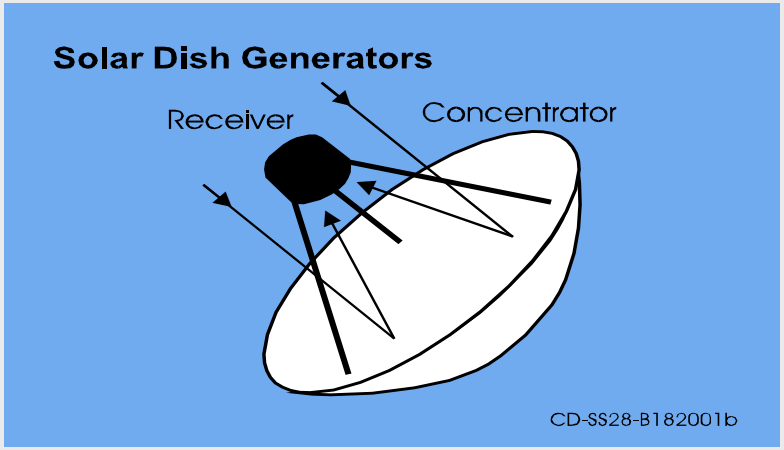
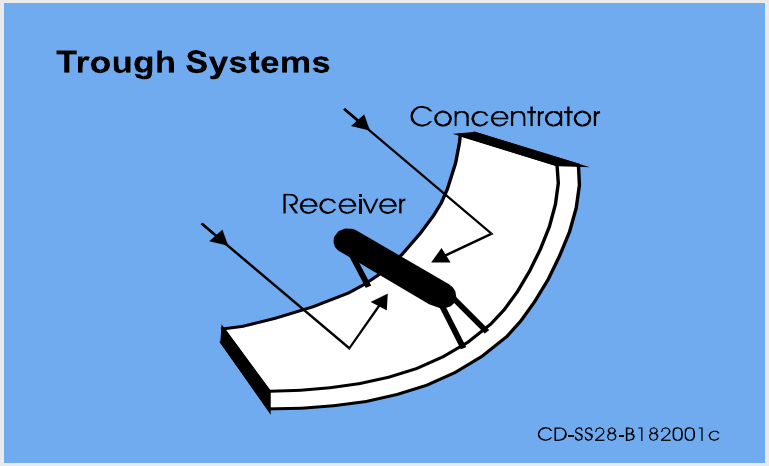
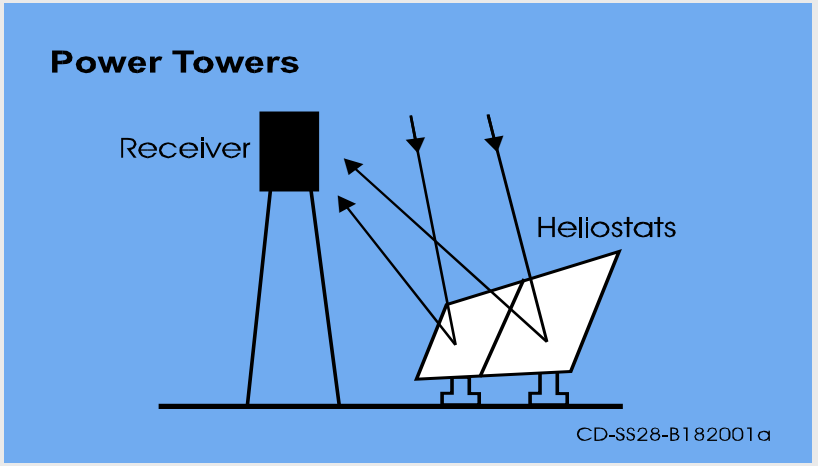
Scope

- CSP attributes and background
- Industry stakeholders
- Value and market issues
- Cost reduction issues
- Subsidies







Framework

- The technologies:

  dish engine – parabolic trough – concentrating PV
  power tower – integrated building systems
- Recent congressional action has formalized a key public goal:

  1000 MW's installed by 2006 using trough,
  tower and dish engine technology
- Individual CSP industry business plans have already been focused on similar objectives
- Industry market presentations will follow this broad overview

the CSP industry

DISH/POWER

Science Applications International Corporation (SAIC) is a large, employee-owned, high technology company whose 25 kWh dish/converter systems have been tested at the Pentagon, in Colorado, Arizona, and Nevada. SAIC intends to license and support its technology worldwide.

STM Power Incorporated develops, manufactures, and sells external heat engine Power Units that all used in traditional cogeneration markets as well as power conversion system in dish/Stirling units.

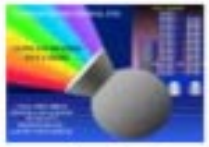
WGAssociates is a small business structured to engineer and field point focusing solar collector systems and large satellite communications dishes. WGA has delivered dish/Stirling concentrators with controls ranging in size from 9.5 kWe to 25 kWe.

Stirling Energy Systems (SES) is developing a 25 kW solar dish Stirling power system that has demonstrated the highest efficiency conversion to date. Current activities are focused on reducing cost and increasing reliability to enable wide application at many sites for utility scale and distributed electrical generating systems.

POWER TOWER

Nexant/Boeing
Nexant, Inc. and The Boeing Company are currently leveraging their long heritage in developing solar power towers into the first commercial project, "Solar Tres", to be located in Spain. The "Solar Tres" molten salt solar receiver will be three times larger than the receiver system for the Solar Two demonstration plant, located near Barstow, California and operated from 1994 to 1999. Future commercial plants will be 100+ MW in capacity.

CONCENTRATOR PV



United Innovations, Inc. (UI²) is an independent advanced technology R&D company. UI²'s revolutionary 3 kW – 100 kW photovoltaic cavity converter (PVCC) technology with record breaking solar-to-electric conversion potential.

Amonix, Inc., is a privately held designer and manufacturer of proprietary, high-performance, solar-electric generating systems. Arizona Public Service (APS) Company is in the process of completing a 500 kW utility-scale installation using Amonix's advanced concentrating photovoltaic technology.

Spectrolab is the leader in photovoltaic solar cells and panels for space applications. Our present-day epitaxial semiconductor capability is responsible for the highest performance space and terrestrial solar power available. Spectrolab recently achieved 34% efficiency for the terrestrial concentrator solar cells as measured by NREL. Spectrolab's terrestrial concentrator receiver modules are integrated into various concentrator systems.
Concentrating Technologies is a small company in Alabama leading the development and deployment of Dense Array High Concentration PV systems. The system's power conversion units are built using the time-tested silicon PV cell technology from Amonix or PV cells from Spectrolab.

ENTECH is a high technology company solely involved in the design, manufacture and installation of solar power systems. The concentrating photovoltaic power plant pictured uses ENTECH's SolarRow product which is ideally suited for immediate deployment of large multimegawatt, solar power plants in the Southwest US.

TROUGHS

KJC Operating Company
Florida Power & Light Energy Operating Services, Inc.
Sunray Energy Inc. operate the 354 MW of SEGS plants in southern California. The largest solar plant in the world has ran reliably for over 11 years providing the reliability and cost effectiveness of trough power systems.

Duke Solar is developing building integrated troughs for cooling. Duke Solar is also developing a 100 MW trough plant (like SEGS) in the southwest.

Distinguishing Attributes of CSP

Proven commercial systems

High market value

Dispatchability

Low cost solar option

Range of applications

Scale, leading to high impact

Jobs (scale related)

CSP Market Value to the Customers and Nation

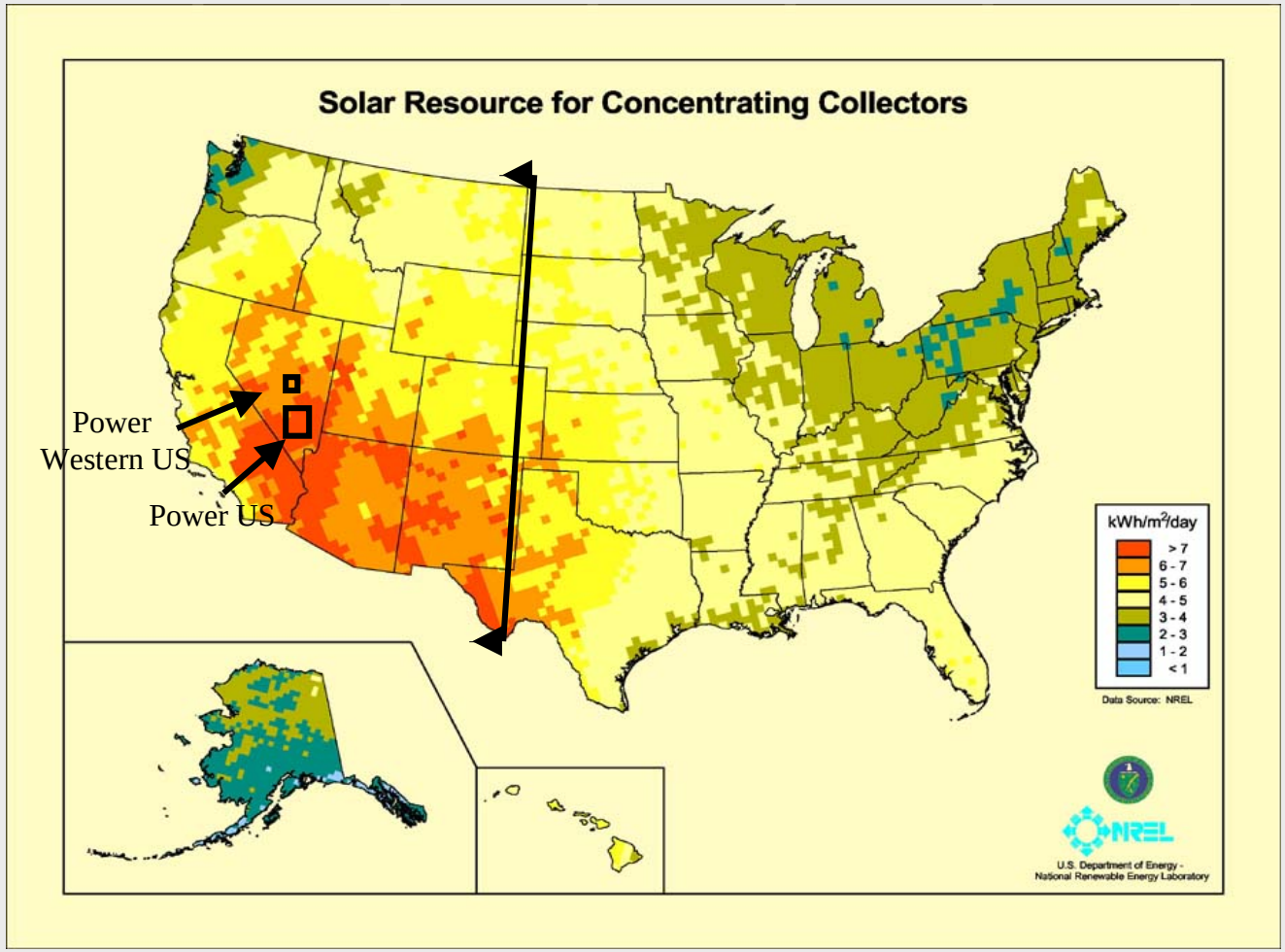
- Energy resource diversity
- High grade thermal energy
- Dispatchability (firm power → power shifting by hybrid operation or thermal storage)
- Large environmental impact due to scale
- 'Fuel' and price stability
- Energy security and independence
- Economic value
- Serves varying scales of applications

Distinguishing Attributes of CSP

- Elegant and effective use of optics to concentrate solar energy into a high temperature medium used to heat a working fluid in efficient thermal power cycles, or to drive concentrating PV cells
- Modular and applicable to large central facilities in the100's of MW down to distributed generation in the 10's of kW
- Dispatchable power can meet peaking and intermediate load demands with hybrid operation or thermal storage → value
- Proven capabilities, e.g., 354 MWe trough plants in operation for 16 years, with demonstration of excellent performance, availability, technology, and significant O&M cost reductions. Other CSP options show their own unique advancements.

Additional Merits of CSP

- Large US resource with broad siting potential in the Southwest and parts of California



Maximum output occurs at peak time of day when elec-tricity is at premium price

Additional Merits of CSP

- Scale can be significant enough to impact climate change targets
- Trough and tower technologies well suited for large scale projects; trough technologies are mature and commercially ready today.
- Thermal systems designed to integrate with conventional power plant design and operation, and can operate in hybrid mode with fossil fuel or with thermal storage to enhance dispatchability (e.g., SEGS plants, Solar Two)
- Lowest actual electricity costs of any solar technology based on commercial operations
- Proven potential for further cost reductions including those resulting from mass production economies, e.g., for glass, steel

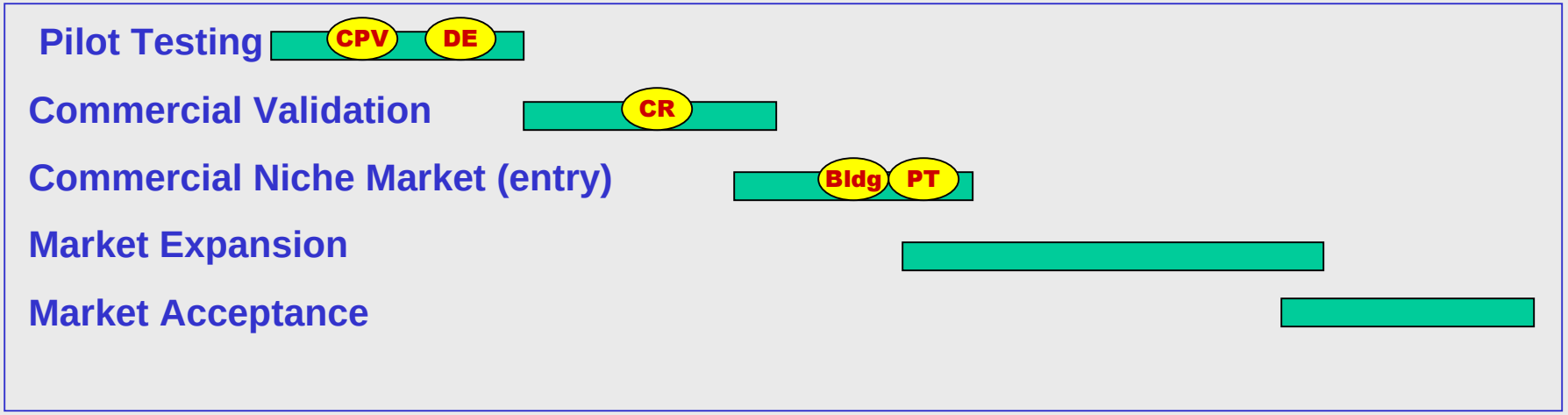
Value of Power from Renewable Technologies

Technology	Dispatchable	Correlation with System Load	Value of Power Produced ¢/kWh	Power Technology Offset	Type of Payments
Dispatchable CSP*	**Yes**	**Good**	**5.5**	**Combined Cycle**	**Energy & Capacity**
PV w/o storage	**No**	**Good**	**2.3**	**Combined Cycle**	**Energy**
Wind	**No**	**Poor**	**1.4 – 2.3**	**Coal & CC**	**Energy**
Geothermal Biomass	**Yes**	**Baseload**	**3.5**	**Coal & CC**	**Energy & Capacity**

* Via hybrid operation or utilizing thermal storage

Market Position of CSP technologies

The commercialization path may be described in five phases:



Market expansion and market acceptance lie ahead for all CSP technologies, with troughs closer to that stage. Structured programs are needed to move CSP technologies through these last three phases.

Central and Distributed applications present different applications and technology cost requirements. Later presentations by CSP technology sector will focus on technology-specific markets and technical programs

Market Potential

CSP is, or is close to, commercial entry markets, with the potential market large enough to justify needed subsidies

- Power market projections for renewable energy vary in details, but agree in general about the very large market potential (100's of GW)
- U.S. and international grid-connected generation is a key market. The operating characteristics of CSP are relatively well matched with the intermediate and peak loads in target countries.
- By 2010, between 2 and 8 GW are predicted internationally, rising to between 20 and 45 GW by 2020. An installation rate of 2 GW/yr is achievable in a mature market.
- Dish engines, building integrated systems, concentrating PV and small trough systems go after distributed market applications
- U.S. market focuses on opportunities in the SW, notably California, Arizona, Nevada, Texas

The task is to aggressively capture significant market share from where CSP is today …

Electricity Price Estimates for Market Take-off Depend on Application

Technology	Market Application	Take-off Prices
Dish	Grid-connected sub-station	5 – 10 ¢/kWh
	Distributed Generation	6 – 12 ¢/kWh
	Rural Generation – Diesel	12 – 30 ¢/kWh
Tower	Central Station – Intermediate	4 – 6 ¢/kWh
	Central Station – Peaking	6 – 8 ¢/kWh
Trough	Central Station – Intermediate	4 – 6 ¢/kWh
	Central Station – Peaking	6 – 8 ¢/kWh

Current price levels vary with the commercial status of individual technologies

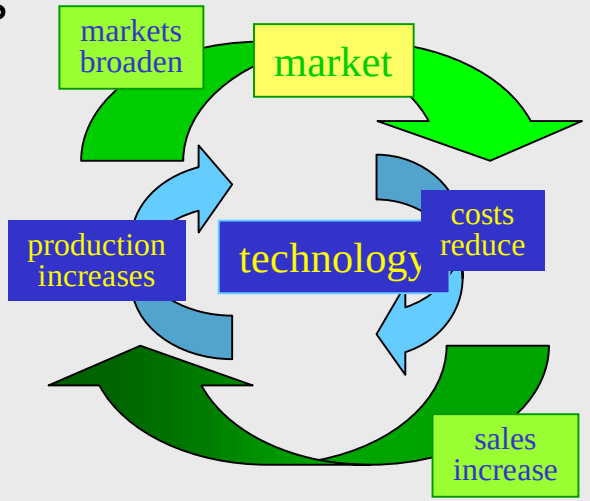
Cost Reduction is a critical step

The three CSP technologies can reach their take-off prices in next five years with a relatively small number of projects, further technology development and subsidies.

Electricity costs – must reduce capital costs via technology and project learning curve improvements and reduce debt service via better financing and subsidies and reduced risk.

- Dish Engine — Critical need is manufacturing scale-up to >1,000 units/yr
- Trough/Tower — Many available options identified to reach take-off costs

With incentives, the necessary "virtuous cycles" of production scale-up – cost reduction – increased market share are feasible and could be rapidly established for all CSP technologies.



Examples of Cost Reduction Potential
Large scale systems

Action	% Cost Reduction	¢/kWh Reduction Based on 14 ¢/kWh base
Increase size from 50 to 160 MW (trough/tower)	20%	-2.8
Mass production	15-30%	up to -4.0
Technology development	10%	-1.4
Multiple siting	25%	-3.5
GenCo financing	10%	-1.4
Tax equity	18%	-2.5
2% debt financing	30%	-4.1

Most of these actions can combine for a strong cumulative effect

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Active International CSP Opportunities

Near-term WB/GEF and country projects

Country/State	Plant Configuration (active)	Next Step	Subsidy
India	140MW ISCCS/**35MW solar**	RFP issue	$45M GEF grant + 150M KfW soft-loan
Egypt	137MW ISCCS/**36MW solar**	RFP prep	$50M GEF grant
Morocco	180MW ISCCS /**26MW solar**	RFP prep	$50M GEF grant
Mexico	291MW ISCCS/**40MW solar**	RFP prep meeting held 11-01-01	$50M GEF grant
Spain	**2x50MW trough + 2x15MW tower (each >40MW equiv.) + 3x25kw / 1.5MW dish engine demo**	Passage of law awaited	Up to 26 pesetas/kWh during all periods
Jordan	**150MW SEGS**	Prelim RFP issued	NA

Active International CSP Programs

Significant R&D Programs

Country/State	Plant Configuration (active)	Next Step	Subsidy
Italy	30 MW SEGS in Sicily + R&D	Definition and awards	$100M total over 3 years
Germany	New CSP R&D: $10.5M over 3 yr	Awards in negotiation	Troughs $7M; other $3.5M
EU	Ongoing R&D in solar thermal		
Iran	60MW ISCCS	GEF application	GEF

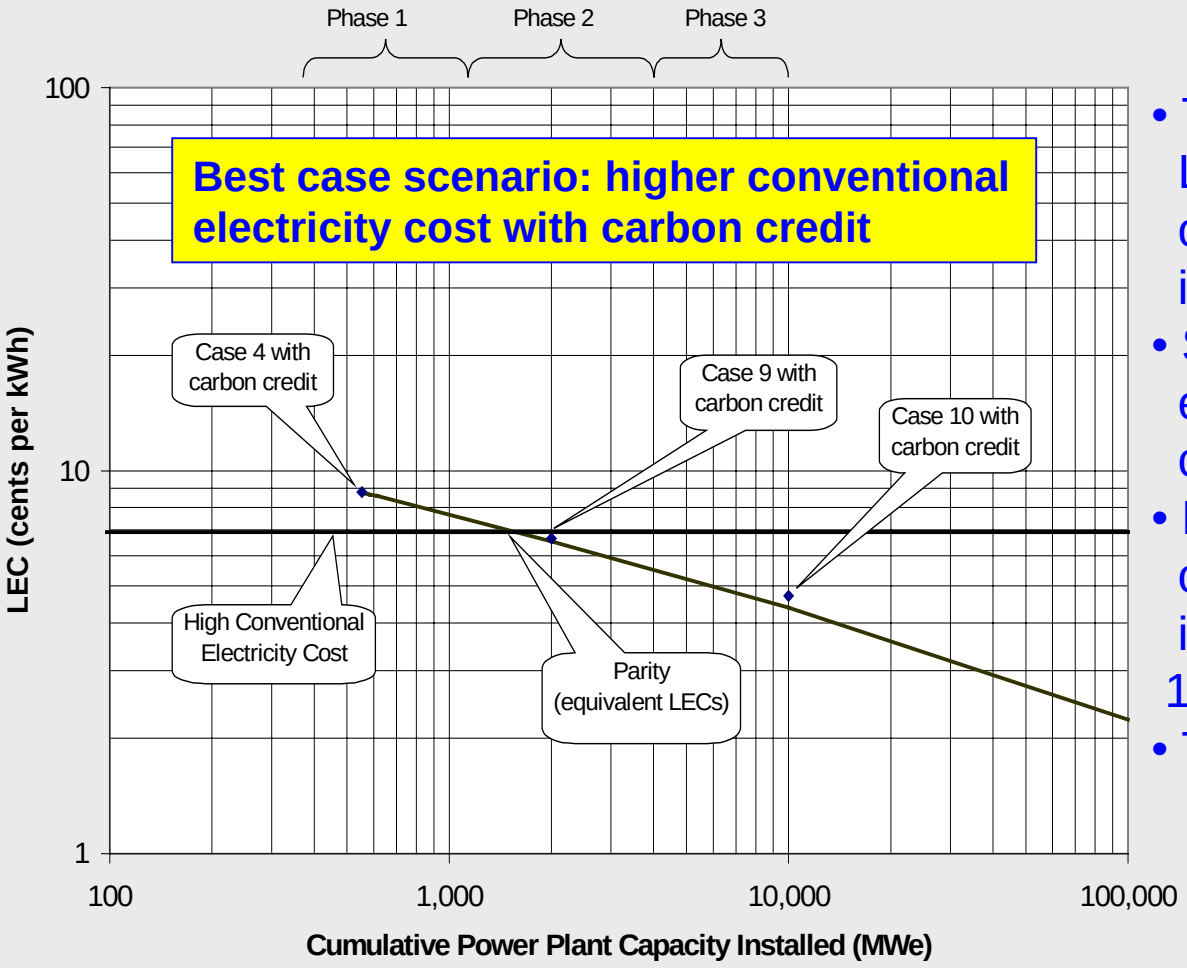
There is an aggressive German-Spanish commercialization team active in solar troughs, with strong R&D support

History of Large-Scale Commercial CSP Development – the 10 SEGS Plants

- Today
  - All plants still operating after 11-16 years
  - At 150MW Kramer Junction site, performance is excellent, with many performance records set over last few years
  - O&M costs significantly reduced as performance has increased
- Development Years: 1984-1990
  - PURPA, Tax Incentives, and Special PPAs allowed development
  - Luz Built 9 Parabolic Trough Plants: 14-80 MWe, 354 MWe Total
  - Declining Energy Prices and Incentives
  - Annual Renewal of Incentives required ⇒ Increased Cost
  - Delay of 1990 Solar Property Tax Extension ⇒ Luz Bankruptcy
- Last Decade …
  - Economic Downswing ⇒ Excess Power Capacity
  - Restructuring of Utility Power Sector
  - Trough Development Efforts Focus on International Markets

  ⇒ No New Plants in Last 10 Years

The World Bank: Cost Reduction Study on Solar Thermal Power Plants (1999, Entermodal Engr Ltd)



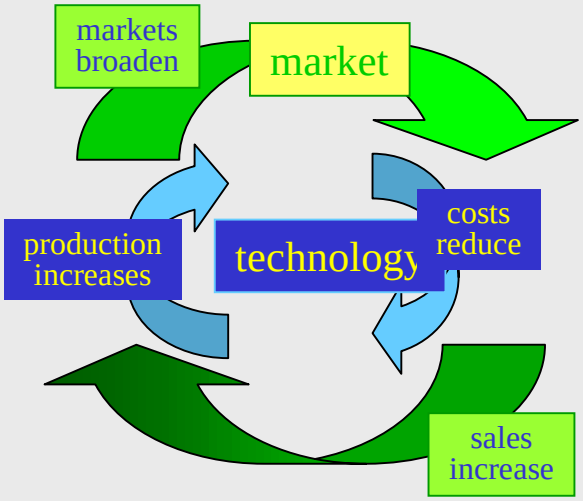
- This shows projection of solar LEC reduction for large trough or tower system as function of installed capacity
- Scenarios varied conventional electricity cost as well as carbon credit for solar system
- Parity at 6.9-4.3 c/kWh over 4 scenarios, requiring installed capacities from 1,600 - 58,000 MW
- Total incremental investment range $ 0.5-9.7 billion

In the near term, subsidies and policy incentives are critically important …

- ✓ Renewable Portfolio Standards
- ✓ System Benefit Charges
- ✓ Utility Restructuring
- ✓ Federal Green Power Purchase Requirements
- ✓ Grants
- ✓ Emission Credits
- ✓ Renewable Energy Credits
- ✓ Production Credits
- ✓ Electricity Feed Laws
- ✓ Non-Fossil Fuel Obligations
- ✓ Low-Cost Capital
- ✓ Taxes
  - – Investment and Production Tax Credits
  - – Solar Property and Sales Tax Exemptions
- ✓ Guaranteed Long Term PPAs

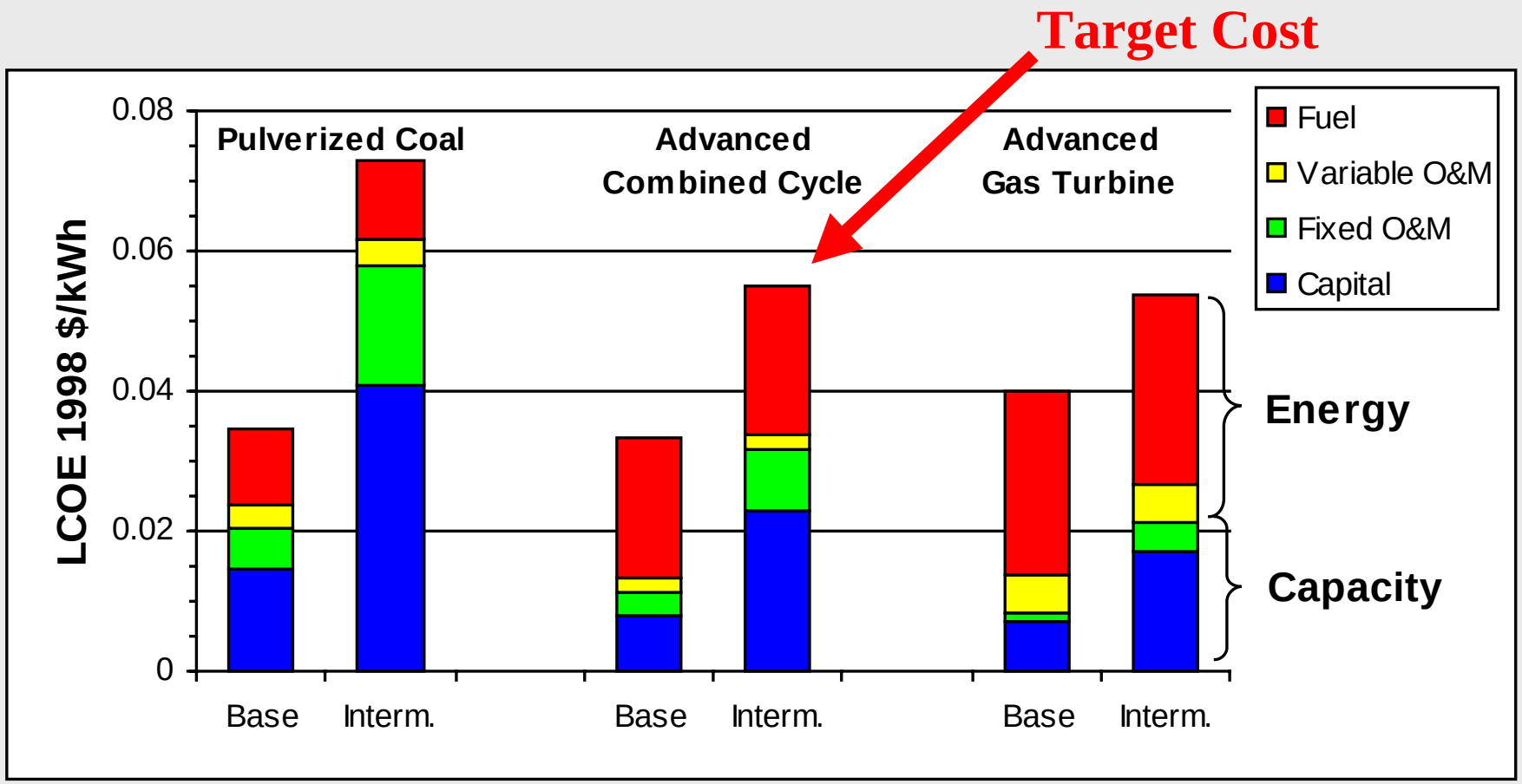
Additional data on following slides

The Virtuous Cycle of Production and Sales



Market opportunities lead to increased production, lowering costs. Sales increase, leading to further rises in production and opening up new market horizons.

Levelized Cost of Electricity for Large-scale Conventional Technologies

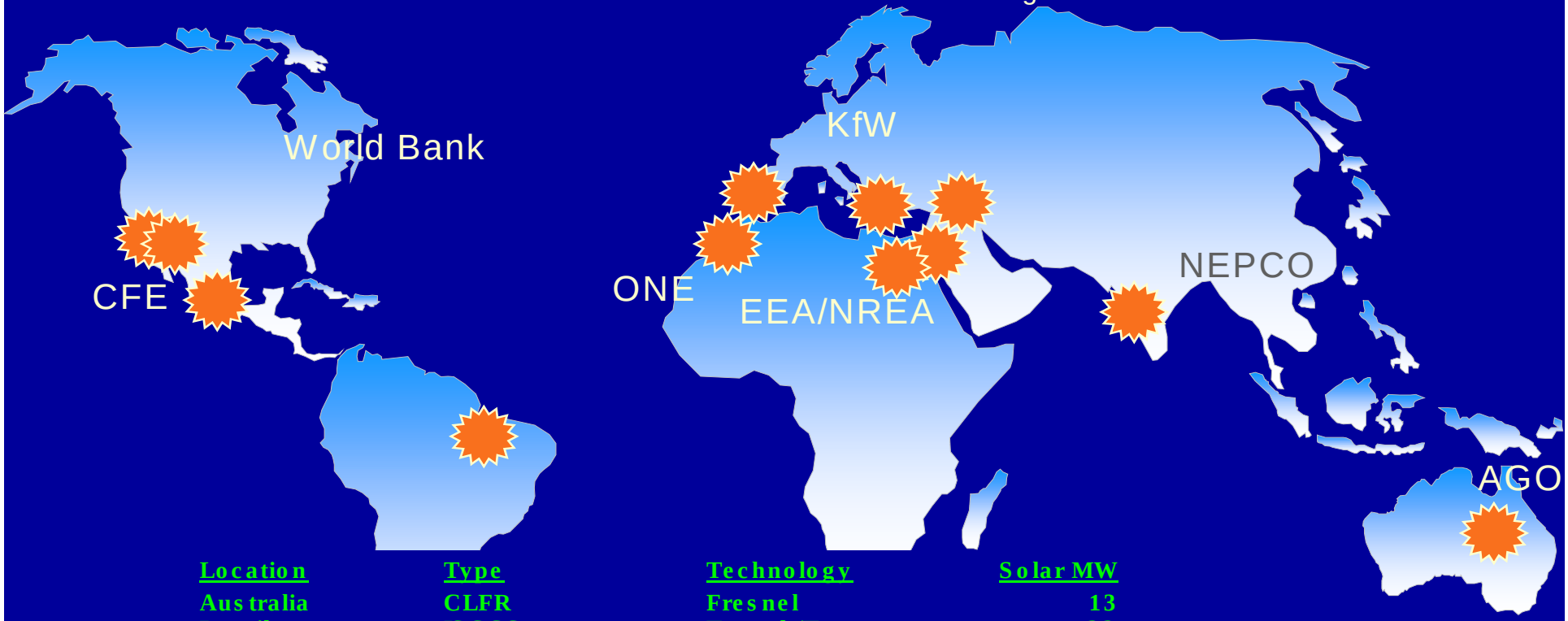


Based on 1999 Fuel Pricing

World Map of CSP Activity

DukeSolar KJC SES
Nextant SMA S&L
Boeing SAIC Siemens

Fichtner Schott Glass
Solar Millennium Pilkington
Gamesa Ghersa
Solel Abengoa



Location	Type	Technology	Solar MW
Australia	CLFR	Fresnel	13
Brazil	ISCCS	Trough/Tower	??
Crete	SEGS	Trough	52
Egypt	ISCCS	Trough,Tower	30-80
India	ISCCS	Trough	35
Iran	ISCCS/SEGS	Trough	30-80
Jordan	PHOEBUS	Tower	30
Mexico	ISCCS	Trough	40
Morocco	ISCCS/SEGS	Trough,Tower	30-80
Spain	SEGS, SP10	Trough,Tower	10-50
USA	SEGS	Trough	354

POLICY ELEMENTS NEEDED TO ADVANCE CSP

A variety of policy strategies are currently being employed around the world to invest public funds in support of the deployment of RETs.

- Renewable Portfolio Standards

  Requires a certain percentage of new capacity to use RETs, if a percentage of that is for solar, will create a market opportunity for CSP.

- System Benefit Charges

  Available for per kWh incentives or can be used to buy-down the difference between the actual electricity price and the market price.

- Utility Restructuring

  Customer choice can enter the market and force the building of green power supplies, hence some CSP

- Federal Green Power Purchase Requirements

  Acts like a RPS in the federal sector

- Grants

  To buy-down the capital cost of clean technologies, as GEF, EU Thermie and the Spanish Royal Decree do, thereby mitigating all or some of the technology risk.

- Emission Credits

  A per kWh credit associated with a carbon emission reduction by a renewable energy technology. Reduces the ¢/kWh thereby reducing the capital cost subsidy required to compete.

- Renewable Energy Credits

  Certificate of proof that 1 kWh has been generated from a renewable source and sold to an end user.

- Production Credits

  Provides a per kWh credit for electricity produced from certain renewable energy technologies

- Electricity Feed Laws

  Sets a minimum price on electricity from certain RETs as a percentage of the average market price.

- Non-Fossil Fuel Obligations

  Provides a premium payment for a certain percentage of electricity from a non-fossil source.

- Low-cost Capital

  Currently pay a risk premium on equity and debt over rates available for conventional power.

- Taxes

  US taxes favor expense-intensive projects and penalize capital-intensive projects. This inequity results in restraining new beneficial technologies.

  - Investment and Production Tax Credits – Fed and State Investment Tax credits provided 55% to the SEGs at the start. Could switch to production credit as for wind.

  - Solar Property Tax Exemption – Property tax is now like tax on 30 years of fuel and is a significant cost penalty for PT. California exempted SEGS from paying property tax on solar property – land and equipment for the solar field and also the conventional plant as it was needed for solar operation. Should be solar field only.

  - Sales Tax Exemption – Fossil fuel plants do not pay sales tax so neither should solar equipment

- Letters of Credit

  To guarantee performance – Need performance guarantee via letter of credit to cover potential warranty payments. Need other approach to ensure investor confidence in the PT. Will be performance warranty with suitable backing such as a fund.

- Guaranteed Long Term PPAs

  An agreement to purchase a specified amount of electricity at a specific price for a specified (long) period of time and guaranteed by a governmental agency.

Conclusion – Many effective policies are being used today to promote RETs. A comprehensive set of policies would be most effective for CSP.