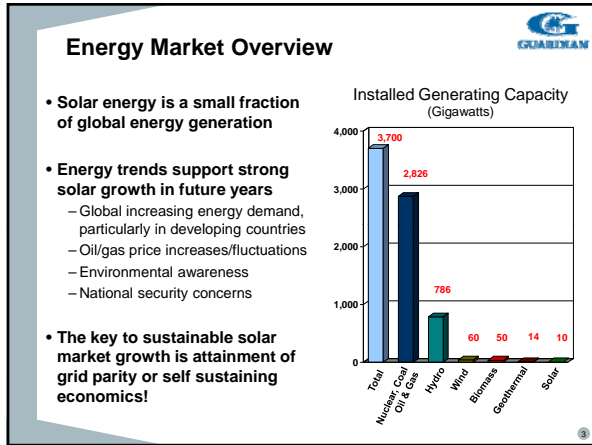
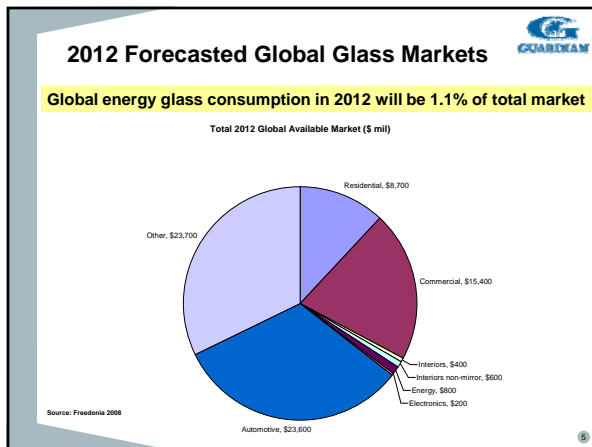




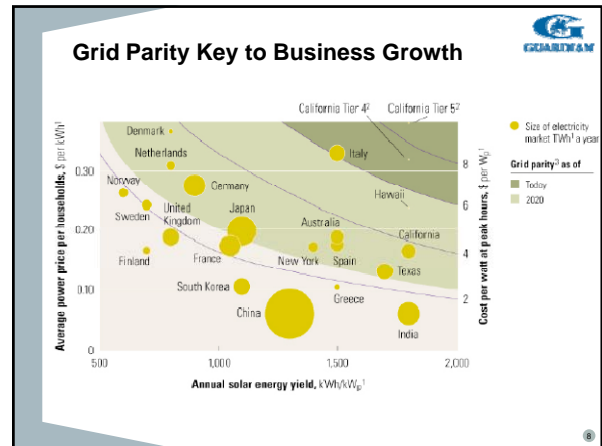
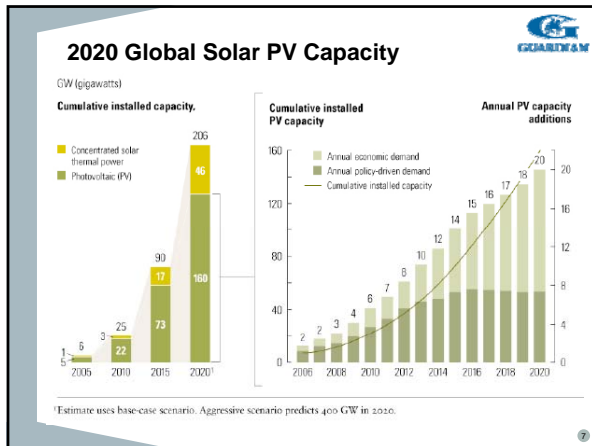
- ### Solar Impact on Glass Industry
- The Emerging Solar Market
 - Solar Energy Economics
 - State and Regional Renewable Energy Goals
 - Concentrating Solar Power for North America
 - Photovoltaics for North America
 - Solar Impact on North American Glass Industry



- ### The Emerging Solar Market
- Solar industry experts feel primary glass manufacturers have been slow to respond to solar glass demand and trends
 - The total solar market has historically been a very small percentage of the installed float and pattern glass capacity
 - In 2007 the total solar glass consumption worldwide was less than 0.1% of the total global glass production
 - Industry experts point to 30-40% CAGR as the primary indicator of the market
 - But primary glass manufacturers commonly focus on tonnage and square meters to drive investments

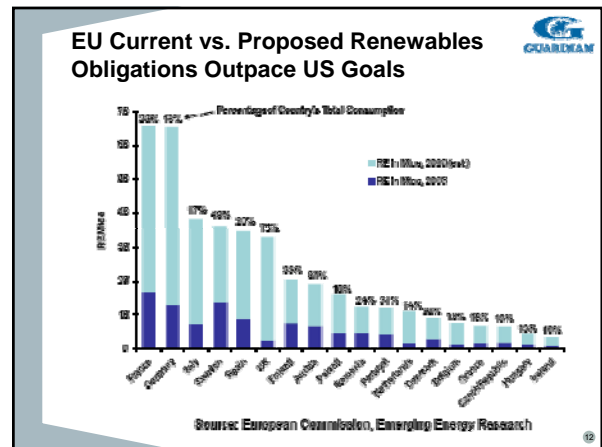
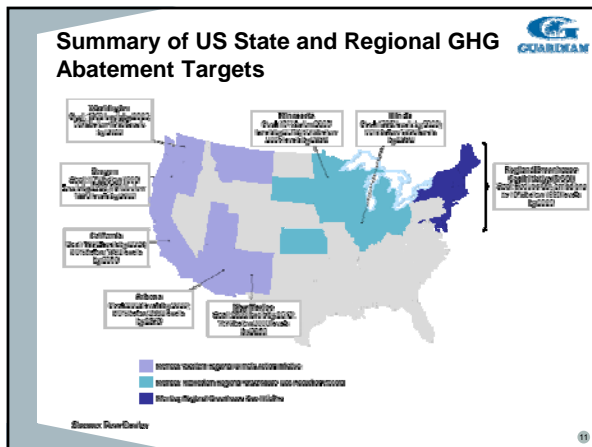


- ### Economics Will Drive Demand Not Hype
- Several market segments have been decimated because they responded to market hype on growth rates as opposed to true, sustainable business demand
 - 90's .com boom to bust
 - 00's telecom boom to bust
 - There is no doubt that the solar market growth will be high but several key factors are driving demand...
 - Government subsidies
 - Green building trends
 - National security concerns for energy generation
 - The industry needs to find solutions to reach grid parity in order for solar to become a long-term viable business



- ### Government Incentives Are Driving Solar Growth
- European Union members are leading the way on Feed-In-Tariffs (FITs) for solar energy which is driving solar growth
 - Germany and Spain are leading the way with on-grid FITs
 - Germany & Spain were 72% of global PV demand in 2008
 - Additional EU countries adding FITs in 2009-2012
 - US demand for solar technologies currently driven by:
 - Tax incentives, GHG abatement, and renewable energy quotas
 - Reduced \$/watt technologies will be required to drive growth in NA without FITs or additional incentives

- ### States Increasing RPS Goals
- At the state level, 14 states have implemented a mix of regulatory strategies to offer incentives for solar development.
 - California is leading the way with a 33% goal by 2020.
 - Two southern states have progressed toward greater renewables generation - North Carolina and Florida.
 - States with general solar minimums in their RPS targets are expected to create significant opportunities for both solar PV and concentrating solar power.
 - CSP's ability to capture a significant share of this opportunity will depend largely on its cost-competitiveness with natural gas and, increasingly, solar PV.
 - Longer-term market growth will be subject to utilities and regulatory authorities, who will decide on the most appropriate solar technologies through permitting.



North American Solar Technologies

There are two viable energy generation solar technologies for the North American Market


Concentrating Solar Power




Photovoltaics



Concentrating Solar Power (CSP)



Central Receiver



Parabolic Engine

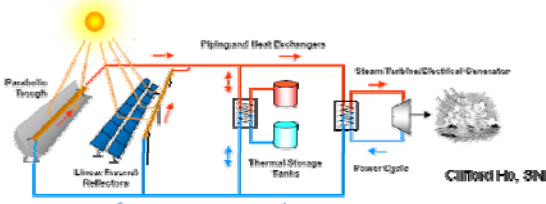


Fresnel Collector




Parabolic Trough

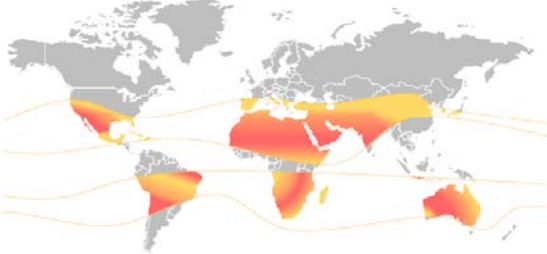
Parabolic Trough CSP System



Clifford Ho, SNL



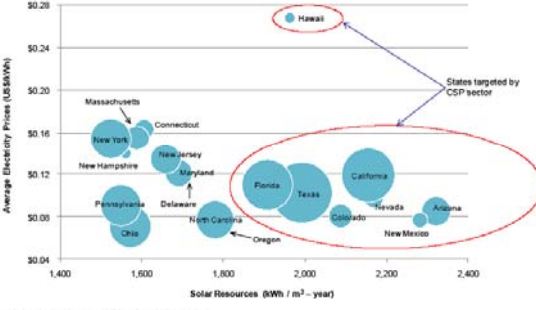
Global Solar Resources for CSP



Southern US is perfect climate for CSP installations

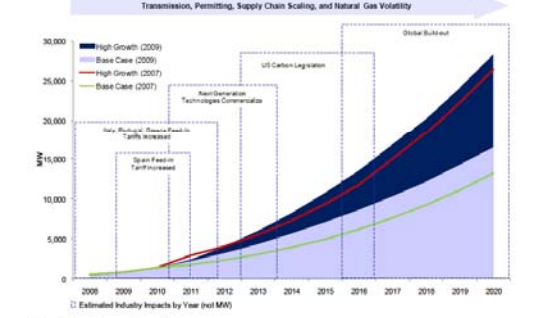
Source: Emerging Energy Research

US State Electricity vs. Solar Resources

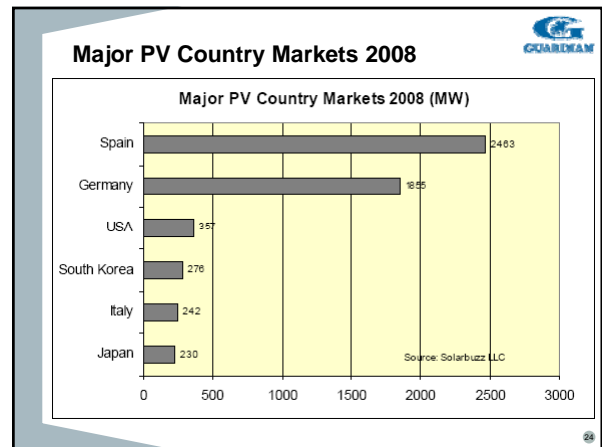
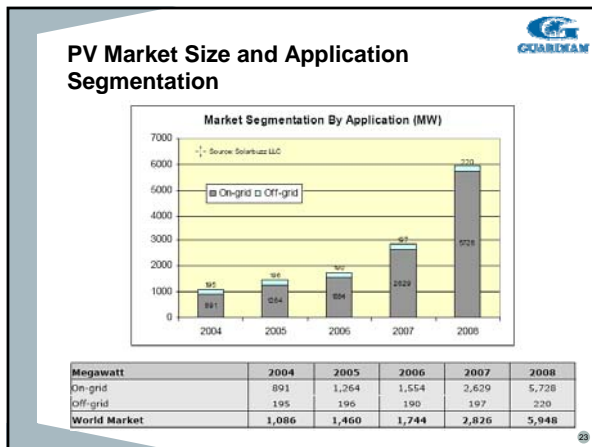
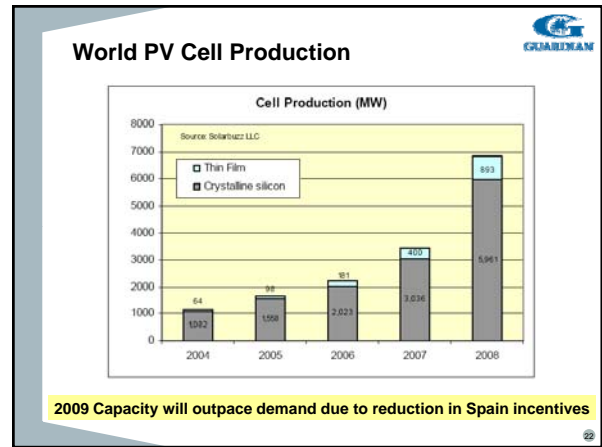
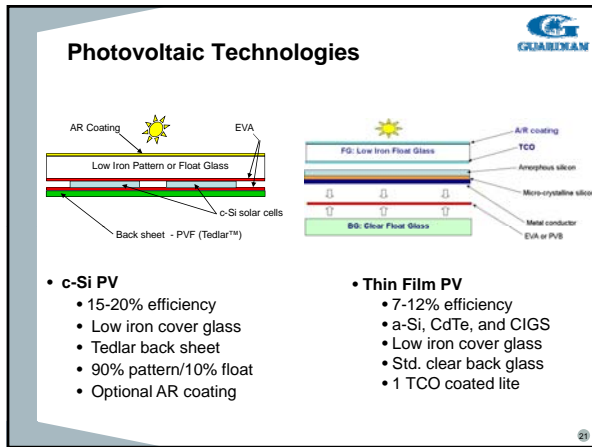
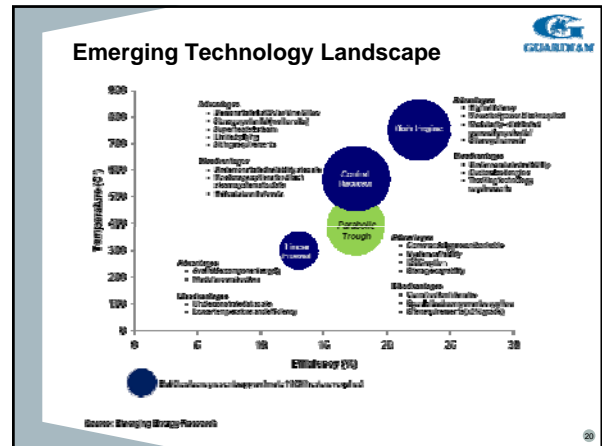
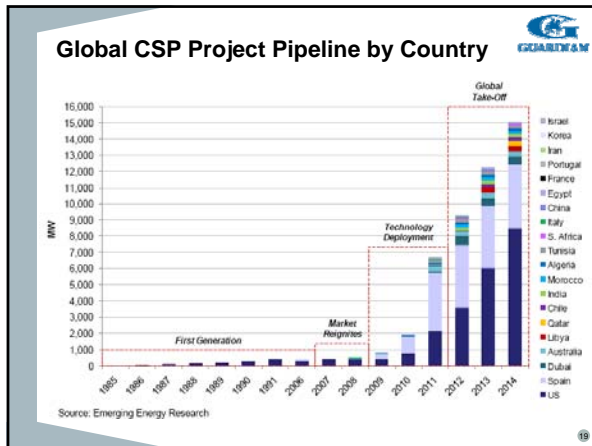


Note: Bubble size represents retail sales in 2007
Source: National Renewable Energy Laboratory, Energy Information Administration, Emerging Energy Research

Global CSP Growth Scenario by Total Installations



Source: Emerging Energy Research



Germany and Spain Feed-in Tariffs for Photovoltaics in C/kWh



System Size	Rate from May 26, 2007, until September 27, 2008, for the first 25 years of system operation	Rate from May 26, 2007, until September 27, 2008, after 25 years of system operation	Incentive Duration
≤100 kW	€0.440381/kWh	€0.352305/kWh	Paid for 25 years, after which the rate is reduced
>100 kW ≤10 MW	€0.4175/kWh	€0.334/kWh	
>10 MW ≤50 MW	€0.229764/kWh	€0.183811/kWh	

Application type	Start of operation	≤30 kW	>30 - 100 kW	Annual decline	>100 kW - 1 MW	> 1 MW	Annual decline
On or at buildings or sound barriers, including BIPV	2009	0.4301	0.4091	8% in 2010, 9% in 2011 and 2012	0.3958	0.33	10% in 2010; 9% in 2011 and 2012
	2010	0.3957	0.3764		0.3562	0.297	
	2011	0.3601	0.3425		0.3242	0.2703	
	2012	0.3277	0.3117		0.2950	0.2459	
Other systems (e.g. ground-mounted)	2009			0.3194			10% in 2010; 9% in 2011 and 2012
	2010			0.2875			
	2011			0.2616			
	2012			0.2380			

Glass Manufacturer Infrastructure



- The solar market impact to the glass industry has been minimal
 - > 90% of production has been low iron pattern solar glass
 - Typical pattern line is 120 mtons versus 700 mtons for float
 - Cost to transition lower on pattern than float lines
 - Pattern line sizes optimized for solar market as opposed to jumbos
- Glass companies could convert architectural pattern lines to solar and/or build green field facilities for solar due to tonnage requirements
- The growth of thin film PV and CSP will significantly increase the global demand for low iron solar float glass
 - Historically required transitions due to low volume requirements
 - TF PV approaching limits of dedicated solar float lines
 - CSP demand will significantly increase in 2011

The Need for Low Iron Glass



- Economics is driving the solar industry (\$/watt)
- The higher the solar efficiency the higher the revenue for all members of the supply chain
- Selection of low iron glass is based on economics and not marketing
- The level of iron content in the glass varies depending on the efficiency and total cost of the solar application
- The key thing to remember is not all low iron glass is low iron solar glass; optimizing for the visible spectrum does not return the necessary value to justify the increased price

Value Added Glass Is The Trend



- The market is also demanding higher performing coatings in addition to ultra low iron glass which will drive investment and market growth
- C-Si PV is migrating to Anti-Reflective (AR) coated low iron pattern and float glass to increase solar efficiency
- Thin film PV is searching for higher performing TCO and conductive coatings to increase cell efficiency; both pyrolytic and sputtered
- CSP alternative designs and higher reflectance mirrors are required to reduce the \$/watt for small, medium and large installations
- Surface #1 glass cleanliness and frequency of required cleaning will drive the need for advance surface control coatings

The Emerging Solar Market



- The solar market is growing at a rapid pace but will still need another 4-5 years to become a major glass market segment
- Glass production for solar has been dominated by low iron pattern glass for c-Si PV
- Thin film PV and CSP technologies will drive the demand and capacity in float assets; until volume is sizable it is difficult to dedicate multiple float lines per continent to the solar industry
- Based on current projections the solar market can equal demand of residential or commercial glass by 2025
- The key to sustaining growth is reduction in the \$ per watt in a controlled manner

Questions

