Renewable Energy in China
Challenge and Opportunity

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Teamwork

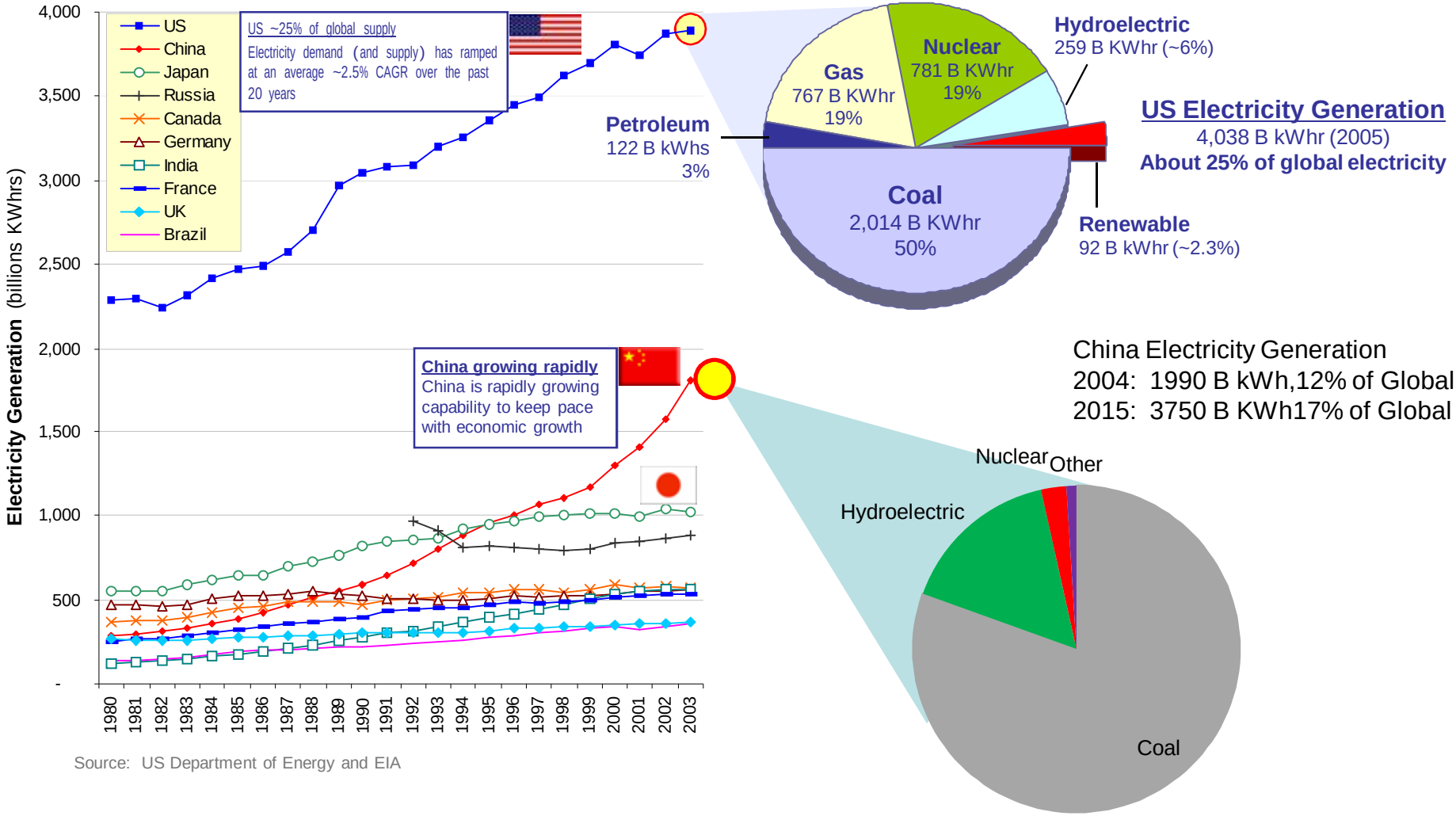
Environmentalist

Entrepreneur

Political Climate in China

- Sustainable growth becomes national principle
- “Save Energy and Reduce Emission” becomes the key objectives of political leaders
- Green GDP are the buzz words
- The Peoples’ Congress passed Renewable Energy Law
- The National Development and Reform Commission (NDRC) will invest $265B to implement the National Medium and Long Term Program for Renewable Energy (MLPRE), aiming to raise energy consumption from renewable sources to 10% and 15% of total energy consumption by 2010 and 2020, up from 7.5% in 2005.
- Reduce energy consumption per 10,000 Yuan GDP by 20% during 11th five year plan
- Very strong local government support on renewable energy

Electricity – big picture view

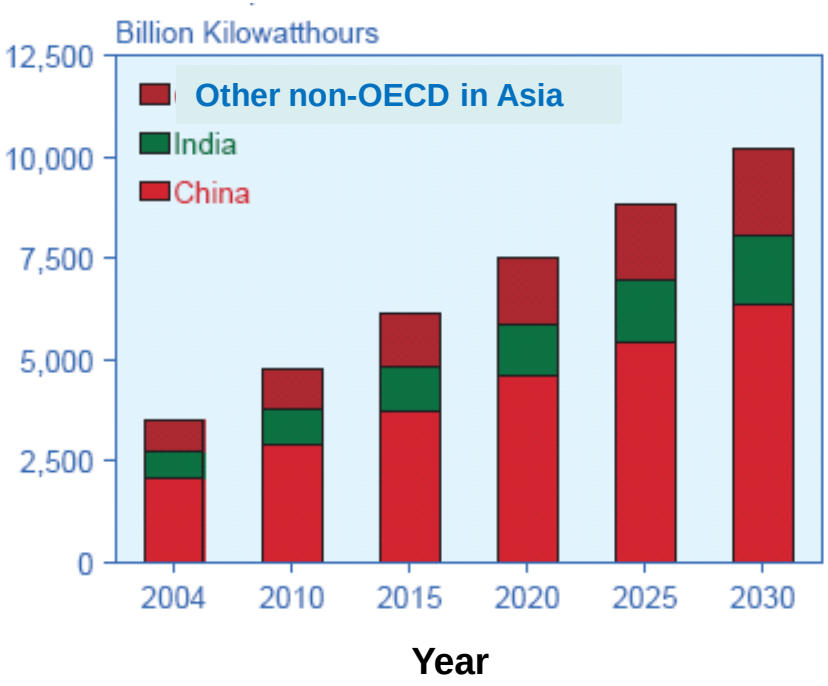


Source: US Department of Energy and EIA

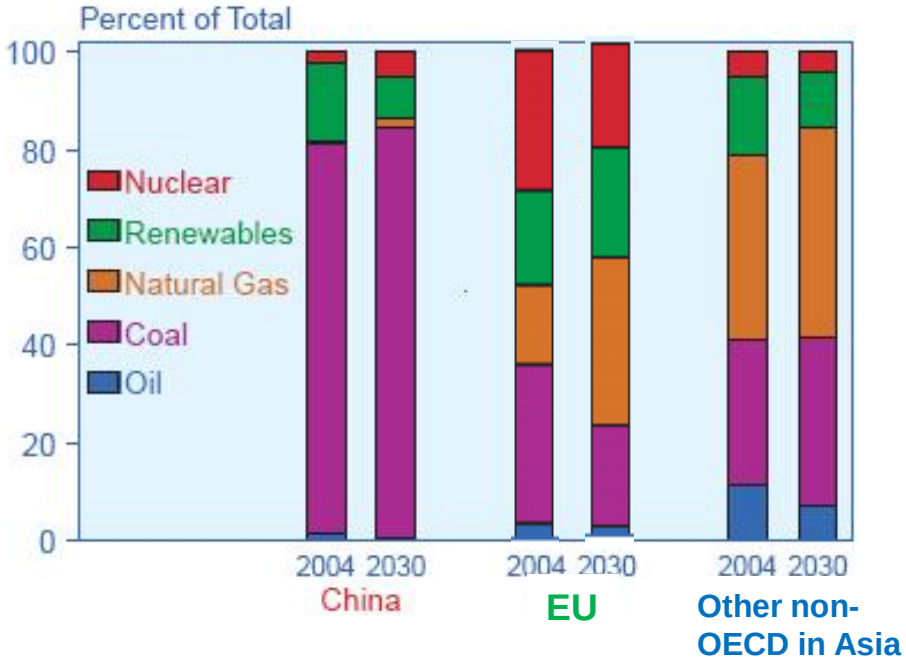
The US is the largest consumer of electricity; China is #2, but growing rapidly.

Electricity Supply and Demand in China

Demand



Supply



Source: International Energy Outlook 2007

Renewable Resources in China

- Hydroelectric resource: 400 GW
- Wind Resource: 300 GW (Continental), 700 GW (off-shore)
- Solar Energy: 2/3 of 9.6 million square kilometers territory has more than 2200 hrs solar radiance.

* Source: NDRC, China

Outline of MLPRE

Goal: 15% renewable energy by 2020, from 7.5%, 2005
Total Investment: RMB 2000B (US$ 265B)

		2005	2010	2020	CAGR
Hydroelectric	Large Scale	79 GW	140 GW	225 GW	7.3%
	Small Scale	38 GW	50 GW	75 GW	4.6%
Wind		1.26 GW	5 GW	30 GW	23.6%
Solar	Photovoltaic	70 MW	300 MW	1.8 GW	24.1%
	Solar Water Heating	80 mil sqm	150 mil sqm	300 mil sqm	9.2%
Biomass	Electricity	2 GW	5.5 GW	30 GW	19.8%
	Solid Fuel		1 mil ton	50 mil ton	47.9%
	Gas Fuel	8B m^3	15B m^3	30B m^3	9.2%
	Ethanol	1.02 mil ton	2 mil ton	10 mil ton	16.6%
	Diesel	0.05 mil ton	0.2 mil ton	2 mil ton	27.9%

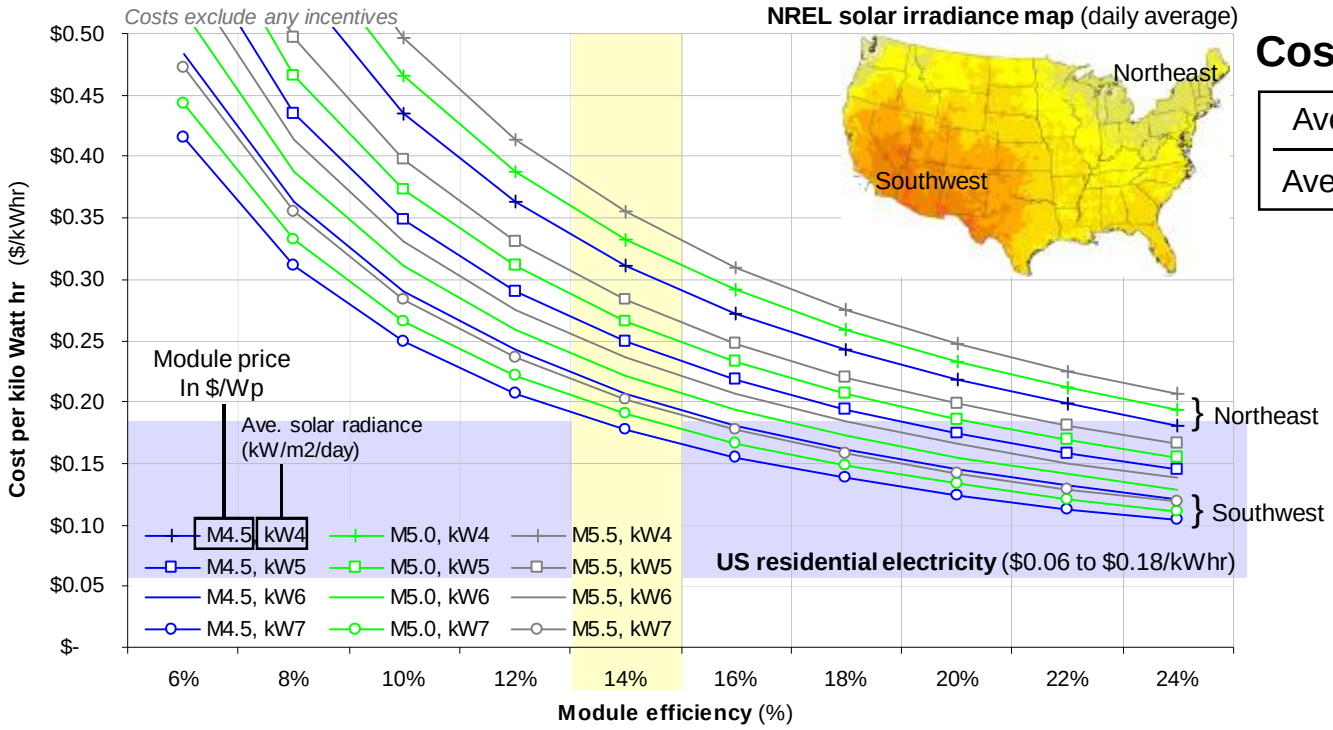
Cost of Renewable Energy In China

	Cost (RMB per watt)
Hydroelectric	7
Wind	6.5
PV	75*
Biomass Electricity	7

* NDRC estimation

PV is the most expensive electricity in China

Solar PV – cost analysis



Cost Analysis:

$$\frac{\text{Ave. daily cost}}{\text{Ave. daily output}} = \textbf{\$ / watt}$$

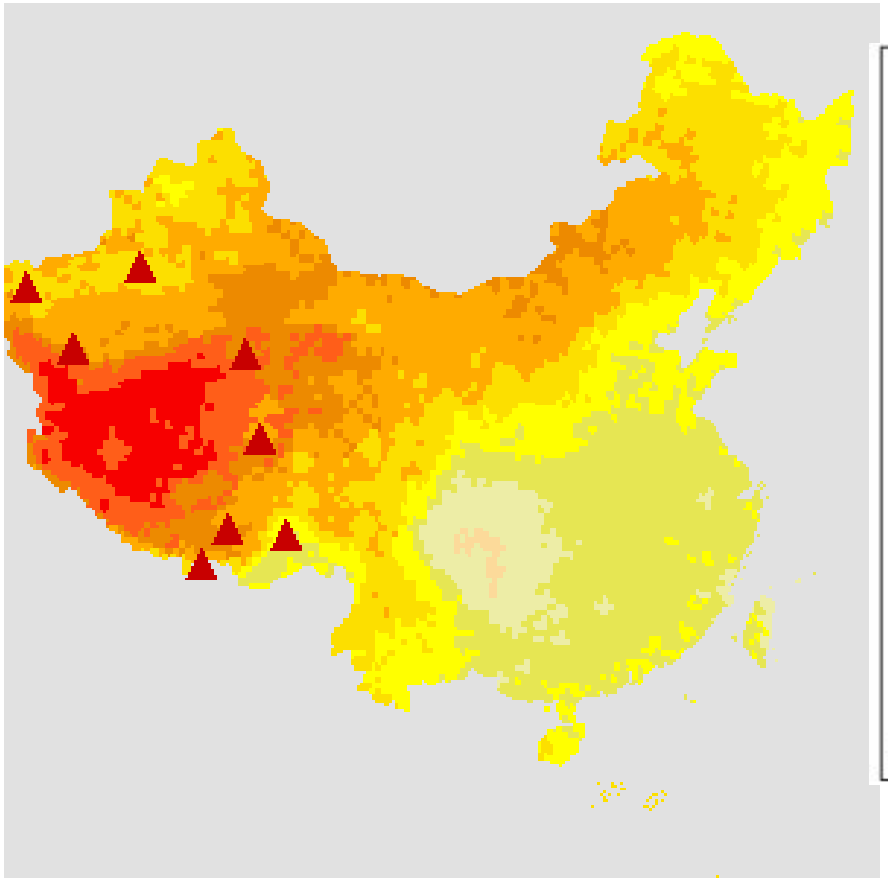
Average daily cost is the total system cost divided by the number of days in an estimated 20 year useful life.

Average daily output is calculated power output using NREL's map of solar irradiation, accounting for losses from less than optimal installation, inverter loss, and other factors

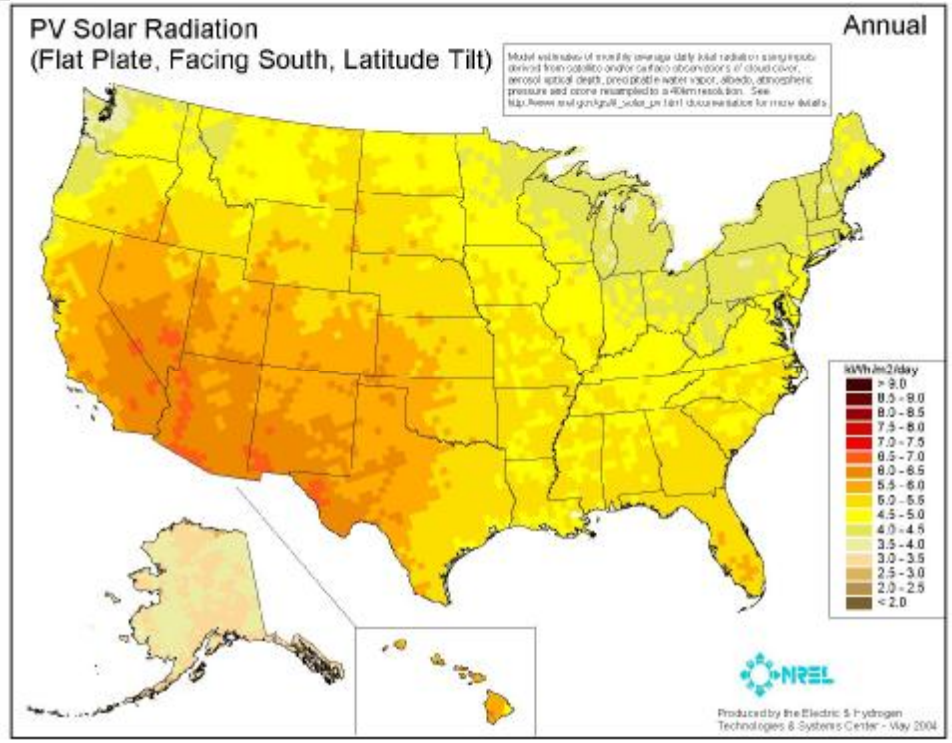
$ / watt is the calculated cost of solar PV generated electricity, and is in the proper metric for comparison to conventional grid supplied electricity.

Cost of solar electricity ($/W) driven by three key cost variables: (1) cost of the installed solar PV module, (2) module efficiency, and (3) amount of sunlight received

Solar Resource: China v.s. US



Source: swera.unep.net



Source: www.nrel.gov

China and US have similar solar resource

Solar Resource: China v.s. Germany

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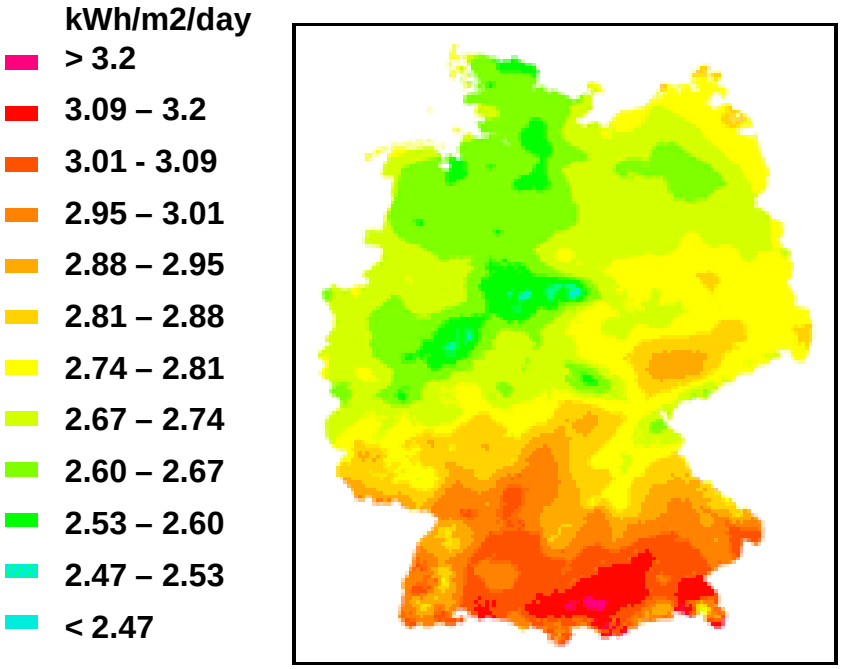
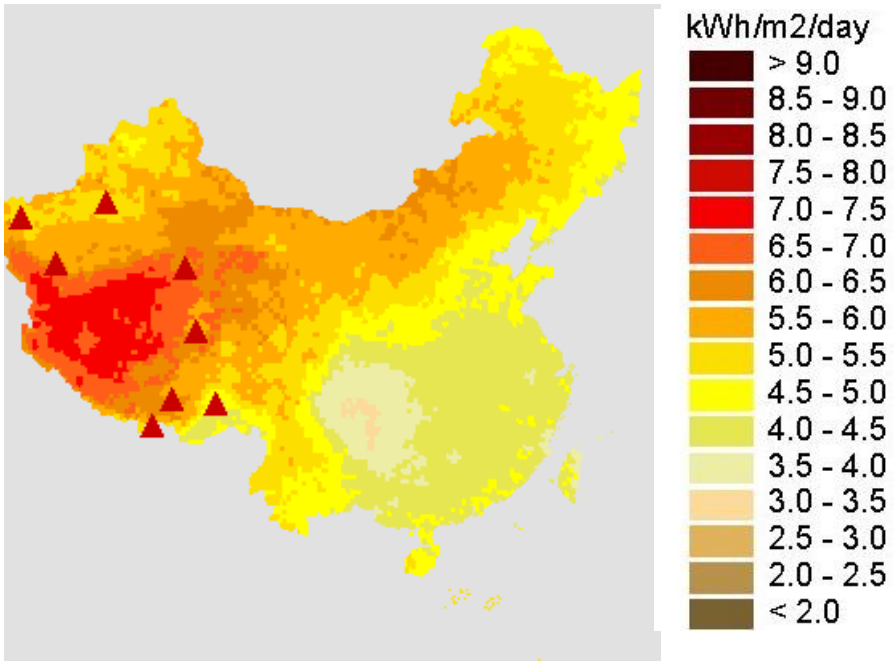
Germany



Source: www.solarserver.de

China



Source: swera.unep.net

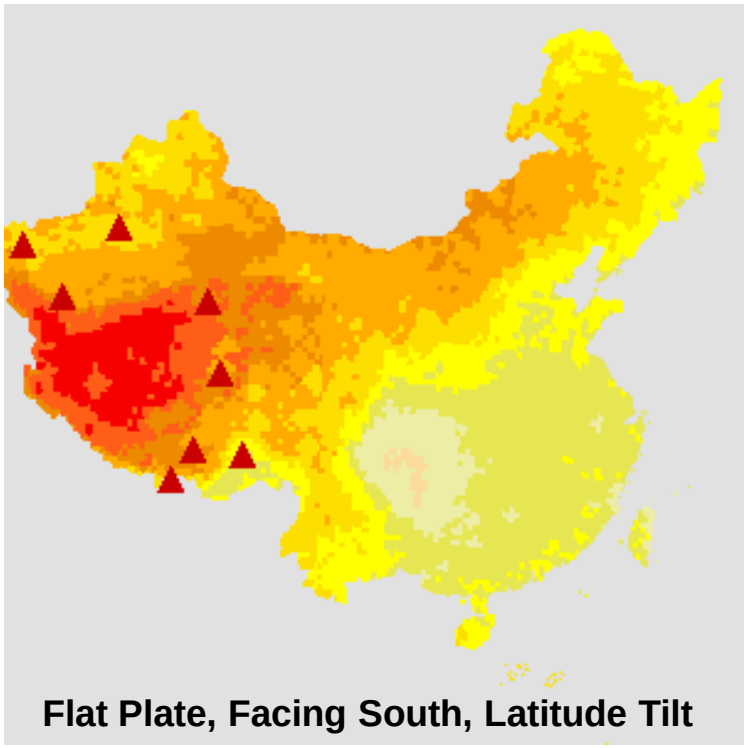
China has much richer solar resource than Germany, why much less PV deployment in China?

Government Incentives

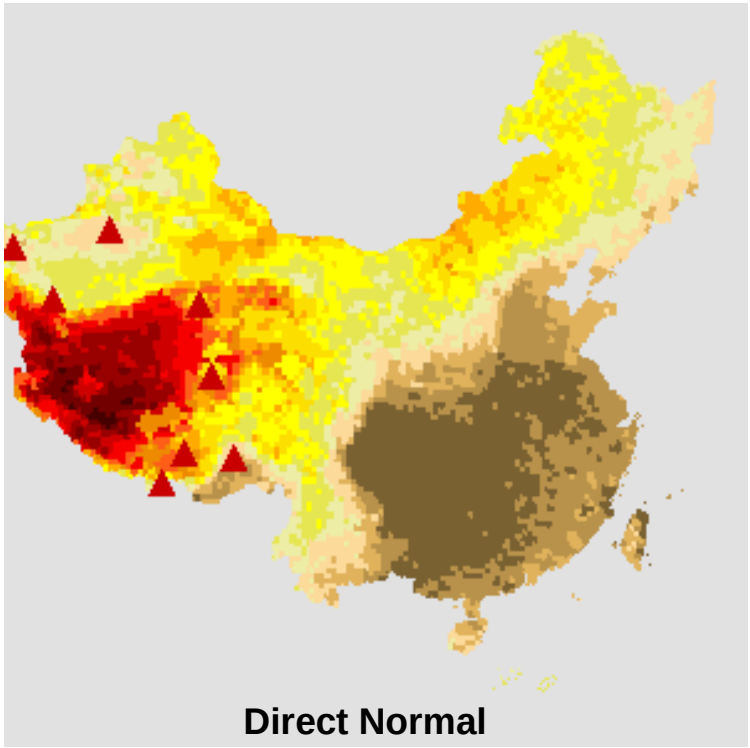
	US		CA	NJ		Germany	Japan
Avg. KW usage per home	3.0		3.0	3.0		3.0	3.0
Cost per Watt	$7.50		$7.50	$7.50		€ 6.67	$7.50
Govt Rebate	$0.00		$2.80	$5.30		€ 0.00	$0.38
Effective Cost per Watt	$7.50		$4.70	$2.20		$6.67	$7.12
Initial System Cost	$22,500		$14,100	$6,600		€ 20,000	$21,360
Avg. Retail px of electricity per KWh	$0.10		$0.13	$0.12		€ 0.20	$0.21
Annual cost savings	$400		$707	$341		€ 1,790	$902
Discount Rate	6%		6%	6%		6%	6%
Solar Energy Cost per kW/h	$0.27		$0.13	$0.12		€ 0.17	$0.24
Years to Payback	25		14	13		9	15
Source: Thomas Weisel Partners LLC estimates, Solarbuzz, DOE, IEA							

Payback from solar system installations depends heavily on grid pricing and government subsidy schemes, German Feed-in-Tariff allows PV owners to sell back electricity to the grid at 0.545 euro per kWh

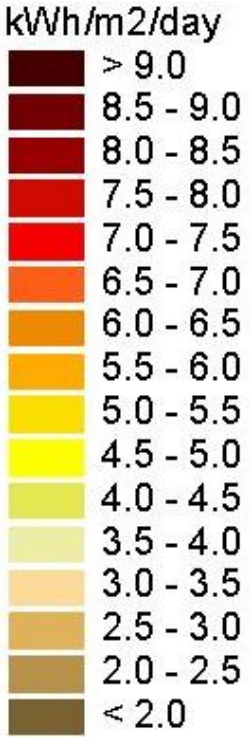
Flat Panel v.s. Concentrator



Flat Plate, Facing South, Latitude Tilt



Direct Normal



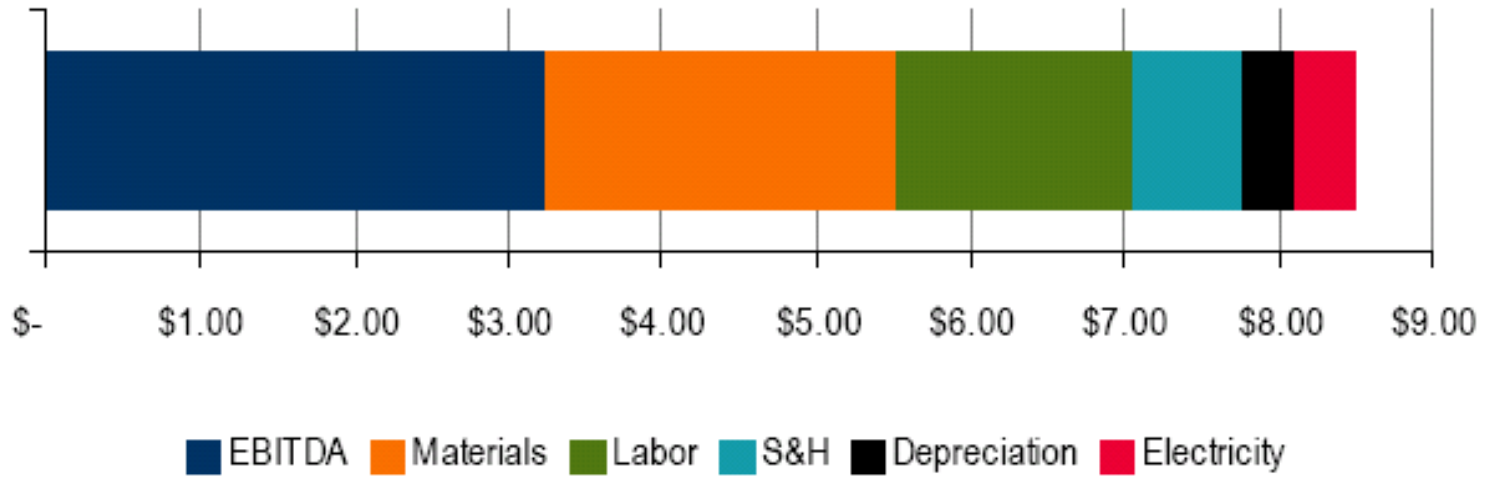
Source: swera.unep.net

Application: c-Si, Thin Film PV

Application: CPV, CSP

Much bigger opportunity for flat panel PVs

Estimated breakdown of 1Wp of installed PV capacity by value

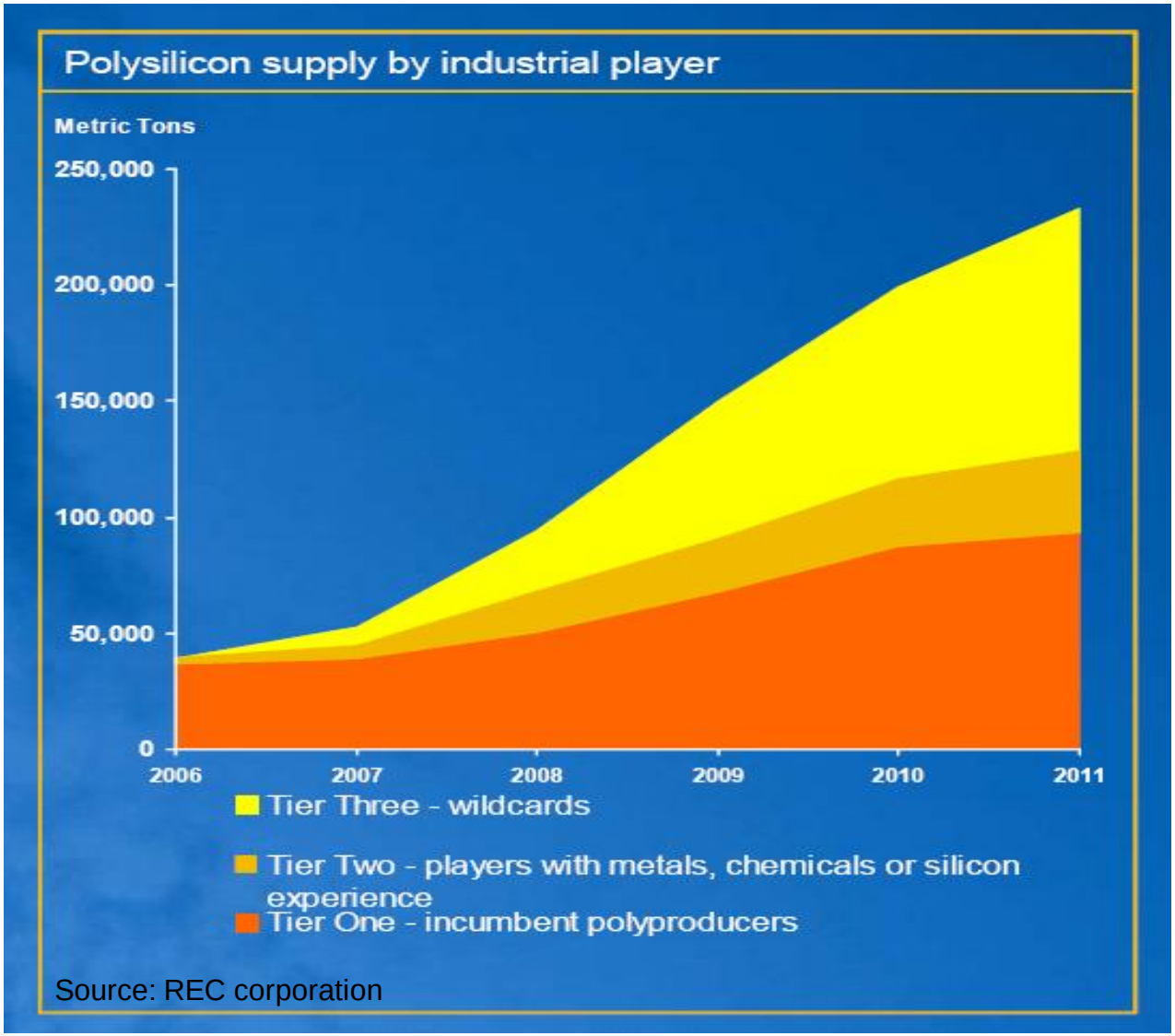


Source: Company Data, ML Estimates

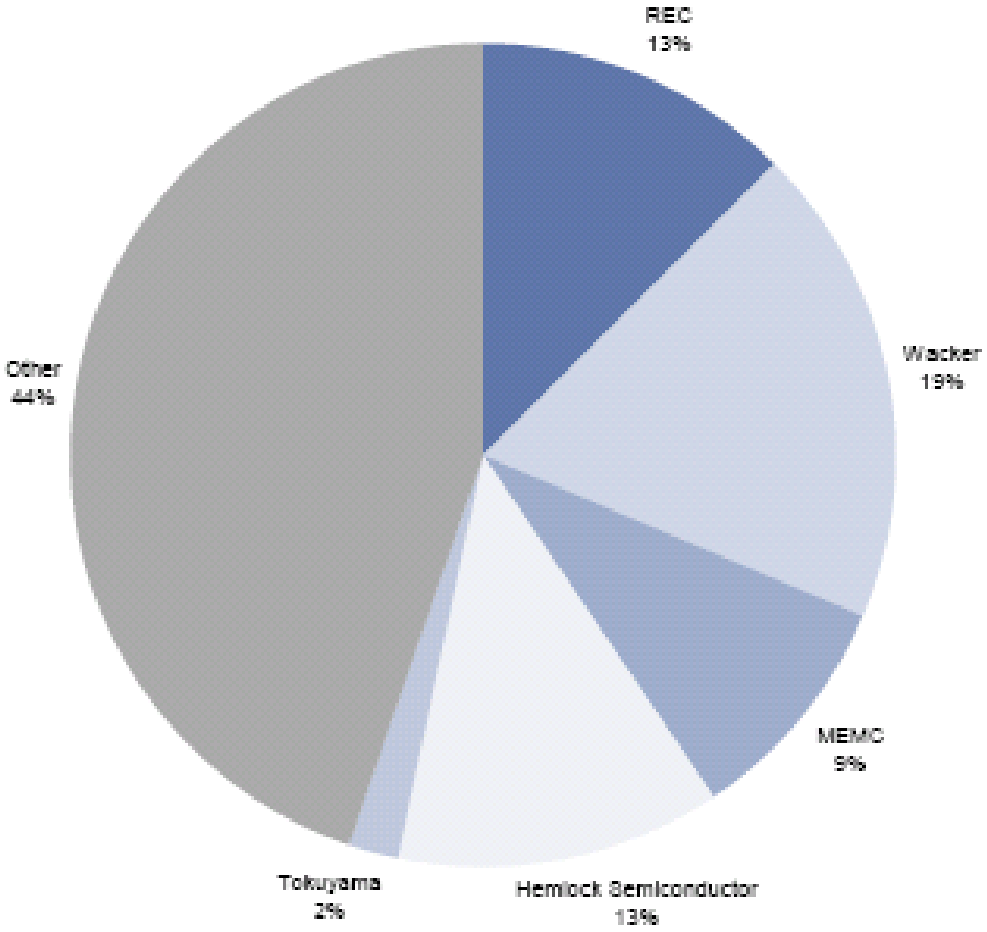
Opportunities

- Materials cost reduction
- Thin Film PV
- Vertical Integration: keep profit in-house

Polysilicon Market

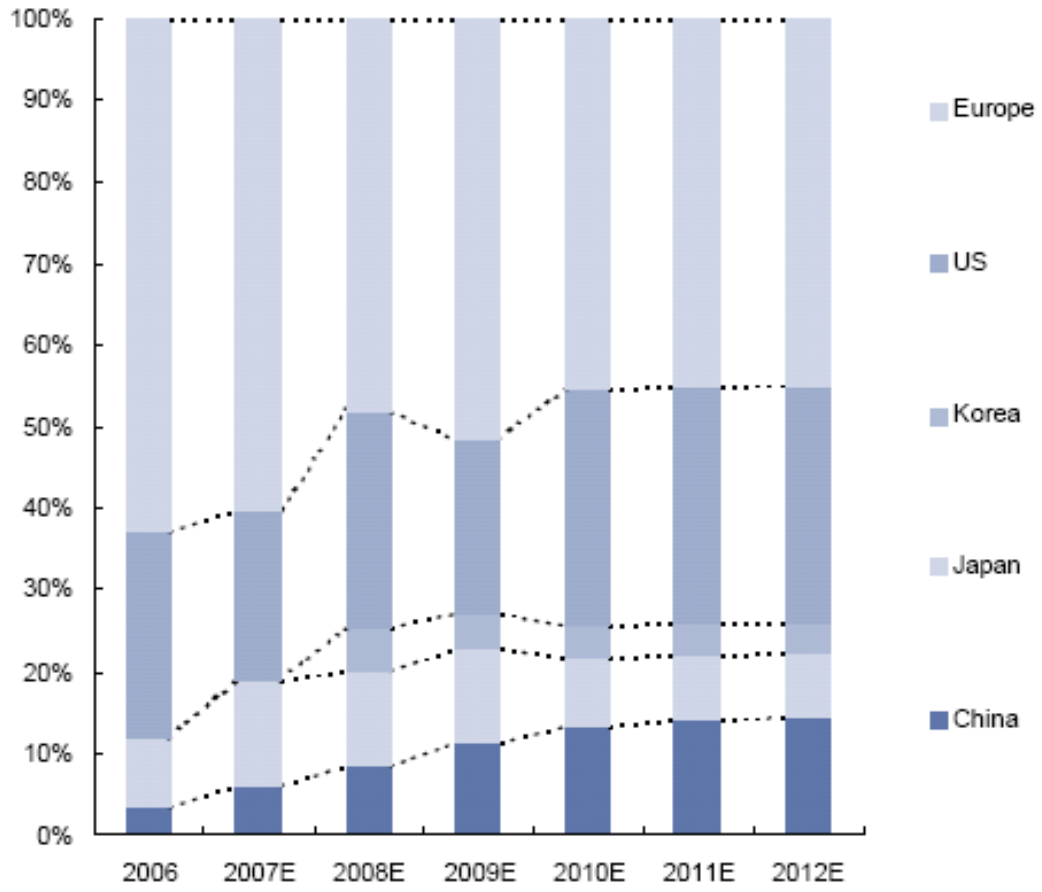


Top 5 Polysilicon Producers in 2008



Source: Goldman Sachs

Growing Polysilicon Supply from China



Source: Gao Hua Securities Research estimates, Goldman Sachs Research estimates.

Polysilicon Players in China

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sichuan Xinguang Silicon Technology				378	1,008	1,932	3,408	3,682	4,208
Luoyang Sino-silicon HighTechnology			285	600	1,400	2,400	2,700	3,200	3,600
Emei Semiconductor Material Factory & Institue			160	180	525	630	1,540	1,920	2,240
Jiangsu Zhongneng PV technology Development				150	525	900	1,200	1,500	1,950
DAQO Group					150	750	1,400	1,600	2,000
Jiangsu Shunda Electronic Materials and Technology					150	450	600	750	825
LDK Solar						900	1,500	2,250	2,250
Jiangsu Sunshine					150	450	1,050	1,200	1,350
Yichang CSG Polysilicon					150	450	675	750	825
Yunnan Aixin Silicon						300	600	750	900
Tongwei Group					125	500	1,050	1,200	1,500
Asia Silicon					150	350	450	500	600
Liaoning Linghai City Jinhua Smeltery					125	250	300	350	400
Cumulative Total (Ton)			445	1,308	4,458	10,262	16,473	19,652	22,648

Source: Goldman Sachs

Production Methods of Polysilicon

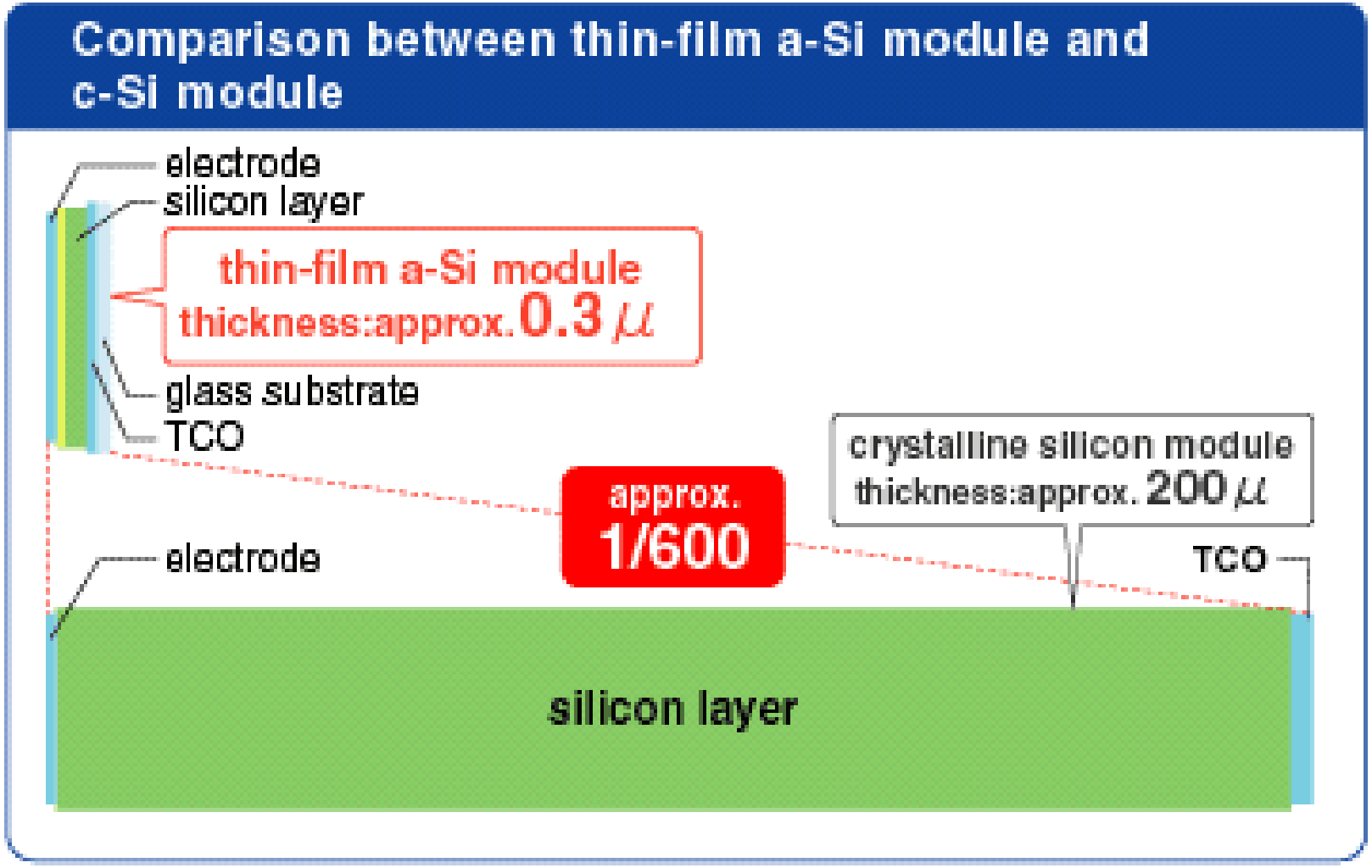
1.Physical Method

- Upgraded MGS

2. Chemical Method

Chemistry \ Reactor	**Siemens Reactor**	**Fluidized Bed Reactor**	**Russian Reactor**
$SiHCl_3$	TCS Siemens	TCS FBR	NA
SiH_4	Silane Siemens	Silane FBR	NA
$SiH(OC_2H_5)_3$	NA	NA	Kremni Polimer

Thin Film v.s. Crystalline Silicon

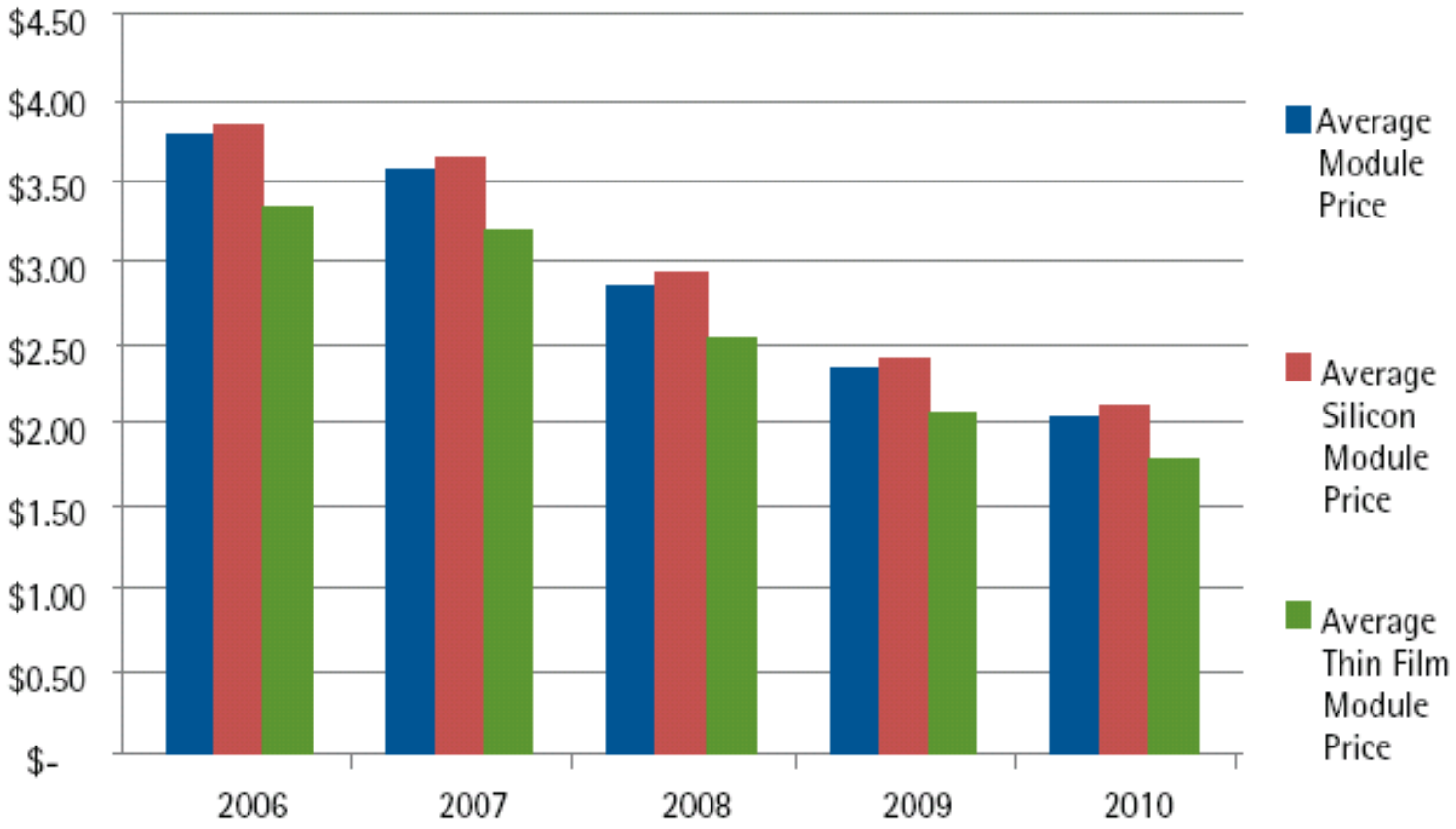


Thin Film PV Market

Unit: MW	2006	2007	2008	2009	2010
CdTe	68	140	33	283	286
CIGS	5	37	138	86	451
a-Si	123	271	622	1,103	1,513
Emerging	-	15	123	223	246
Total Thin Film Modules	196	463	1,115	1,894	2,496
Total Silicon and Thin Film Modules	2,082	2,799	4,869	8,508	11,258
Growth in Available Supply		34%	74%	75%	32%
Percent Thin Film Production	9.4%	16.5%	22.9%	22.3%	22.2%

Source: PV News

PV Module Price Erosion



Source: PV News

Only differentiated products and high operation efficiency will survive this market

Solar Cell Producers Marketshare

Solar Cells Suppliers	Location	2004	2005	2006	2007E
Sharp	Japan	37%	26%	18%	14%
Q-Cells	Germany	9%	10%	13%	13%
Suntech	China	0%	4%	8%	10%
Schott Solar	Germany	7%	6%	7%	5%
Kyocera	Japan	12%	9%	6%	5%
Sanyo	Japan	7%	8%	6%	5%
BP Solar	UK	10%	5%	6%	5%
Motech	Taiwan	4%	4%	6%	5%
Solarworld	Germany	0%	2%	5%	4%
Sunpower	USA	0%	5%	3%	4%
Mitsubishi Electric	Japan	9%	6%	3%	2%
Total Capacity (in MW)		**881**	**1639**	**3271**	**4218**

- **STP and SPWR gaining share**

Market Opportunity in China

- Low cost c-Si PV for residential and commercial market
- Low cost and high efficiency thin film PV for utility market (Solar Farm)
- Low cost high reliable inverter

about Sierra Solar

- Founded in February, 2007
- Head quarters: Silicon Valley
- Manufacturing Center: China
- Planned Capacity: 250MW by 2011
- Lead investors: Mayfield China, DT Capital
- Technology: Si based thin film technology
- Website: www.sierrasolarpower.com

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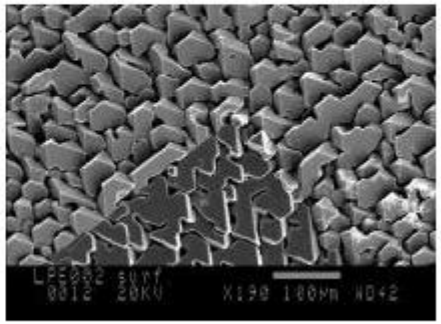
Upgraded MGS

Slag Refining

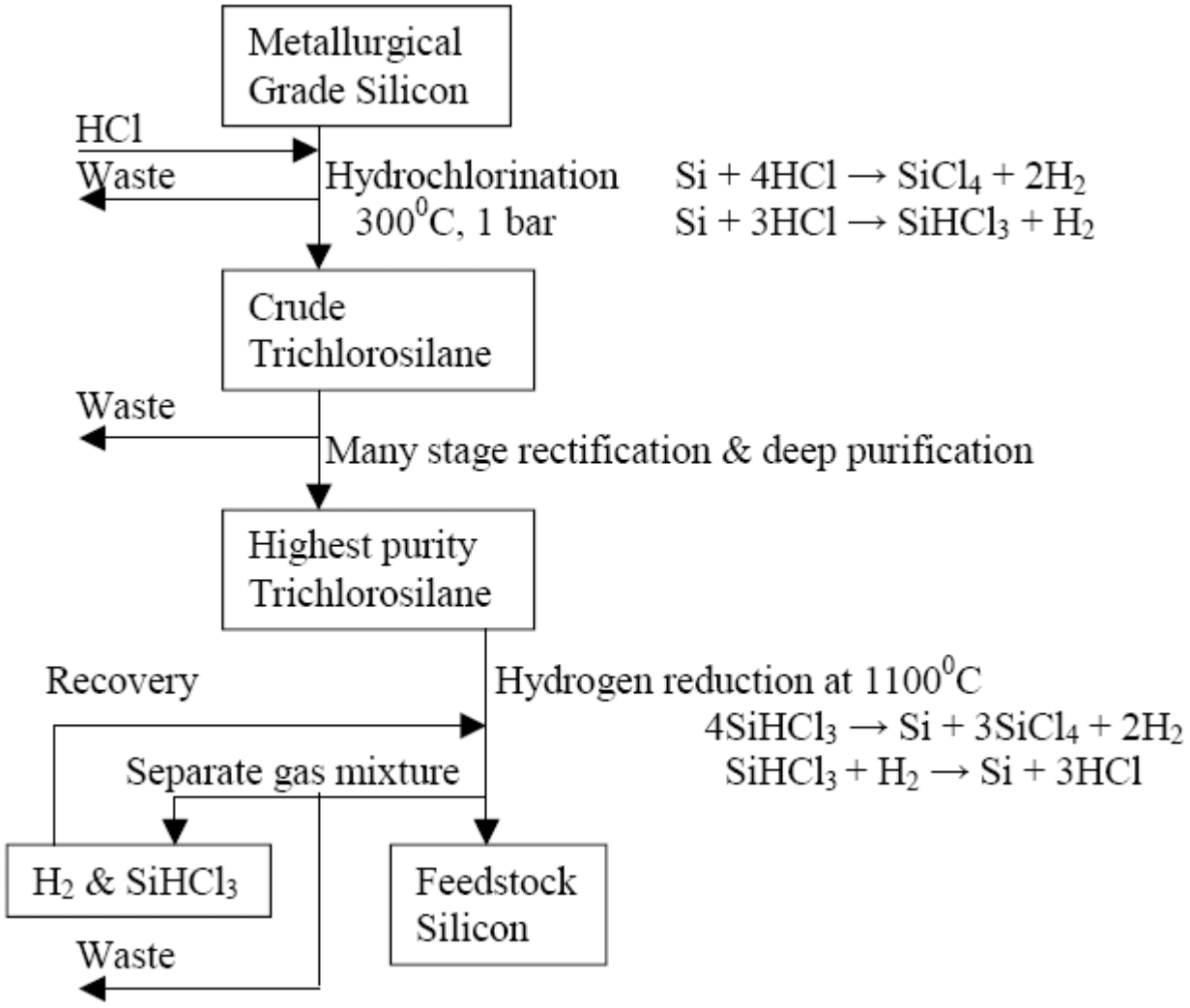
Leaching

Solidification

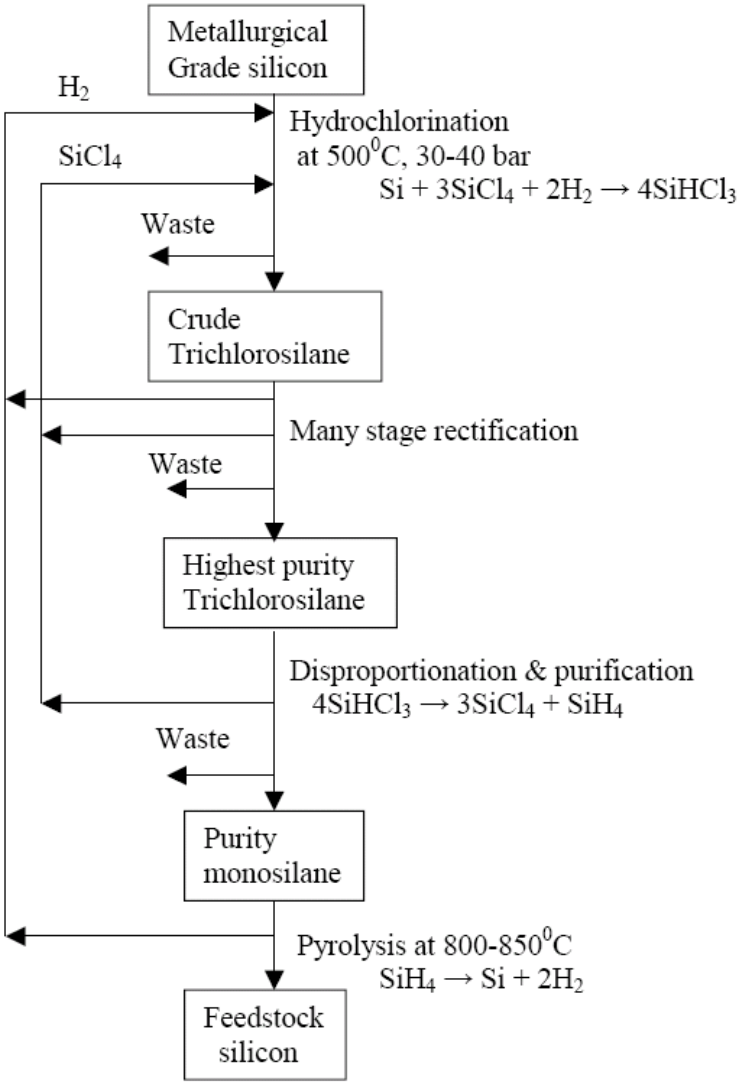


Source: REC Corporation

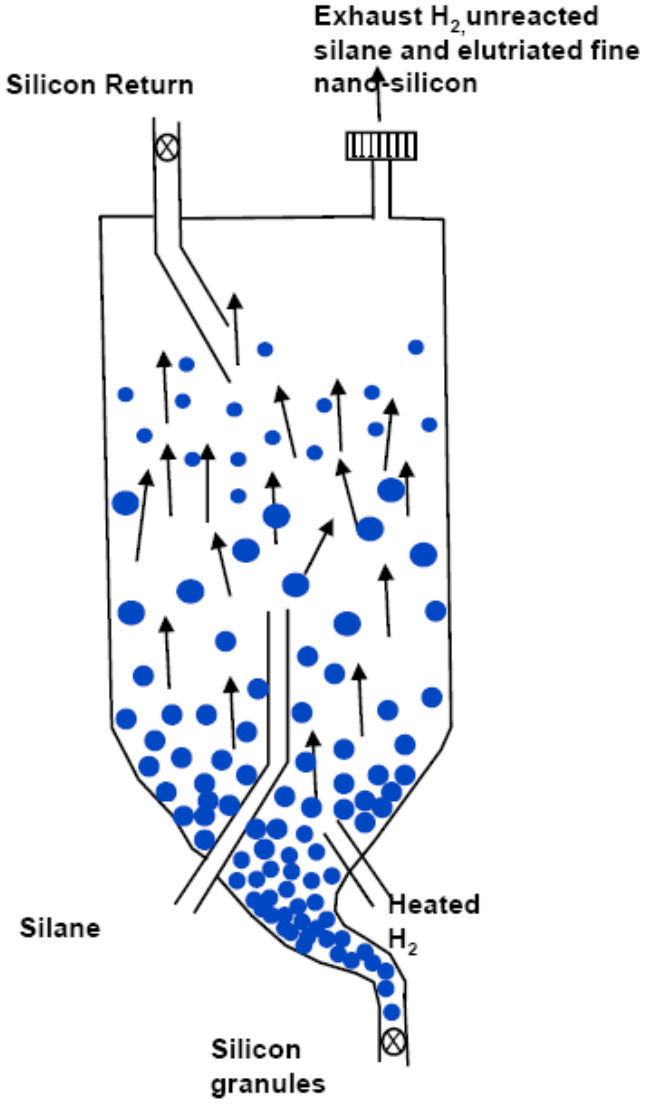
TCS Method

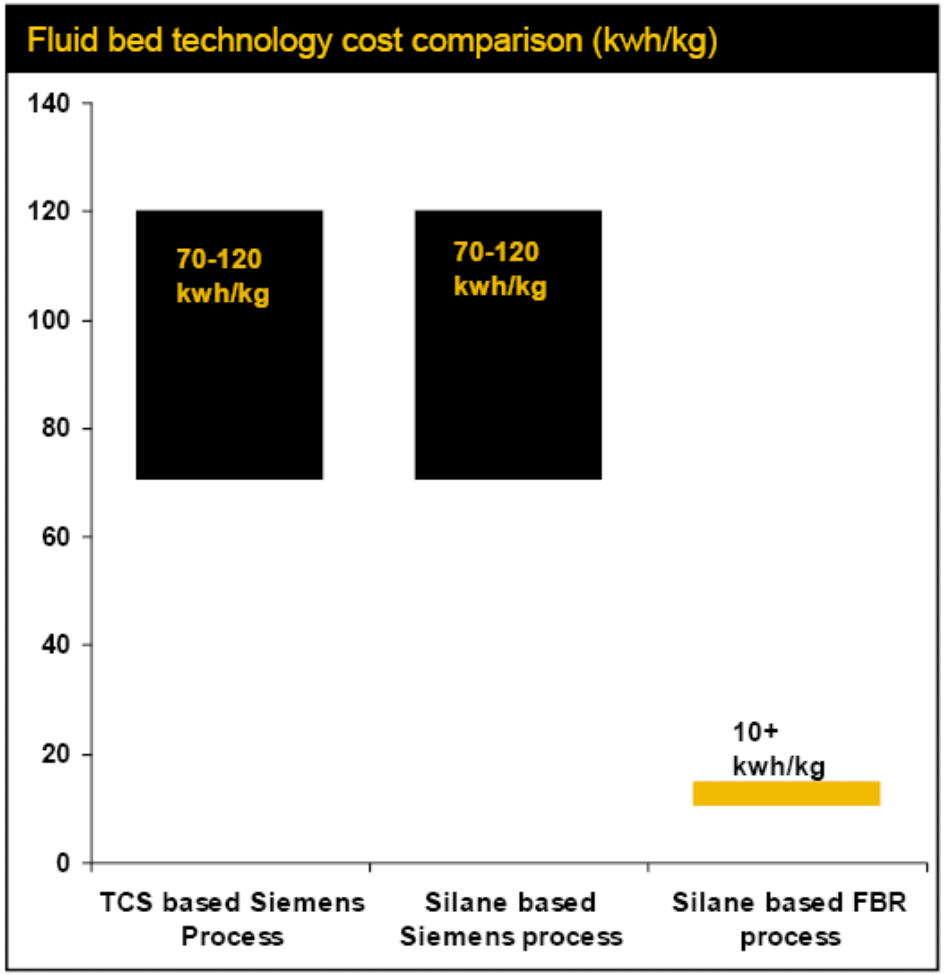

Metallurgical Grade Silicon
HCl
Waste
Hydrochlorination
300^{0}C, 1 bar
$Si + 4HCl \rightarrow SiCl_4 + 2H_2$
$Si + 3HCl \rightarrow SiHCl_3 + H_2$
Crude Trichlorosilane
Waste
Many stage rectification & deep purification
Highest purity Trichlorosilane
Recovery
Hydrogen reduction at 1100^{0}C
$4SiHCl_3 \rightarrow Si + 3SiCl_4 + 2H_2$
$SiHCl_3 + H_2 \rightarrow Si + 3HCl$
Separate gas mixture
H_2 & $SiHCl_3$
Feedstock Silicon
Waste

Silane Method



Silane – Fluidized Bed Reactor





Source: REC Corporation

Triethoxysilane Method