Where are we going and how will we get there – PV Production Capacities and the PV Value Chain

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Where are we going and how will we get there?

1. PV Capacities Past Present & Future
2. PV Value Chain – more than just silicon
3. And what about silicon …
4. Five year Capacity and Demand Forecast
5. Conclusions

Capacity – what is it?

Three Categories:

- **Company Statements made on press releases, etc., typically as enticements to investors, to counteract bad press, in general to affect stakeholder opinion.**

- **Nameplate Capacity: The installed the capacity of the equipment, that is, what can be produced in a perfect world with machinery running at 100% and no downtime. Typically assumes perfect commercial viability of the technology, complete access to raw material, and perfect demand.**

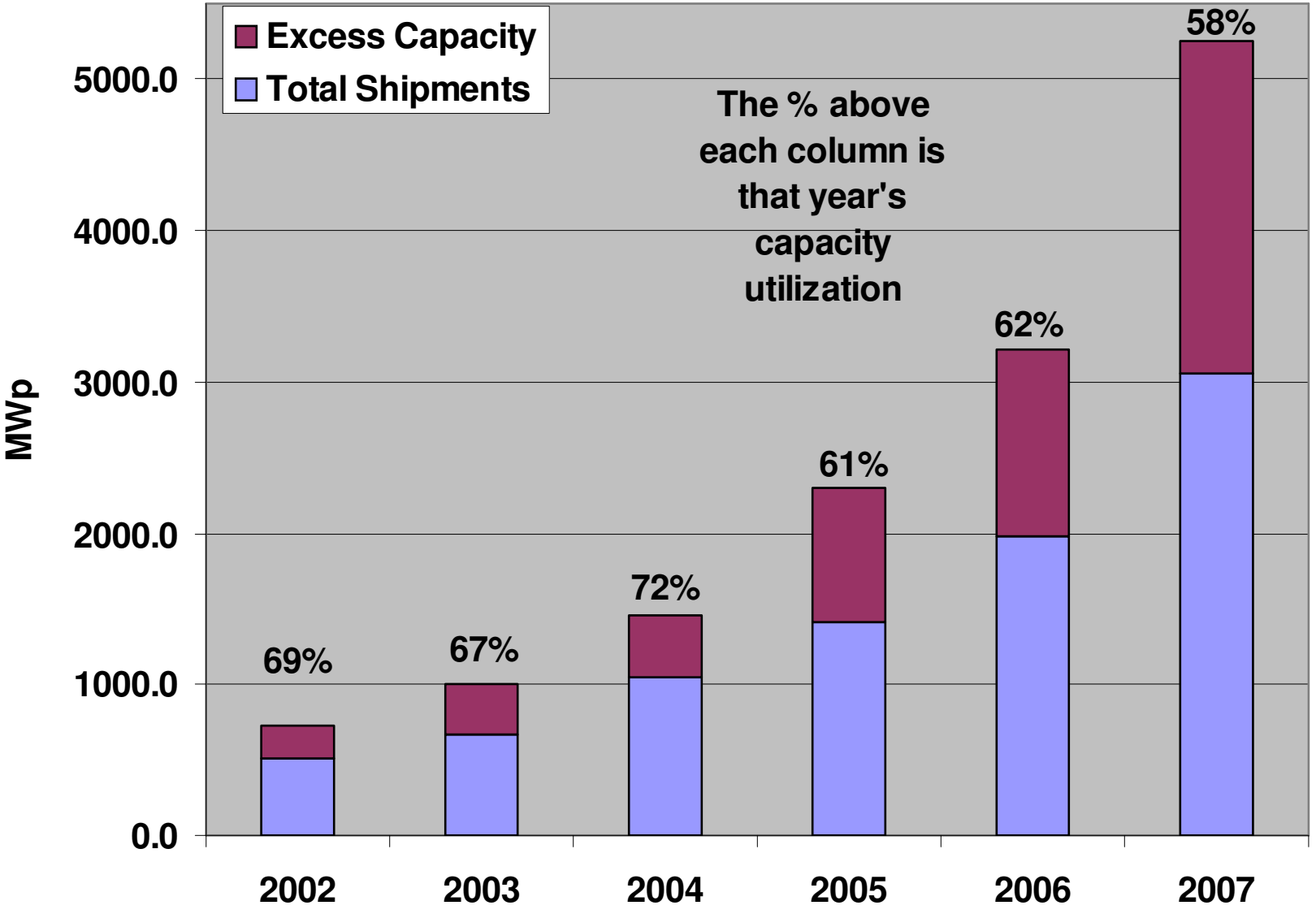
- **Run Rate Capacity assumes raw material conditions, where the manufacturer is on the development timeline (R&D, pilot stage, commercial production), downtime for retooling and other reasons, start up time of new equipment, raw material availability, etc.**

PV Capacities Past, Present & Future
Part 1, the whole picture

In 2007, the PV industry's total capacity to produce technology topped 5-gigawatts

From 2002 to 2007, the industry increased capacity by a CAGR of 48%

During the same period, excess capacity increased by a CAGR of 58%



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A Little Perspective

2002	Total: $3.31 Power: $3.25 Large quantity: $2.75	As a result of distributors double-ordering during the prior supply-limited year, and with total industry capacity increasing, during the first quarter of 2002 distributors reported slow sales activity, a typical situation in a market dominated by rooftop installations. Second-quarter activity picked up, with ASPs declining moderately.
2003	Total: $3.14 Power: $3.10 Large quantity: $2.65	Strong increases in demand, spurred by the successful German feed-in tariff law, strong demand in Japan, and the expansion of programs in the U.S. markets of California and New Jersey, enabled manufacturers to reduce inventory by the end of 2003.
2004	Total: $3.65 Power: $3.35 Large quantity: $2.90	Extraordinarily strong demand in 2004 led to an increase in shipments of 54%. The situation of high demand and low silicon starting material supply led to higher prices (increases of 16% for total, 8% for power, and 9% for Large quantity).
2005	Total: $3.85 Power: $3.65 Large quantity: $3.03	Silicon supply limitations continued and ASP's increased. Cell/module manufacturers reported sold-out conditions, and the distribution channel began stocking up on product. Silicon prices began to rise steeply.
2006	Total $5.00 Power $3.90 Quantity $3.39	Significantly higher silicon prices (up to $400/kilogram on the spot) and high module prices continue, as demand remains strong. Supply constraints projected to last through mid 2008.
2007	Total $4.50 Power $3.75 Quantity $3.48	Raw material remains tight, and demand softens towards the end of the year. In the U.S., the federal tax incentive is not extended. Due to tight raw material supplies, average prices remain flat.

PV Capacities Past, Present & Future
Part II, Regional Capacity and Shipments

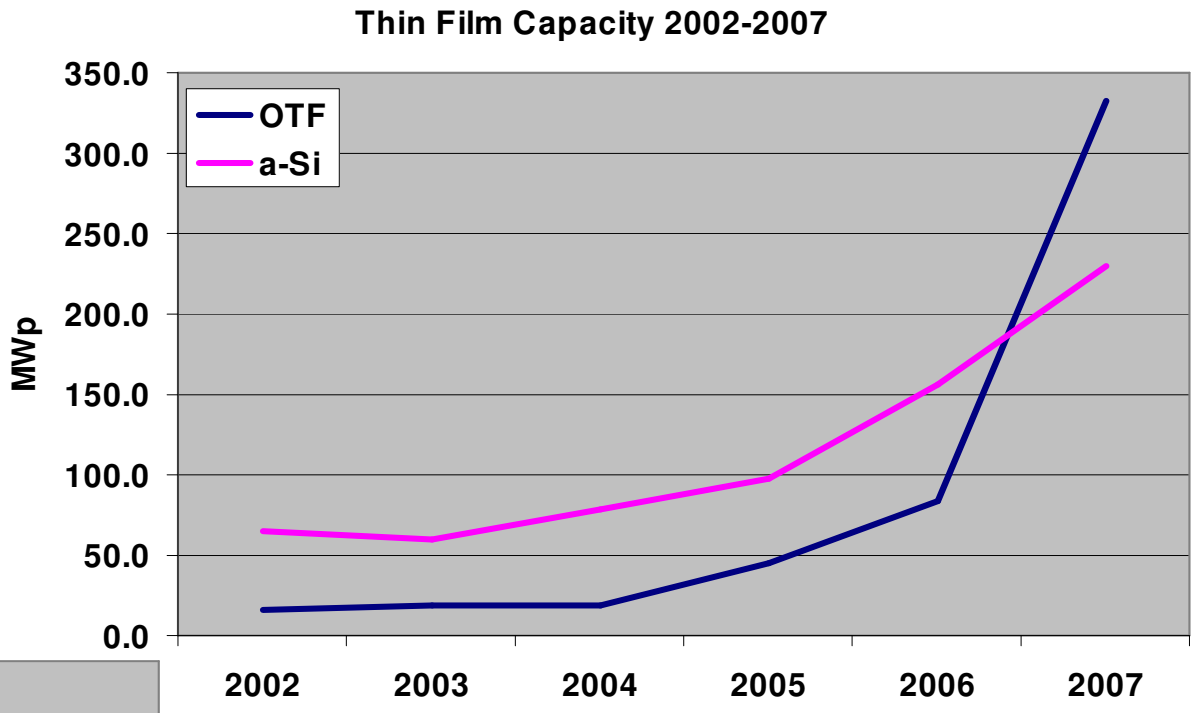
In 2007, Regionally, Europe took the number one market share in terms of shipments of technology and the ROW Region (consisting of India, Australia Taiwan, China, and others) had the highest capacity of all four regions (US., Europe, Japan, ROW).

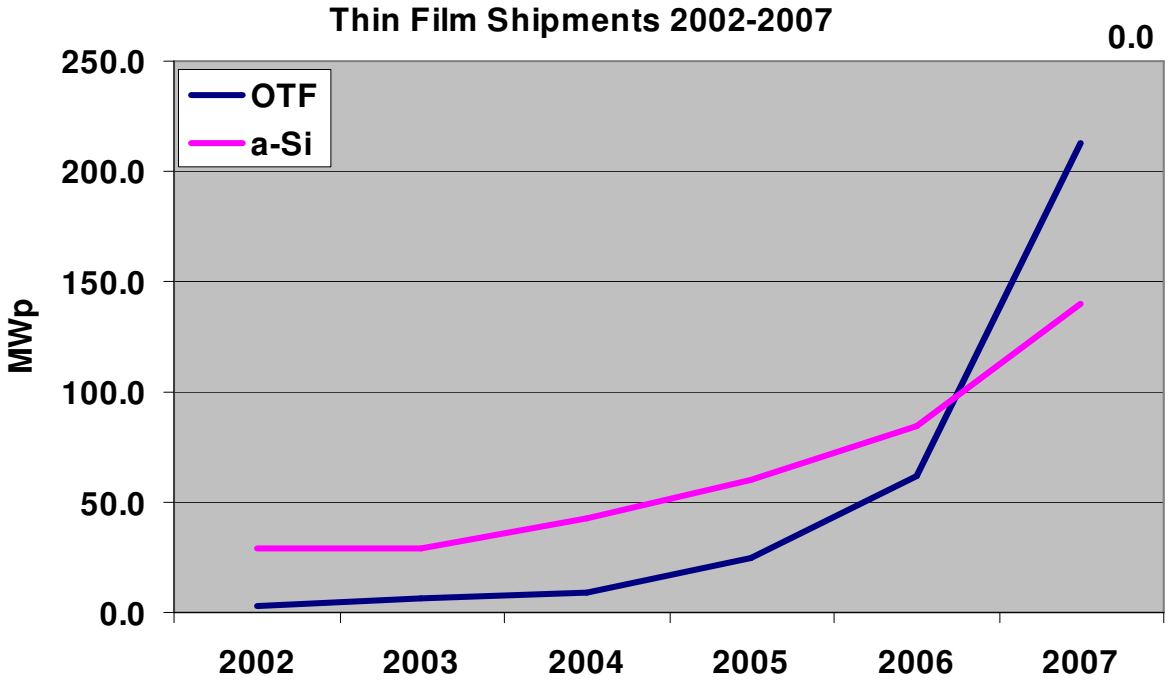
Regional Capacity	2002	% Chg 02-03	2003	% Chg 03-04	2004	% Chg 04-05	2005	% Chg 05-06	2006	% Chg 06-07	2007	CAGR 02-07
U.S.												
Capacity	179.3	-5%	169.5	9%	185.5	14%	212.0	48%	314.0	18%	371.5	16%
Shipments	107.8	-15%	91.5	54%	140.6	-5%	133.6	2%	136.6	70%	237.3	17%
Utilization	60%		54%		76%		63%		44%		64%	1%
ROW												
Capacity	66.3	33%	88.5	100%	177.2	51%	267.0	153%	675.7	155%	1722.0	92%
Shipments	39.9	50%	60.0	49%	89.2	72%	153.2	131%	354.1	146%	870.9	85%
Utilization	60%		68%		50%		57%		52%		51%	-3%
Europe												
Capacity	187.3	64%	306.3	51%	463.1	60%	742.3	37%	1016.0	59%	1657.6	55%
Shipments	123.4	40%	173.1	58%	272.9	49%	406.9	50%	611.3	62%	1008.9	52%
Utilization	66%		57%		59%		55%		60%		61%	-2%
Japan												
Capacity	295.5	48%	438.0	45%	634.0	71%	1082.0	11%	1205.0	25%	1504.5	38%
Shipments	233.8	50%	350.6	56%	547.0	31%	714.0	24%	882.6	7%	943.9	32%
Utilization	79%		80%		86%		66%		73%		63%	-5%
Total												
Capacity	728.4	38%	1002.3	46%	1459.8	58%	2303.3	39%	3210.7	62%	5255.6	48%
Shipments	504.9	34%	675.3	55%	1049.8	34%	1407.7	41%	1984.6	53%	3061.0	43%
Utilization	69%		67%		72%		61%		62%		58%	-3%

PV Capacities Past, Present & Future
Part III, Thin Film Capacity and Shipments

In 2007, the other thin film category, primarily CdTe, surpassed amorphous in both capacity and shipments

CdTe was 92% of OTF shipments in 2007, and 76% of OTF capacity in 2007





From 2002 to 2007, OTF increased capacity by a CAGR of 82%, while shipments grew by a CAGR of 133%

For the same period, a-Si increased capacity by a CAGR of 29% while shipments grew by a CAGR of 37%

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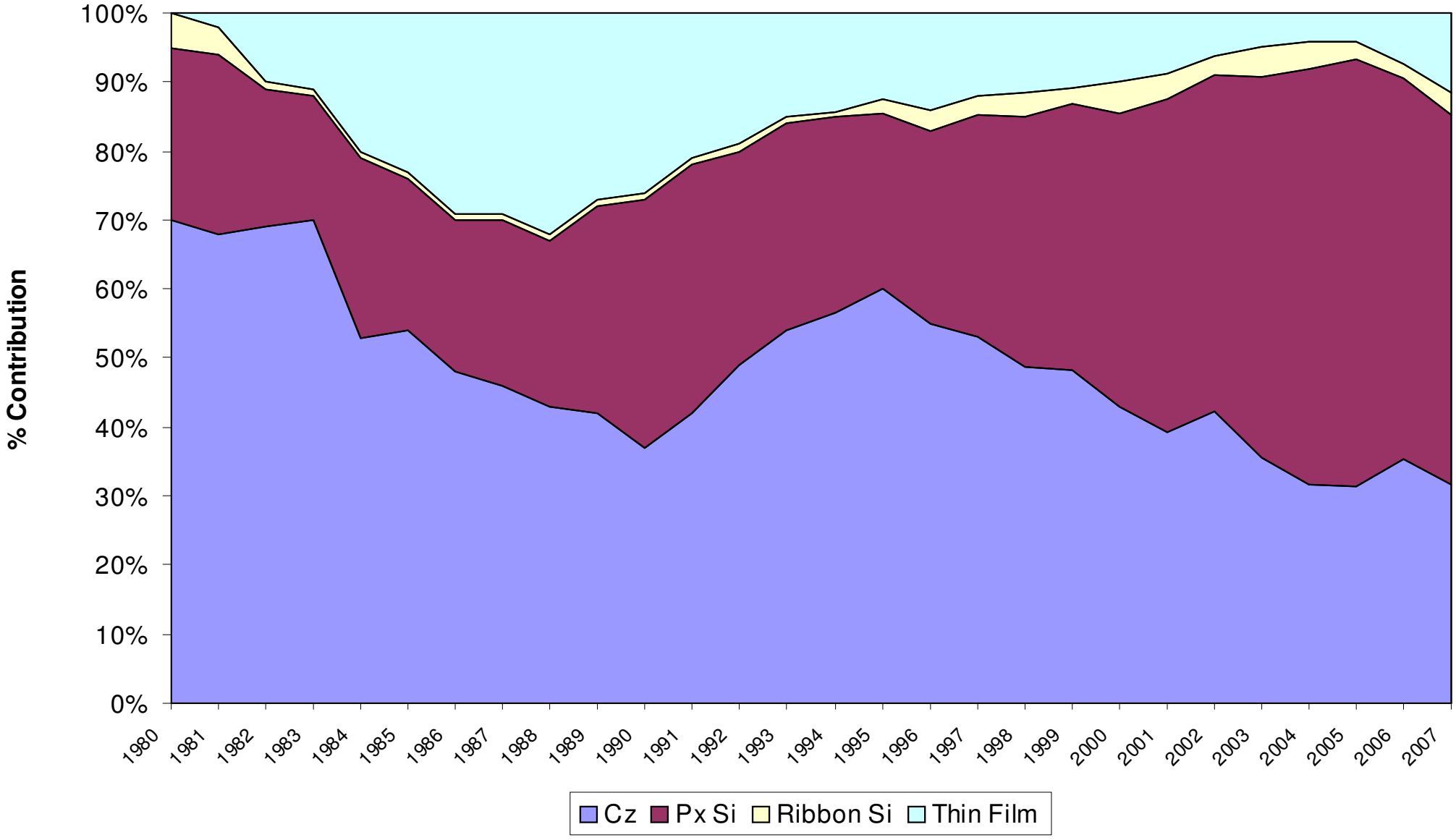
PV Capacities Past Present & Future
Part IV, Technology Share of Shipments 1980 to 2007



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PV Value Chain – more than just silicon

The Primary Commercial PV Technologies are:
Monocrystalline: Czochralzki ingots and wafers
Float zone ingots and wafers
Multicrystalline: Bridgeman ingots and wafers
Ribbon wafers
Amorphous Silicon (a-Si): Silane
Cadmium Telluride (CdTe): Tellurium
Copper Indium Gallium Selenide (CIGS): Indium
Copper Indium Diselenide (CIS): Indium

Raw material suppliers can experience supplier slowdowns and shortages, which can impact solar

The value chain begins with
Suppliers to the raw material manufacturers
Continues with raw material manufacturers
Equipment and consumable suppliers (all through the chain)
Ingot and wafer manufacturers
Cell and module manufacturers
Module assemblers
BOS Manufacturers
The PV selling channel
To the end user

The end user can be the system buyer, the investor (s) or the buyers of the PV generated electricity

PV Value Chain – more than just silicon

Potential Bottlenecks can start with the suppliers of equipment, etc., to raw material (primarily silicon) suppliers – availability of steel, pumps, along with pipe and valve material along with delivery time and manpower can adversely affect delivery.

The silicon shortage has encouraged new thin film and other low use silicon entrants, however, technology has a long start up ramp from R&D to pilot stage to commercial production, and lack of available commercial capacity has been a limiting factor to industry growth

The most important limiting factor to industry growth is demand – the PV industry does not have true demand pull, that is, demand is artificially stimulated by incentives. Demand is effected by the availability of substitutes (including energy efficiency), the high up front price of the technology (price and cost are often disconnected, market determines price), and economic factors such as downturns.

If we build it, they may not come.

And What About Silicon ….

Given, even with current problems, expected increases in silicon supply, there will be significant supplies of raw material beginning in 2010.
This will exert extreme downward pressure on average prices for all technologies, but particularly thin films.
Technologies with lower conversion efficiency will always need to offer product at a lower price per watt.

Conservative	Total Shipments	Cz Shipments MWp	Avg MT/MWp	PV Silicon Req	SemiReq	Total Avail Silicon	MT Sil Surplus or Shortage	Surplus to MW
2006	1984.6	1838.6	9.8	17936.0	18500	34082	-2354	-241
2007	3061.0	2708.2	9.0	24427.8	19055	44085	602	67
2008	4279.7	3723.3	8.6	31947.7	19817	53000	1235	144
2009	5697.1	4899.5	8.2	39991.2	20808	69500	8701	1066
2010	7125.6	5914.2	7.7	45695.3	21848	95220	27676	3582
2011	9055.2	7787.5	7.2	56373.3	23159	138960	59427	8209
2012	11518.8	10021.4	6.8	67968.8	24549	142100	49582	7310

Accelerated	Total Shipments	Cz Shipments MWp	Avg MT/MWp	PV Silicon Req	SemiReq	Total Avail Silicon	MT Sil Surplus or Shortage	Surplus to MW
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2007	3061.0	2708.2	9.0	24427.8	19055	44085	602	67
2008	4591.4	3994.5	8.5	33939.3	19817	53000	-757	-89
2009	6674.1	5873.2	8.0	46765.9	20808	69500	1926	242
2010	9548.4	8211.6	7.4	60369.4	21848	95220	13002	1769
2011	13699.4	12055.5	6.8	81828.9	23159	138960	33972	5005
2012	18379.1	16173.6	6.2	99829.8	24549	142100	17721	2871

Silicon Suppliers:

Major Suppliers:

- Hemlock
- Wacker
- REC
- Tokuyama
- MEMC
- Mitsubishi Materials
- Sumitomo Titanium

For new entrants (and current suppliers), some increases announced for 2008 are delayed.

By the end of 2009, planned quantities are approximately 24000 MT, by 2010 an additional 24000 MT are planned.

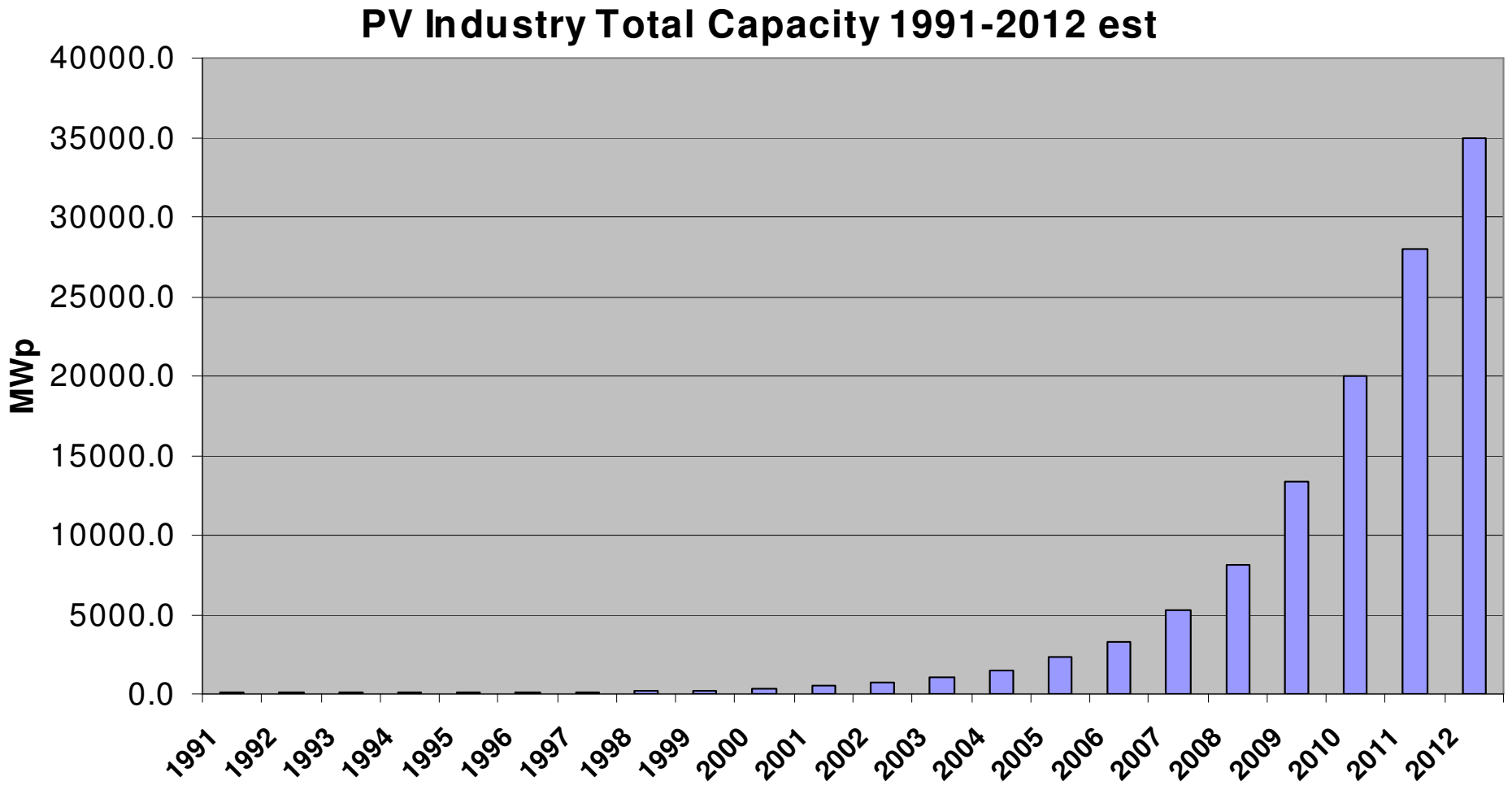
Of course, plans can and quite frequently do, turn into delays.

Overview of New Entrants:

- Dow Corning (MgSi)
- JFE (MgSi)
- ELKEM (MgSi)
- Solar Value Ag (MgSi)
- Scheuten Solar (MgSi)
- Bencancour (MgSi)
- DC Chemical (Siemens)
- EMEI (Siemens)
- Asian Silicon (Siemens)
- Jiangzu (Siemens)
- YICHANG Nanbo (Siemens)
- Louyang Shonggui (Siemens)
- Schuan Xinguang (Siemens)
- Leshan Yongxiang (Siemens)
- Leshan Silicon (Siemens)
- SILPRO (Siemens)
- LDK (Siemens)
- Yichang SCG (Siemens)
- DAQO Poly (Siemens)
- Shunda Materials (Siemens)
- NITOL (Siemens)
- Hoku Materials (Siemens)
- M SETEK (Siemens)
- Silpro (Siemens)
- LDK (Siemens)
- JSSI (Tube)
- Silicio Egergia (FSR)
- AE Polysilicon (FBR)

Five Year Capacity And Demand Forecast: Capacity

Run Rate Production Capacity is defined as the volume that can be produced using current resources – factoring in machine downtime, raw material capability, and commercial viability.
Commercial production differs from pilot production in that it has repeatable results.
In 2007, the industry had 58% capacity utilization. So, the question is …. if we could have manufactured more product … would it have sold?



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Five Year Accelerated Capacity and Demand Forecast

Category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total Industry Capacity MWp	728.4	1002.3	1459.8	2303.3	3210.7	5255.6	8100.0	13355.0	20000.0	28000.0	35000.0
% Thin Film Capacity	11%	8%	7%	6%	7%	11%	10%	11%	10%	9%	9%
Yearly Total Capacity Increase	45%	38%	46%	58%	39%	64%	54%	65%	50%	40%	25%
Demand MWp	504.9	675.3	1049.8	1407.7	1984.6	3061.0	4591.4	6674.1	9548.4	13699.4	18379.1
% Shipments Thin Film	6%	5%	5%	6%	7%	12%	13%	12%	14%	12%	12%
Capacity Utilization	69%	67%	72%	61%	62%	58%	57%	50%	48%	49%	53%

Capacity has to be usable to be counted, that is, not an announcement, not R&D, and not pilot stage production.
Usable capacity is capable of producing commercial product.
Between announcement and commercial production … anything can happen to slow progress.
Disruptions, raw material shortages, and down time are normal in a manufacturing process, just as announcements are a normal marketing function.
There may not be sufficient demand to support current capacity announcements.
This will lead to significantly lower prices, which is good, and lower profits, which is not.

Five Year Forecast: Regions

Conservative	2007	% Change	2008	% Change	2009	% Change	2010	CAGR
North America	336.7	48%	498.2	11%	552.6	26%	698.1	28%
Europe	2075.4	48%	3081.4	41%	4329.8	25%	5415.4	38%
Japan	280.7	-23%	215.7	12%	242.1	29%	312.6	4%
Rest of World	368.2	32%	484.4	13%	546.6	29%	699.5	24%
Total	3061.0	40%	4279.7	33%	5671.1	26%	7125.6	33%
Accelerated	2007	% Change	2008	% Change	2009	% Change	2010	CAGR
North America	336.7	65%	555.6	42%	787.5	45%	1145.8	50%
Europe	2075.4	53%	3168.1	62%	5139.1	41%	7256.8	52%
Japan	280.7	21%	339.9	15%	392.2	33%	520.1	23%
Rest of World	368.2	43%	527.8	-33%	355.3	128%	625.7	30%
Total	3061.0	50%	4591.4	45%	6674.1	43%	9548.4	46%

This is a preliminary forecast. It indicates that Europe, with its lucrative feed in tariff incentive programs, will continue to absorb volume.
It takes into account, particularly under the conservative scenario, the economic slowdown in Japan, along with problems in its building market.
The conservative scenario also considers current economic concerns in the U.S., including the housing crisis, uncertainty about the federal tax incentive and credit concerns in general.
The accelerated forecast assumes that the Rest of the World will consume significant volume in 2010, this includes India, China, and South Korea.
This last assumption is extremely problematic.

Conclusions: It's a balancing act, the industry should not overbuild, yet it must be ready for continued strong demand.

Raw material supply will begin easing by the end of 2008, and with no further delays, there will be an abundance of silicon in 2010. Of course, in the future, thin films may experience raw material issues that constrain growth.

This abundance, along with planned capacities of thin films, will lead to significant downward pressure on prices – this is very good for the distribution channel, and extremely good for investment installations which do not rely on system sales, and require the lowest cost of hardware to be successful.

Assuming that the global market will absorb excess module product is problematic, particularly considering the current global economic situation, housing downturn in the U.S. and Japan, continued need for incentives to drive demand – and, the availability of substitutes including energy efficiency.

Solar electricity will narrow the affordability gap eventually. Until that time it needs long term incentives to thrive.

Manufacturing costs must decline, efficiencies must rise and the selling channel must be involved in the dialog – as they set the price and have access to the end user.

Thank You,
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