

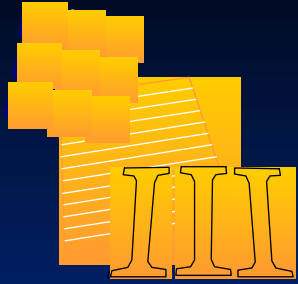


SOLA3020 PV Manufacturing

Topic: Trends in Photovoltaics

Stuart Wenham

8th October, 2012



Trends in Photovoltaics

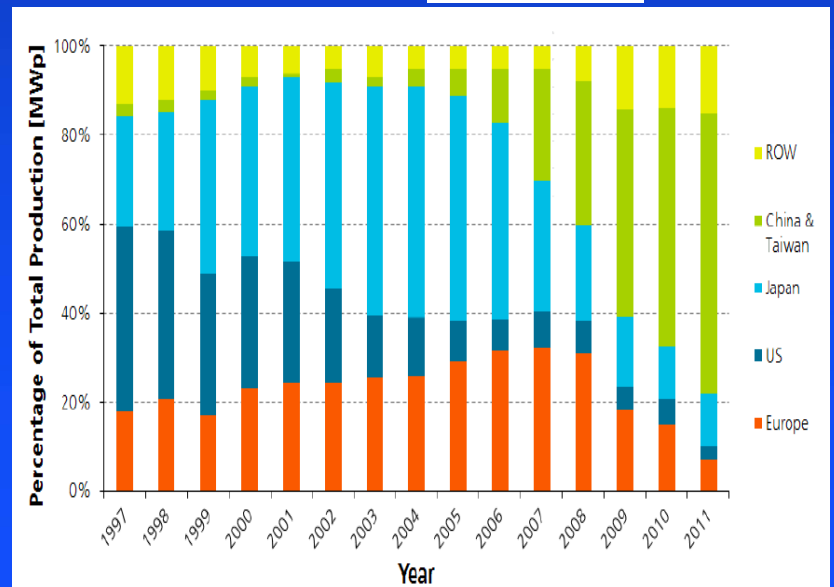
1. Trends in PV Manufacturing
2. Price and Market Trends
3. Applications
4. Trend in Technology
5. Trend to replace Ag with Cu
6. Wafer Trends
7. Encapsulation
8. Balance of System
9. Trends in Education & Training

China's Dominance in Manufacturing



2007	MW	2008	MW	2009	MW	2010	MW	2011	MW
Q.CELLS	389	Q.CELLS	582	First Solar	1100	SUNTECH	1573	SUNTECH	2096
SHARP	363	First Solar	504	SUNTECH	704	JA SOLAR	1400	YINGLI SOLAR	1721
SUNTECH	336	SUNTECH	494	SHARP	595	First Solar	1300	First Solar	1711
KYOCERA	207	SHARP	473	Q.CELLS	586	YINGLI SOLAR	1100	JA SOLAR	1695
First Solar	200	JA SOLAR	300	YINGLI SOLAR	525	Trinasolar	1000	Trinasolar	1623

- China threatens PV manufacturing??
- Trade tariffs
- China helped drive down module prices 80% in recent years
- Also 80% of jobs downstream



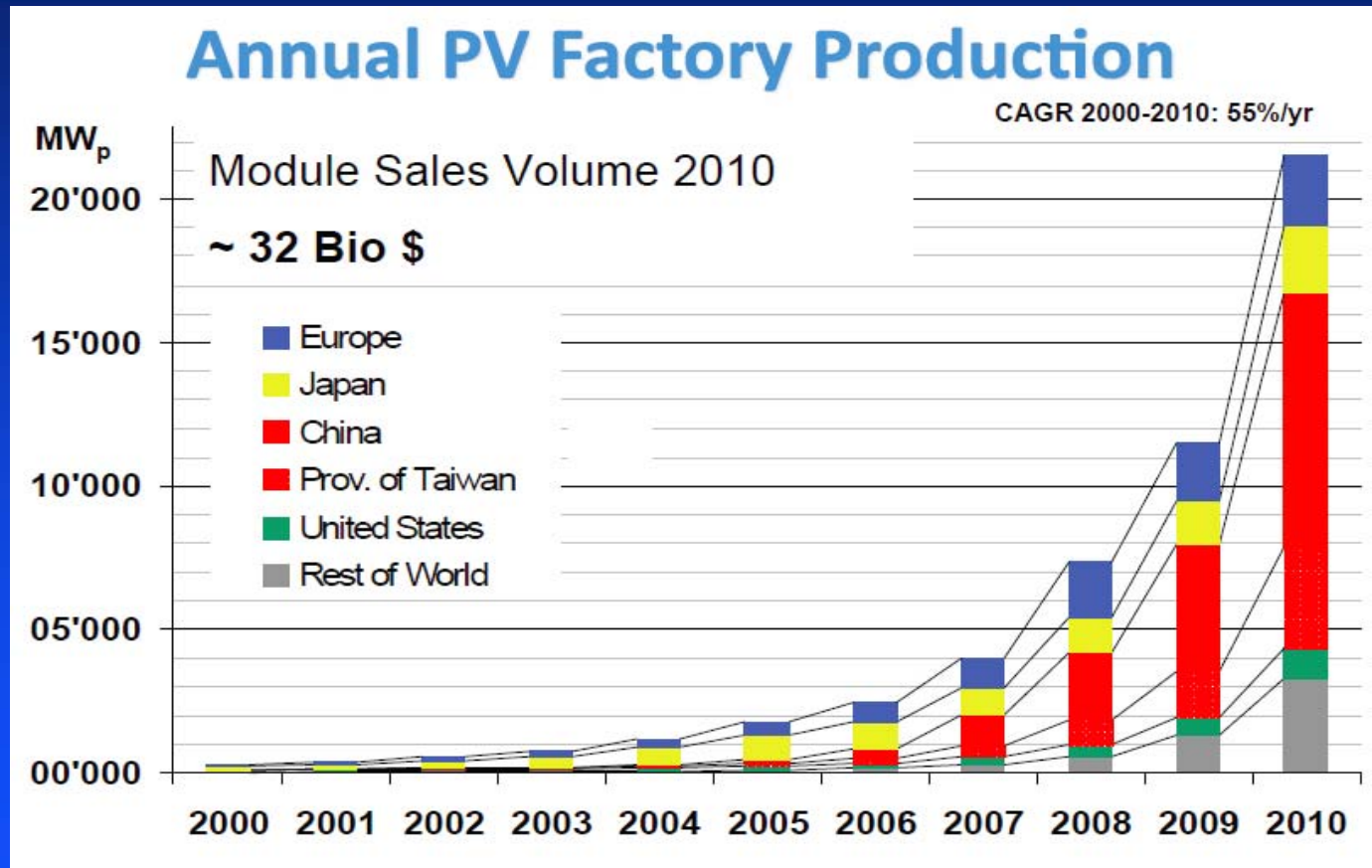


Trends in Photovoltaics

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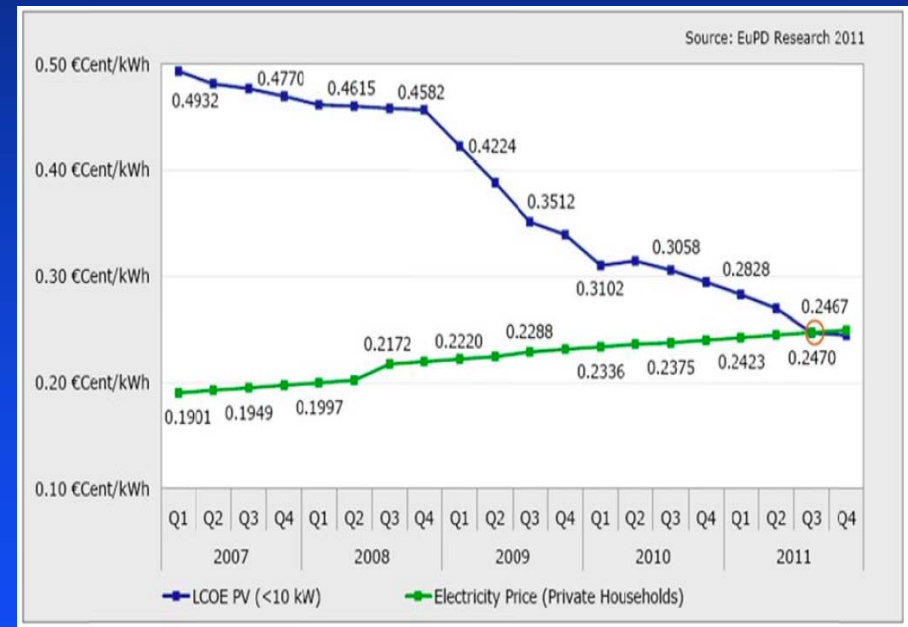
Fastest Growing Industry World-wide

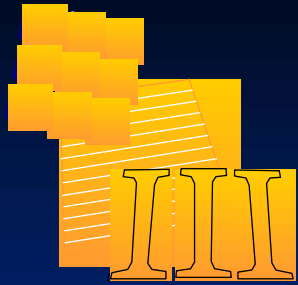




Huge 80% PV Module Price Reduction

- PV module costs no longer limiting market growth in many countries
- Red-tape, approvals, electricity supply agreements + other BOS costs are now major issues
- Examples of roof-top systems (module costs US\$0.80 /Wp) :
 - US system costs US\$4.40 /Wp
 - Germany costs < US\$2.50 /Wp
 - Many countries still without grid-interconnection policies

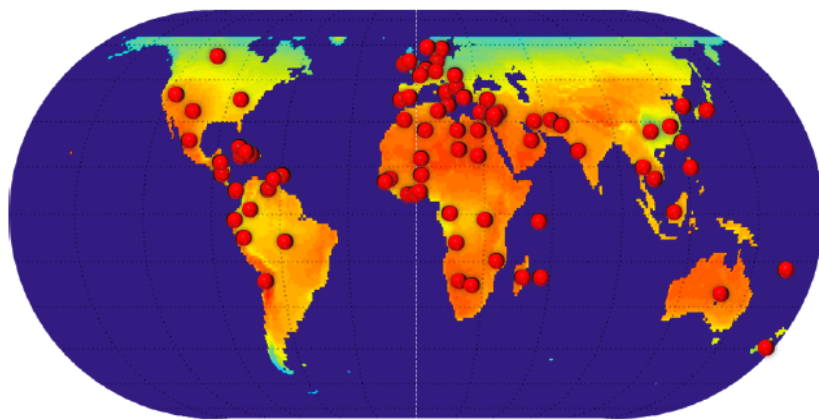




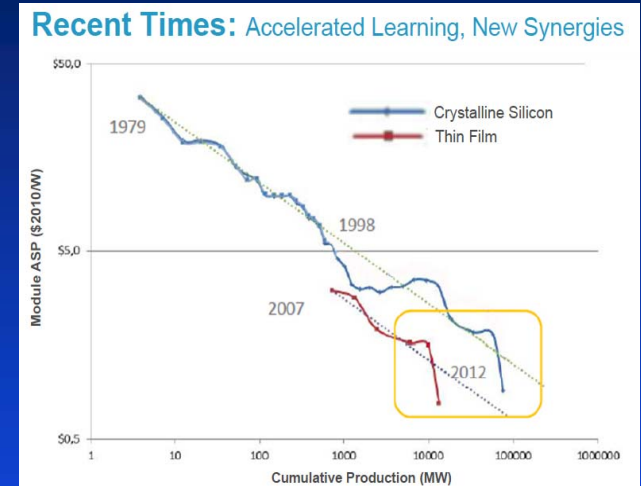
Implications of Price Reduction

- Grid now parity in >100 countries
- Reduced importance on subsidies & FITs
- Erratic policies contribute significantly to industry instability

2012 Status: PV Solar at Grid Parity



Now
2012
102
countries
have
reached
grid parity



Germany installs record 4,300 MW photovoltaic solar energy in first half

August 2, 2012

[Other renewables](#)





Germany installed a record of around 4,300 megawatts of solar power capacity in the first half of 2012, raising the total in the world's largest photovoltaic market to more than 28,000 MW, the federal network agency (Bundesnetzagentur) reported on Thursday.

Nearly half of that amount, or about 1,800 MW, came in June in a building frenzy just before a 30 to 40 percent cut in government-mandated incentives took effect in July.

You are here: [Home](#) / [Business & Economy](#) / Australia Could Be World's 1st Solar PV Mass Market, Yingli States

Australia Could Be World's 1st Solar PV Mass Market, Yingli States

July 14, 2012 By [Giles Parkinson](#) [2 Comments](#)

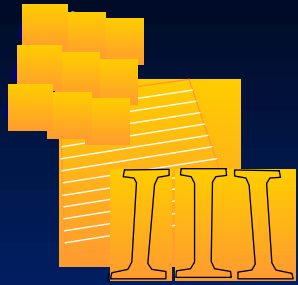
submit  32  3  33  2  1

Like Tweet Share

One of the world's biggest solar PV manufacturers, Yingli Green Energy, has announced it will set up its regional headquarters in [Sydney](#) after concluding that Australia represents one of the most promising solar PV markets in the world.

However, the company says Australia is set to be a “world leader” in coming years — the result of rising retail electricity prices, falling PV [costs](#), new financing options and a lot of sun. And as some of its principal partners move into the country, it has chosen to do so too.

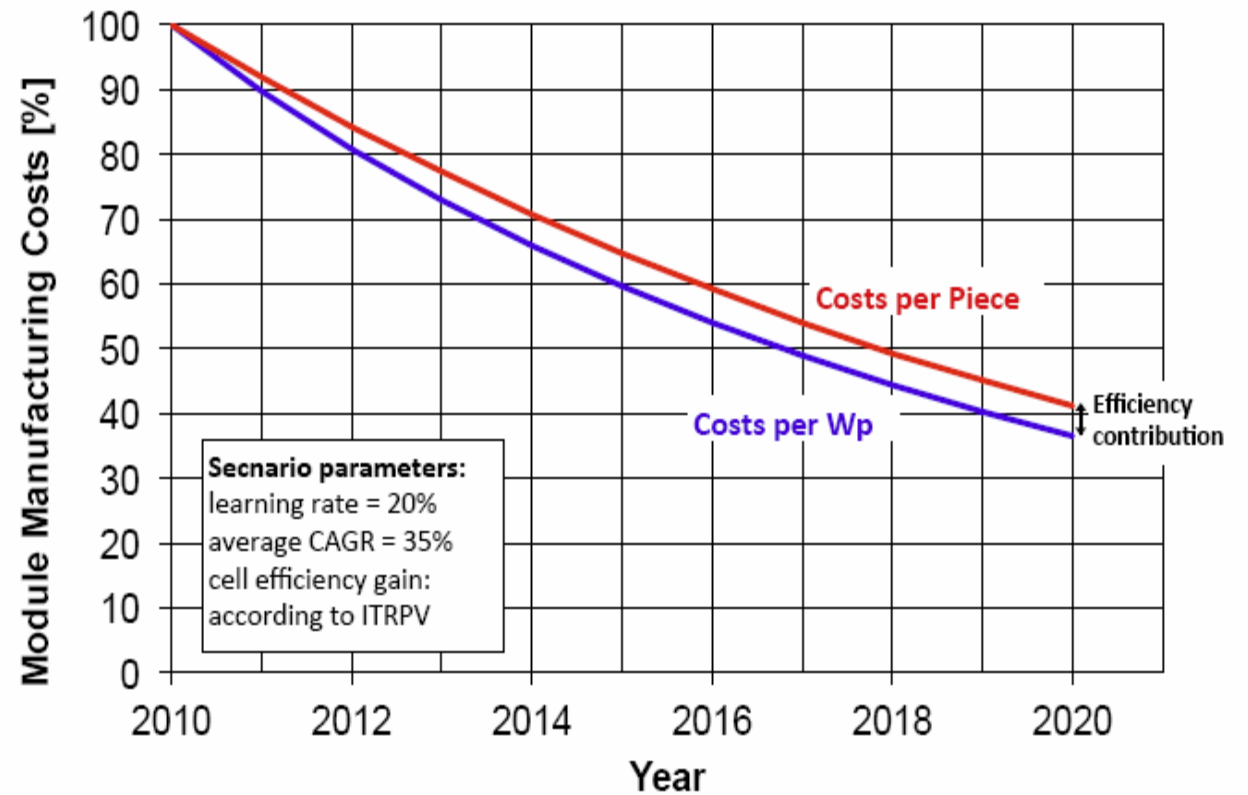
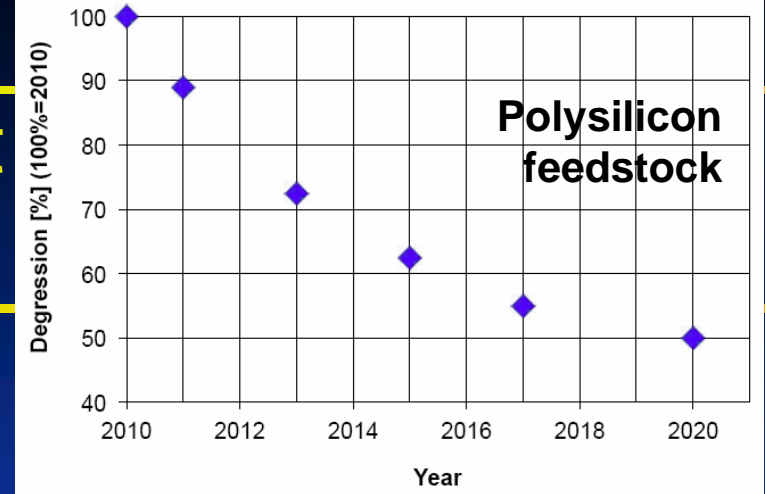
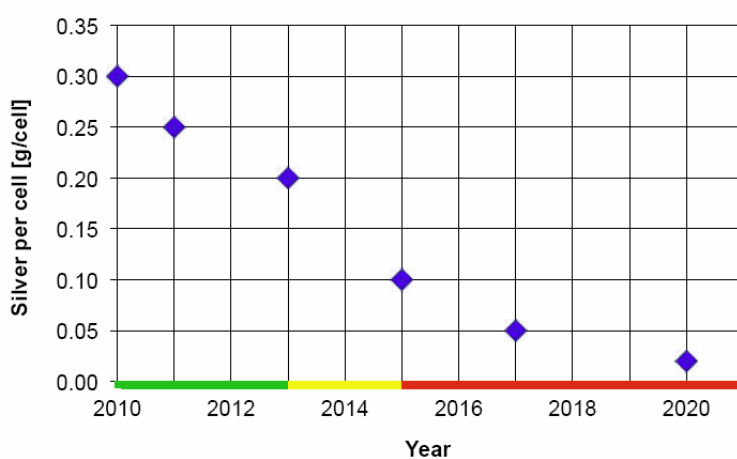
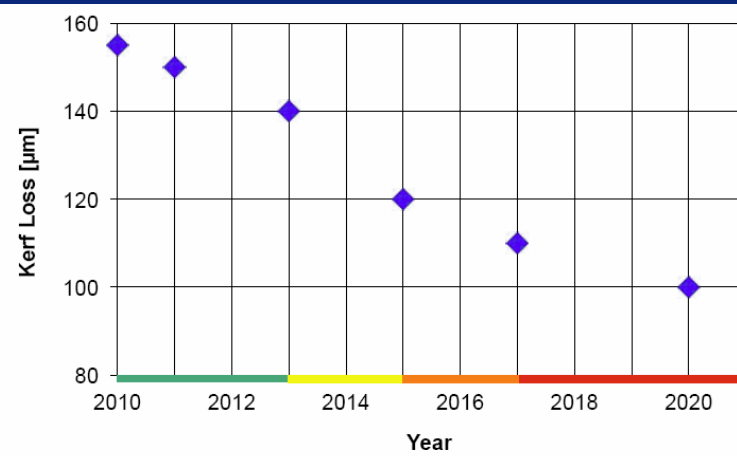
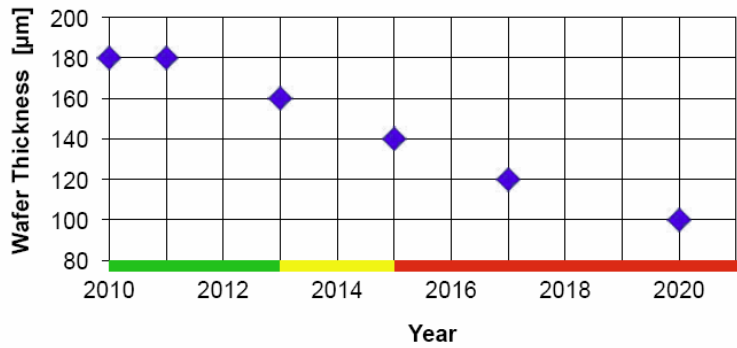
- Rules & Regulations around distributed generation will become significant



Experts expect prices to keep falling



Predicted Cost Reductions





Trends in Photovoltaics

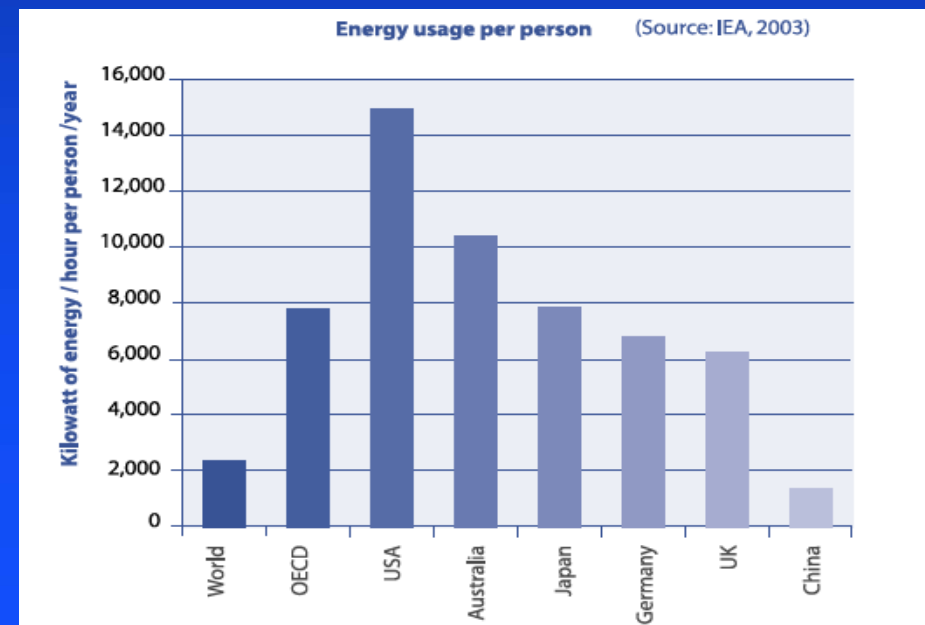
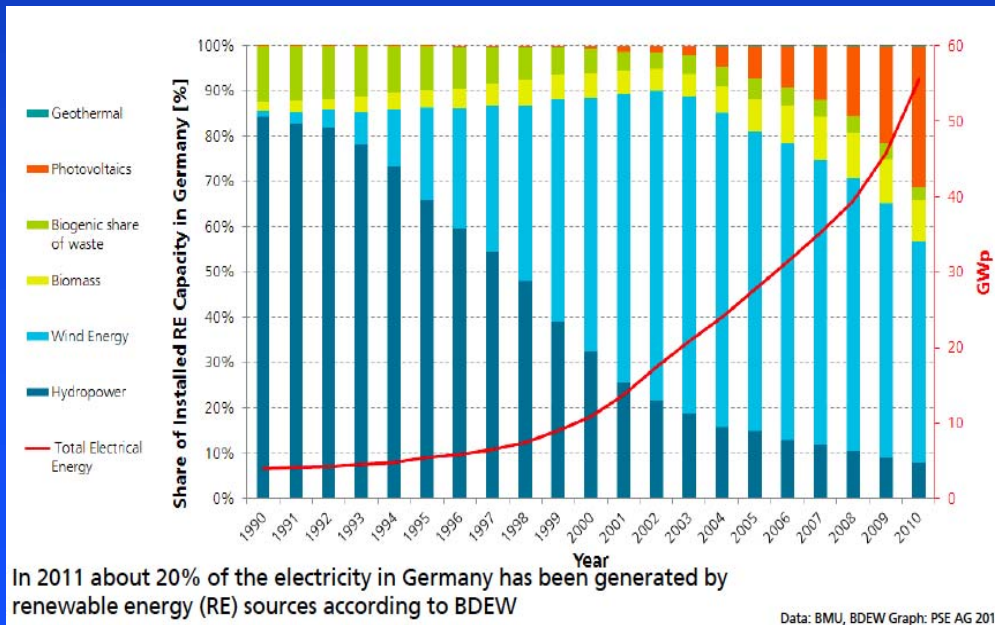
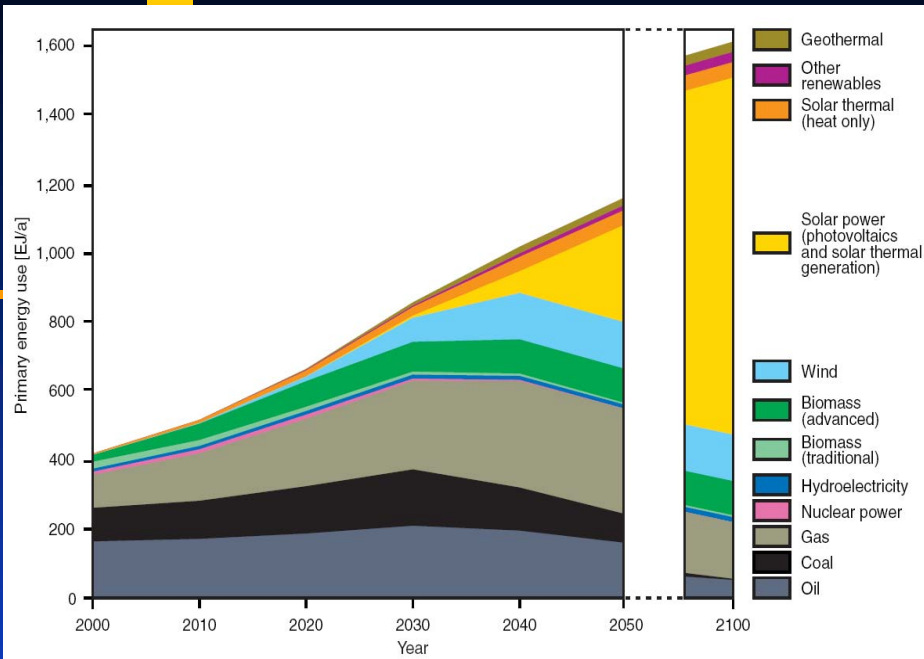
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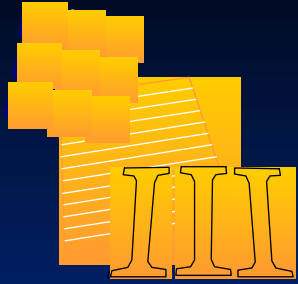
Application Trends

- **Rooftop Systems**
- **Utility Scale Systems**
- **Stand-alone Systems**
 - developing countries



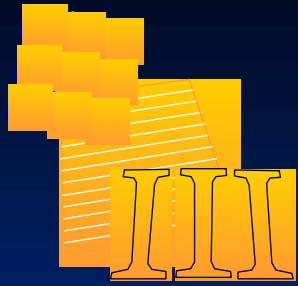
Future Energy Sources + Current Consumption





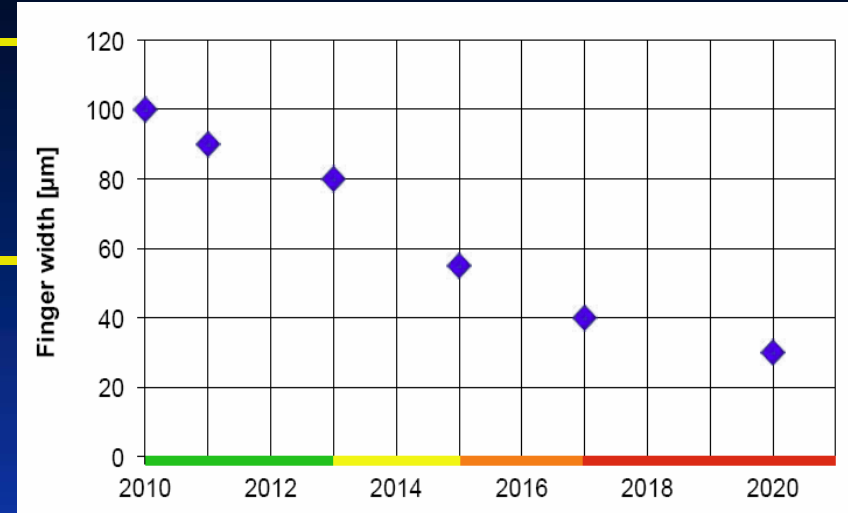
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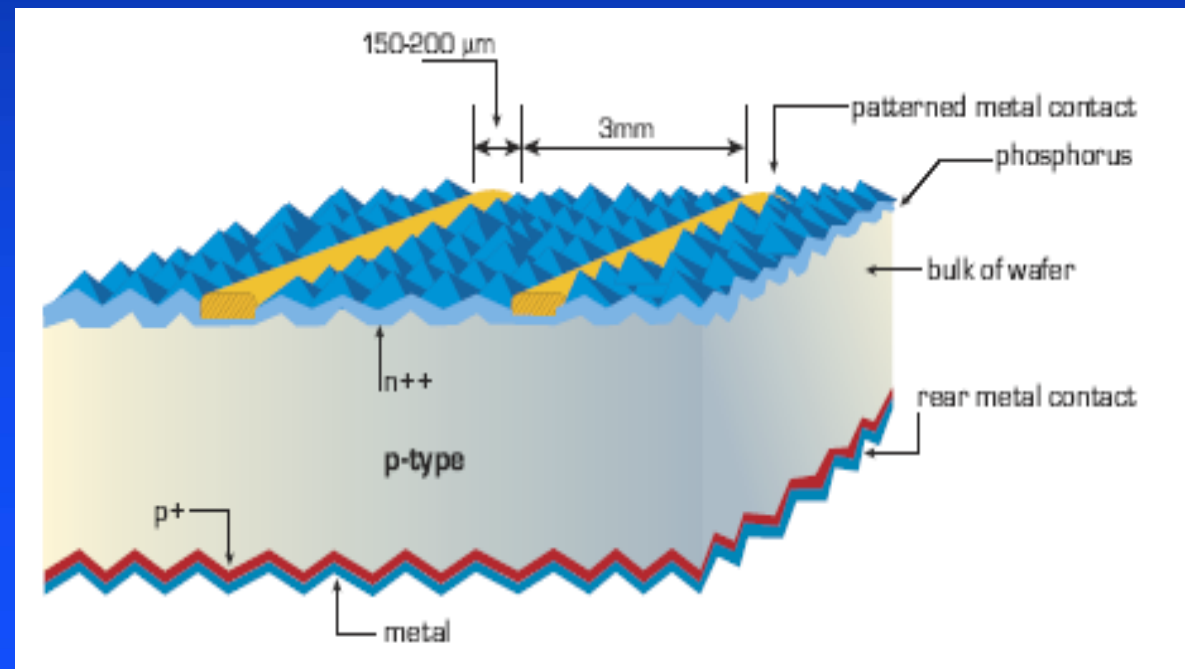


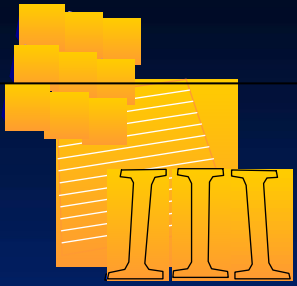
Trends in Screen-Printing Technology

- Efficiency more important when $S > D$
- Huge impact by Dupont - new pastes
- Lightly doped emitters
- Narrower metal lines
- Selective emitters
- Rear surface passivation
 - $\text{AlO}_x/\text{SiN}_x$
 - $\text{SiO}_2/\text{SiN}_x$
 - SiO_xN_y
- Rear metalisation
 - SP Al
 - LFC
 - Laser doping

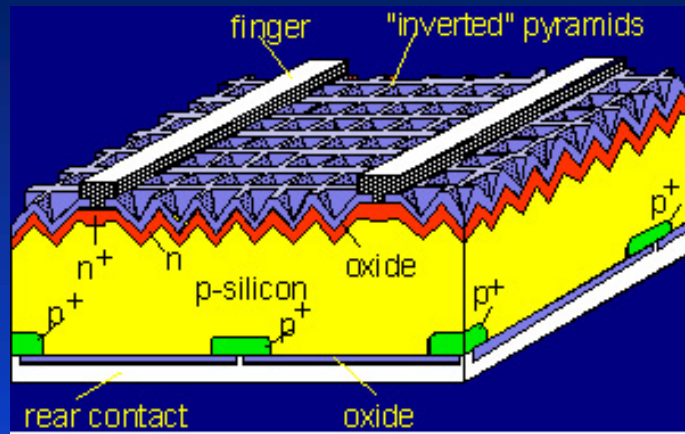
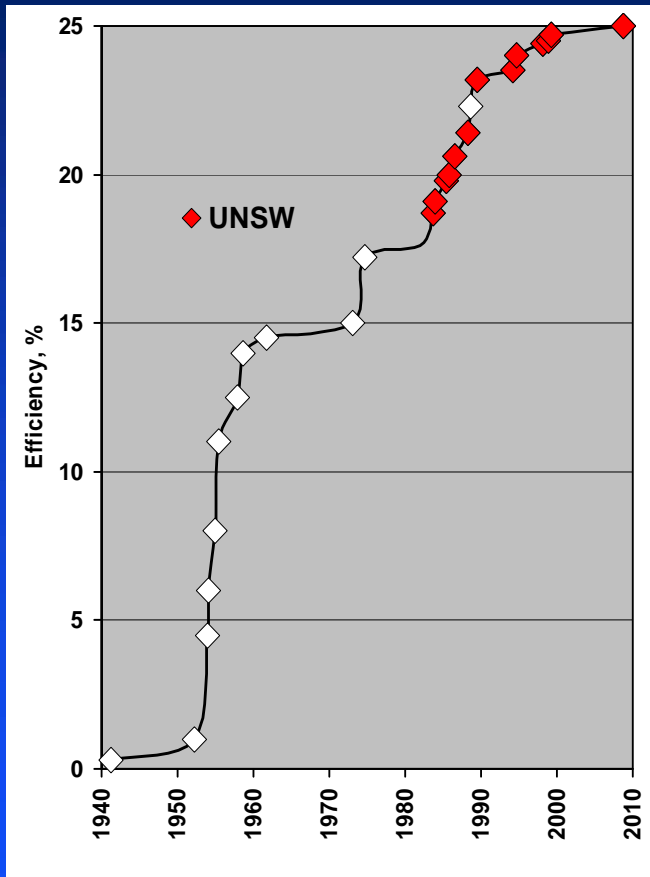


Screen Printed Solar Cell

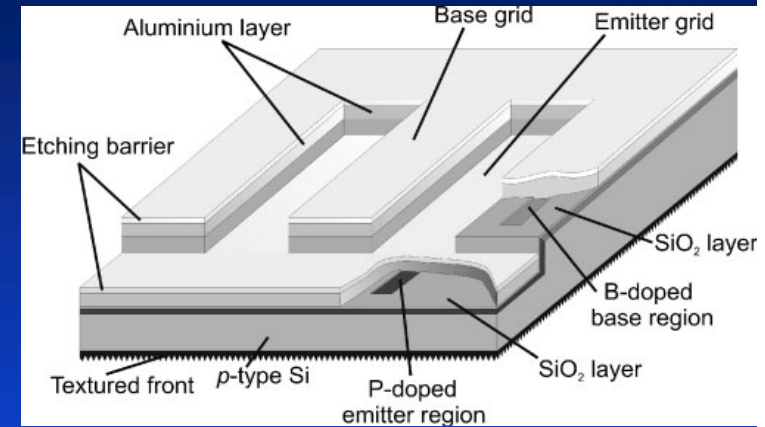




Trends in High Efficiency Technologies



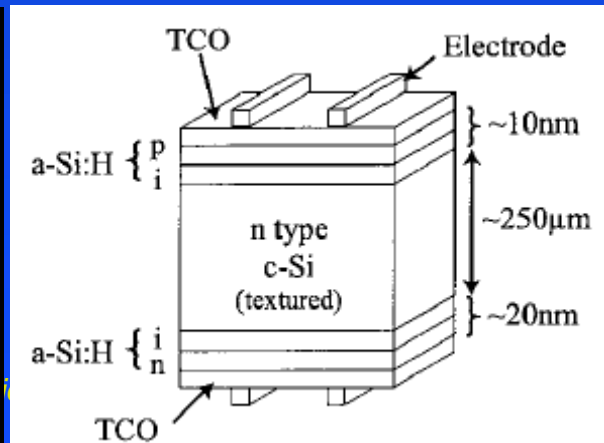
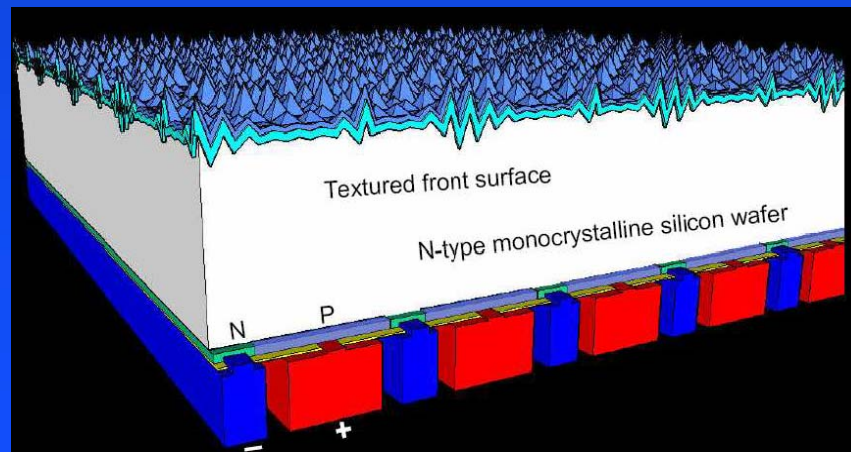
UNSW – 25% PERL cell



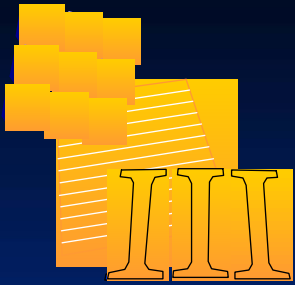
ISFH – 22.4% RISE cell

Stanford – 24% Rear Point Contact

Sanyo – 23% HIT cell

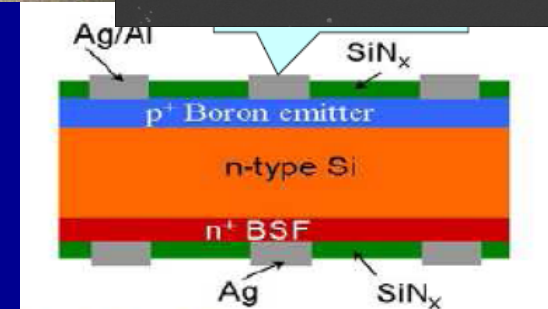
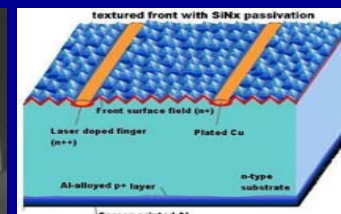
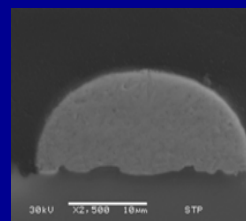
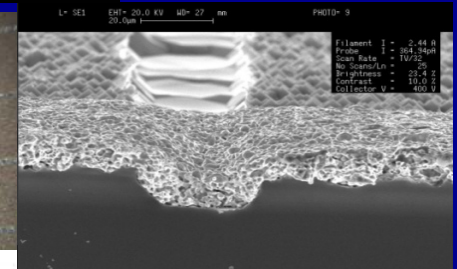
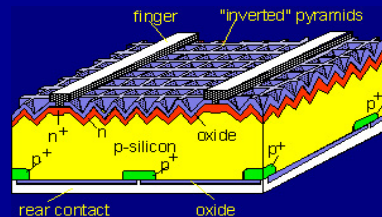
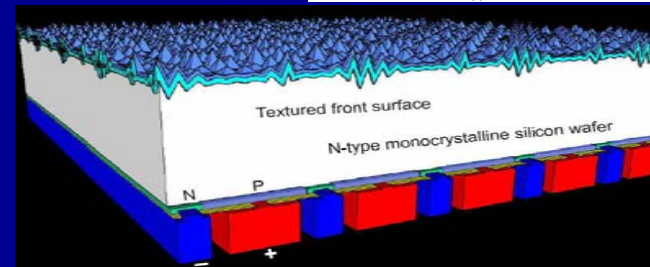
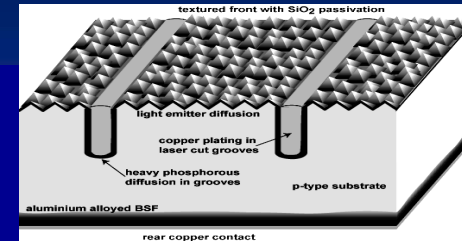
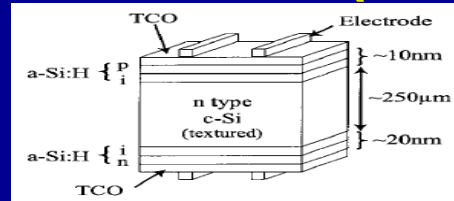


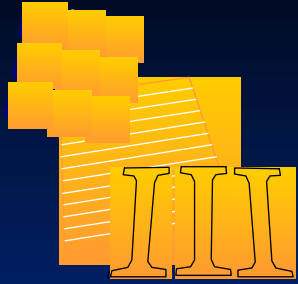
UNSW



Commercialisation of High Efficiency, Low Cost Technology

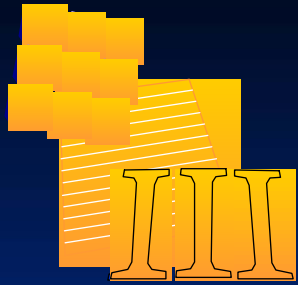
- Buried Contact Solar Cells (Australian)
- HIT cell (Japan)
- Rear Point Contact Cell (USA)
- Pluto (Australia)
- Semiconductor Finger Cells (Australia)
- Yingli n-type Panda technology (Netherlands)
- Laser Doping (Australia)
- Innovalight (USA)





Trends in Photovoltaics

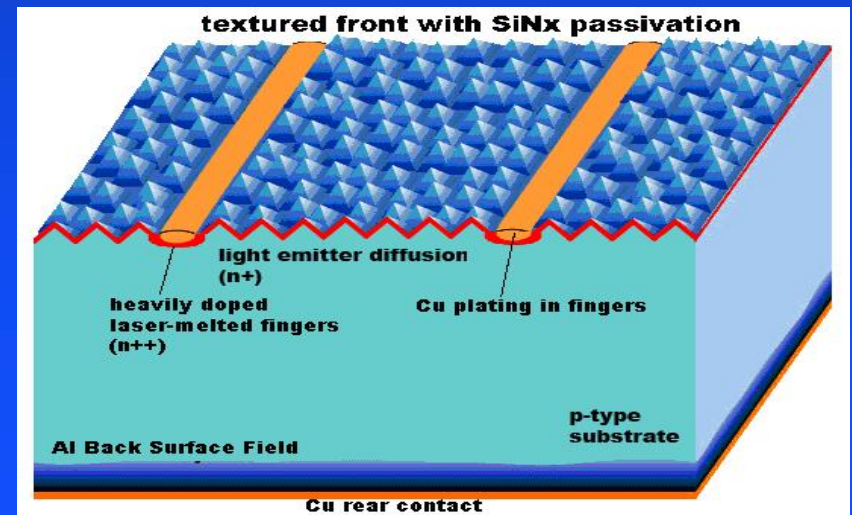
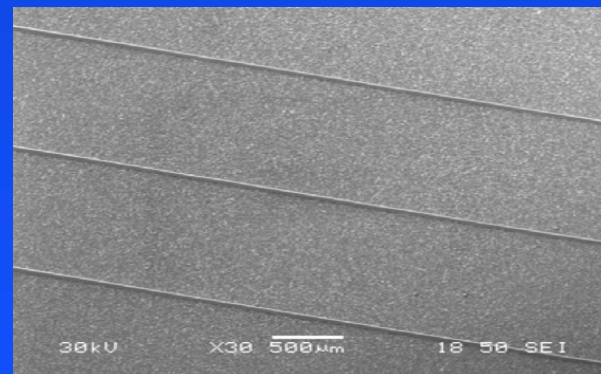
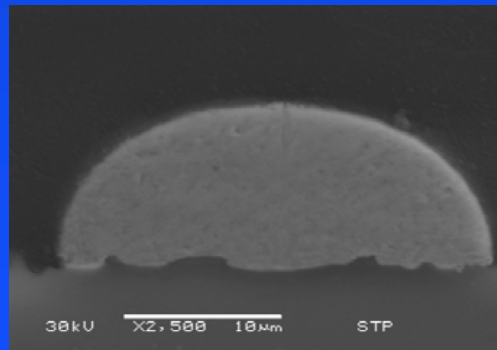
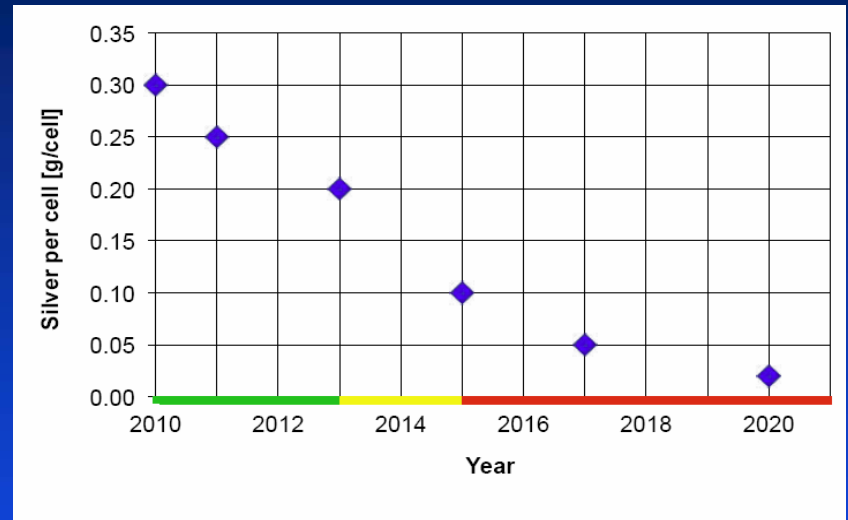
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Trend towards Cu replacing Ag

1. Focus of many companies
2. Kuttler plating baths now available!
3. Printed seed layer plated with Cu
4. Good results also with all plated contacts:

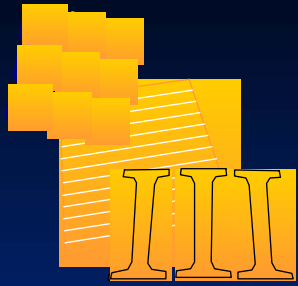
- Suntech
- IMEC
- HHI
- Shinsung
- UNSW
- RENA





Trends in Photovoltaics

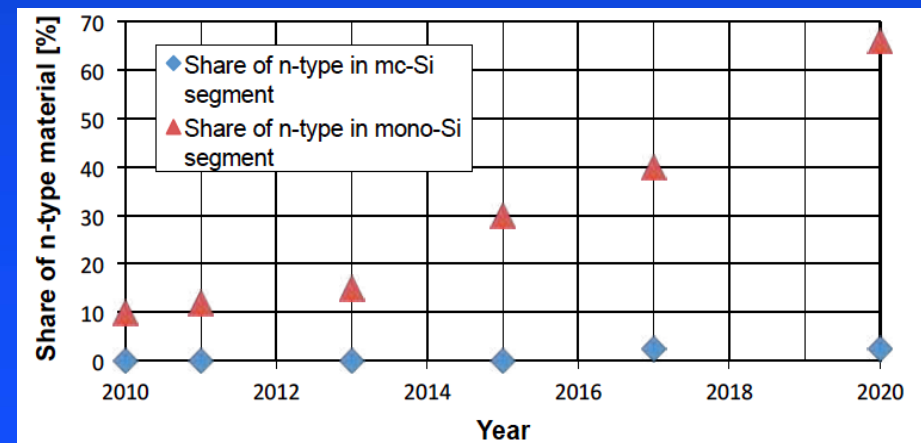
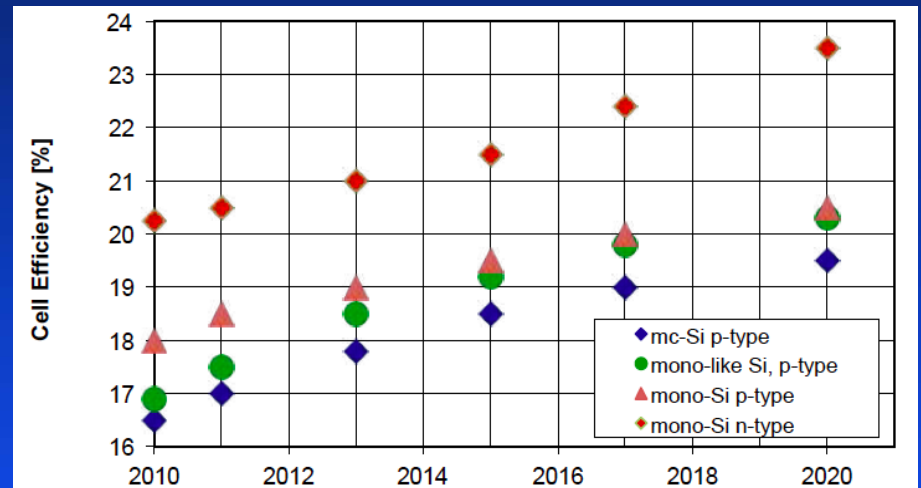
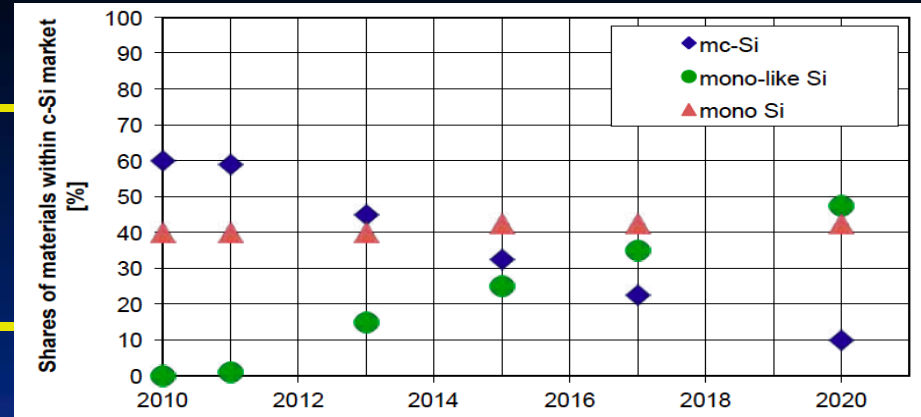
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Wafer Trends

- Wafer costs now \$0.25 - \$0.28 /W
- Less important to use thinner wafers
- N-type predicted to dominate for high efficiency devices
 - Good EU PVSEC paper by Stefan Glunz
 - IBC structure favoured
 - This structure needs highest quality Si
- P-type may do better than expected
 - B-O problem seems solvable
 - 700mV now achievable
 - More suitable for multi wafers

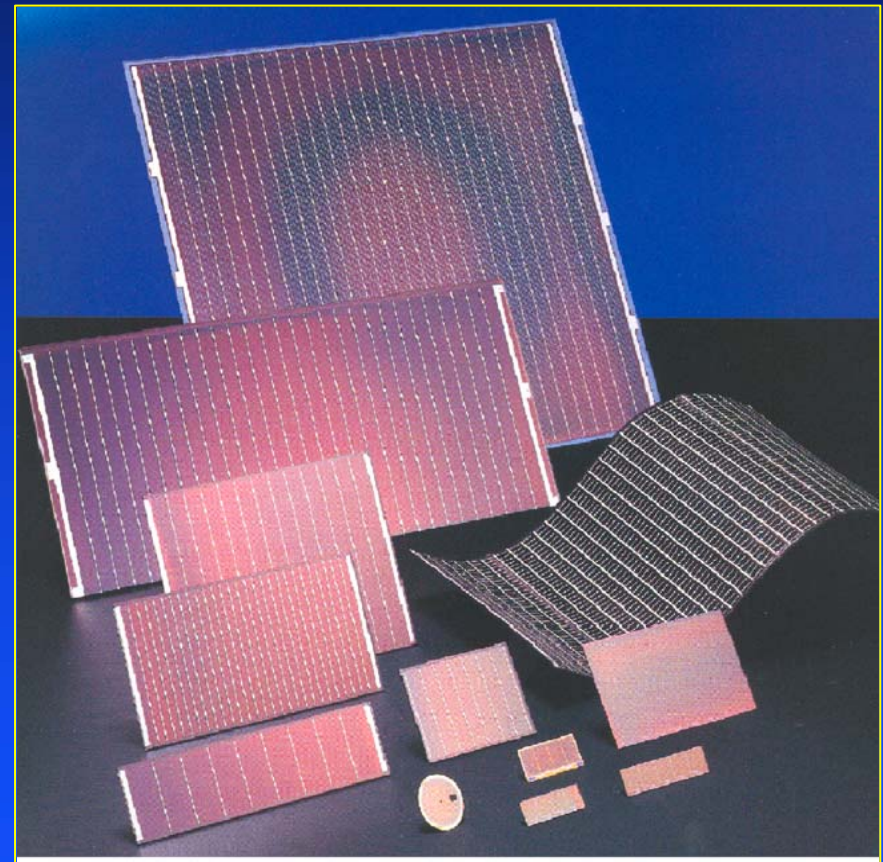
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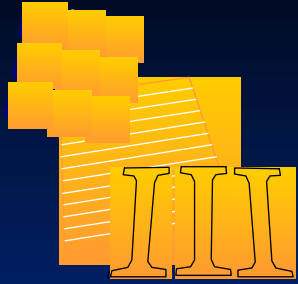




Challenge for Thin-Films

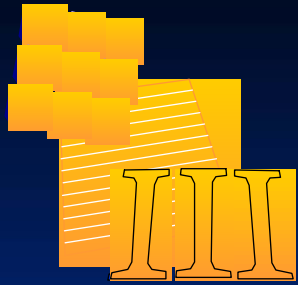
- Silicon efficiencies increasing while costs are falling rapidly
- Falling market share
- Recent durability concerns in hot environments
- No thin-films have as yet demonstrated long-term stability or durability
- Dependence on rare elements





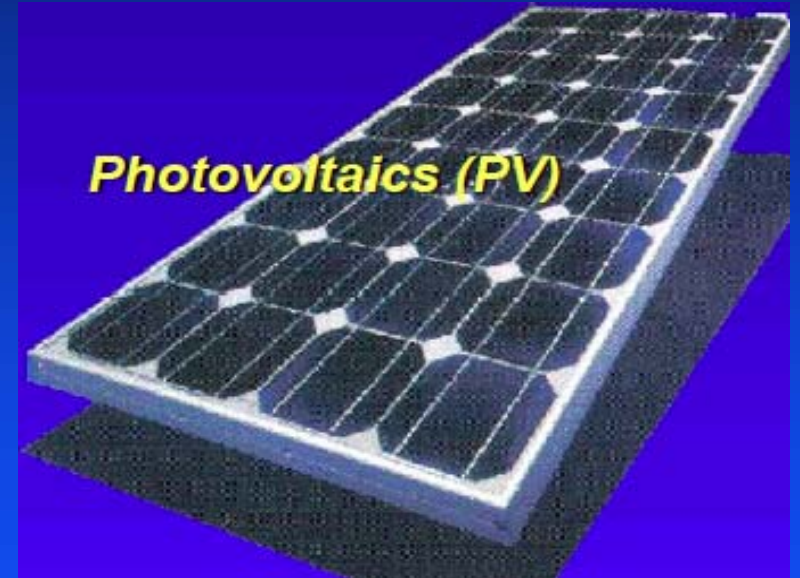
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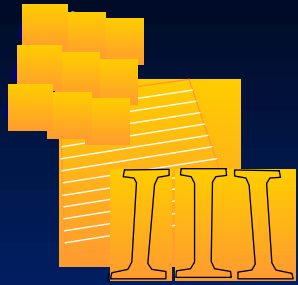
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Trends in Cell Encapsulation

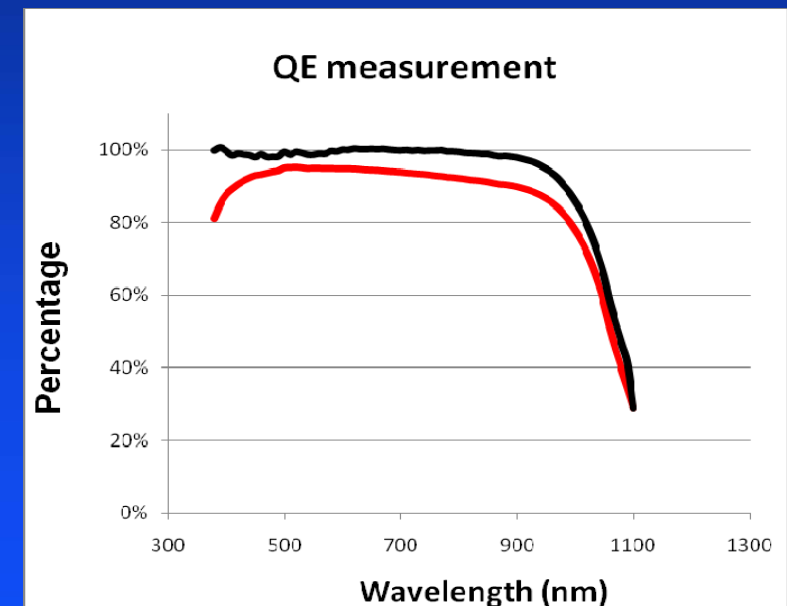
1. Encapsulation costs now dominating.
Per watt costs are typically:
 - \$0.26 Wafer
 - \$0.14 cell conversion
 - \$0.34 encapsulation
2. Manufacturers very conservative
(25yr warranty)
3. Importance of bankability –
compromised by technology changes

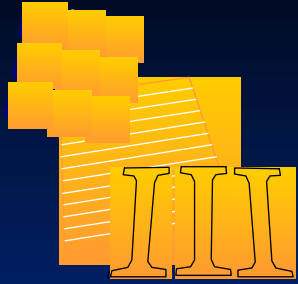




Trends in Cell Encapsulation

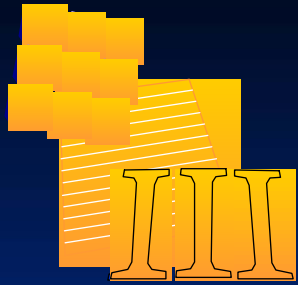
1. Pb free solders need higher temperature
 - Thinner interconnects due to thermal stress
 - Problem for thinner wafers
 - Glued interconnects
2. EVA no good for selective emitters
3. Glued interconnects
4. Rear contacts preferred.
5. PCB approach to interconnection





Trends in Photovoltaics

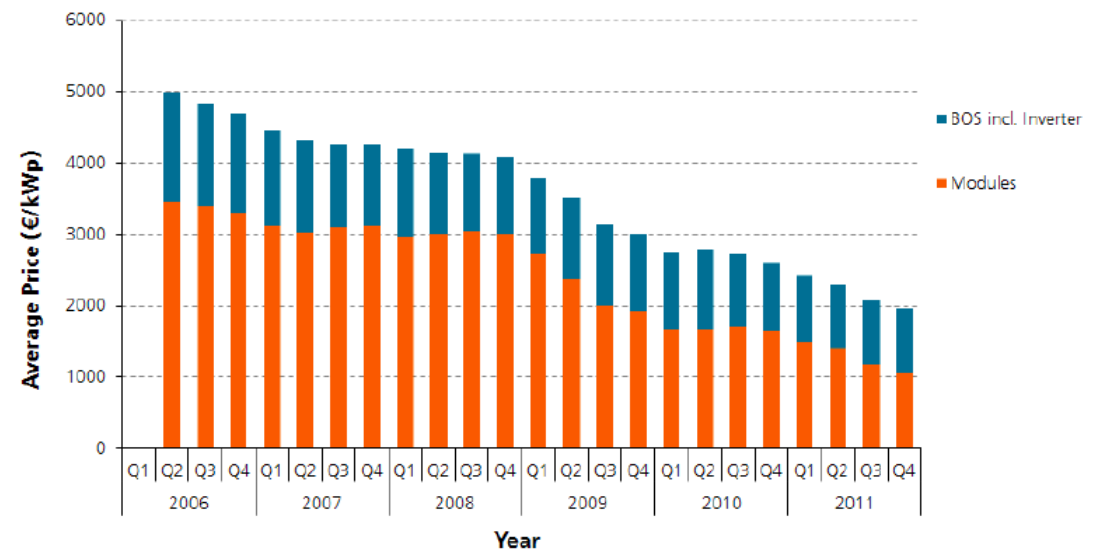
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BOS Costs need to be reduced

1. Module costs only 20-30% of roof-top system costs in USA
2. BOS costs about 50% in Germany
3. Other countries need to learn from Germany
 - Reduced red-tape
 - Efficient installations
 - Advanced electronics

Average Price for PV Rooftop Systems in Germany (10kWp - 100kWp)



39

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Trends in Photovoltaics

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Trends in Education & Training

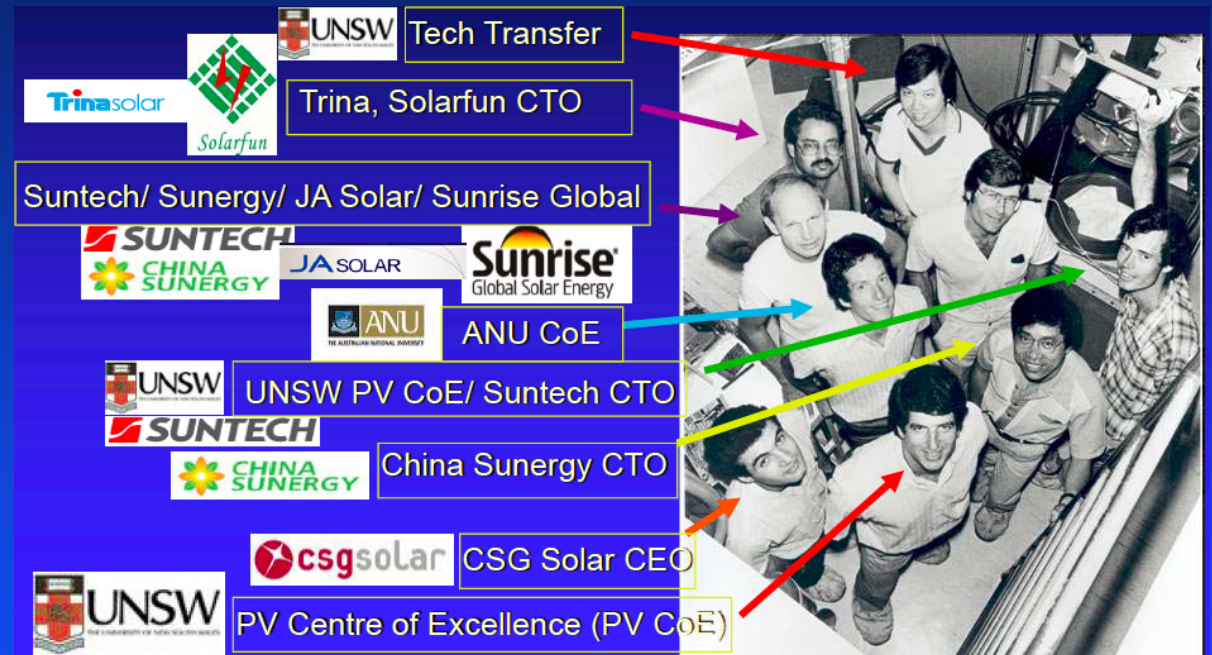
- Increasing company interest in training and technology transfers
- Many more training & education programs being established
- UNSW Education – World's only PV Degree,
>500 enrolled
- >40 former UNSW students in senior positions of PV companies

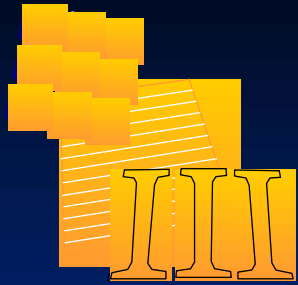




Leadership Positions Held by Former UNSW Students

- 6 x CEO's
- 6 x VP of Technology
- 16 x CTO's
- 2 x COO's
- 2 x Managing Director
- 6 x Research Director
- 5 x Company Directors
- 2 x Directors of Centre of Excellence



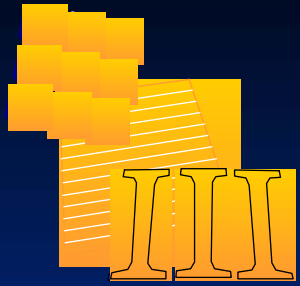


22 former UNSW students as CTO's or VP's of Technology World-wide

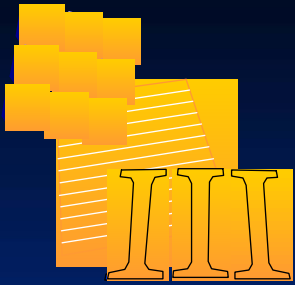
- Includes 8 of China's 10 largest cell manufacturers in present or former positions
- Guarantees Australia's continued technical leadership

* denotes current position

Wenham Stuart	* Suntech-Power
Narayanan Mohan	Trina Solar
Song, Dengyuan	* Yingli Solar
Dai Ximing	JA Solar
Yun Fei	* LDK Solar
Yao, GuoXiao	JinkoSolar
Guo, Allen	* Jinko Solar
Narayanan Mohan	* Solarfun (Hanwha)
Wang Aihua	* China Sunergy



Thank You



US DOE Secretary Stephen Chu concluded: *“China’s leadership not due to low cost labour but superior technology”*

- Reduced energy in production
- Increased cell efficiencies



Face of solar: Suntech's headquarters building in Wuxi, China, which features a solar façade, is also its main solar cell manufacturing facility.
Credit: Suntech

BUSINESS

Chinese Solar Companies Thrive on Manufacturing Innovations

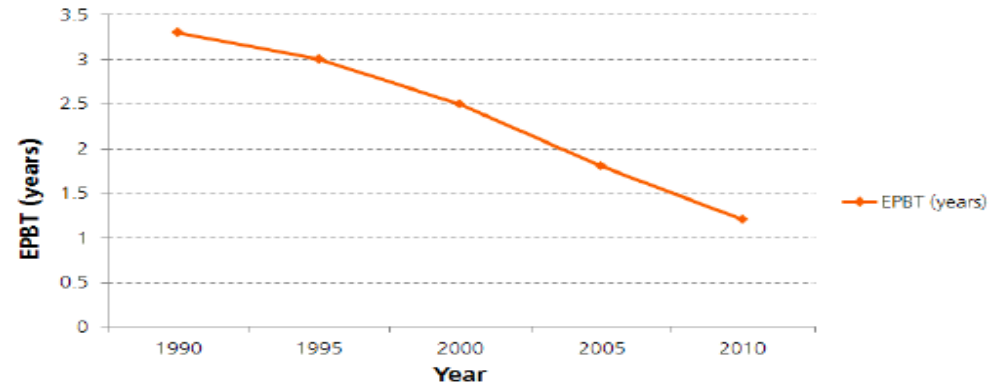
Suntech Power's CTO argues that the secret to China's success is not cheap labor but advanced equipment for making solar cells.

WEDNESDAY, JULY 6, 2011 | BY KEVIN BULLIS

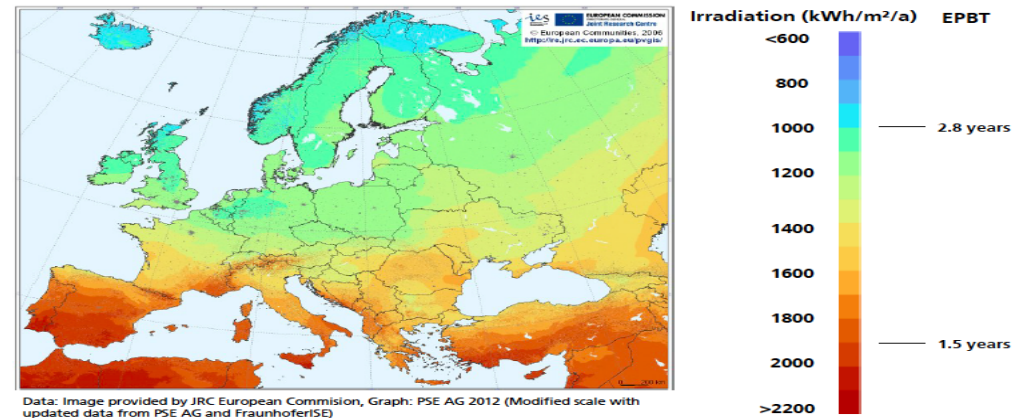
Audio »

Five years ago only one of the 10 largest solar cell producers was based in China. But by last year, four of the top five were based there, and each is growing fast: all four doubled their production last year. It's widely believed that this success is due to low labor costs, but Stuart Wenham, CTO of the largest solar cell maker in China, Suntech Power, argues that the real causes are advances in manufacturing technology that have improved solar cells' performance and cut costs.

Rooftop Installations in Southern Europe (1700 kWh/m²/a)



Energy Pay-Back Time of Multicrystalline Silicon PV Systems - Geographical Comparison



Suntech Sets World Record 20.3% Efficiency for Pluto Cell Technology

2 messages

ir@suntech-power.com <ir@suntech-power.com>
 Reply-To: ir@suntech-power.com
 To: E-SUNTECH <s.wenham@unsw.edu.au>

Mon, Mar 12, 2012 at 11:01 PM

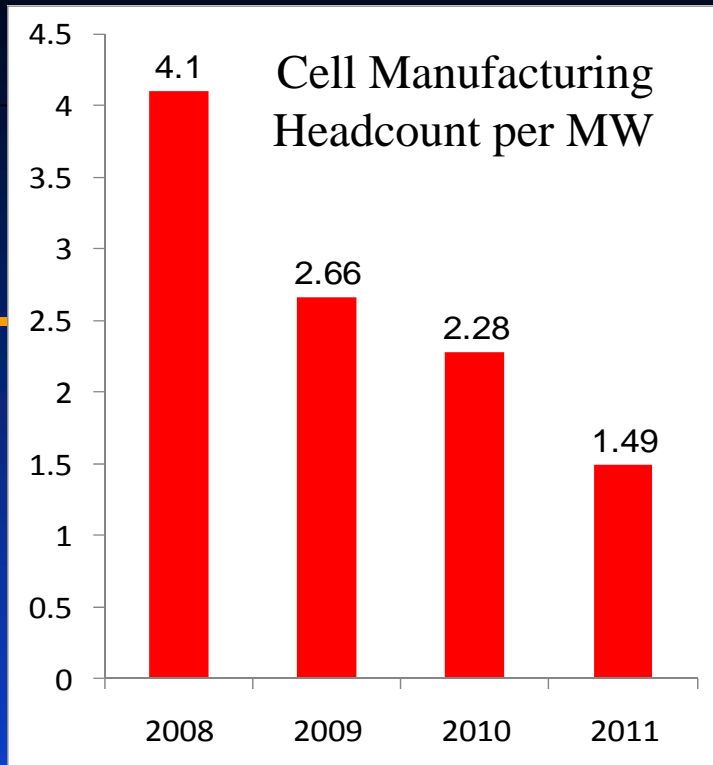
Suntech Sets World Record 20.3% Efficiency for Pluto Cell Technology

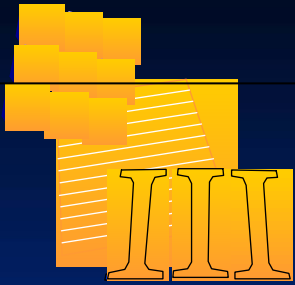
WUXI, China, March 12, 2012 /PRNewswire-Asia/ – Suntech Power Holdings Co., Ltd. (NYSE: STP), the world's largest producer of solar panels, today announced that its industry-leading Pluto cell technology set a world record 20.3% efficiency for a production cell using standard commercial-grade p-type silicon wafers.

Developed by Suntech's research and technology development (R&D) team, in collaboration with the University of New South Wales, the incremental innovation in Pluto cell technology underscores Suntech's investment in R&D that delivers the best solar technology to its customers at an affordable price.

Cell Manufacturing
Headcount per MW

Automated vs Labour





Challenge to Upgrade Technology

- Compatibility with multi wafers essential for success
- J_0 reduction from 1600 to 400 fA/cm² gives +40mV in V_{oc}

