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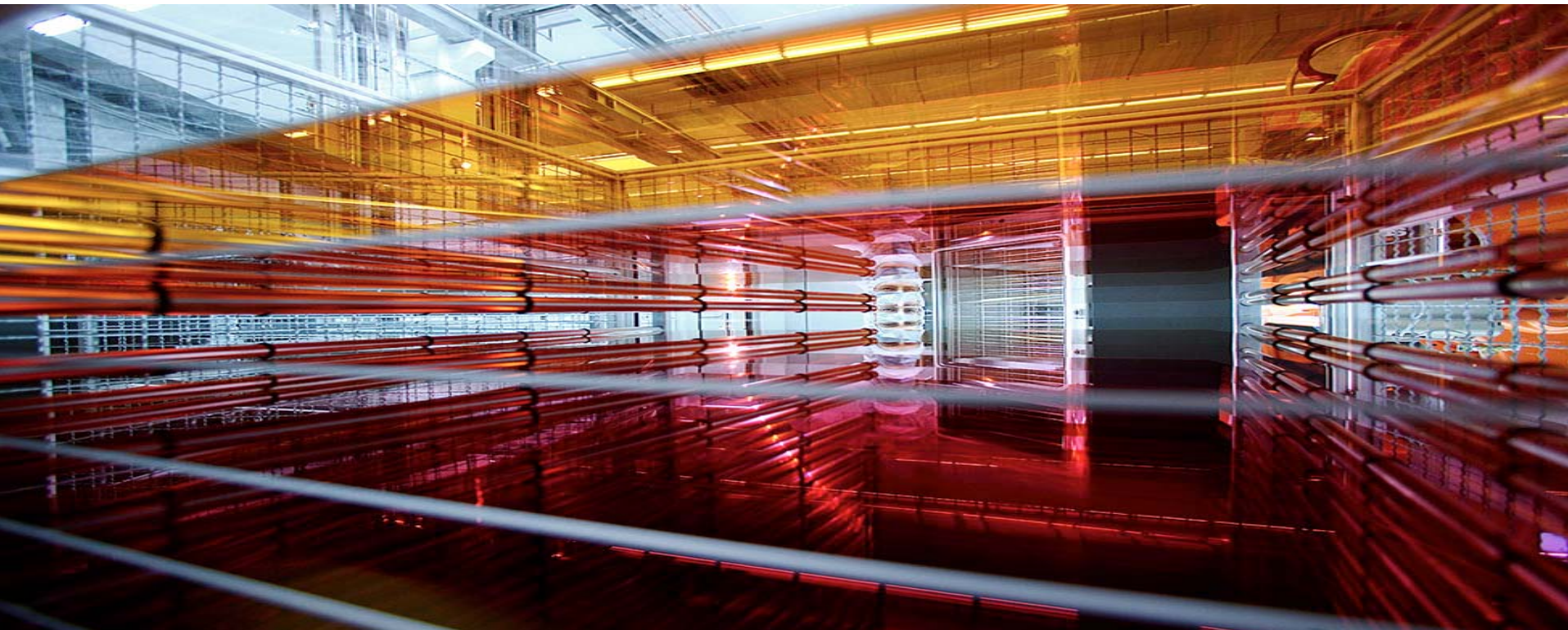
Photovoltaic Solar: Market and Technology Trends (Industrial Application of Organic Photonics)

June 24, 2008

Fachri Atamny



Photovoltaic Solar Environment and Issues: Outline

- **Solar Cell Market Environment and Issues**
  - Market growth drivers
  - Market size, segments, and growth
- **Photovoltaic Solar Technologies**
  - Trends, Changes and Disruptions
- **Industrial Applications of organic Photonics**
  - SC vs. Displays vs. Solar

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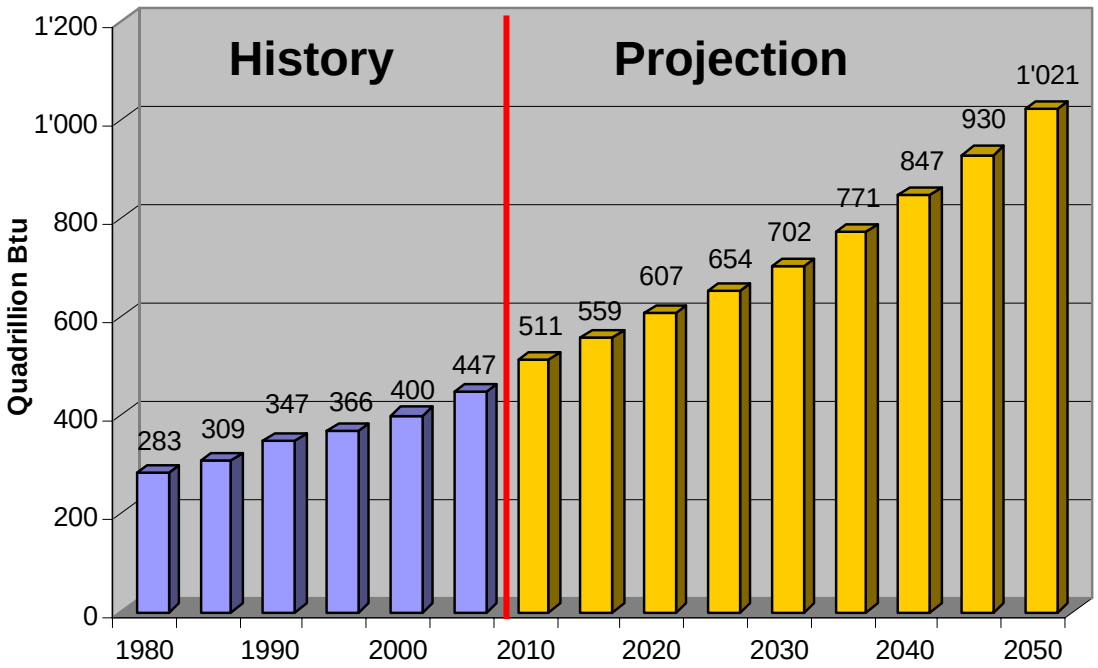
Solar Cell Market Growth Drivers

- Primary Driver:
  - **Energy demand**:
    - 2007: 13 terawatts - 2030: 18 terawatts - 2050: 26 terawatts
- Secondary Drivers (most are result of the primary driver: energy demand)
  - Environmental issues (global worming / climate changes, CO_2 reduction/penalties)
  - Oil Price (30 $ > 100$)
  - Natural Gas Price
  - Coal Price
  - National Security (energy security concerns)
    - Politics: Subsidy, feed in tariff (artificial market)
  - Grid Parity (real market)

Solar Cell Market Growth Drivers

Energy Demand: World energy consumption 1980-2050



13 terawatts (2007)

18 terawatts (2030)

26 terawatts (2050)

Projection: assumption that 1.9% growth in energy consumption p.a.

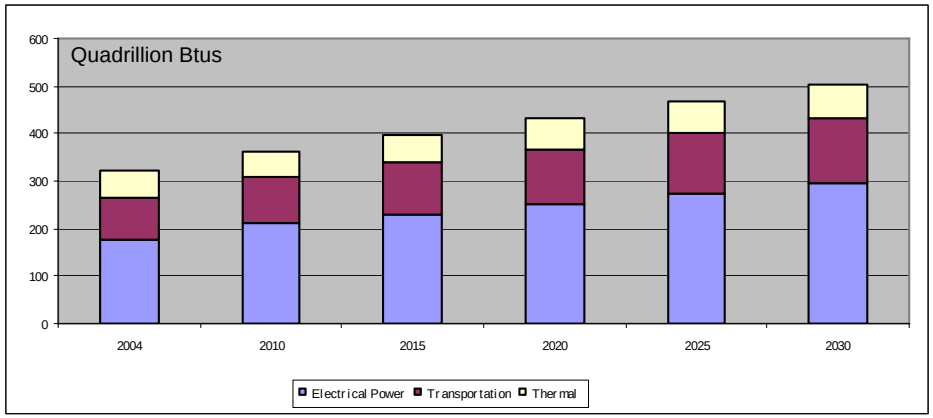
1 terawatts
1000 Nuclear Reactors

Source: International Energy outlook 2007, 5/2007, Energy Information Administration, U.S. department of Energy.

Market size, growth, and segments

Energy Demand by Segmentation

	2004	2010	2015	2020	2025	2030
Electrical Power	**54%**	**58%**	**58%**	**58%**	**59%**	**59%**
Transportation	**27%**	**27%**	**27%**	**27%**	**27%**	**27%**
Thermal	**19%**	**15%**	**15%**	**15%**	**14%**	**14%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**



58% Electricity

27% Transportation

15% Thermal

Source: International Energy outlook 2007, 5/2007, Energy Information Administration, U.S. department of Energy.

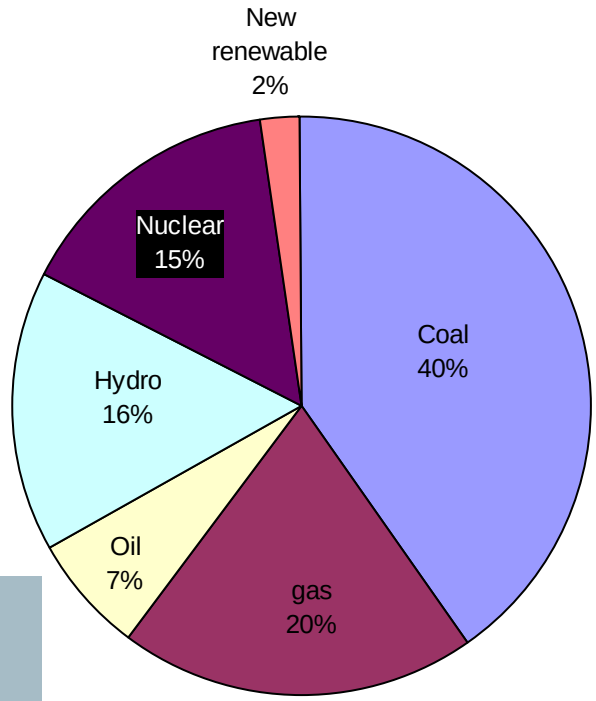
Market size, growth, and segments

Energy Total Market Size: Electricity

	[%]
Coal	40.3
gas	19.7
Oil	6.6
Hydro	16
Nuclear	15.2
New renewable	2.2
Total [%]	100

67%

31%



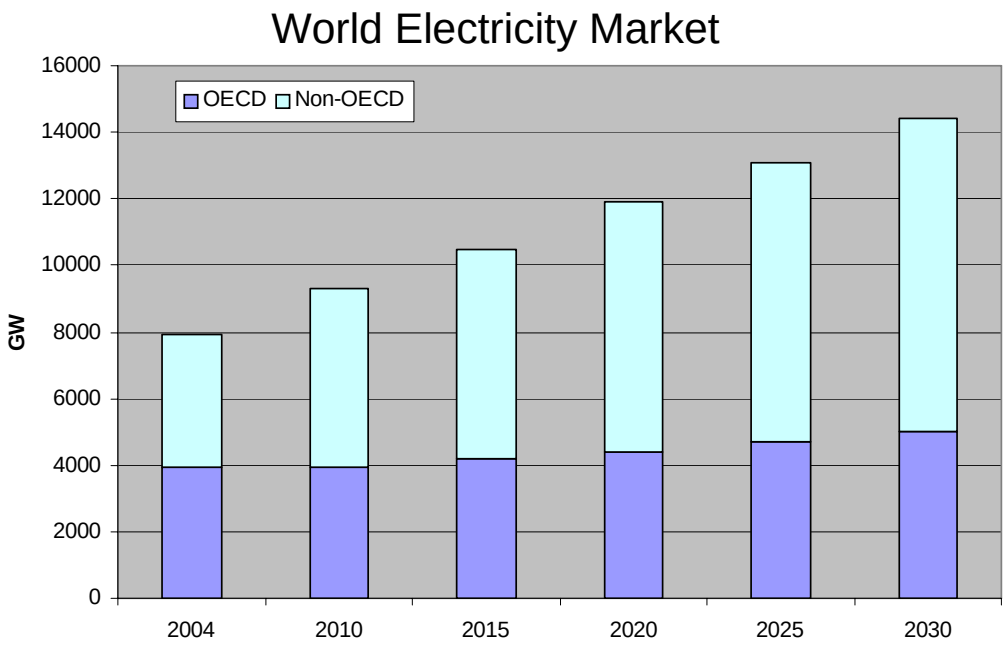
- 2004 only ~0.06% of electricity generated worldwide was from PV solar.

Source: Credite Suisse, November 2007. Total Electricity Production Mix – 2005; CLSA, Solar Maximum, May 2007. EIA, EPA, International Energy outlook 2007, 5/2007, Energy Information Administration, U.S. department of Energy.

Market size, growth, and segments

Electricity World Market Size

ca 150 GW per year



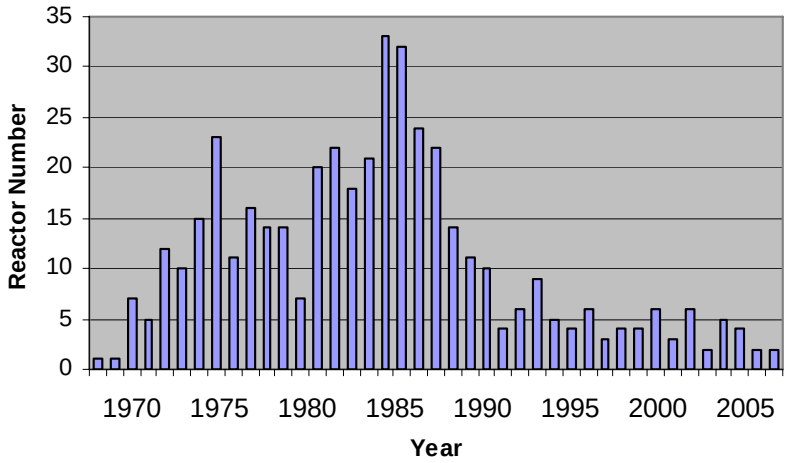
Electricity market:

2004	8 TW
2010	9.3 TW
2015	10.5 TW
2030	13 TW
2050	15 TW

Source: Credite Suisse, November 2007; International Energy outlook 2007, 5/2007, Energy Information Administration, U.S. department of Energy.

Solar Cell Market Growth Drivers: Energy Demand

Electricity Generation from Nuclear Power



-	115	30 years old
-	156	27 years old
-	328	20 years old

	2004	2015	2030
[GW]	369	420	492
Delta		51	123
China			36
India			17
Russia			20
South Korea			16
Japan			14
U.S.A			13
Canada			6

Ca 10 Years are needed for planning and building a nuclear power plant

Source: International Energy outlook 2007, 5/2007, International Atomic Enregy, World Nuclear Association; Energy Information Administration, U.S. department of Energy.

Solar Cell Market Growth Drivers

Environmental Issue: CO_2 Reduction

CO2 level:
(if **NO** CO_2 reduction takes place)

2007: 380 ppmv
2050: 550 ppmv
2100: 750 ppm

There is no natural destruction mechanism for carbon dioxide (CO2) in the atmosphere.
Unlike the ozone depletion, it will not heal by itself through chemical processes.

The time needed for 500 to 600 ppmv of CO2 to decay back o 300 ppmv is between 500 and 5000 years.

CO_2 [ppmv]	Global Temp. Rise [°C]	Consequences /Remarks
380		
550	+2	Coral reefs die. Upper limit.
750		Serious for humans

The clean, carbon-free energy needed to stabilize CO2 level at 550 ppmv in 2050 is

15 – 20 terawatts

Source: Engineering & Science 2/2007, World Energy Assessment Overview 2004, UNDP.

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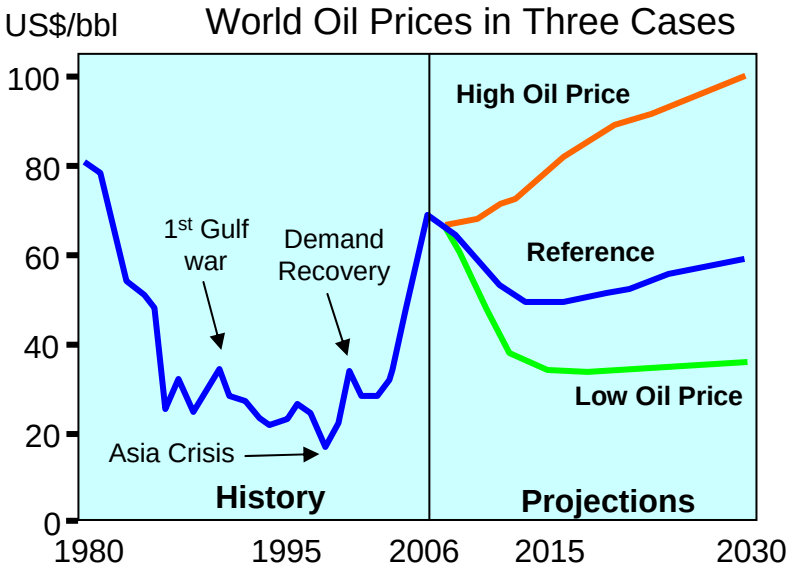
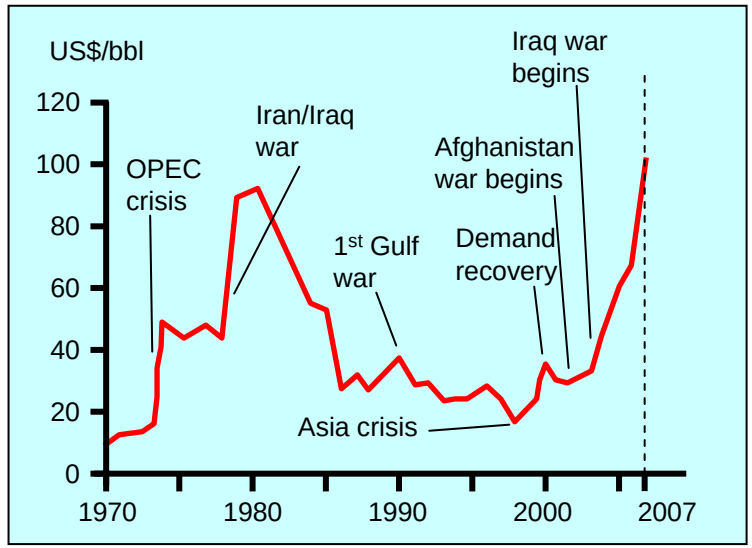
Solar Cell Market Growth Drivers: Energy Demand

Oil Price Development





Reference case

	2006	2014	2030
Oil Price $	68	49	59*

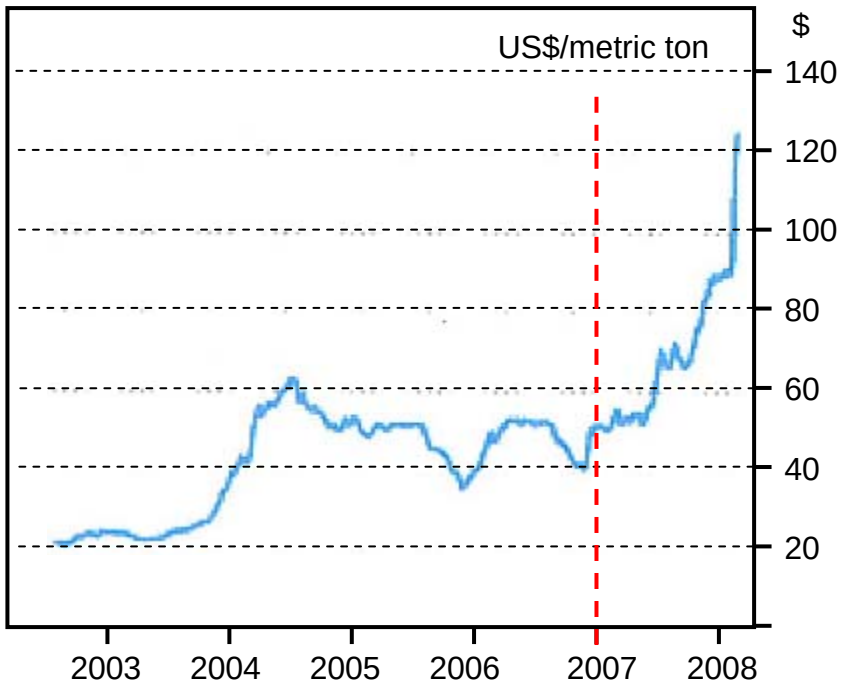
* $95 per barrel on a nominal basis.

2007 already $100 (!)

Source: International Energy outlook 2007, 5/2007, Energy Information Administration, U.S. department of Energy. The Council of the European Union.
bbl=Barrel

Solar Cell Market Growth Drivers: Energy Demand

Coal Price Development



The price per metric ton for coal out of Newcastle, Australia, is a key benchmark for the Asian market.

40%

of the Electricity is generated using coal.

Increase of coal price

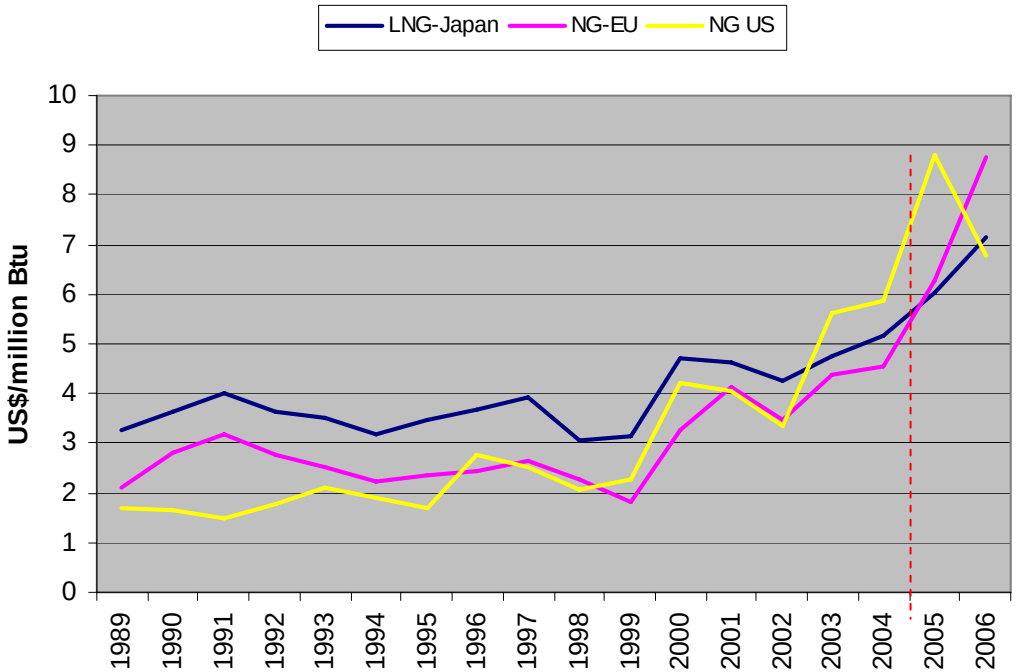
leads to increase of

Electricity price

Source: Photon Consulting, 3/2008; Wall Street Journal;

Solar Cell Market Growth Drivers: Energy Demand

Natural Gas Price Development



20%

of the Electricity is generated using gas.

Increase of gas price

leads to increase of

Electricity price

US$/million Btu = cost + insurance + freight

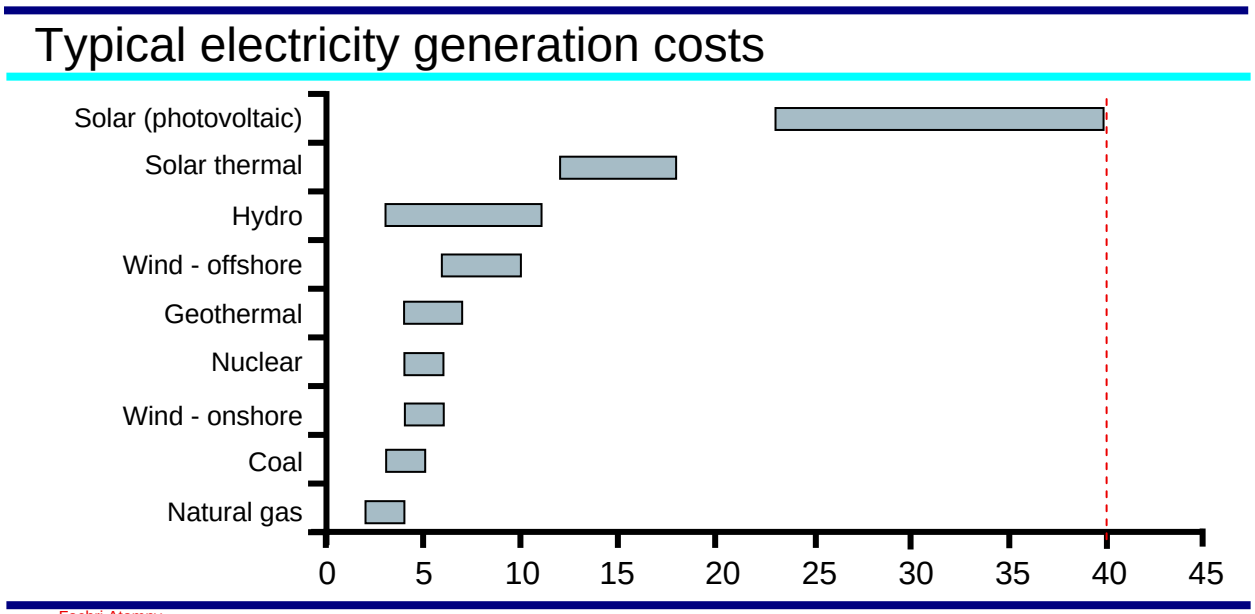
Source: natural gas week

Solar Cell Market Growth Drivers

Conclusions: Market Drivers

- Market is there: 13 TW (2007); 18 TW (2030); 26 TW (2050)

- To Dos
  - Create real market by achieving grid-parity to be competitive with conventional energy sources.



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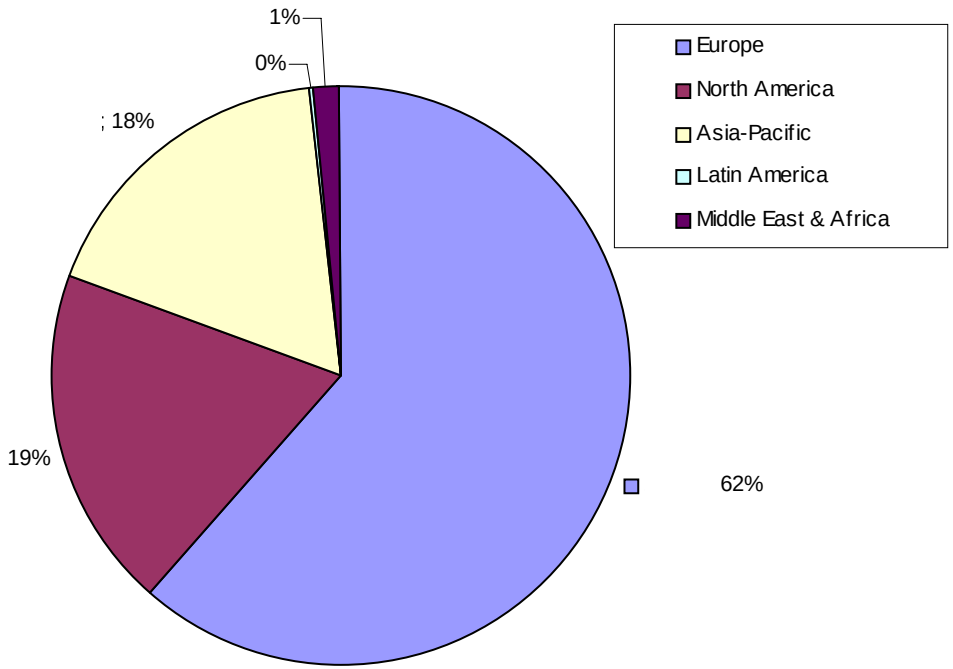
PV Solar Market Size and Growth 2007-2011: Summary



Focus on:

- **EU: 61%**
  - DE, SP, Italy, France, Greece, Portugal
- **Asia: 18%**
  - Japan, China, S-Korea, India
- **N-America: 19%**
  - US
- ***Middle East 1%***
  - Dubai, Oman, Abu Dhabi

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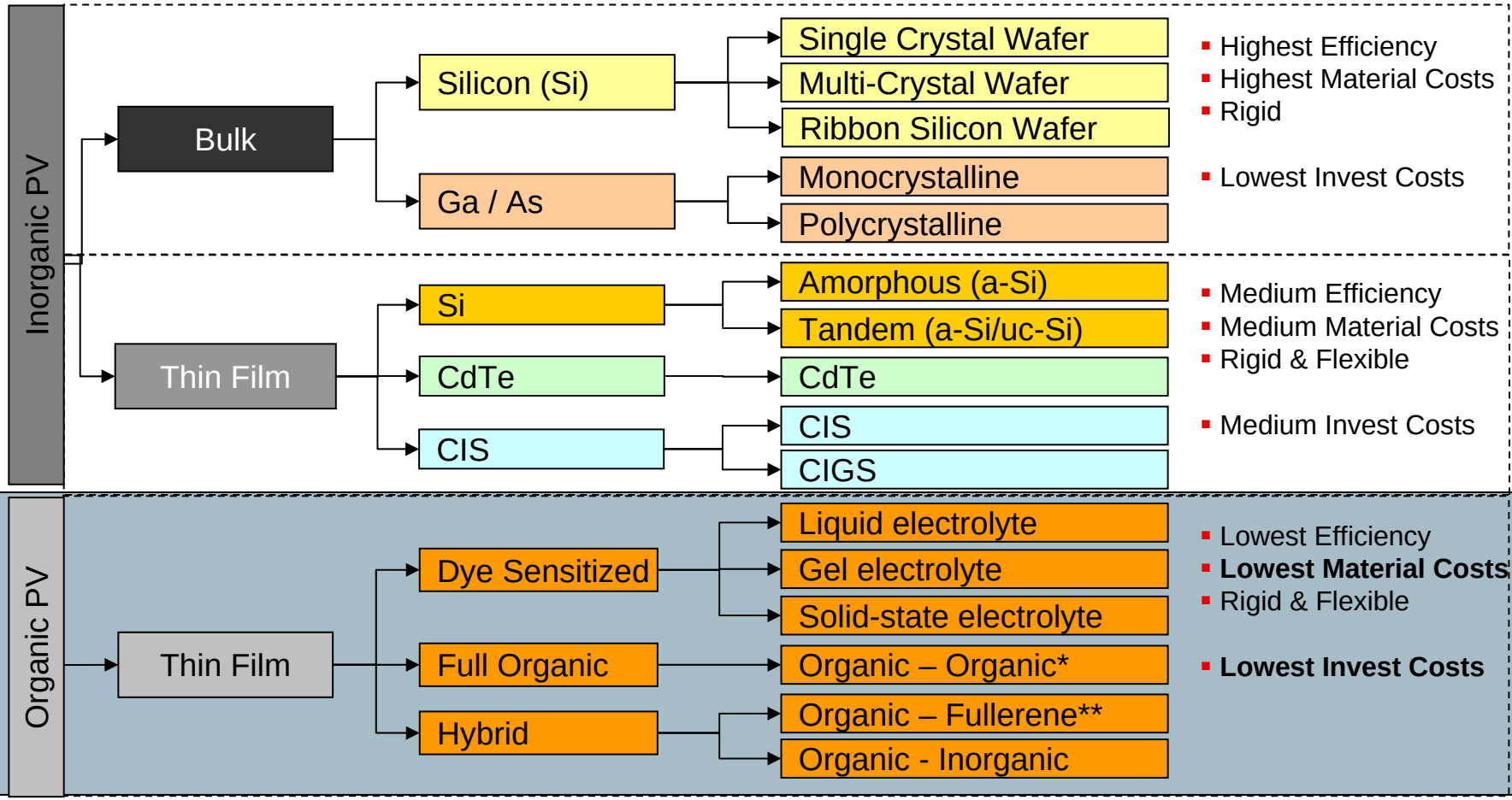
Photovoltaic Solar Technologies

Technology Trends, Changes & Disruptions



* Organic includes organic molecules as well as polymers. Organic – Organic means that both the donor and the acceptor are organic based materials. ** The polymer or the organic molecule acts as donor and fullerene derivates molecules acts as acceptors.

Source: Oerlikon

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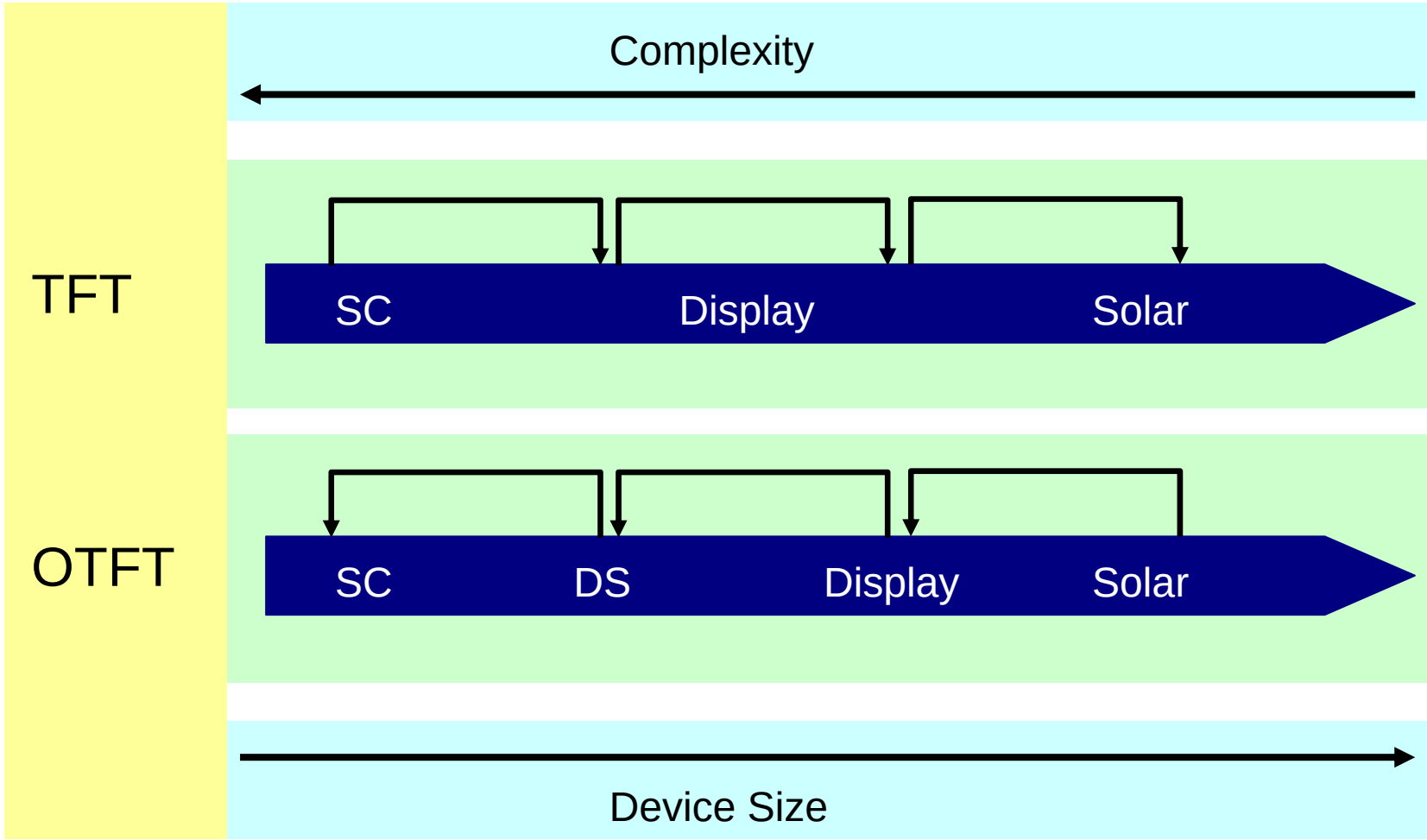
Semi, Displays, Solar: Complexity vs. Device Size



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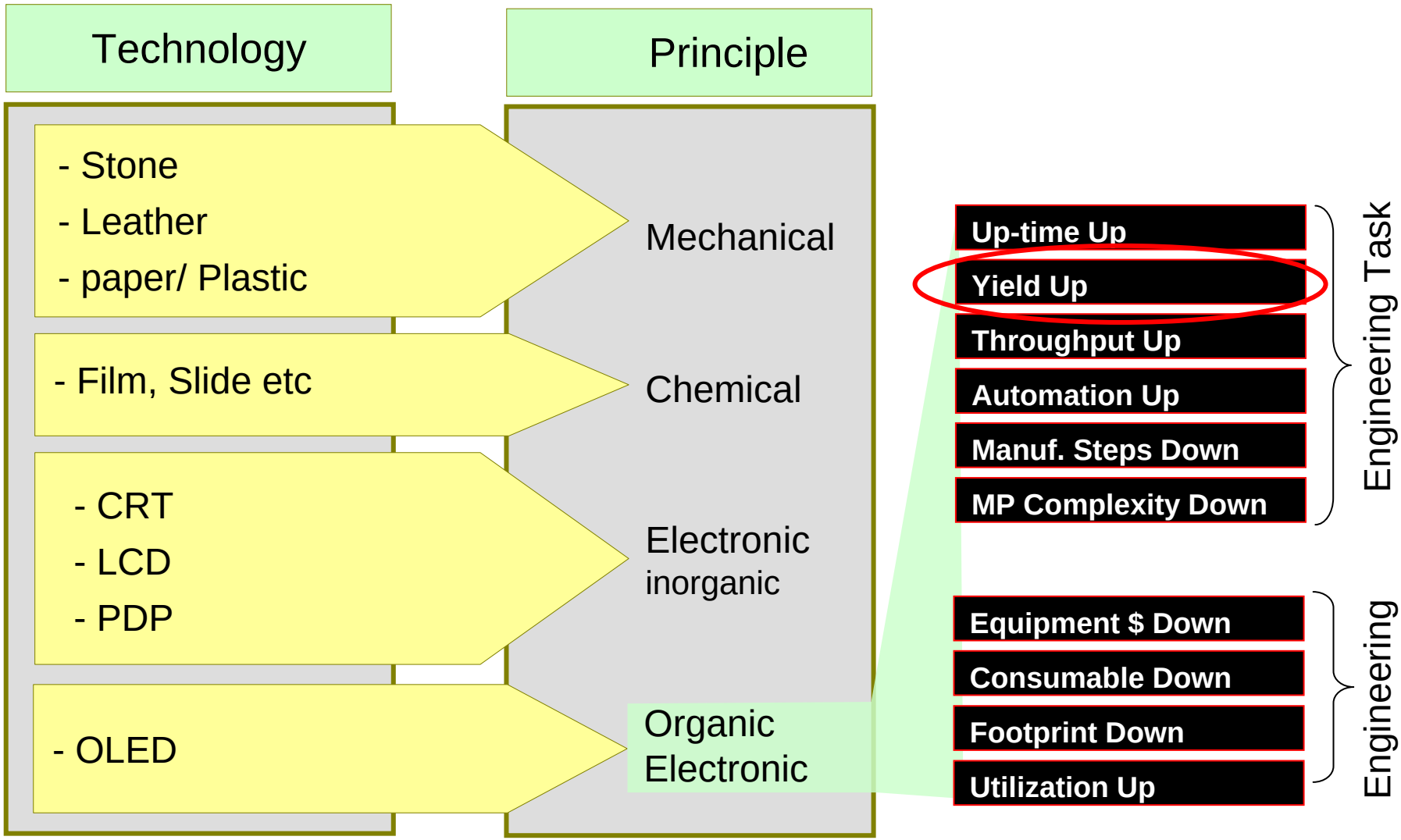
Information & Data Displaying



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Dye Sensitized Cells: Production Volumes & Planned Capacities

Company	Country	Semi-conductor	Production End 2006	Capacity End 2006	Capacity End 2007	Capacity End 2008	Capacity End 2009	Capacity End 2010
G24 Innovation	UK	TiO_2/dye	5	5	30	<200	(200)	(200)
Orionsolar PV	Is	TiO_2/dye	-	-	2	(5)	(10)	(25)
Solar Technol	Greece	TiO_2/dye	-	-	-	1.5	2	3
Peccell Technol	Japan	TiO_2/dye	-	-	-	0.5	1	2

Comparison:

Semiconductor	Production in 2005	Capacity end of 2005	Production in 2006	Capacity end of 2006	Production in 2007	Capacity end of 2007	Capacity end of 2008	Capacity end of 2009	Capacity end of 2010
Thin-film silicon	81.6	115.1	127.1	193	336	532	846	1,261	1,599
Cadmium telluride	27.5	36	57.5	86	99	193	337	378	380
CIGS and CIS	4	6.9	8.5	74	141	431	921	1,772	2,688
Dye-sensitised cells	–	–	–	5	5	32	207	213	230
Total	113	158	193	358	581	1,188	2,311	3,624	4,897

Source: Sun & Wind Energy 1/2007; Capacity=MWp