الجامعة المصرية اليابانية للعلوم والتكنولوجيا
E-JUST
Egypt-Japan University of Science and Technology
エジプト日本科学技術大学

Concentration Photovoltaic Power Generation

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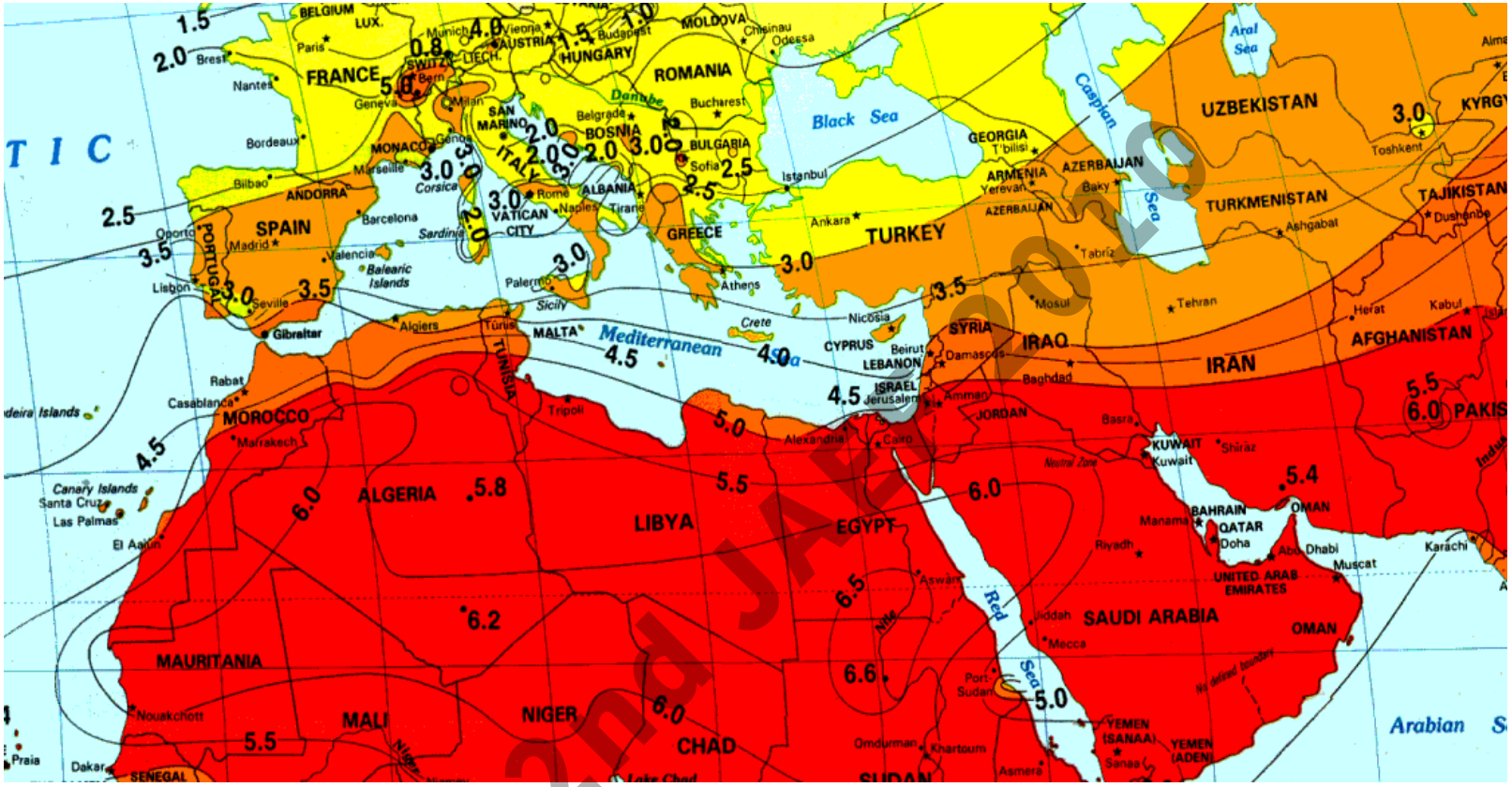
- Concentration Photovoltaic Power Generation
- Gained Experience with PV in hot arid area

Arabian Countries Horizontal Surface Solar Radiation Data



Isoflux contours of solar radiation from satellite images.

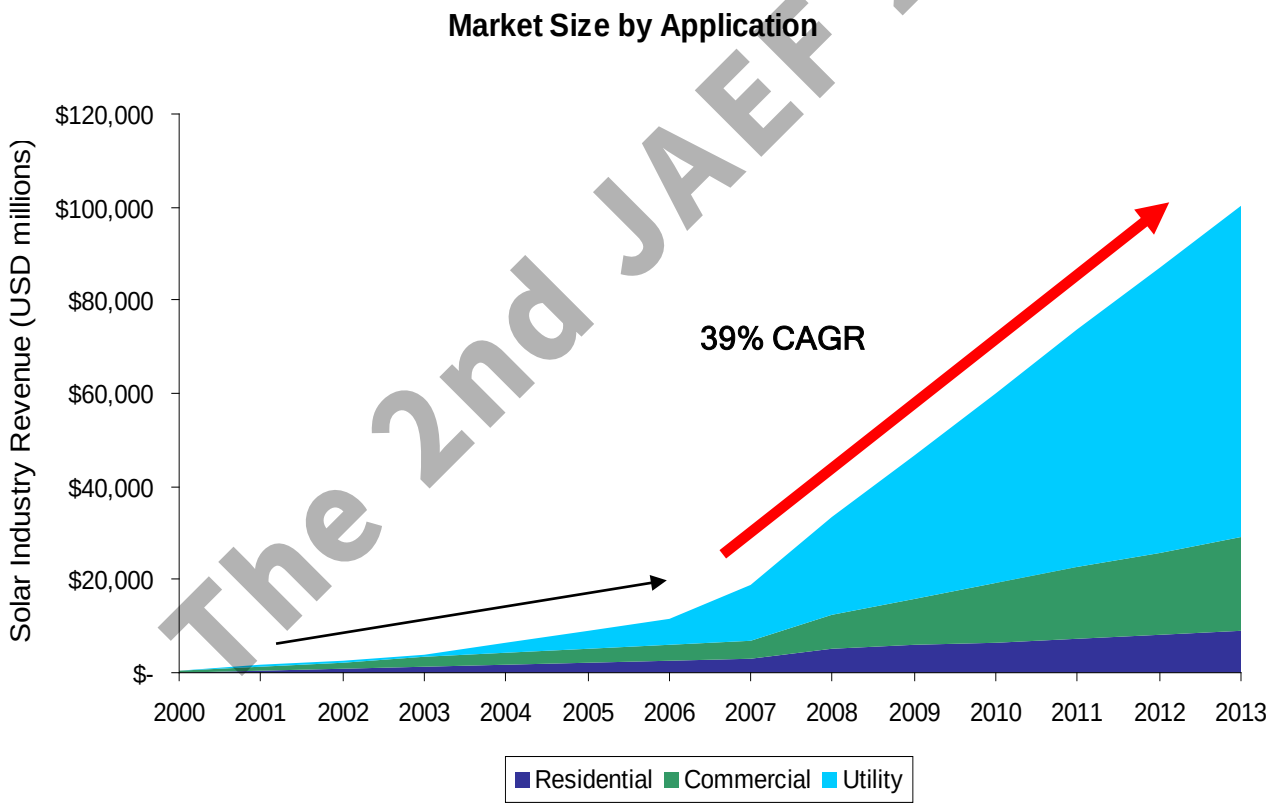
The units on the map are in kWh/m^2/day and represent the minimum case values at an optimum tilt angle.

http://www.pvcdrom.pveducation.org/

Flat PV Solar panels power generation plant for Mall and Club at EJUST

Global Solar Market to Grow to $100 Billion in 5 Years

- 2008 Global Solar Market estimated at $33.3B
- Utility-scale installations will emerge as the dominant solar application
  - Global utility installs are projected to reach ~$70B and comprise over 70% of the market in 2013



Source: Lux Research

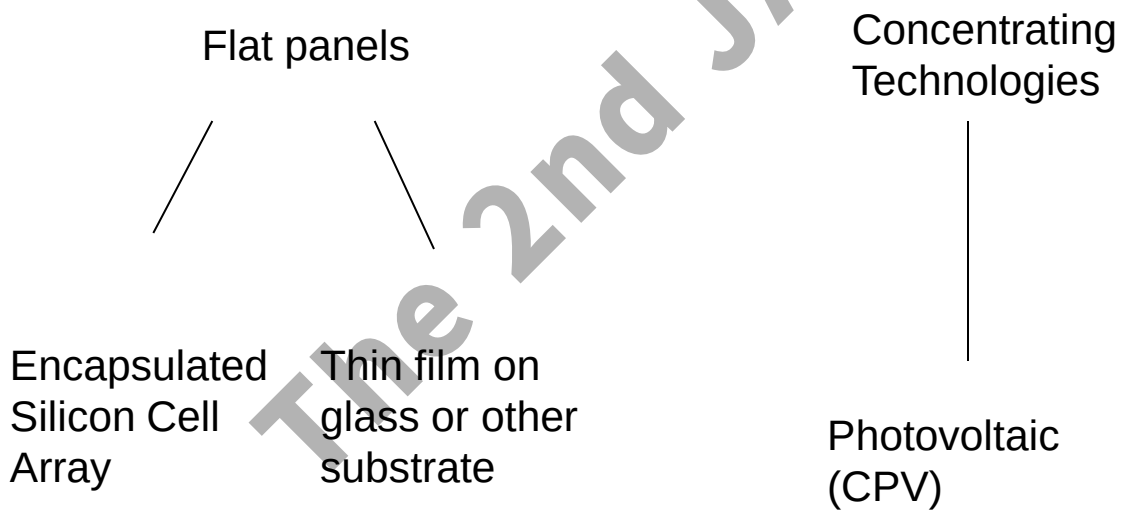
Egyptian Research-Oriented University with Japanese Partnership

Flat Panels Photovoltaic Power Generation

PV Technology
What is the Target?

- Reasonable Price PV Solar Power Generation

Solar PV Power Systems



Flat PV Panels

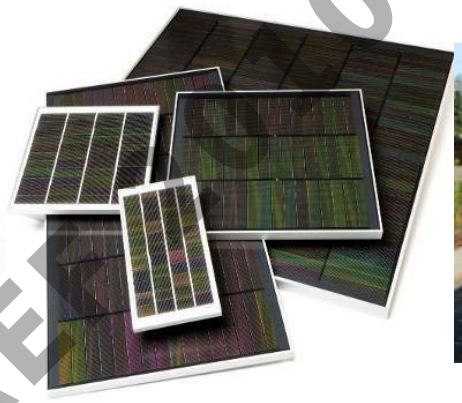
- No tracking required (but it increases output)
- Converts diffuse radiation on cloudy days

Thin film panels

Sunpower silicon panels on trackers

Products in the Market

Rugged Environment



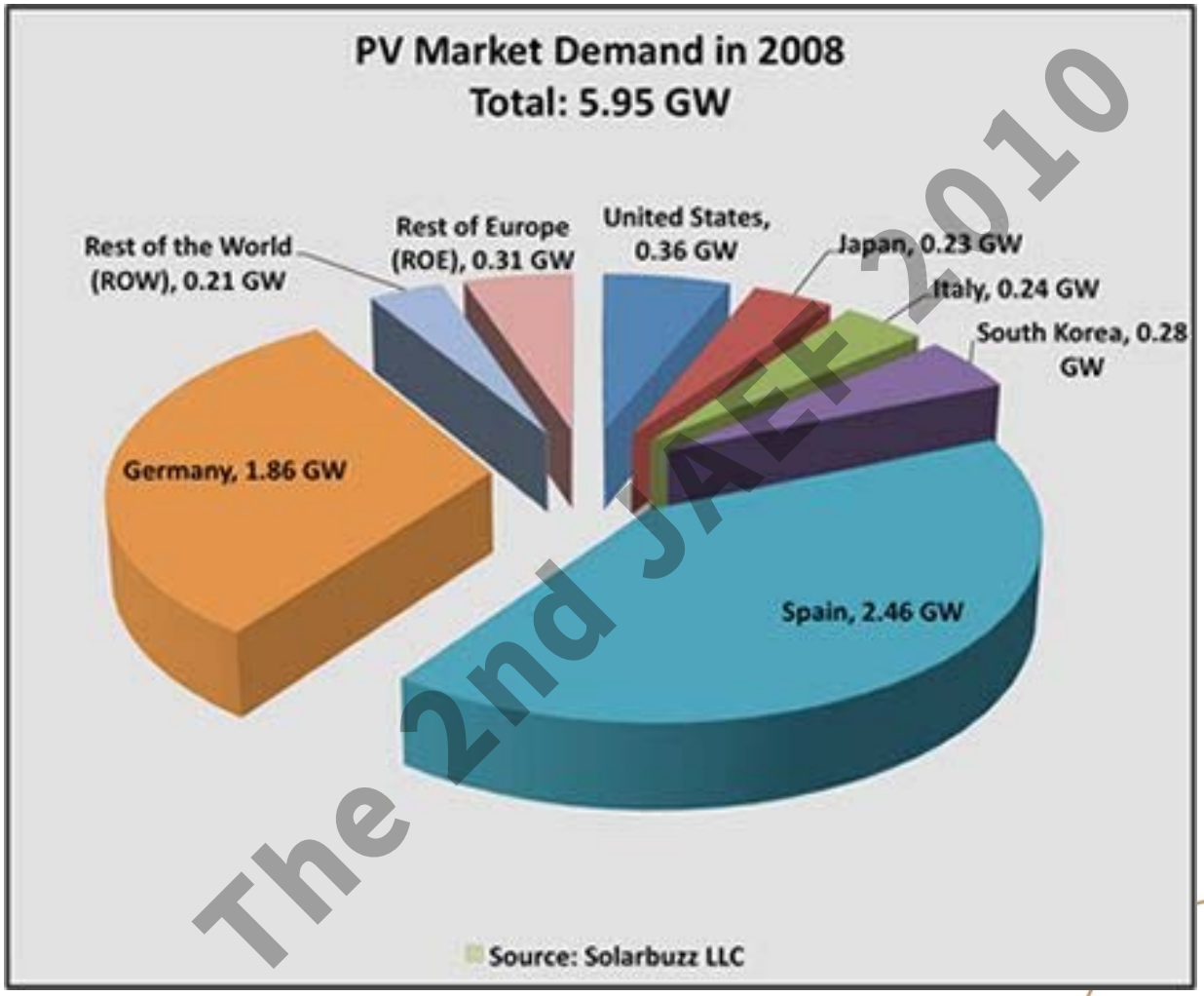
Standard Solar Modules

Commercial Products

=

Silicon Cell Replacement

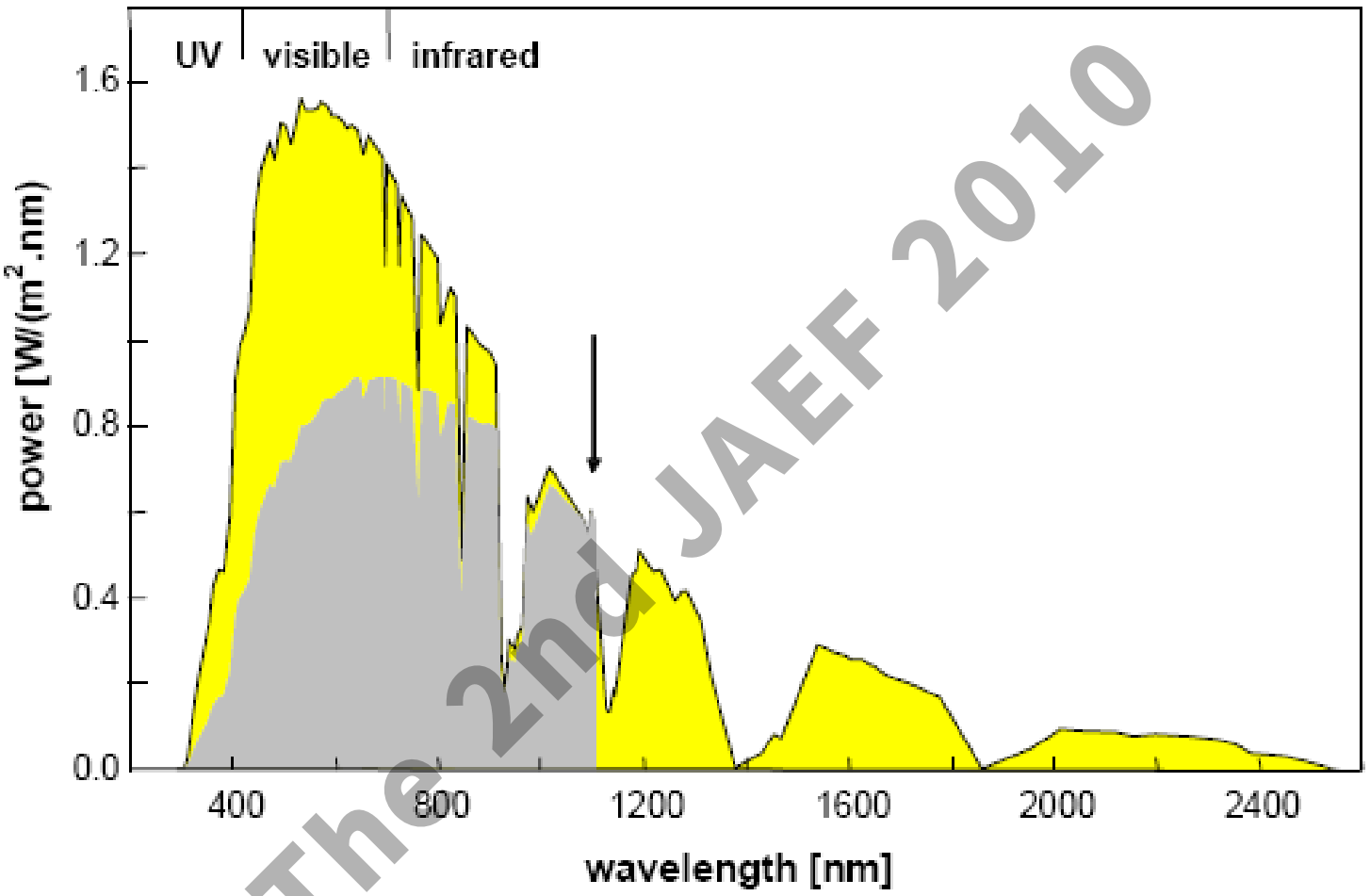
PV in the global context



PV Installation by market 2008
Source: (Marketbuzz, 09)

Flat PV Panels

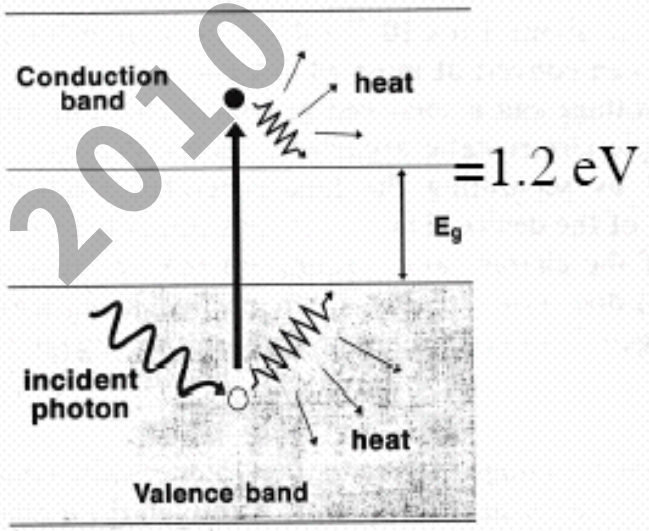
- Higher efficiency
  - Currently Global Solar Cells are 9-12% (at SRC)
- Lower cost (in volume)
  - Process costs are lower
  - Manufacturing costs are lower
- Features
  - Flexible substrate
  - Cell size can be easily changed



Solar spectrum and the portion converted into electric power

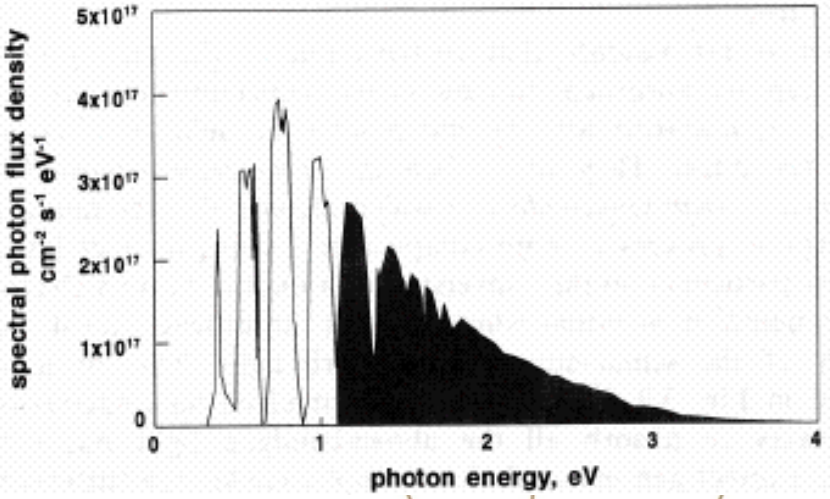
The Photoelectric Effect

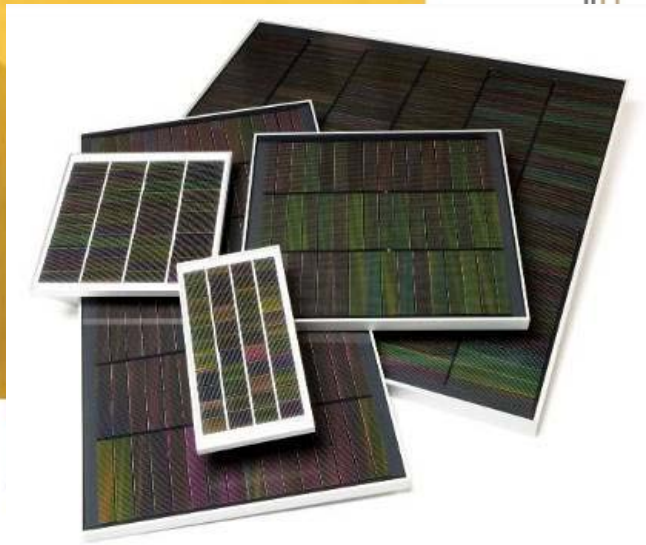
Operation of solar cells is based on the photovoltaic effect



Incident light generates mobile charge carriers

Only light with $h\nu > E_g$ is efficiently absorbed



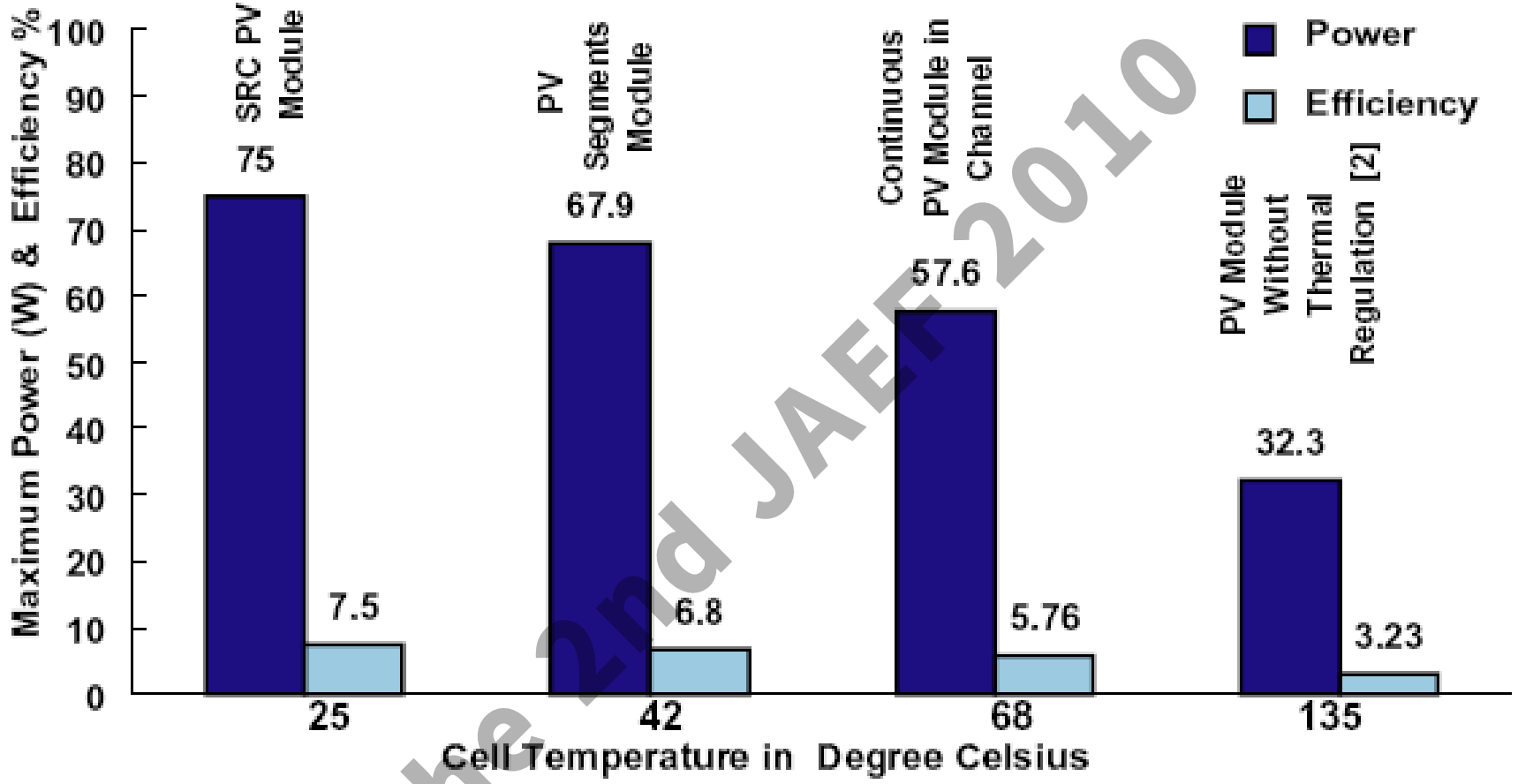


Operation of flat PV panels in Hot Arid Areas

- **The unconverted part of the solar radiation into electricity is absorbed in a PV module leading it to experience very high temperatures.**

- **Increased PV modules temperatures lead to decrease in its efficiency by 0.05% points per one ^{o}C rise relative to that value reported at SRC.**

- **In hot arid areas, Deseret of the Arab Countries, the ambient temperature in the summer times exceeds 45 ^{o}C, however it is expected that the flat PV modules temperature will be higher than 135 ^{o}C.**



Comparison of GP 75 PV module characteristics at different operating temperature with those at SRC.
(Ahmed Hamza (2005) Applied Thermal Engineering 25, 1381–1401)

Gained Experience

- **All flat PV panels in the market has no means of thermal regulation.**
- **Most of the market available flat PV panels when works in hot arid Areas (All Arab countries), the PV module performance was degraded half or less (total efficiency 2-3%).**
- **Moreover, the dust accumulated on the panel surface decrease the transmitted solar radiation.**

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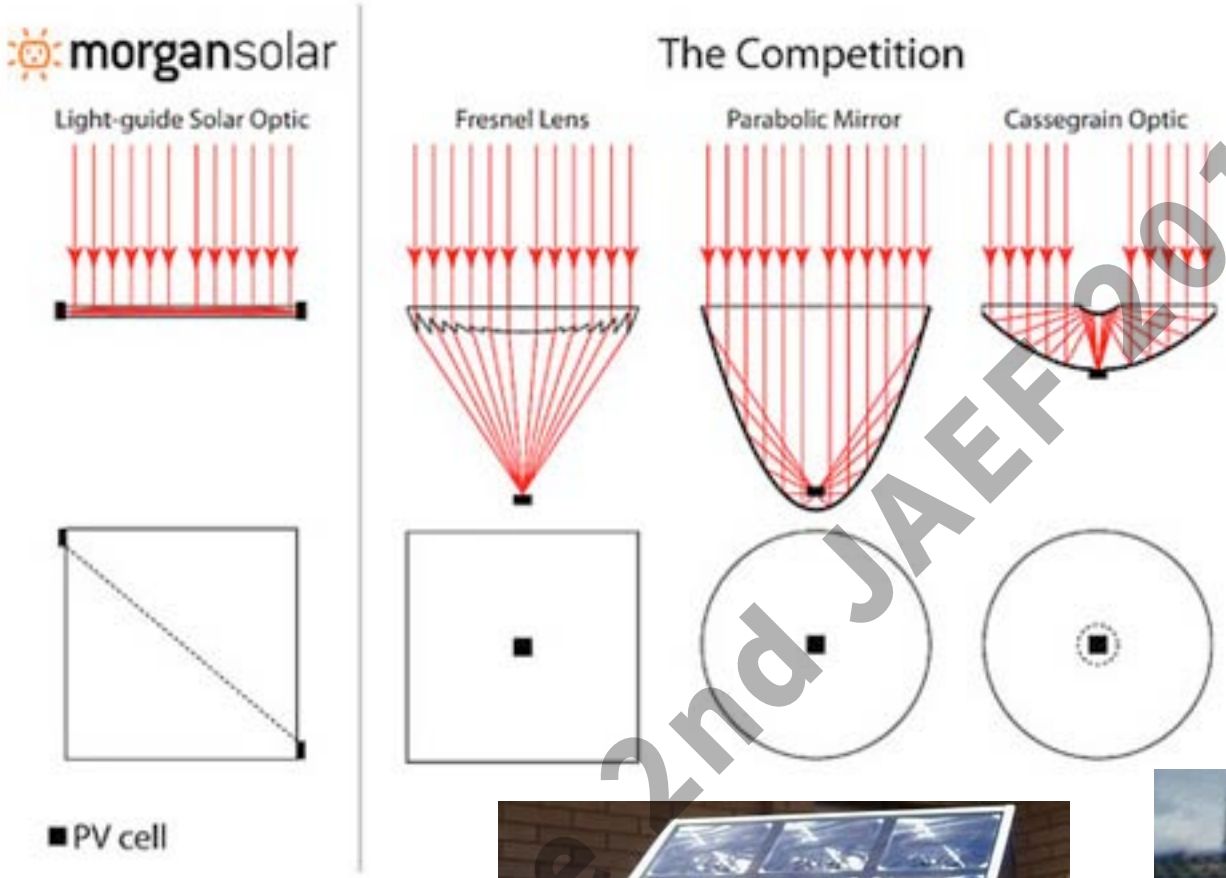
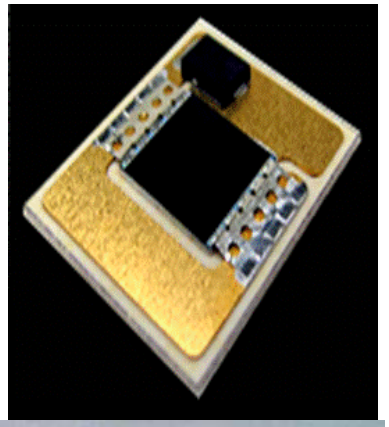
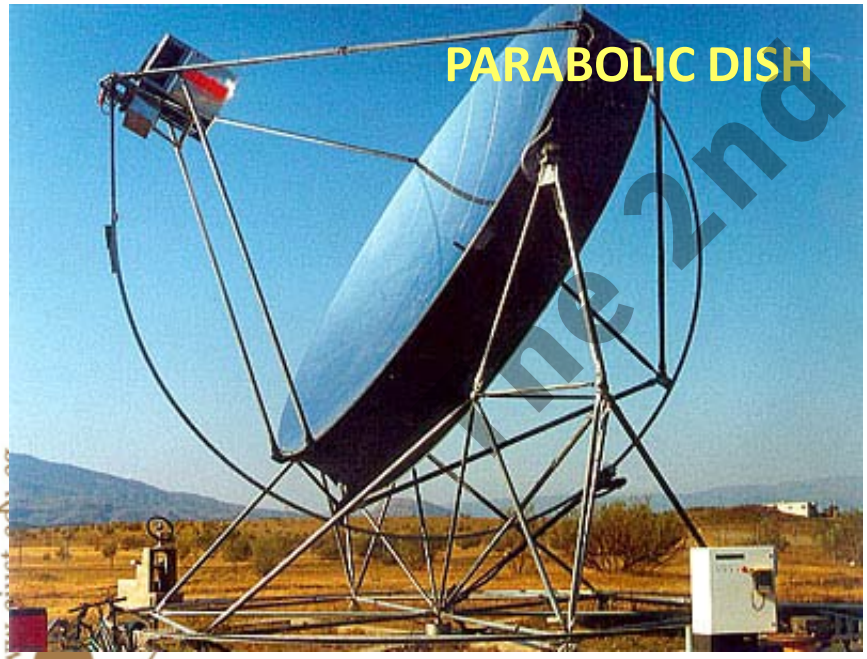
Concentration Photovoltaic Power Generation

Solar Radiation Concentration for CPV







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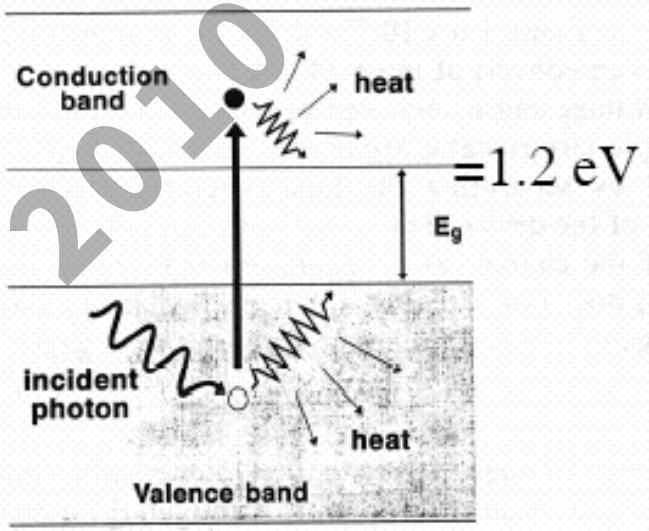

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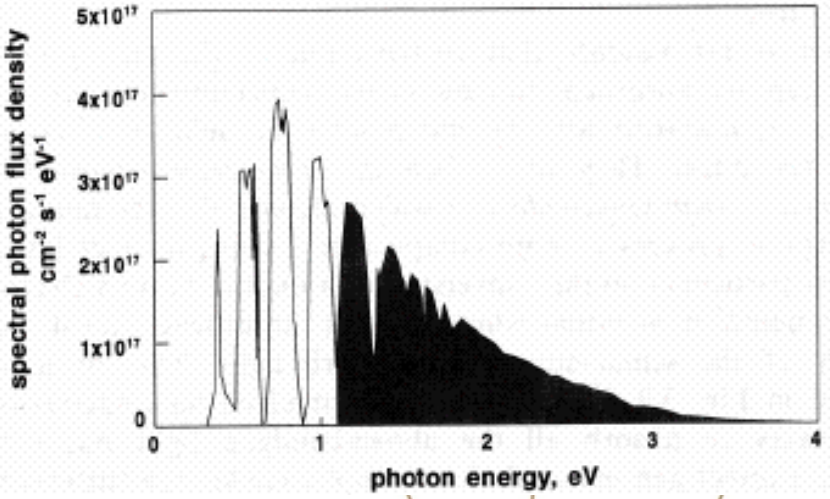
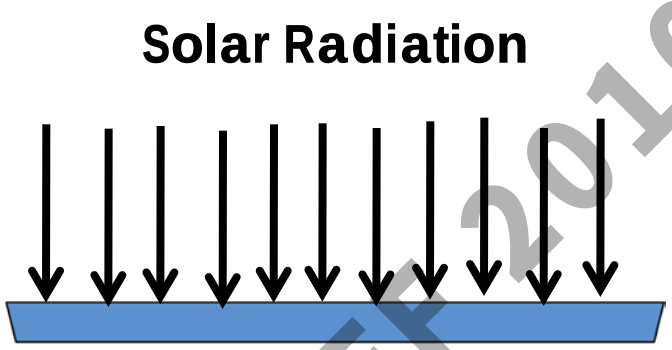
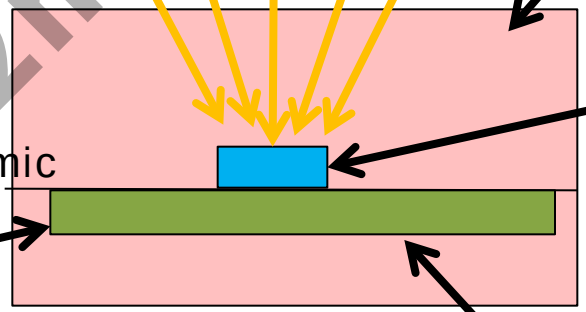


Sketch of CPV

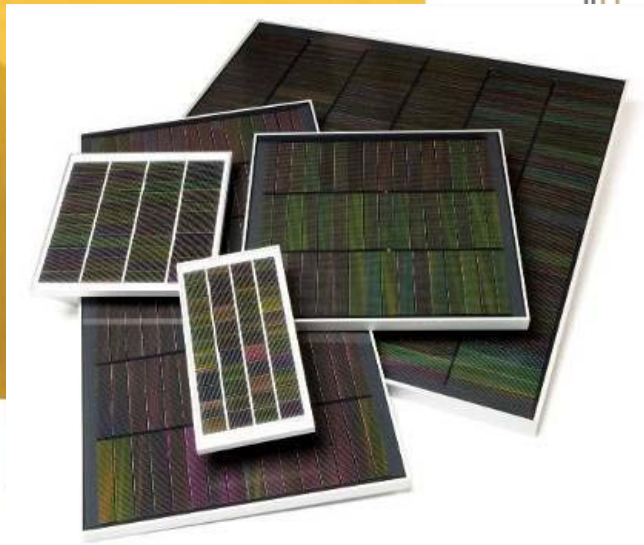


To achieve void free solder die attach for high power application, advanced reflow system is required.

Surface between die and ceramic

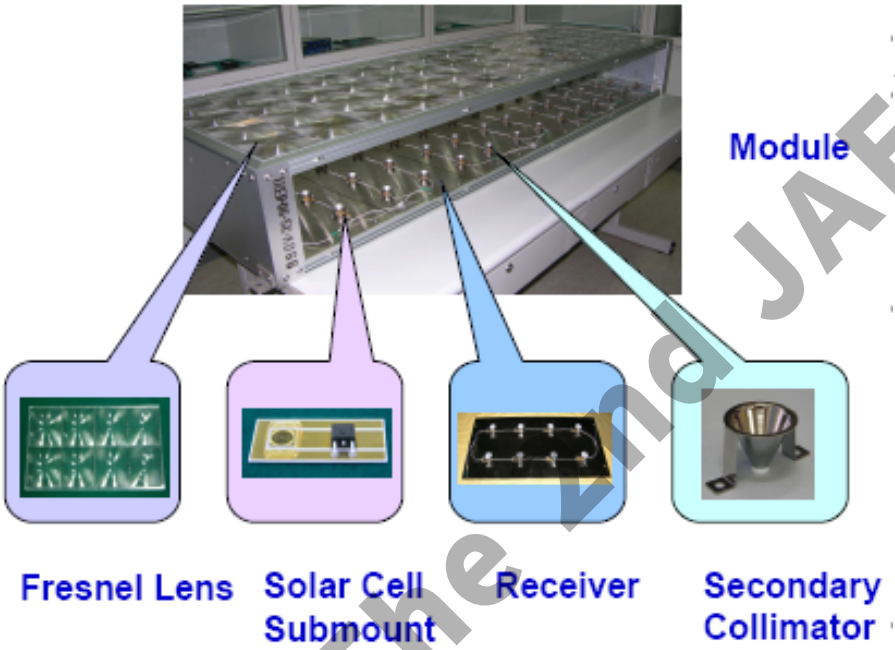


Using DBC process to metalize the Ceramic substrate.



For Arab countries Hot Arid Areas CPV is better than PV

Module of CPV

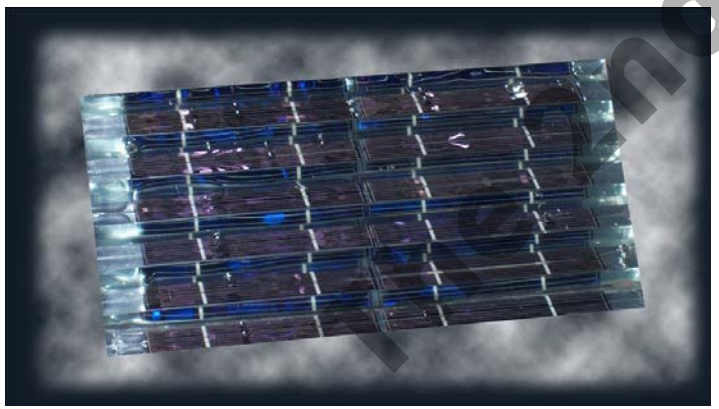


CPV – Latest Emerging PV technology Uses Space quality solar cell with high efficiency

Two types of PV Concentrators

Low Concentration

- Si and CIGS
- Stationary
- Distributed Generation (rooftops, 5x energy value)
- Can accept diffuse light



High Concentration

- III-V Multijunction Cells
- Requires Tracking
- Requires Arid Climate
- Utility Scale Installations

Concentrating Photovoltaic Cell Technologies

Characteristics of concentrator solar cells, examples

Silicon:

	C	η
Sunpower	100	26,8
Amonix	250	24,1
Fraunhofer ISE	92	25,0
UPM-IES	110	20,6

III/V:

	C	η
Spectrolab (multijunction)	175	37,3
Sharp Co. (multijunction)	498	37,2
Fraunhofer ISE (multijunction)	630	35,2
UPM-IES (GaAs singlejunction)	1000	26,2

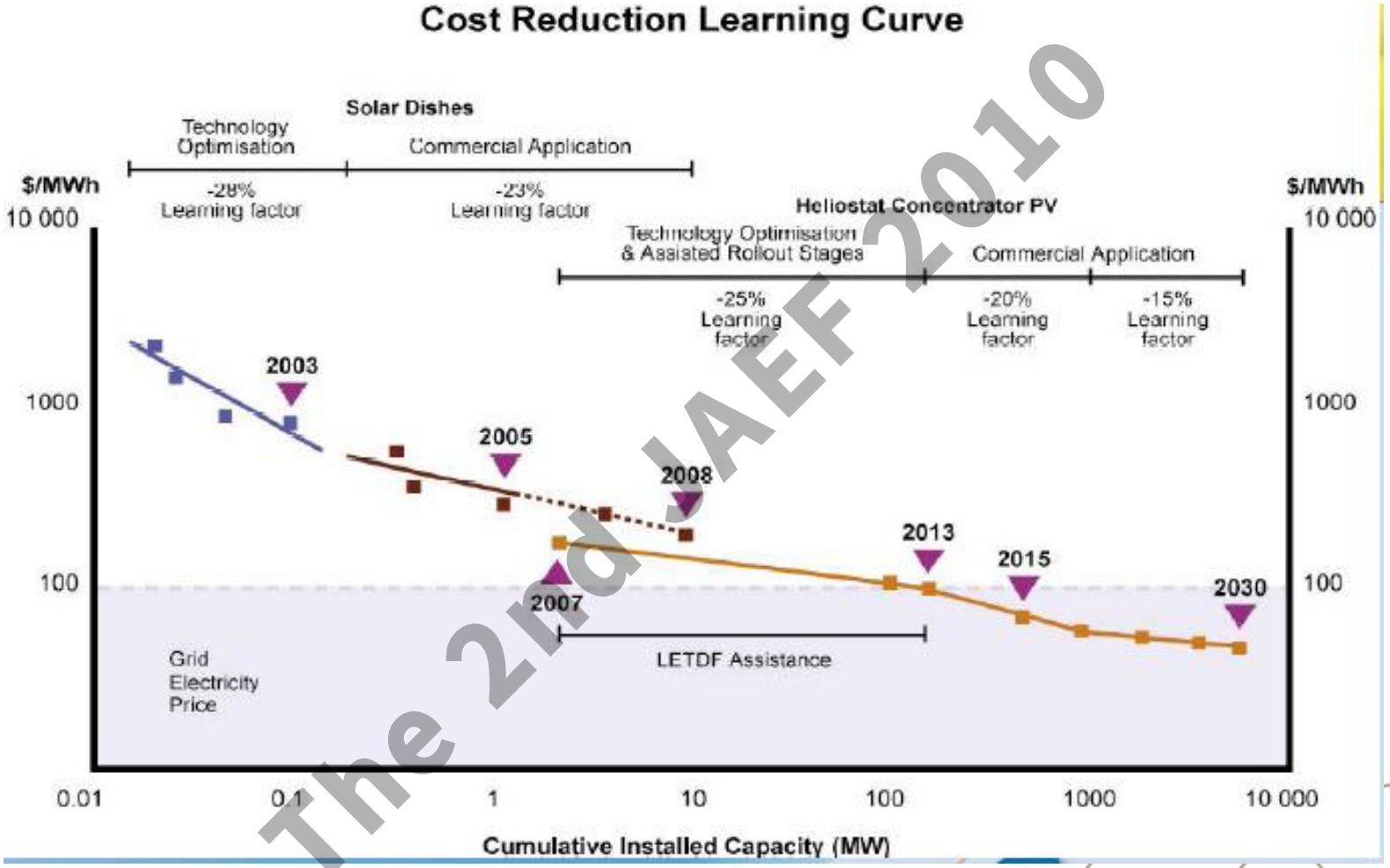
Courtesy Fraunhofer Institute

Concentrating Photovoltaic

- Tracking Required
- Upgradeable to new cell technologies

MegaWatt Solar Piedmont EMC Pilot Plant

- **Friction-drive dual-axis tracking**



Conclusion

for Concentrating PV (CPV)

- **Designed with thermal Regulation techniques.**
- **CPV – Latest Emerging PV technology**
- **Uses Space quality solar cell with high efficiency and optical lenses for concentration (High Concentration Ratios: 200-1000)**
- **Very High Efficiency (26-37%), higher energy output compared to PV (~ 9 -12%)**
- **Also holds promise for cost reductions in the very near future.**

Optics for concentrating Sunlight, HCPV

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Thank you

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