Generation X Photovoltaics

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Outline

- Definition of ‘Generation X PV’
- Advantages
- Myths
- Current status
- Potential for future

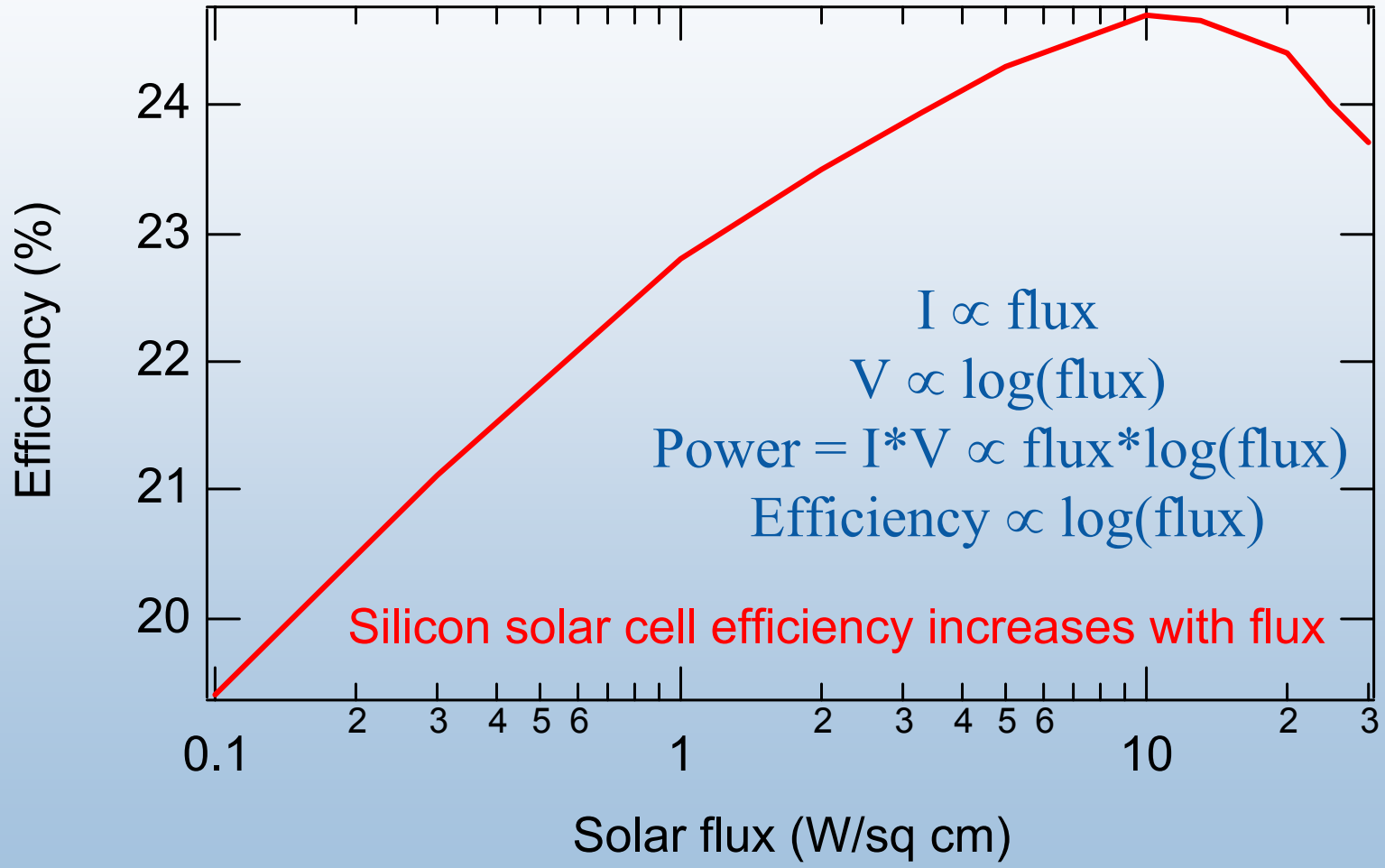
Three generations of PV based on efficiency limits (one sun)

- 1st gen.: Optically thick single junction (practical efficiency ~ 27%)
- 2nd generation: Thin single junction (practical efficiency ~ 29%)
- 3rd gen.: Multijunction or ‘full spectrum’ (practical efficiency ~ 38%)

Three generations of PV based on PV history

- 1st generation: Silicon solar cells (first successful solar cell)
- 2nd generation: Thin-film solar cells (low-cost cells developed to replace Si)
- 3rd generation: Multijunction, multiple electron-hole pairs, hot carrier, multiband, etc. (research opportunities for the future)

Concentrated sunlight increases efficiency

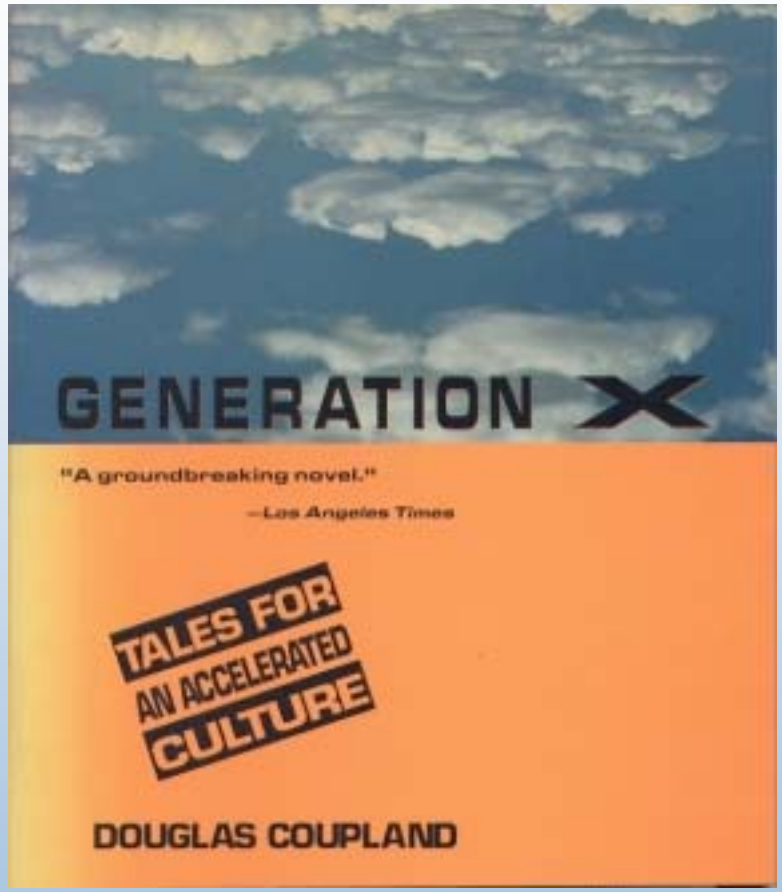


Data taken from SunPower website

Introducing:

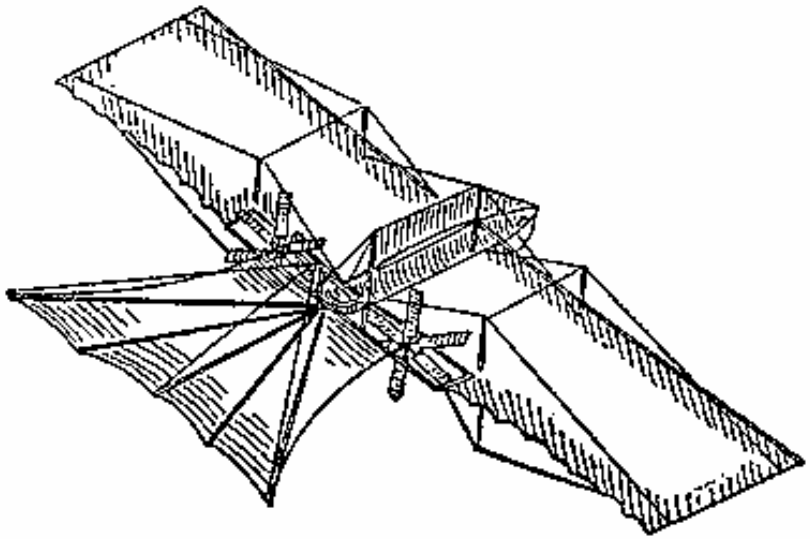
Generation X Photovoltaics

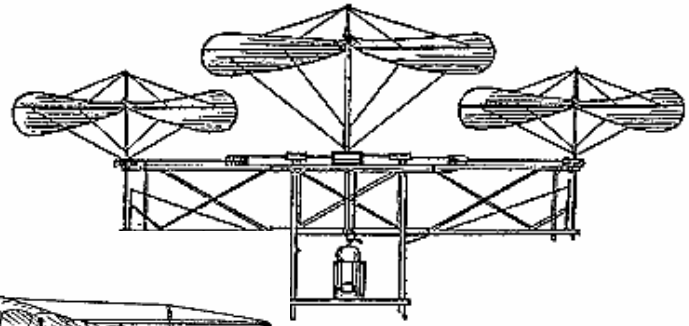
Not to be confused with:

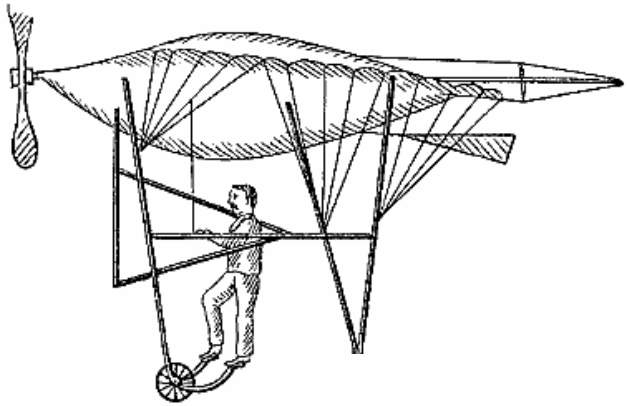


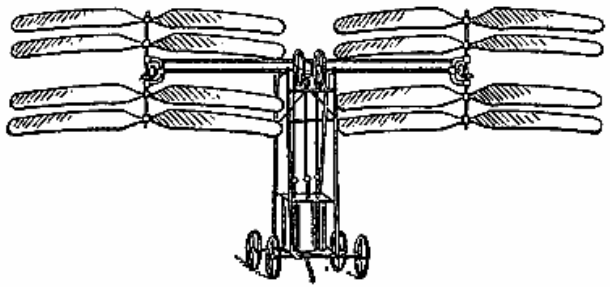
Generation X PV, "Tales of an accelerated solar future"

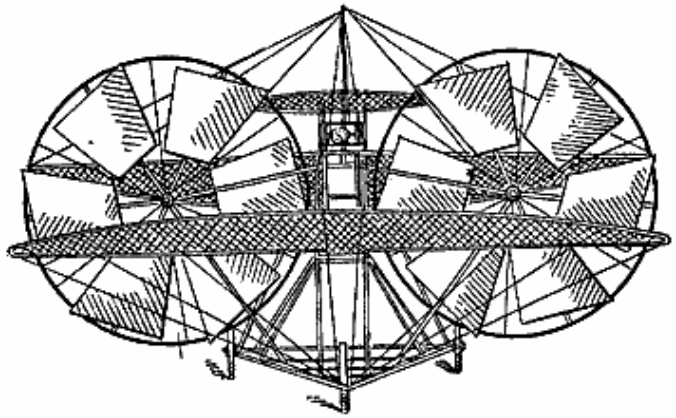
The Wright brothers worked to define a new image



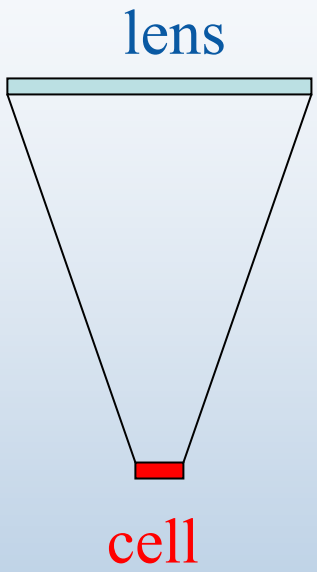


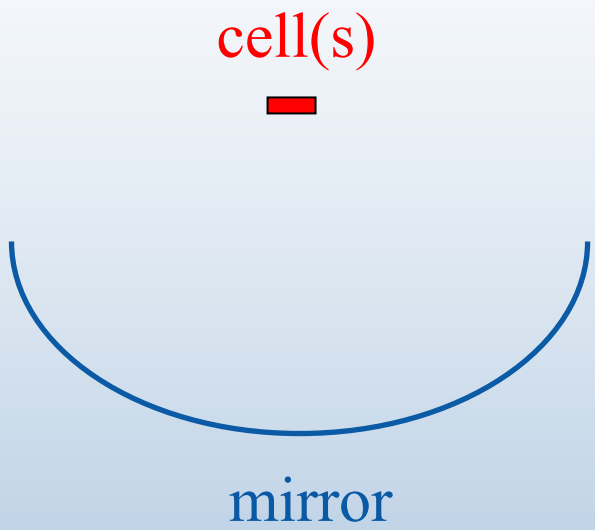






Form of XPV is not yet clear



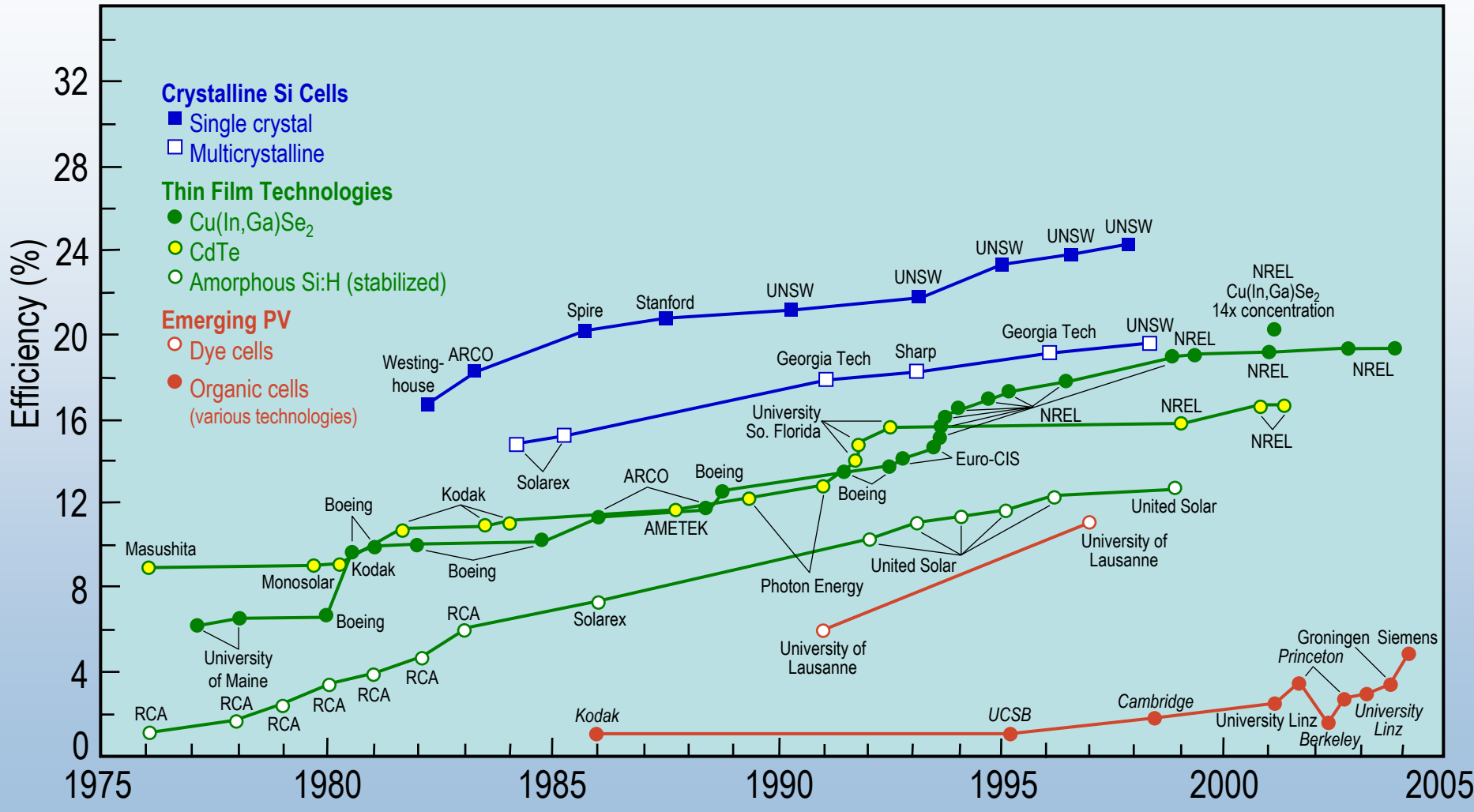


Based on refractive and/or reflective designs, there are dozens of designs being explored

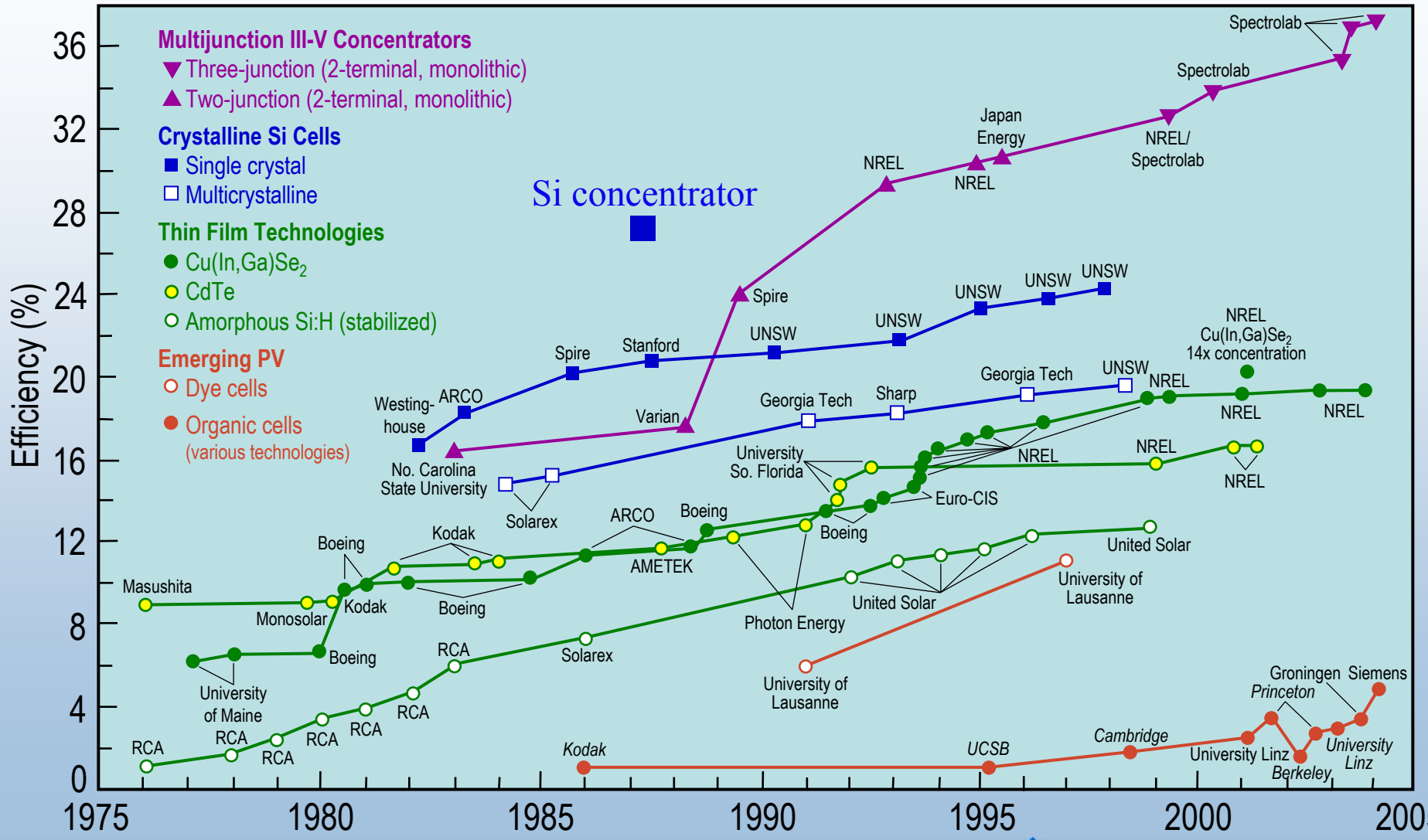
Why use X?

- Potential for higher efficiency
- Potential for lower cost
- Potential for large-scale deployment

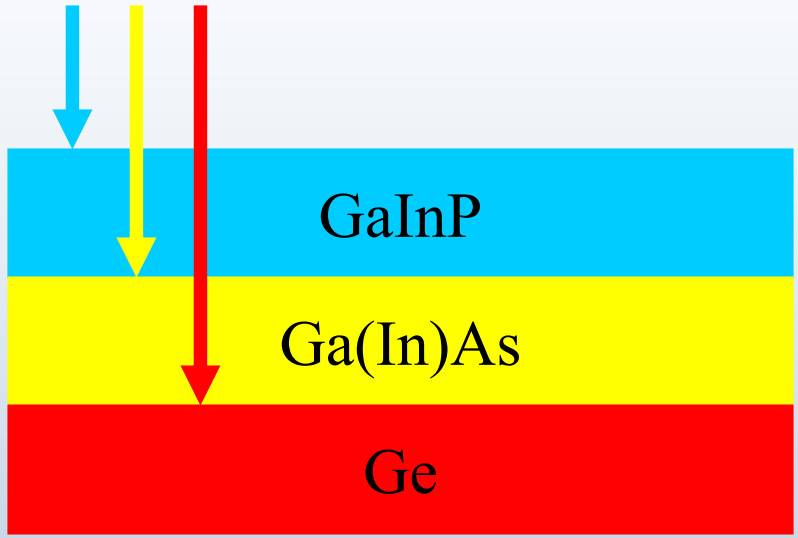
Flat-plate efficiencies are increasing



X efficiencies can go much higher

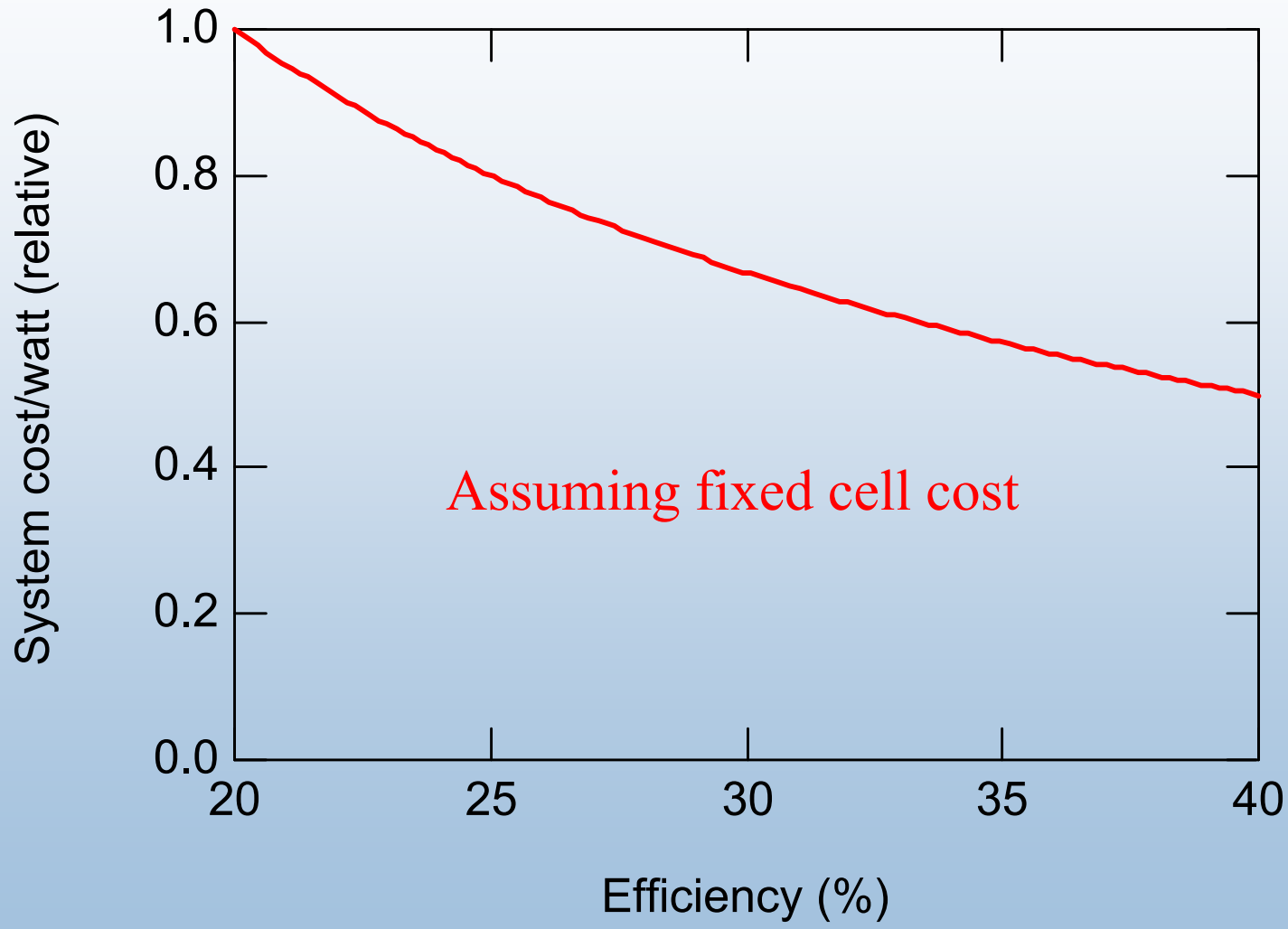


Multijunction 37.3% efficiency



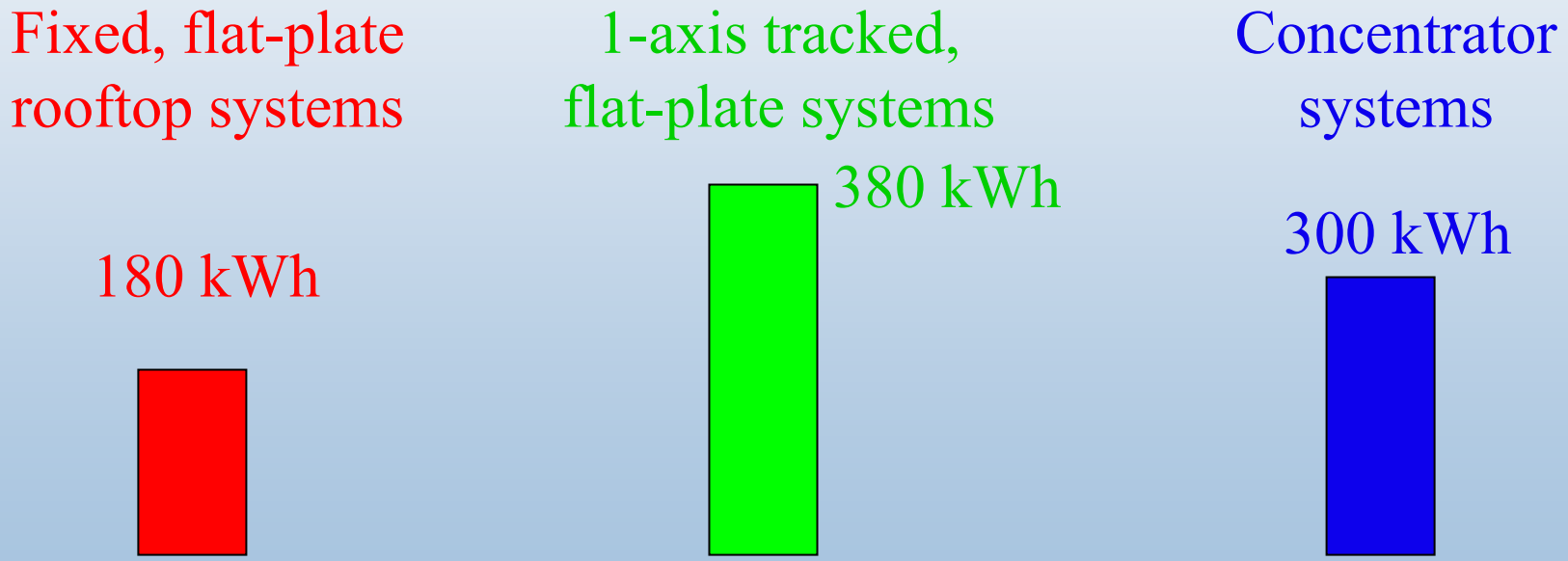
37.3% efficiency record set by Spectrolab this year

Value of high efficiency to XPV



Cost benefit - Summary of Wednesday presentation

If I invest $1000 in PV installations,
then measure the electricity generated in a year,
how much electricity do I get?



Data from installations in Arizona, by Arizona Public Service

Concentrator cost is already competitive!

Large-scale deployment

Technology	Estimated cost to build a production facility for 100 MW/year
Silicon	$150-300M
Thin-film	$150-300M
X PV	$12-50M

Note: initial development cost is high for XPV

Myths

1. XPV can never be reliable because of moving parts
2. XPV has been around for a long time and has never been successful, so it never will be successful
3. Series-connected, multijunction cells are too spectrally sensitive to be practical

Myth #1 - XPV can never be reliable

- Current XPV users report that the inverters are a bigger reliability problem than the trackers

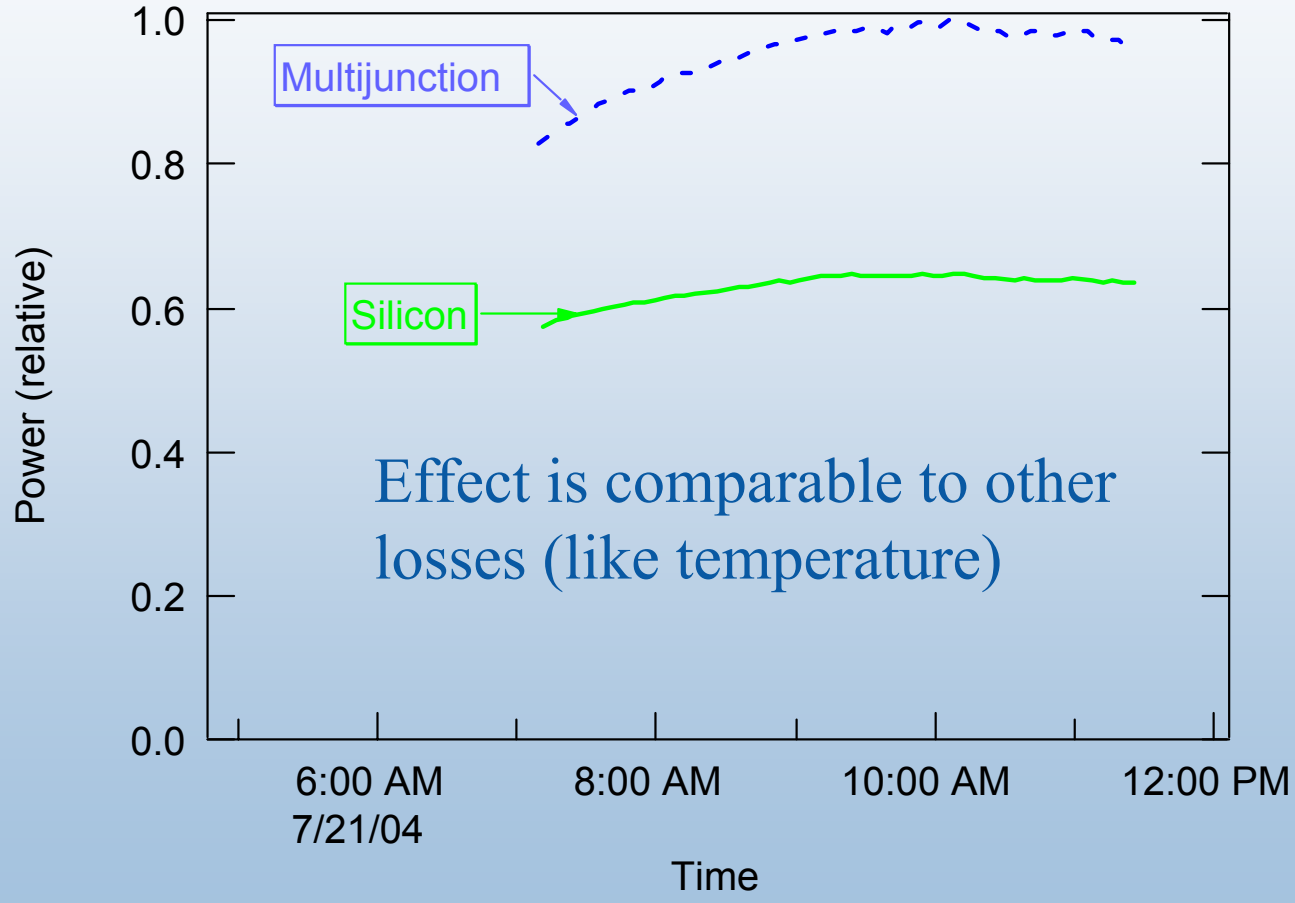
- Nevertheless, new XPV companies almost always underestimate the investment needed to achieve a reliable product

Myth #2 - We tried XPV and it didn't go anywhere…

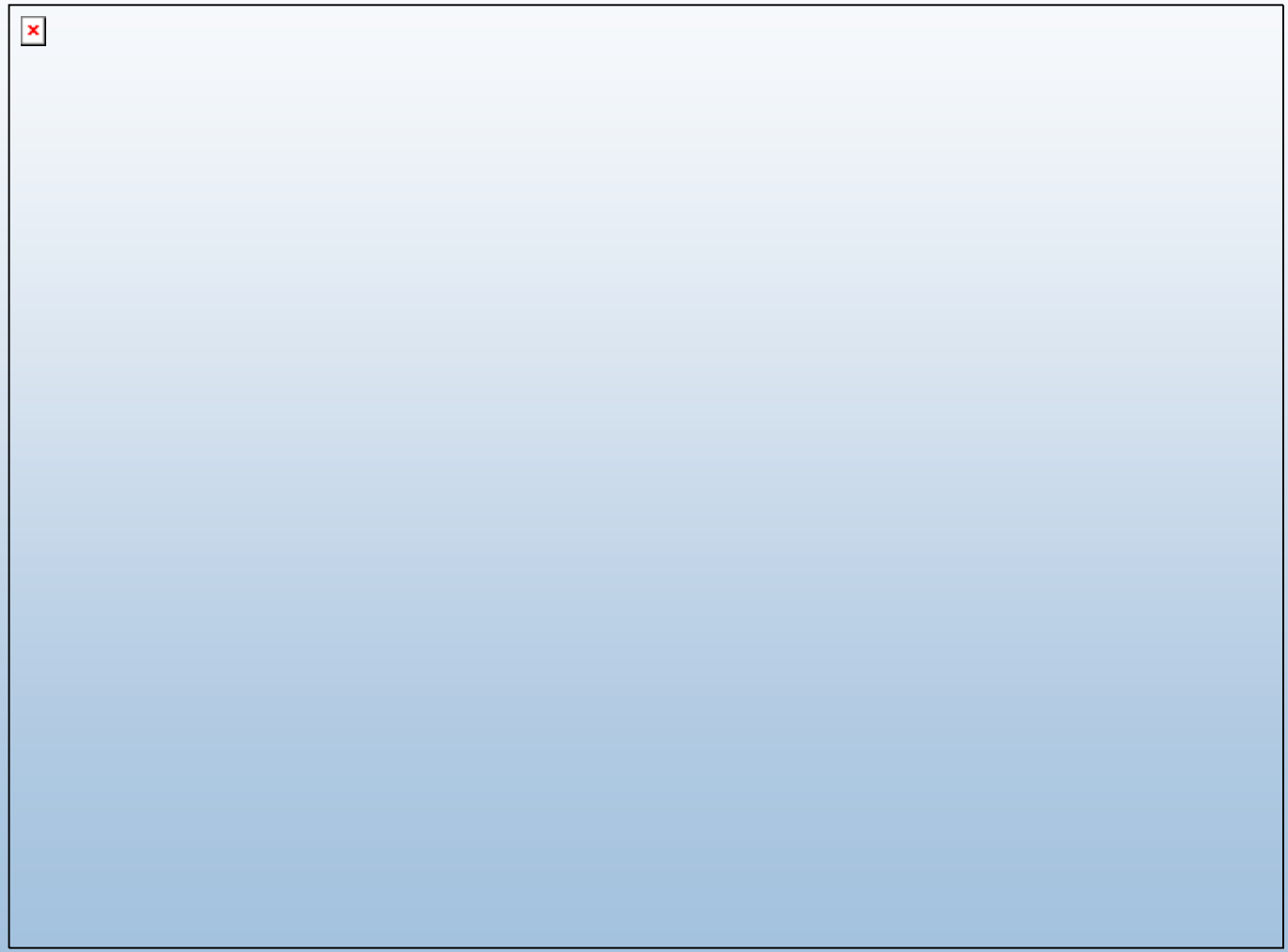
- Markets have changed: XPV is well suited for utility market, and that market is just now growing

- Technology has changed: systems with >30% efficiency have never been tried

Myth #3: Series-connected multijunction cells are too sensitive to the spectrum



Reality: XPV effectively uses only direct (not diffuse) light



Current status

Solar Systems has installed 200 kW in Australia, is currently installing 750 kW, and are negotiating for 4 MW. Current technology uses silicon cells.

Current status

Amonix and Arizona Public Service have installed >570 kW of CPV in Arizona, and plan to install more each year under Arizona's portfolio standard. Current technology uses silicon cells.

Current status - multijunction cells

- Efficiency record of 37.3% was set for a cell grown in a production tool
- Similar cells are in production for space applications
- Production capacity: ~ 500 kW/yr (one sun)
- At 1000X, current capacity ~ 500 MW/yr
- Cell cost at 1000X could be ~ $0.10/W
- At least a half a dozen groups have tested multijunction cells on-sun at high concentrations

Potential for the future - higher cell efficiencies

- *Multijunction approach allows great flexibility*
- NREL's High Performance Project plans to achieve 40% cell and 33% system efficiencies
- Many multijunction approaches are undeveloped; (lattice mismatched materials, mechanical stacks, voltage matched, etc.)
- 5- and 6-junction approaches are being explored

Generation X PV - summary

- New market opportunities as PV market grows and utility market is entered
- New, emerging technology is reaching efficiencies never reached before
- Possibility of rapid scale up

Generation X PV:

"Tales of an accelerated solar future"

Thanks to:

- Many people who have contributed
- Robert McConnell, NREL
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