

# Solar Cell Market Evolution

*Can we predict the next wave of innovation?*

*Jim Rand*

*8 May 2014*

Market Highlights  
Supply  
Demand  
Price

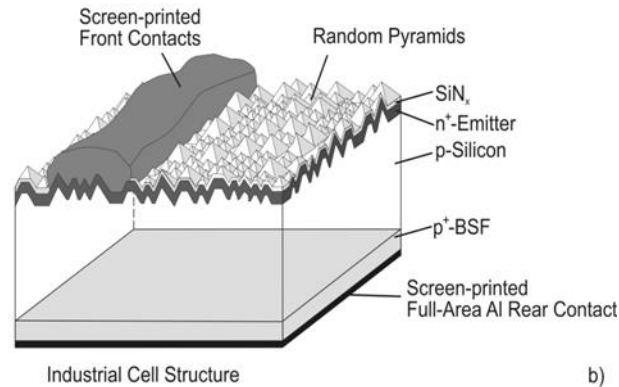


Ramification on  
Technology

1. Look Forward for Growth Potential
2. Look Backward for What Triggered Change
3. Look Forward for Guidance on Technology

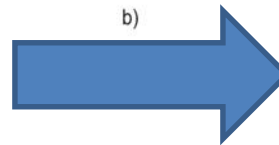
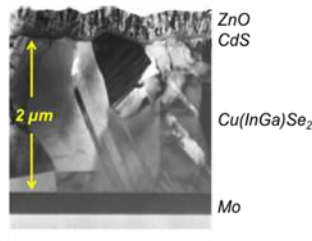
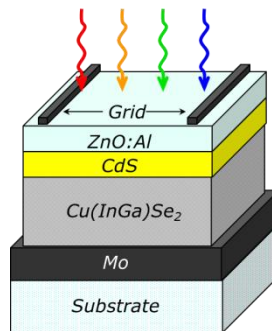
# Definition: "The Market" = Flat Plate PV

*Conventional Silicon PV Modules*



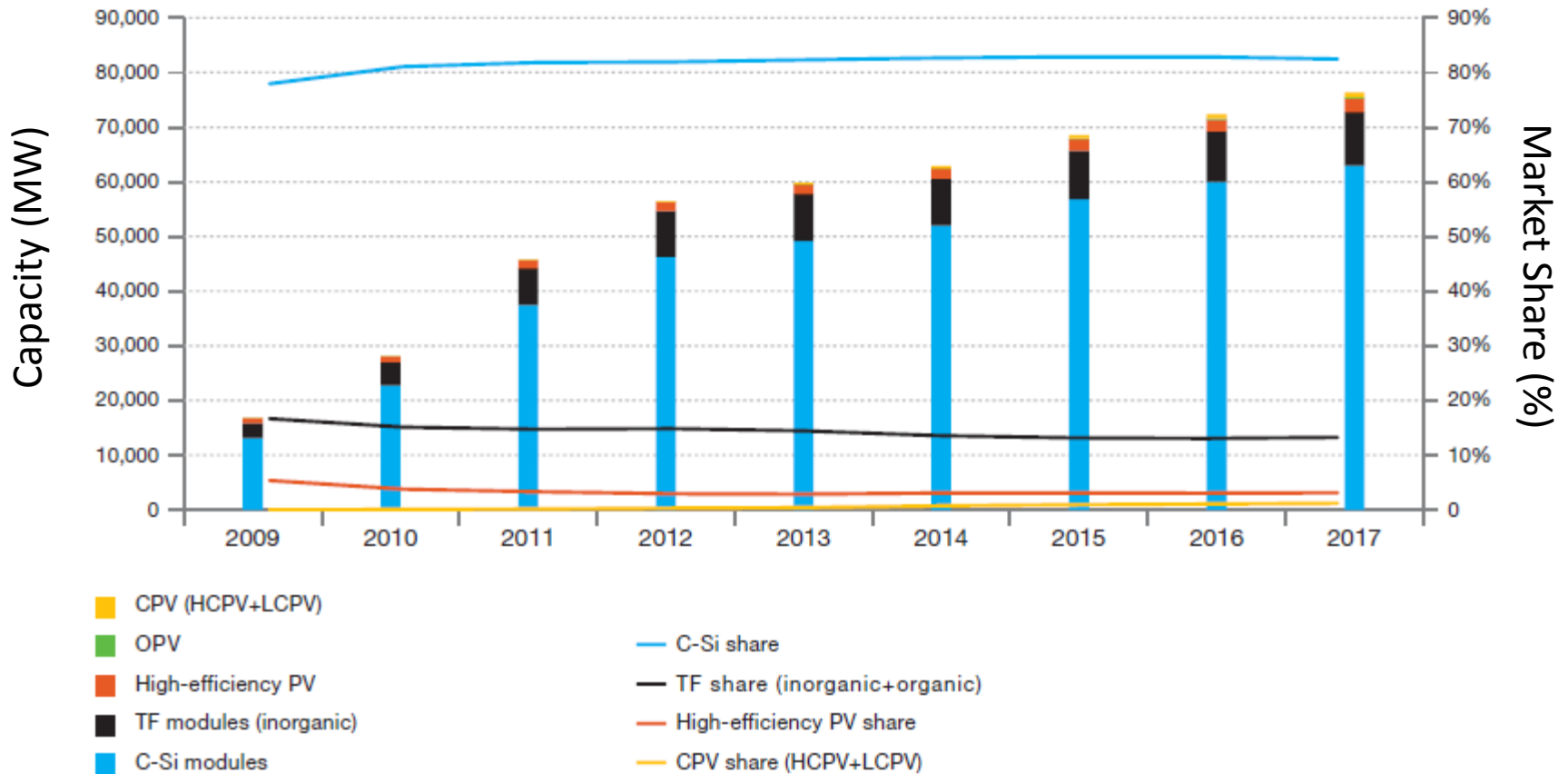
Industrial Cell Structure

*Thin Film Modules (CdTe, CIGS)*



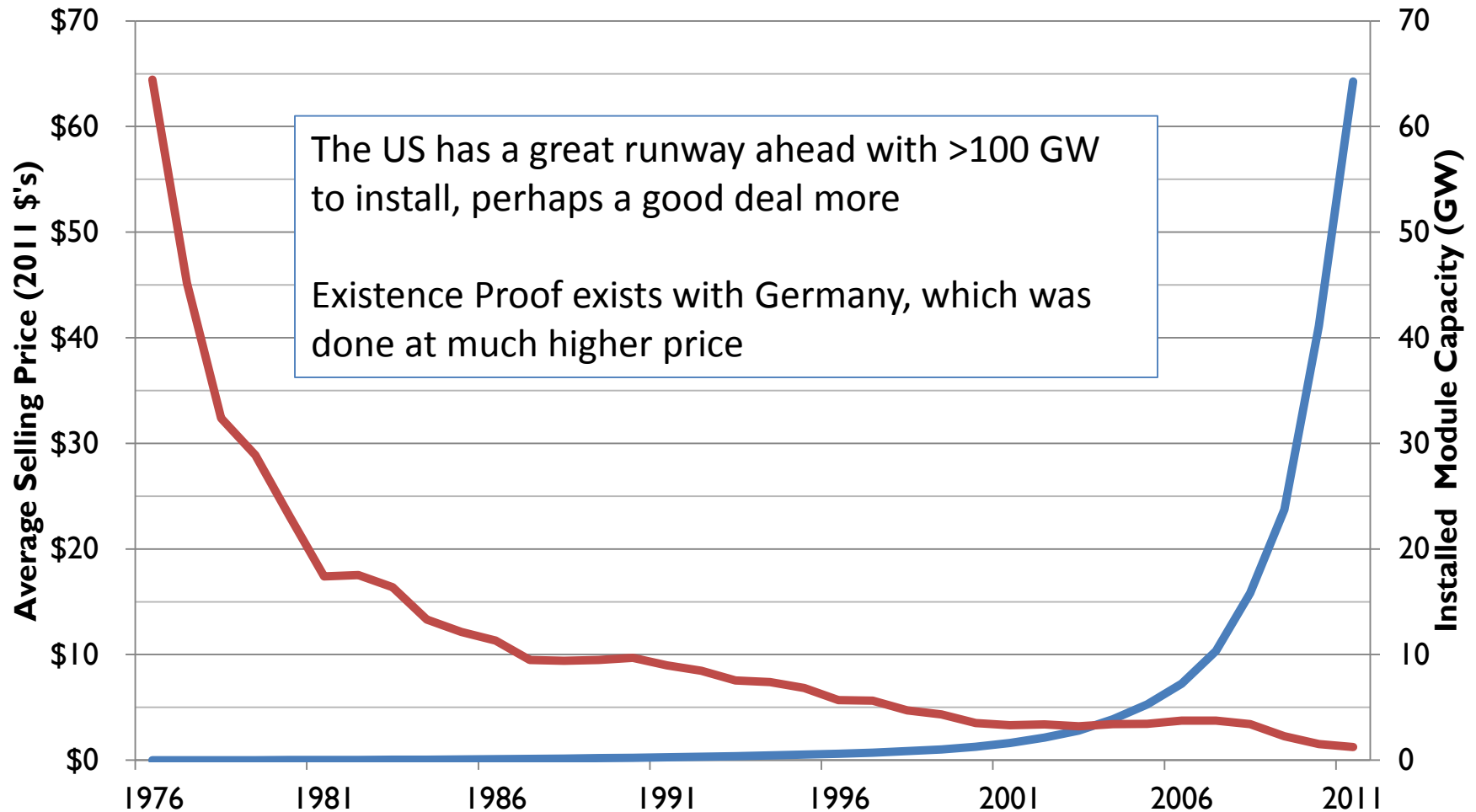
*Convention, Rack Mounted, One-Sun, Flat-Plate Modules*

# Definition: "The Market" = Flat Plate Silicon PV

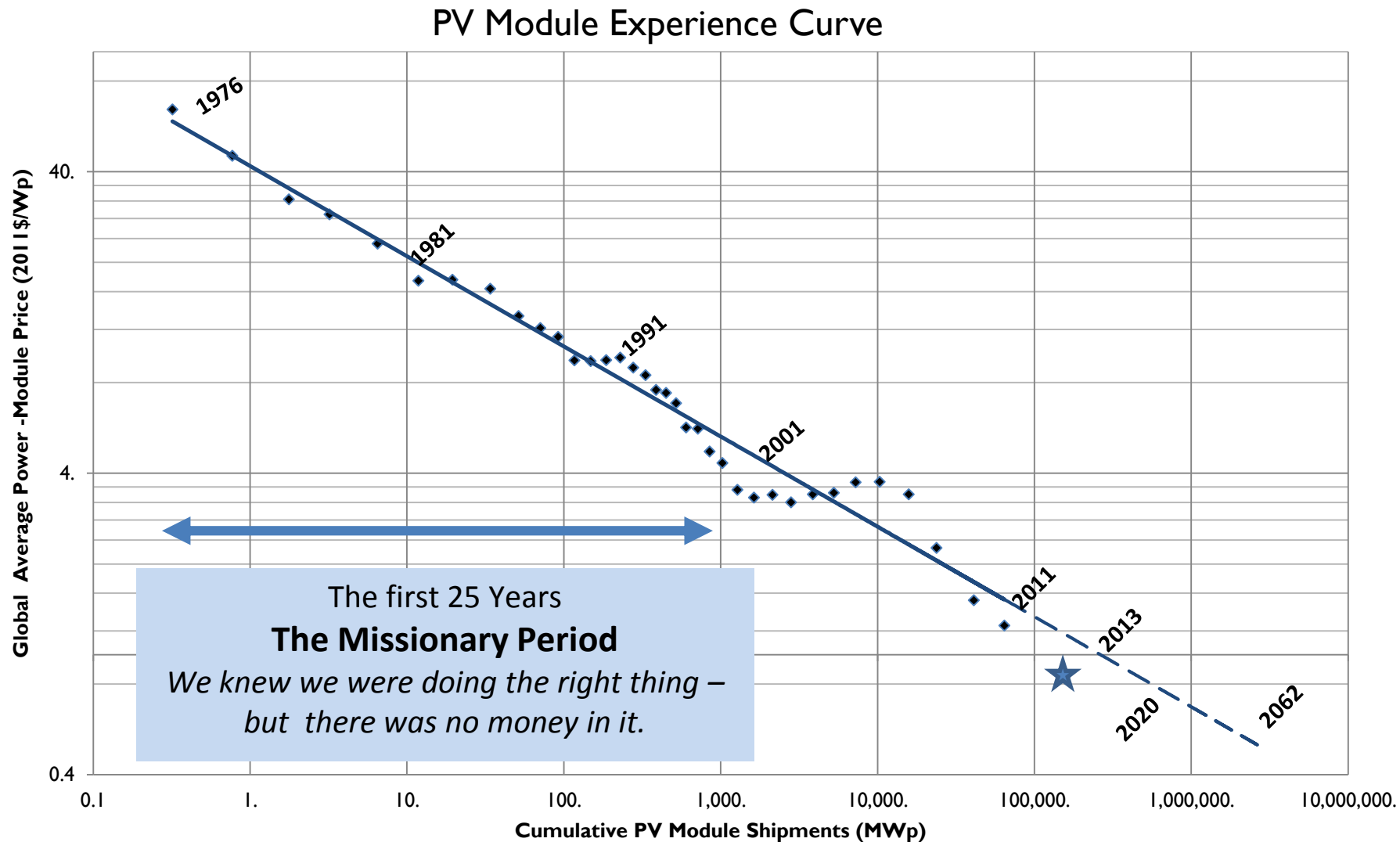


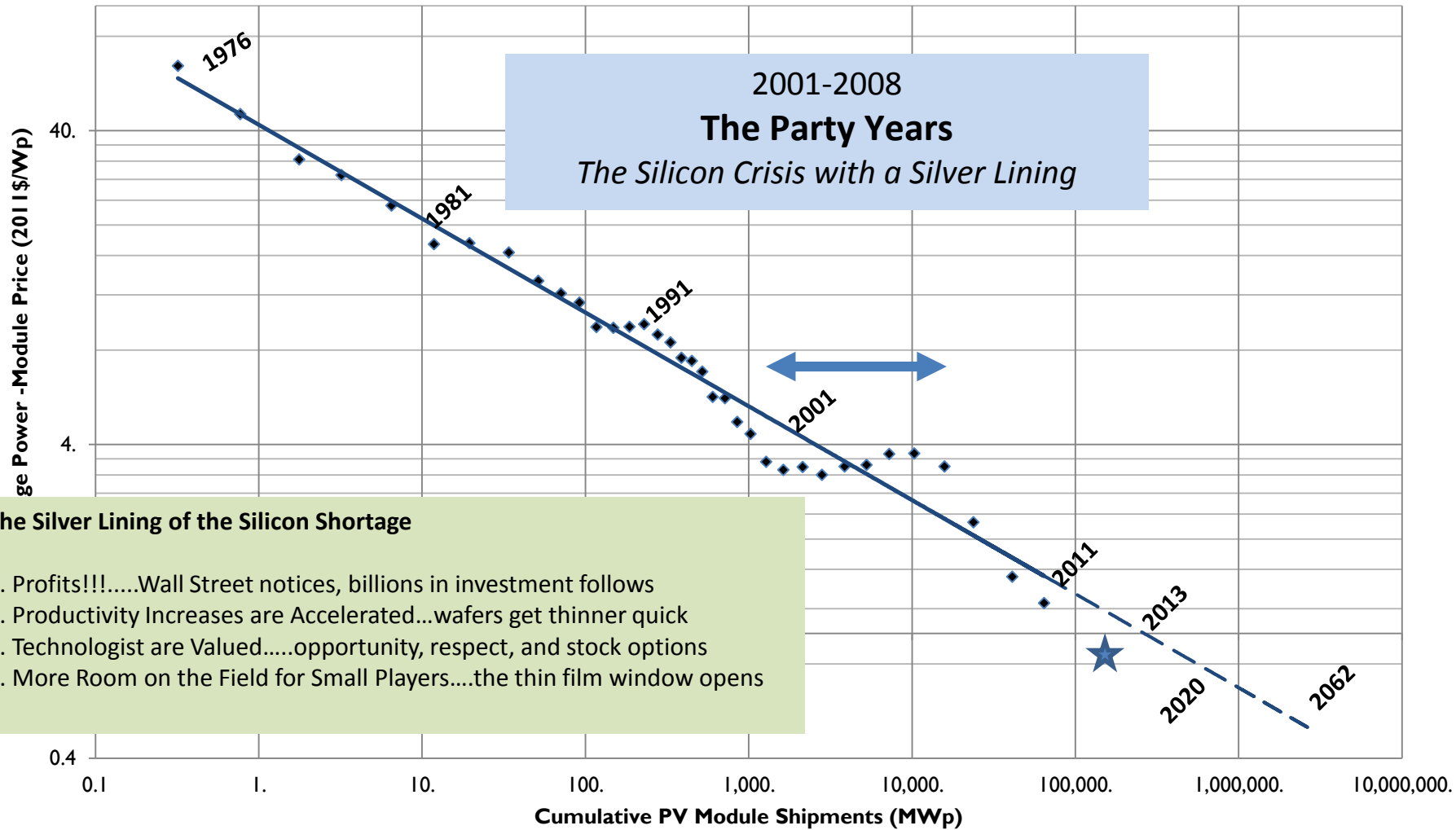
Source: EPIA, IHS Solar, PV Insider and SNE Research

# 1. Look Forward for Growth Potential

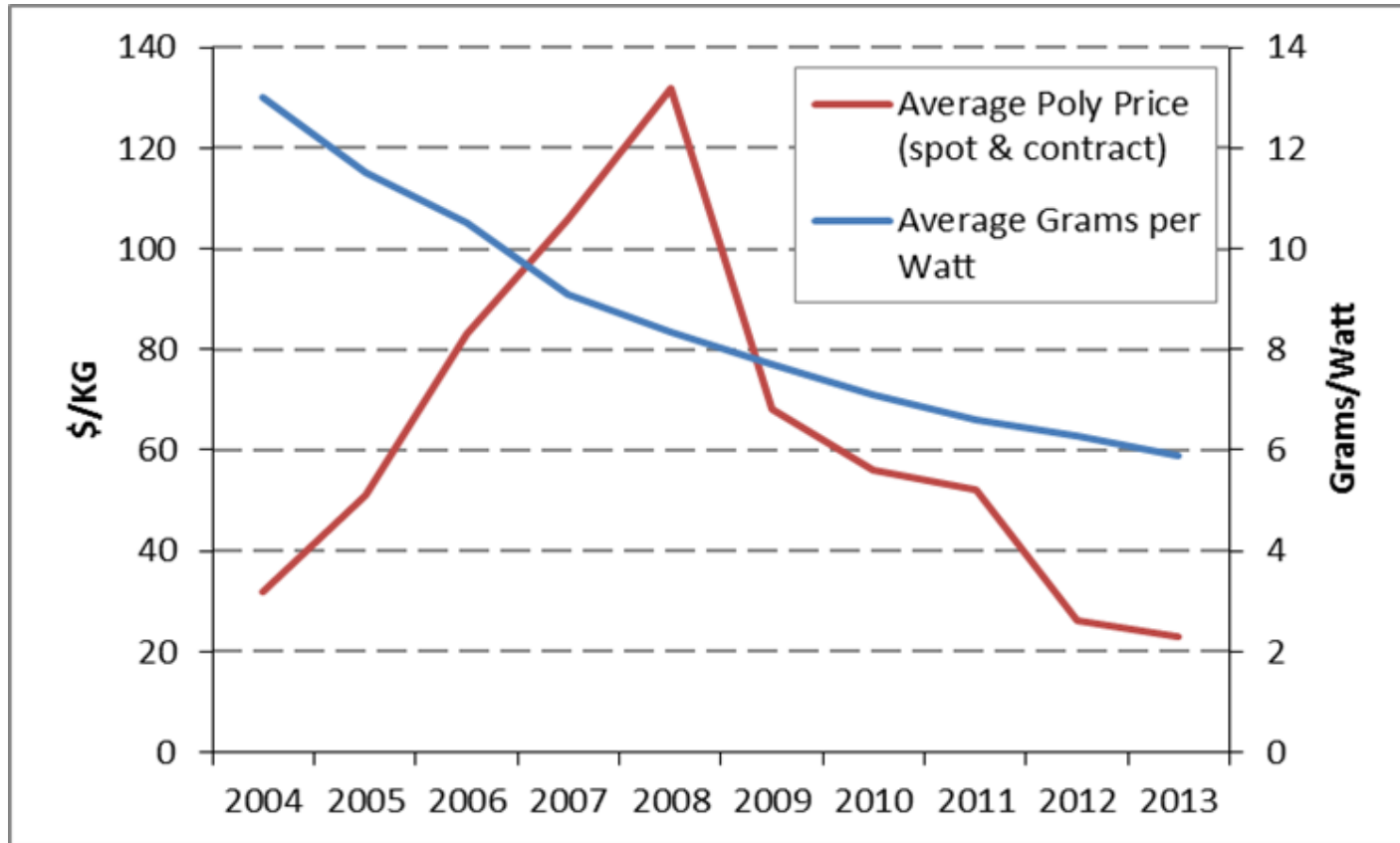


## 2. Look Backwards for Triggers to Change

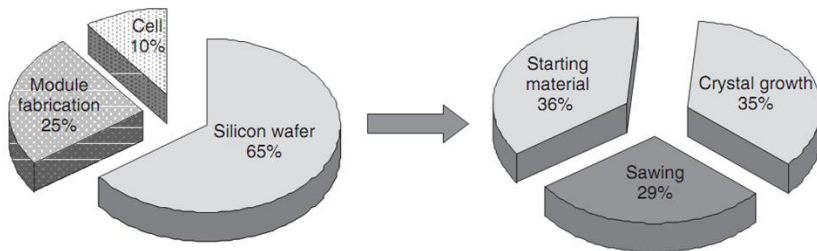




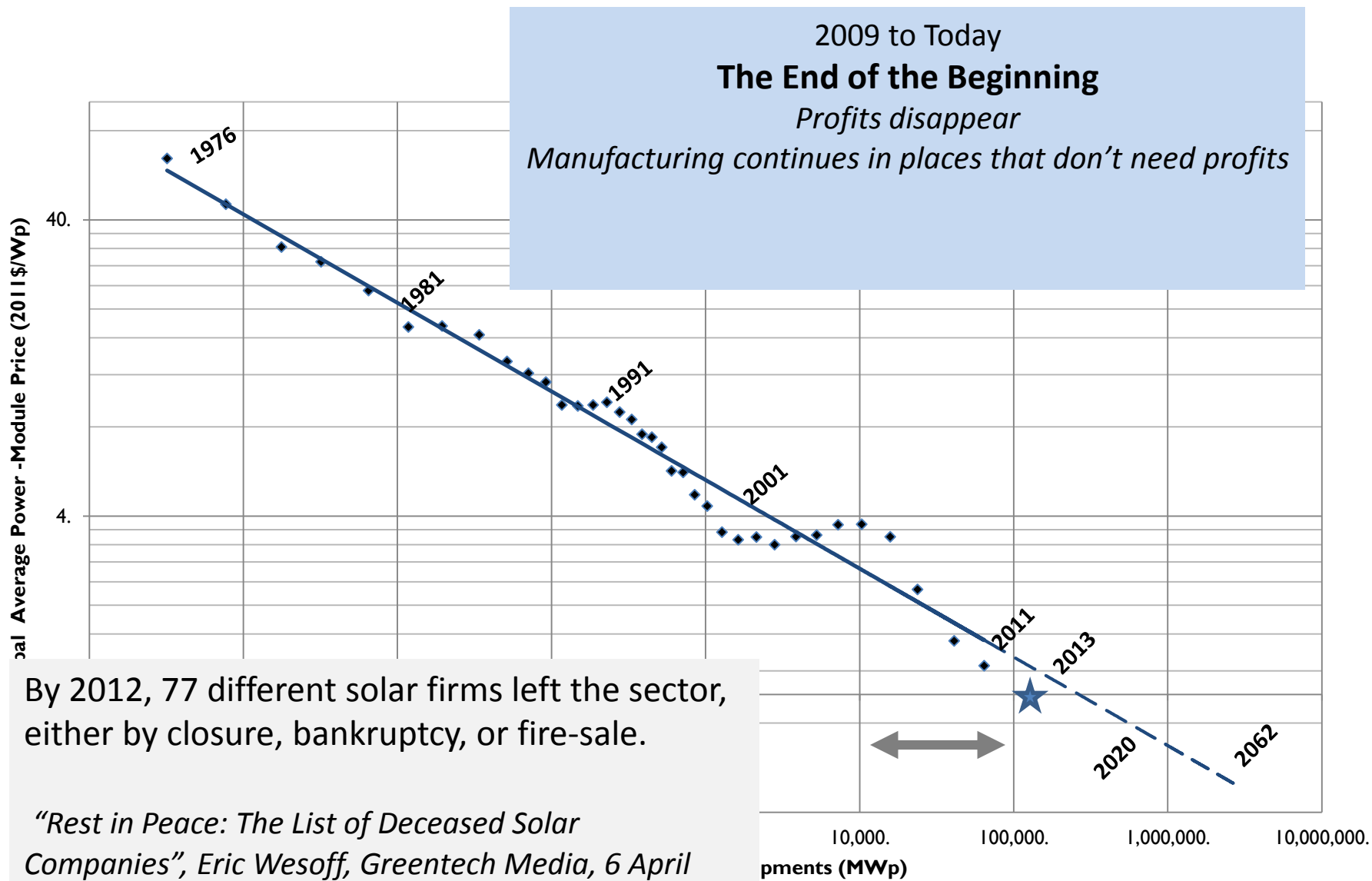
# Huge Gains in Productivity



Similar gains in all aspects of manufacturing (with the possible exception of labor)



Compiled by David Feldman. Sources: 2004 CLSA. Solar Power: Sector Outlook. Michael Rogol. July 2005. 2005-2013 Photon Consulting. Solar Annual 2007, 2008, 2012, 2013.



By 2012, 77 different solar firms left the sector, either by closure, bankruptcy, or fire-sale.

*“Rest in Peace: The List of Deceased Solar Companies”, Eric Wesoff, Greentech Media, 6 April 2013*



# Recap of Present Status

- The Silicon Technology is Firmly in Place
  - Supply Chain
  - Manufacturability
  - Market Acceptance
    - Proven in the Field
- Prices are “dirt cheap”
- Investment Community Has Moved On
- Any new incremental technology improvement will be taken up by the existing manufacturers in Asia
- We are STILL not competitive without Incentives

# Addressing the Key Elements of \$/kwh

- Reduce the Cost of the “Active” Solar Cell Material and Device
- Cost of the “Package”

Make a cheaper module...only with comparable efficiency and reliability

- Enhance Productivity - 1400 kwh/kw<sub>pv</sub>

Widespread use of Trackers? Just AZ?

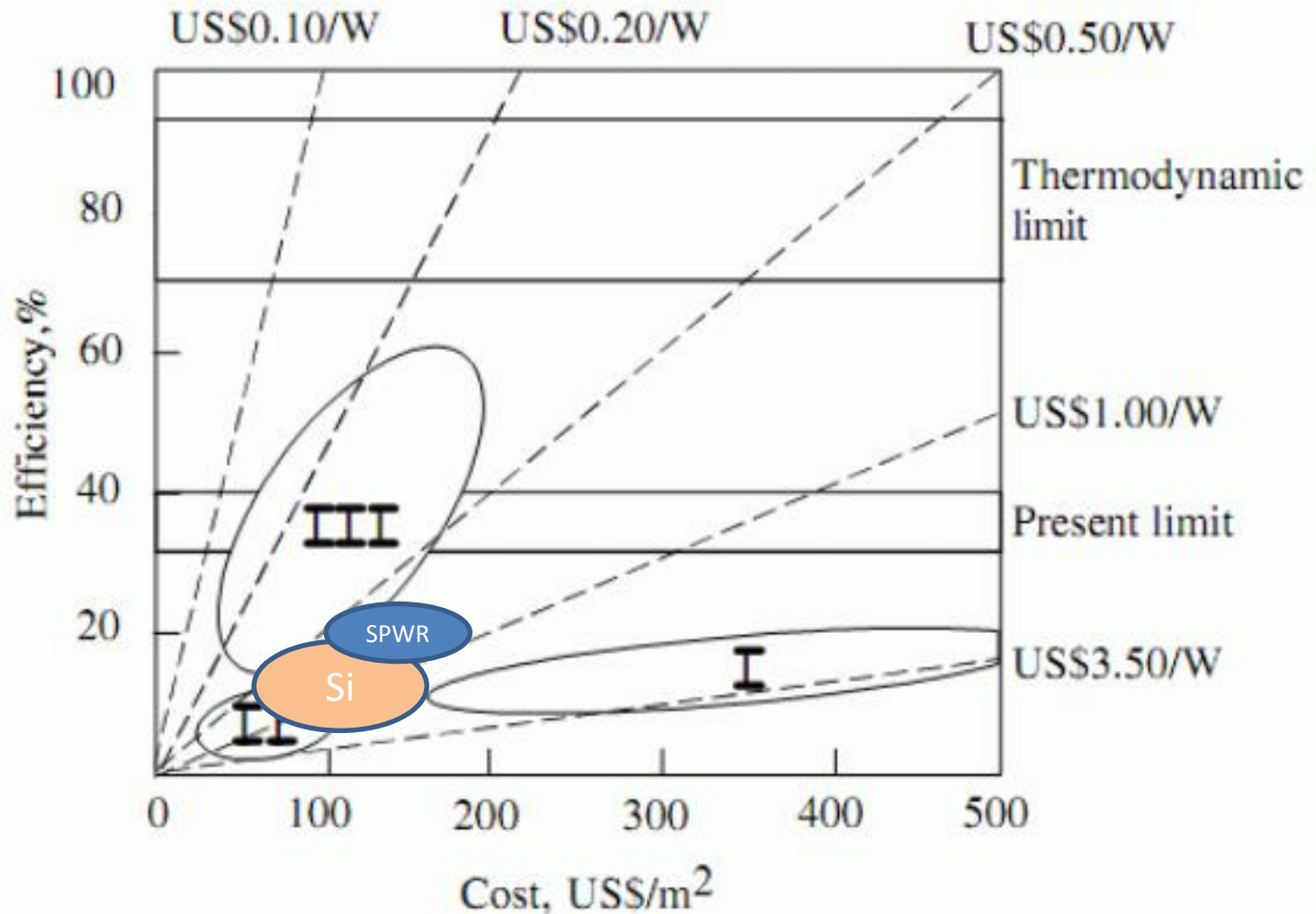
- Decrease BOS

We can all agree

- Big Increase in Efficiency

>30%....nothing incremental

# High Efficiency at the Module Level

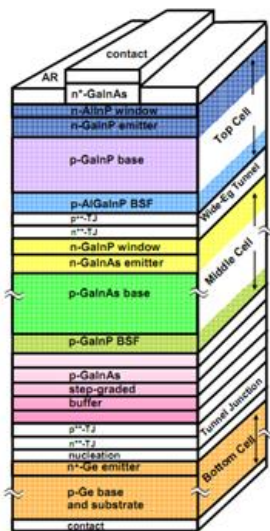


# Big Gains in Efficiency Come From:

1. Intermediate Bandgap
2. Thermal Photovoltaics
3. Hot Carrier Solar Cells
4. Multiple Electrons per Photon
5. **Multi-Junction Solar Cells**

## 3<sup>rd</sup> Generation Solar Cells

**Only Multi-Junction Solar Cells have been shown to work.**



*SpectroLab record efficiency multi-junction device structure which has demonstrated 40.7% under concentration.*

*“CPV, mainly HCPV, is considered by some as a sleeping giant. CPV is expected to reach around 1 GW of production capacity by 2017”*

Global Market Outlook, 2013, EPIA

# End

- [Jim.rand.solar@gmail.com](mailto:Jim.rand.solar@gmail.com)

- My Next Venture:  
Performance and Reliability at  
the Module Level