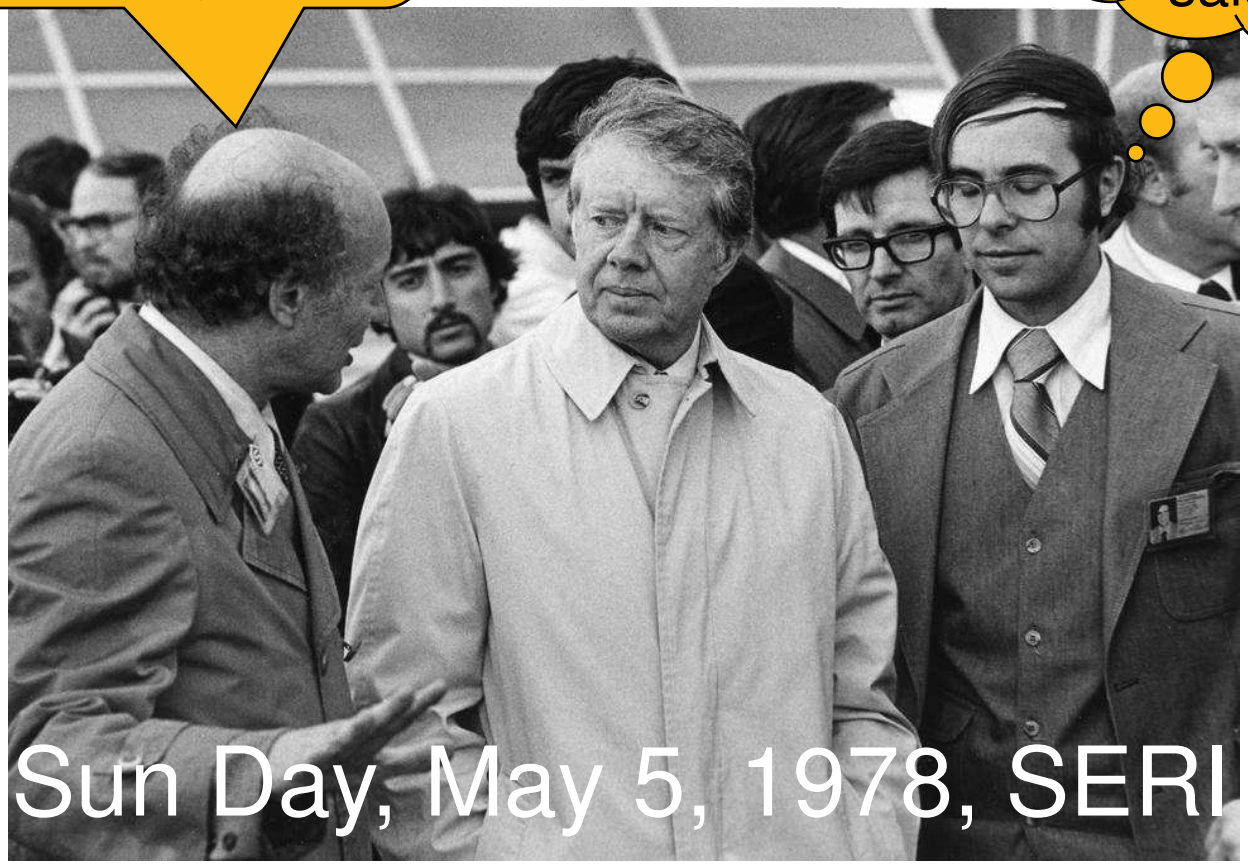
The SunPower Story

The path from R&D concentrator cells to a high volume PV panel and system manufacturer

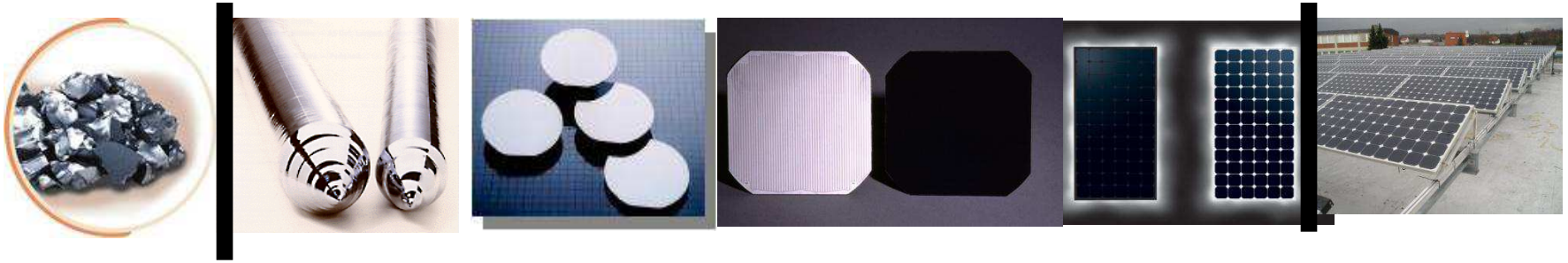
Dick Swanson

The 1970s oil crises sparked interest in PV as a terrestrial power source



Sun Day, May 5, 1978, SERI

Situation in 1973



Polysilicon → Ingot → Wafer → Solar Cell → Solar Module → Systems

$300/kg

3 inches in diameter

Sawn one at a time

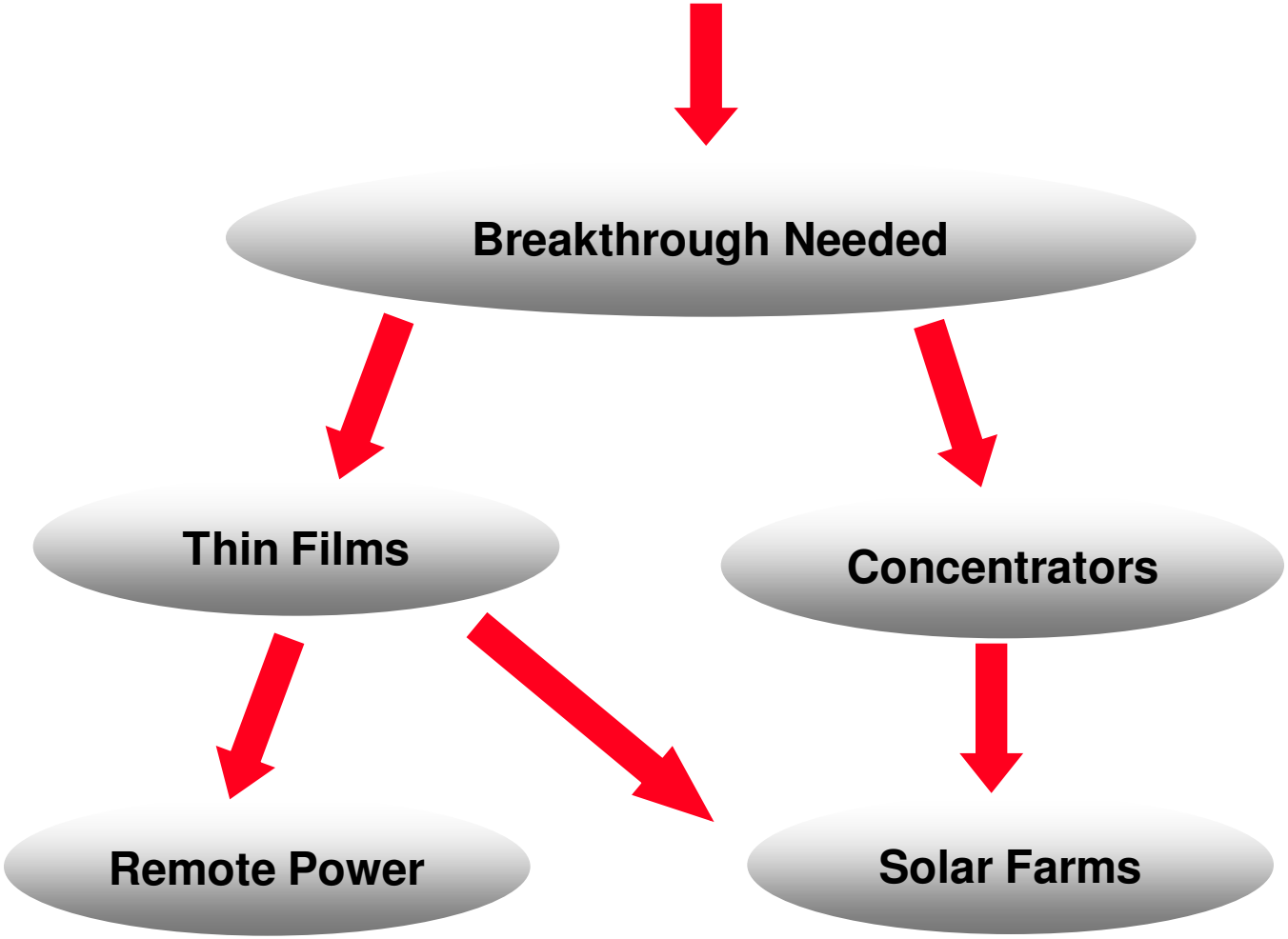
0.5 watts each

$100/watt

$200/watt

1975 View

Wafered Silicon Hopelessly Too Expensive



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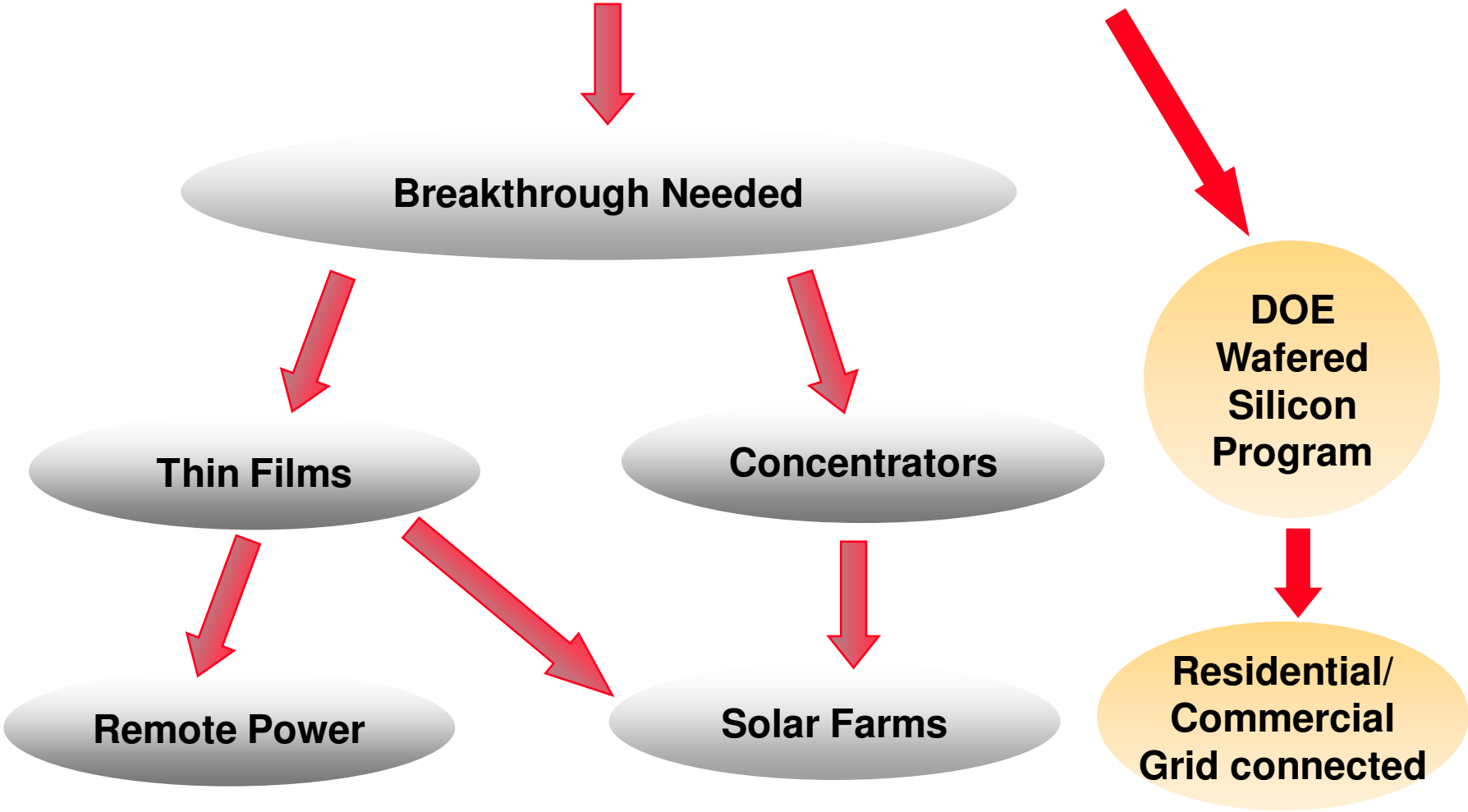
What Actually Happened

Wafered Silicon Emerges as the Dominant Technology



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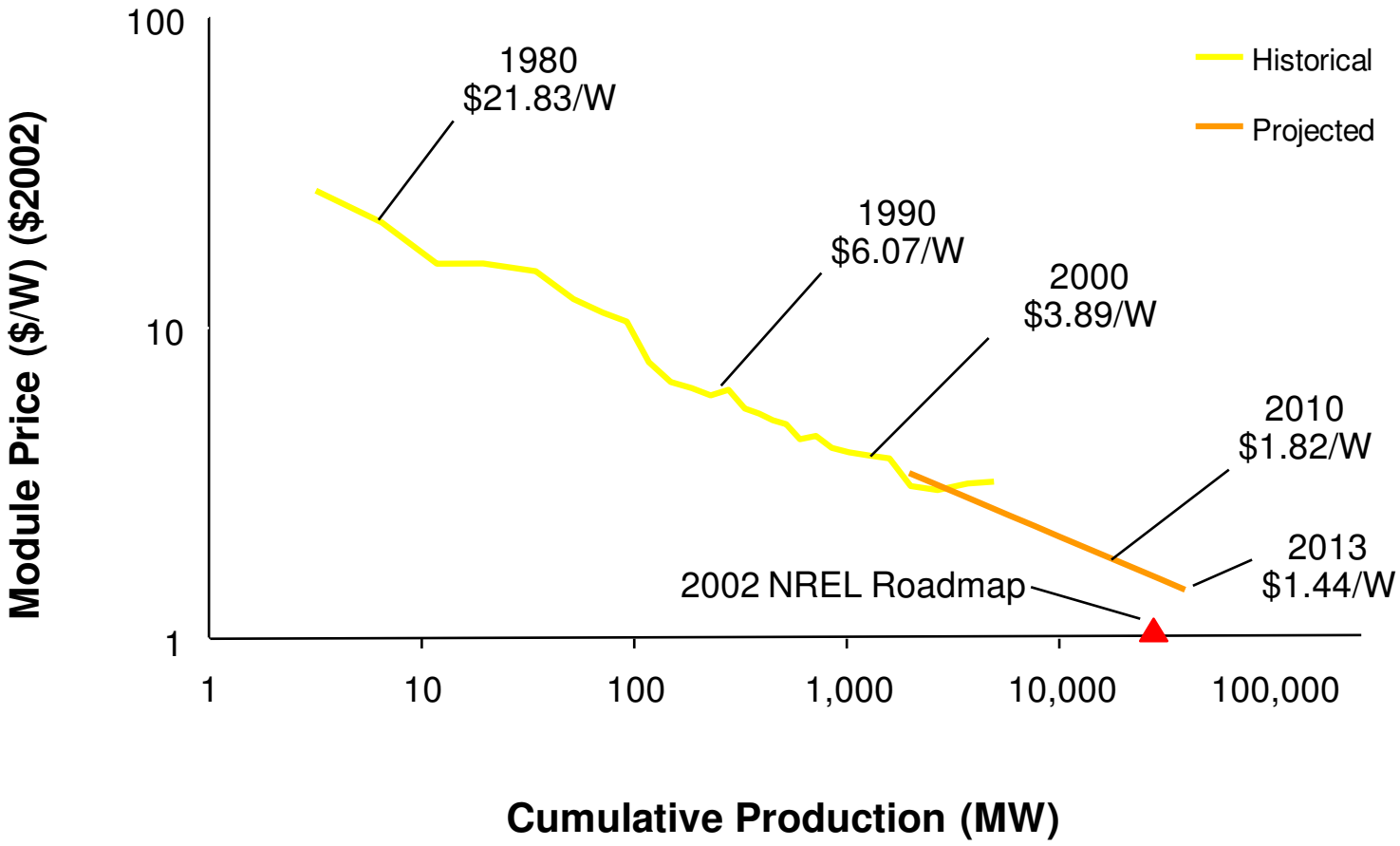
Why Wafered Silicon Still Dominates

We never envisioned:

- The dramatic cost reduction potential of wafered silicon
- The dominance of residential and commercial grid connected markets

Historic and Projected Module Cost Reductions



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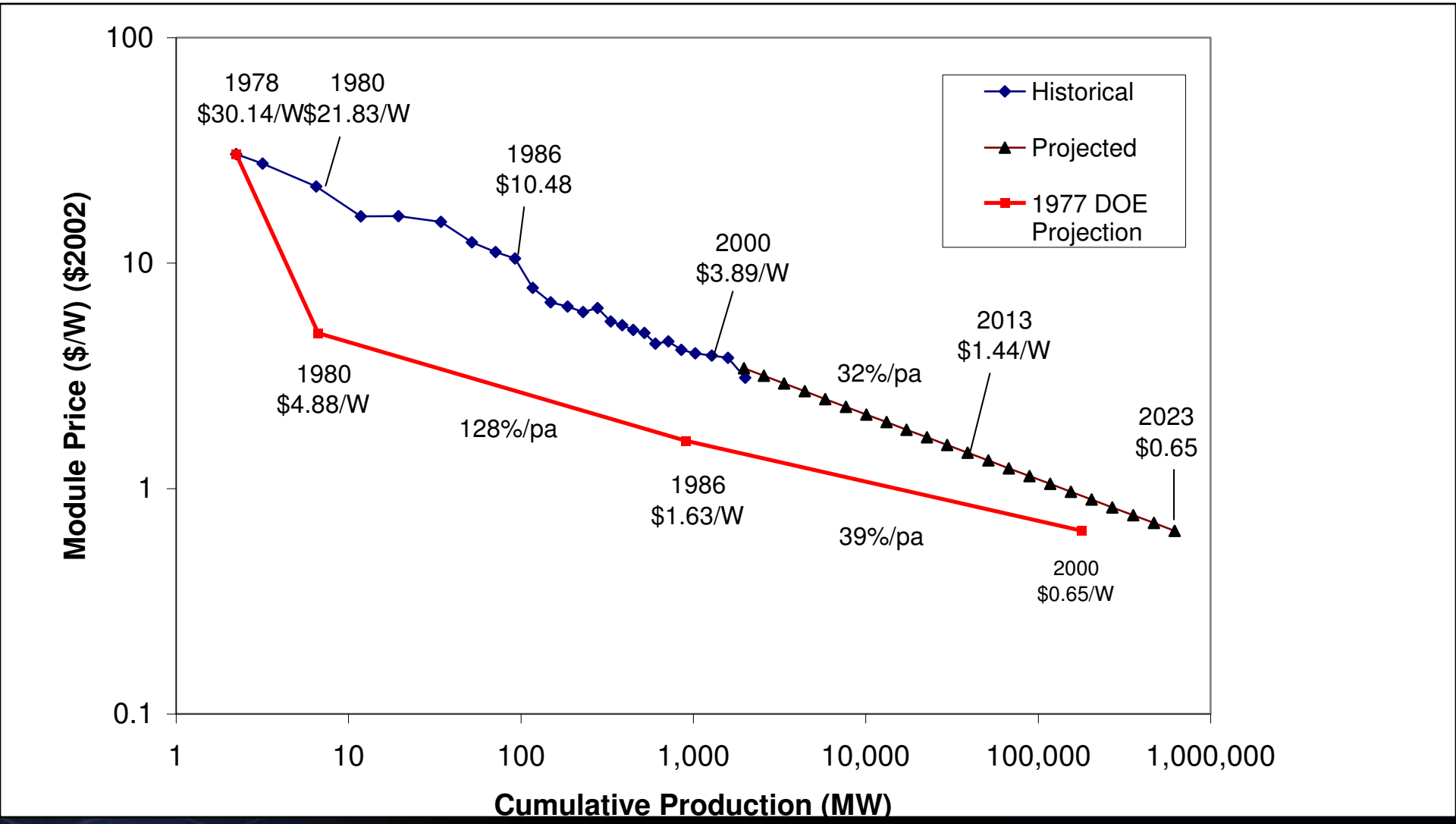
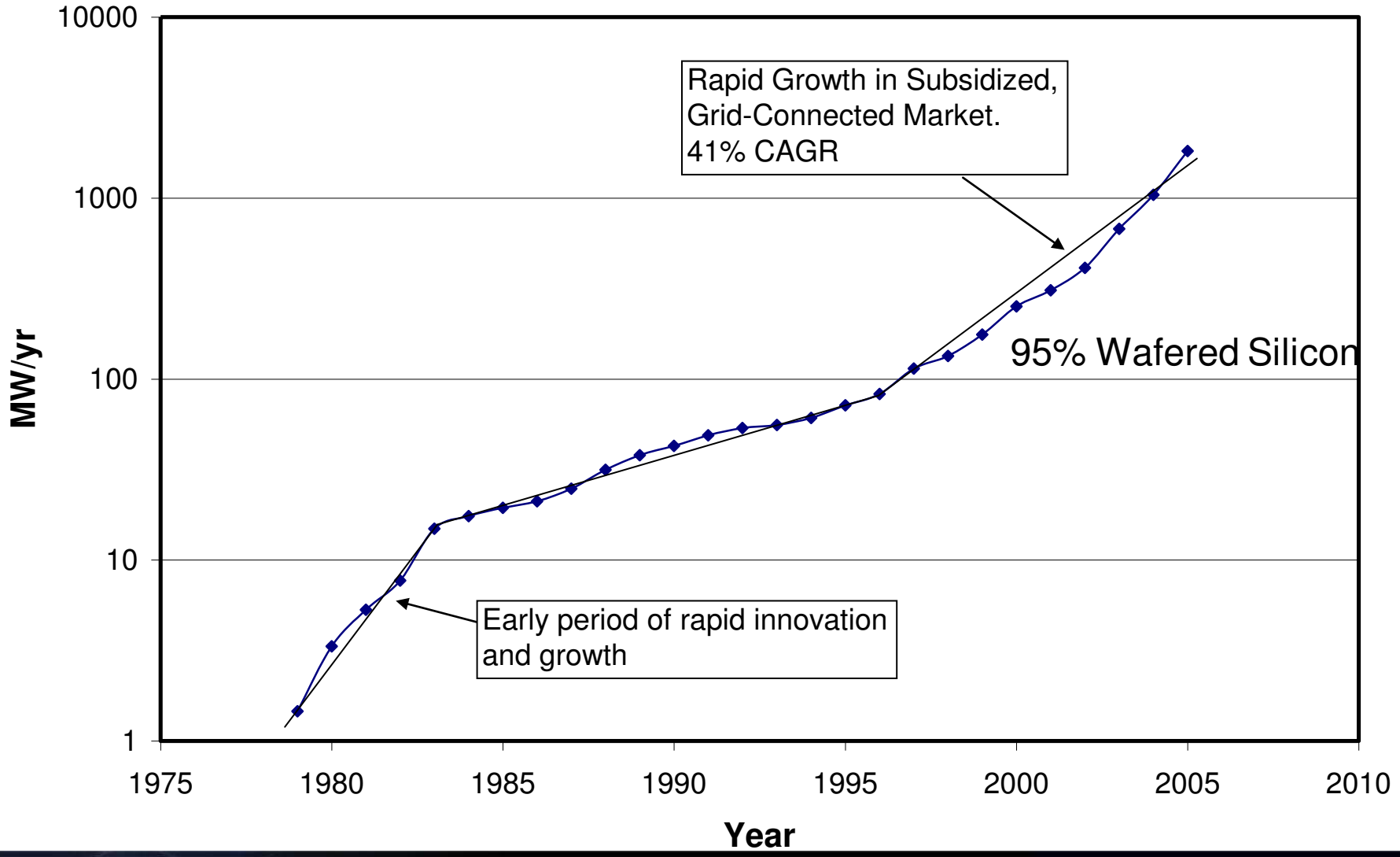
Comparison to 1977 DOE Projection



PV Market Growth



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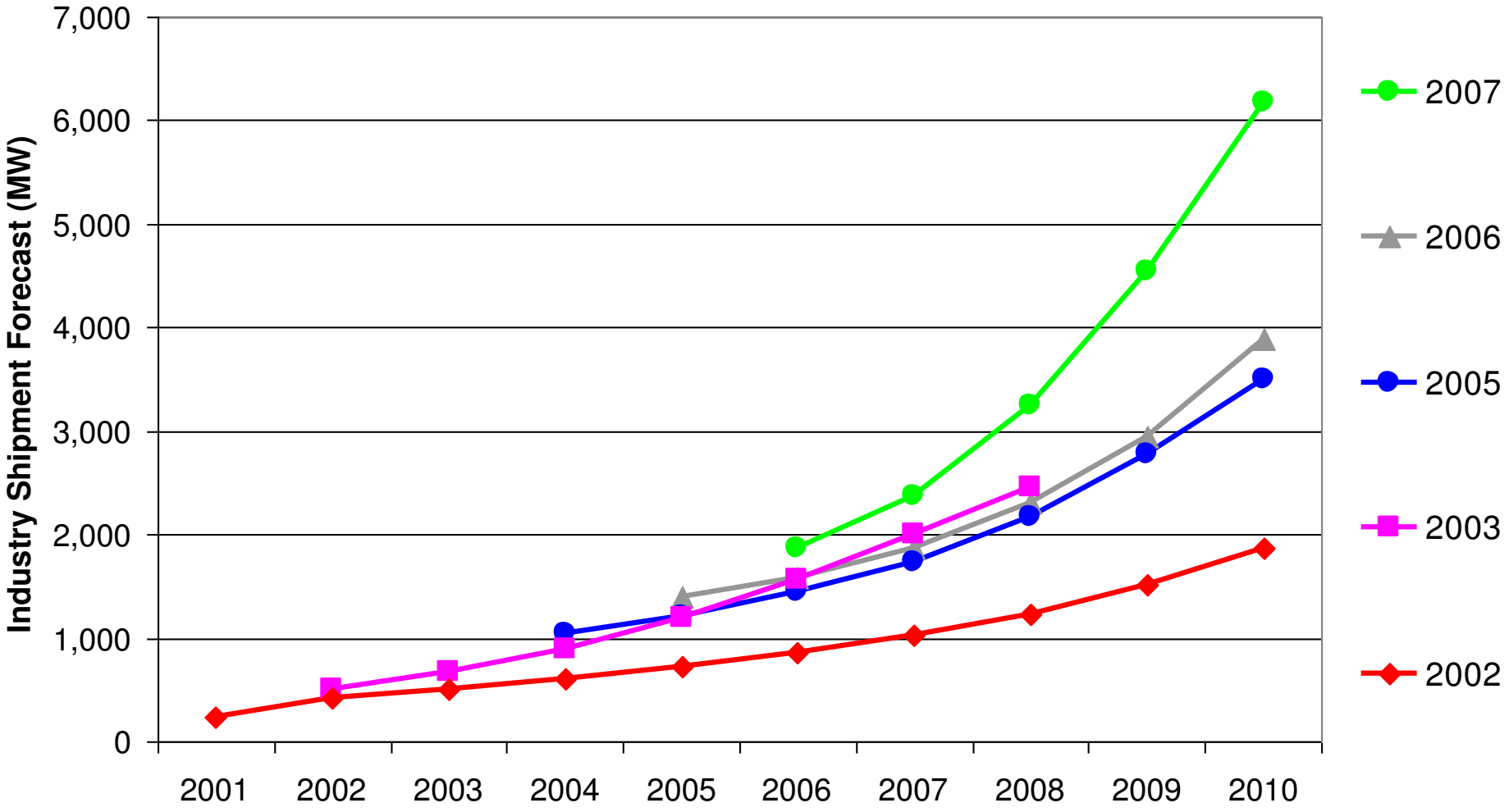
Navigant Forecast History



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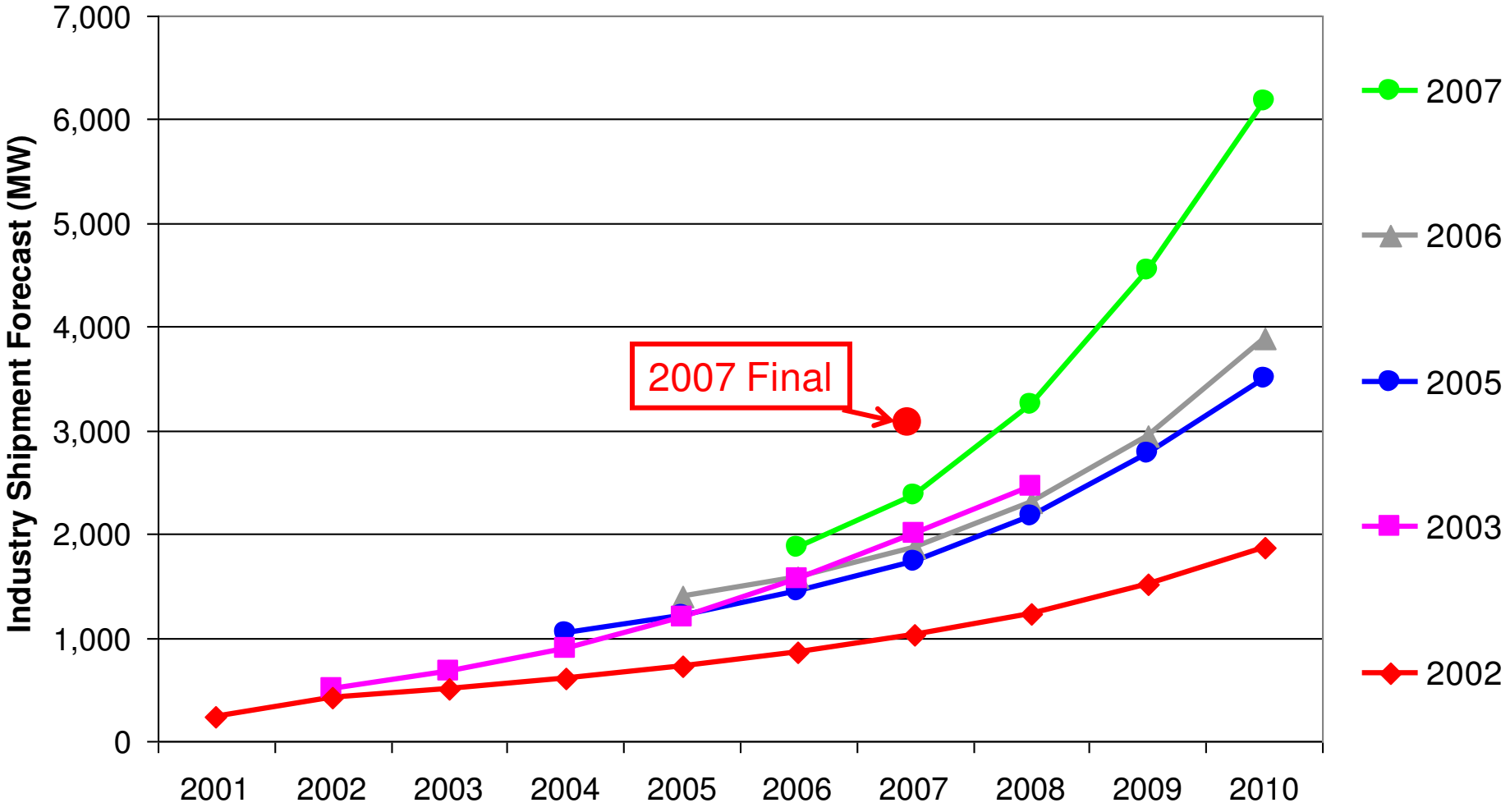
Navigant Forecast History



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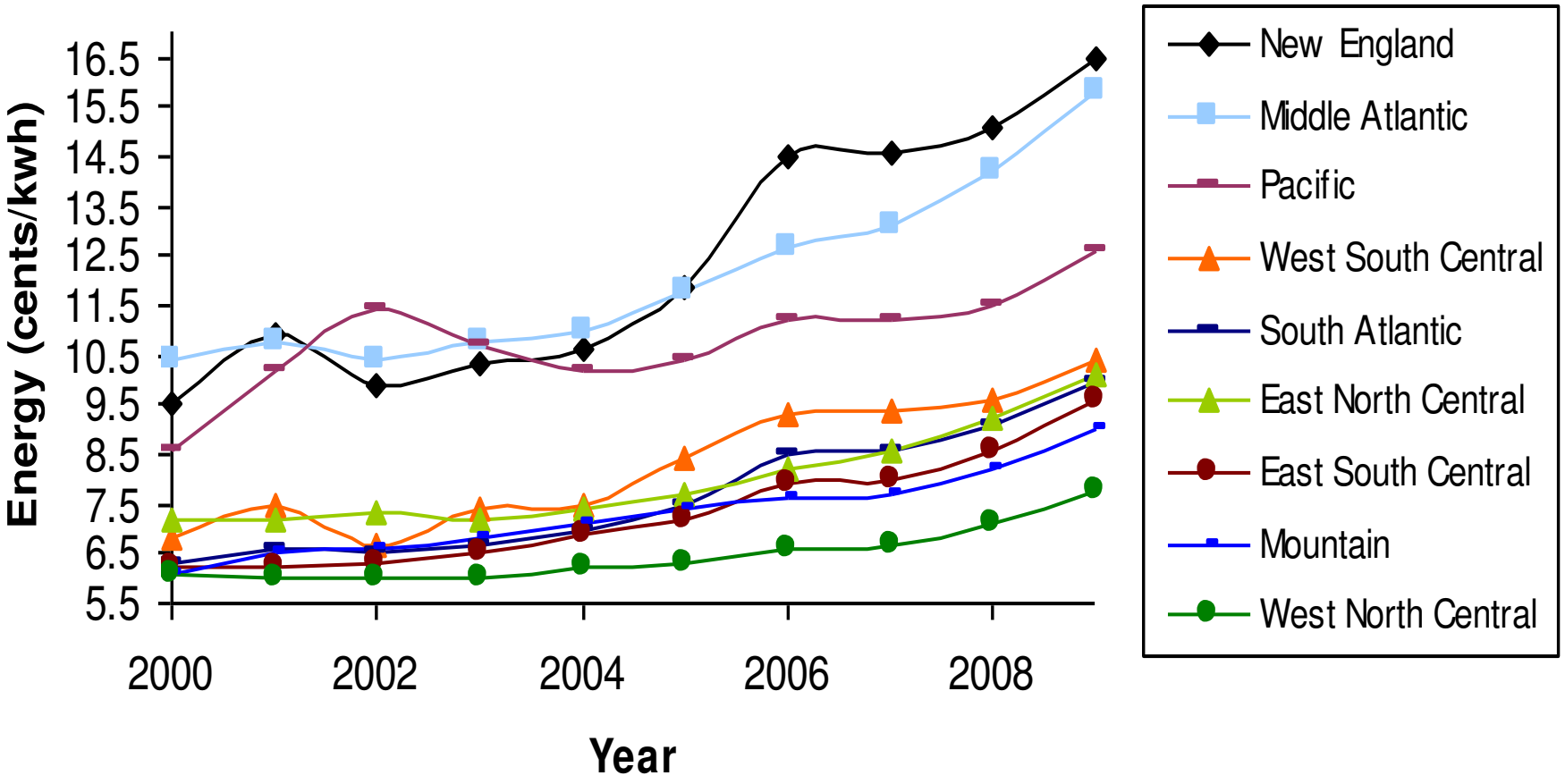
Electricity Prices are Increasing

- Commercial electricity prices have increased 4.76% each year, on average, for the past 8 years.



Source Electric Power Monthly, DOE/EIA-0226

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Recent Industry Milestones

- 1999 — 1 GW accumulated module production
- 2001 — More square inches of silicon used than in entire microelectronics industry
- 2004 — 1 GW production during year
- 2006 — More tons of silicon used than in microelectronics
- 2008 — FPL purchases the first utility-owned PV plant

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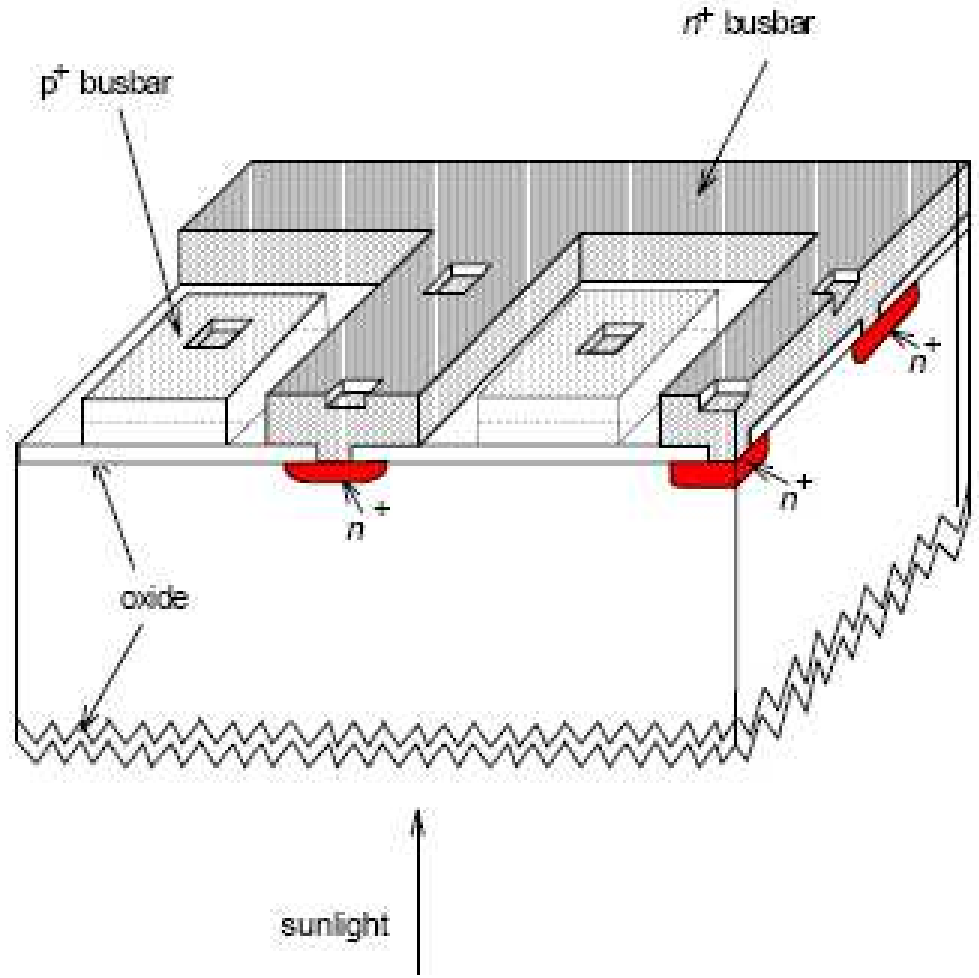
1986 TO 1999

Formation

And

Fund Raising

The Point Contact Cell (27.0% 200x)



- Low Recombination
  - Minimal diffused regions
  - Oxide/Alneal passivated surfaces
  - Point arrangement of pn-junctions
  - High injection operation
- High Generation
  - Zero grid obscuration
  - High-res, high-tau wafers
  - Good internal optics
- Low Parasitics
  - Rear electrodes
  - Double level metallization

- High-tau FZ wafers
- Multiple High-tau Tube Diffusions
- Photolithographic Features

Photo from M.A. Green, CLEAN ELECTRICITY FROM PHOTOVOLTAICS, eds Mary D Archer & Robert Hill (Imperial College Press, 2001)

My concentrator group visits PG&E, ca. 1982

Fundraising Proved Difficult

US Federal PV Program Spending
($ millions)

1981	133
1982	74
1983	27

Talked with over 40 venture capitalists

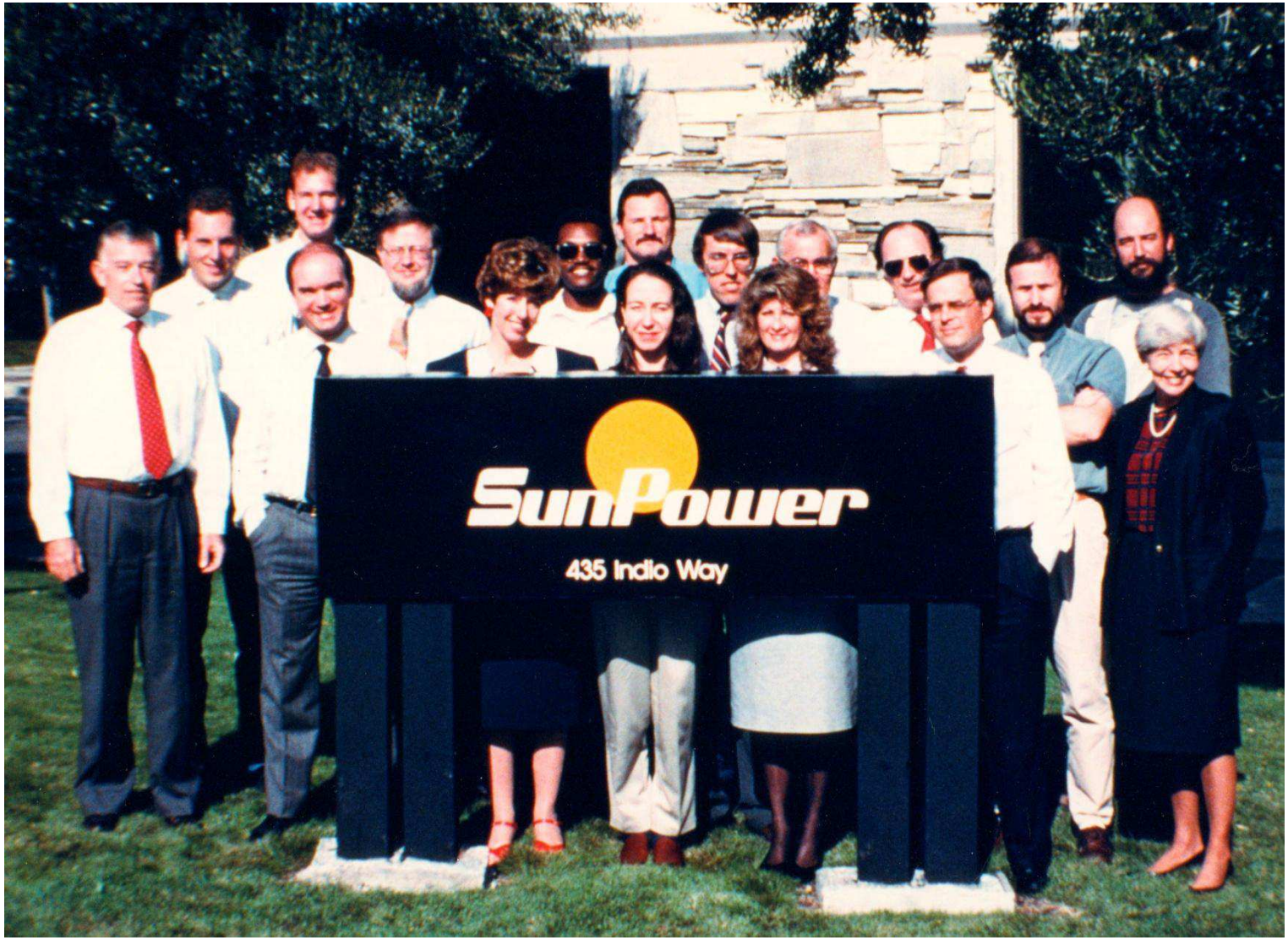
Finally in 1990, we put together
a triad of funding sources:

- EPRI
- DOE, Concentrator Initiative
- VC's, AVI and TFI

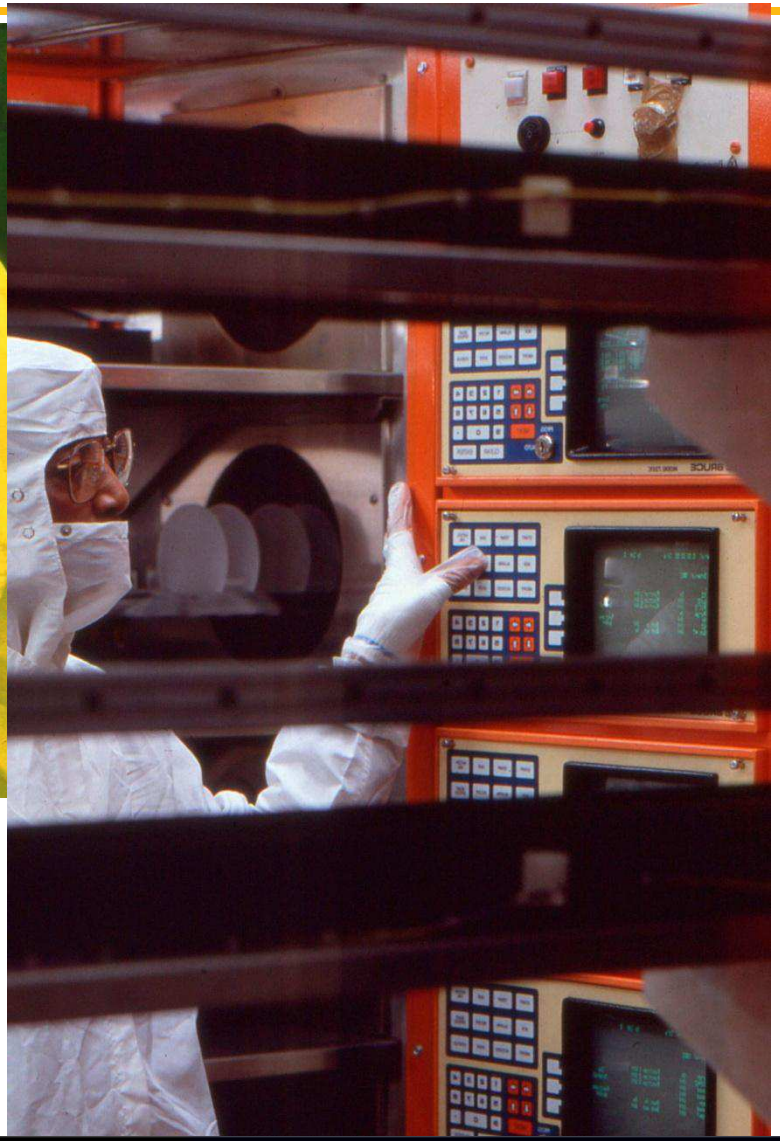
1990 TO 1992

Enthusiasm

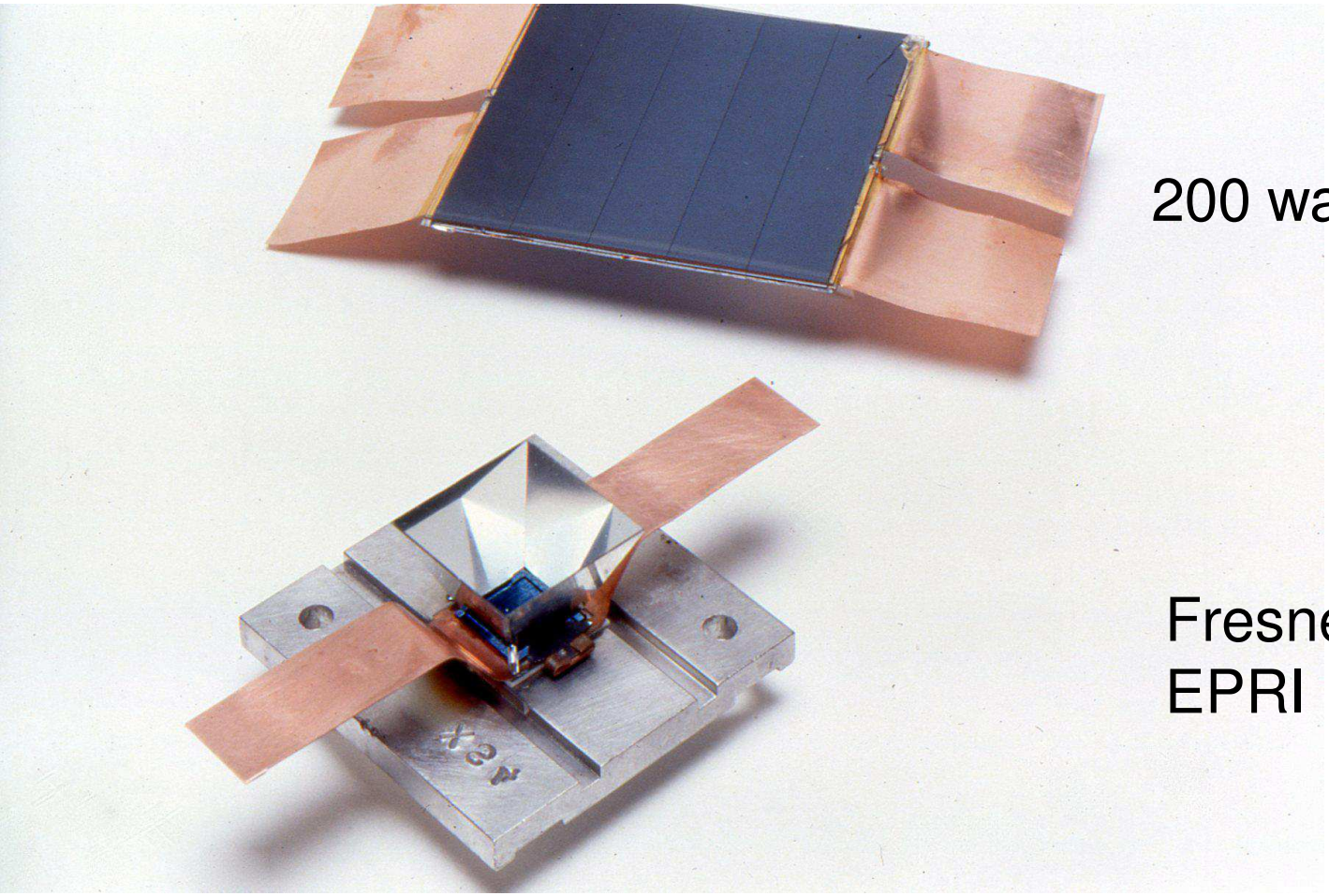
1990: SunPower begins operations



The Cell Pilot Line



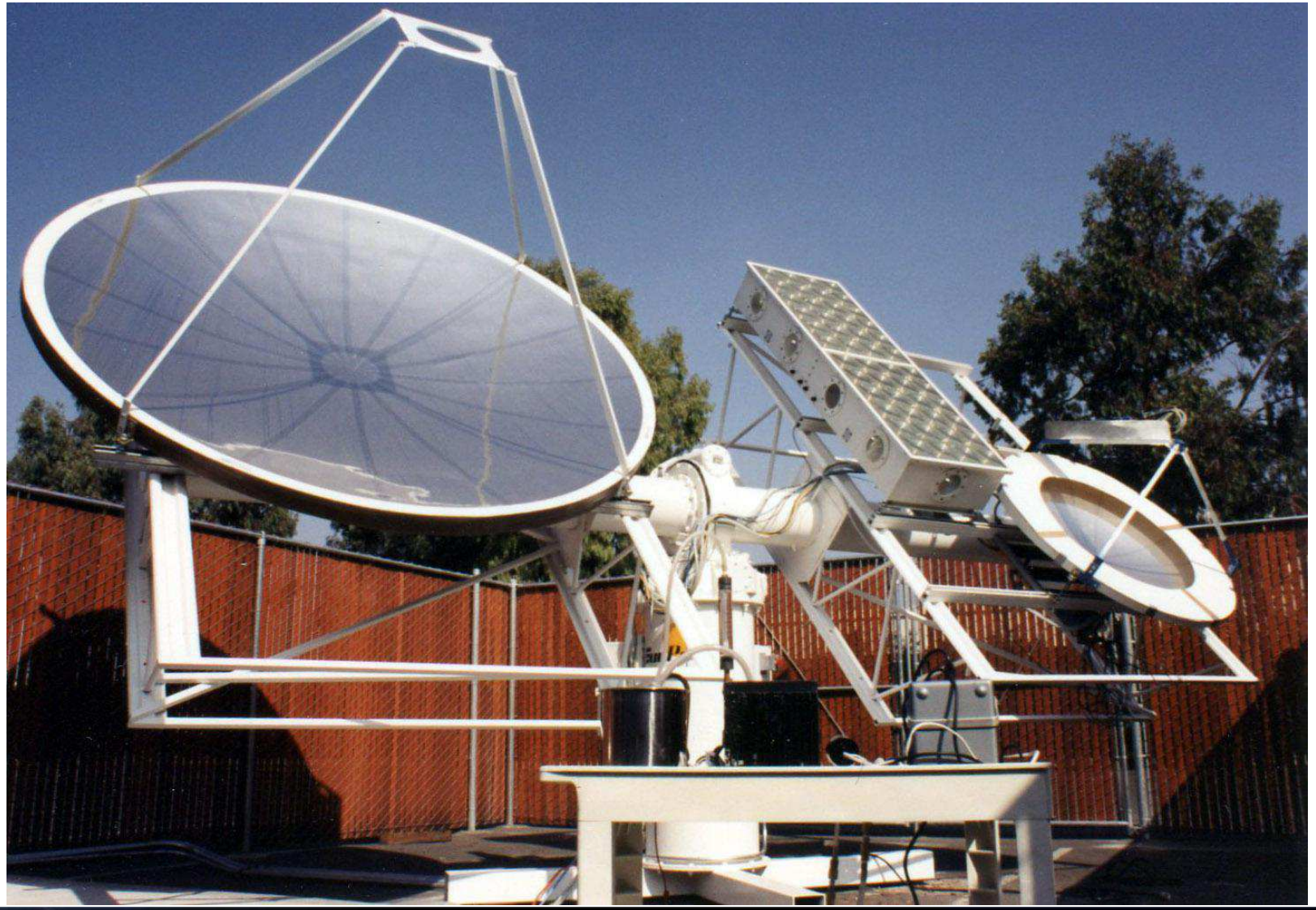
First products



200 watt dense array

Fresnel lens cell for EPRI

Tested various concentrator modules



Built 1 kW Segmented Parabolic Dish

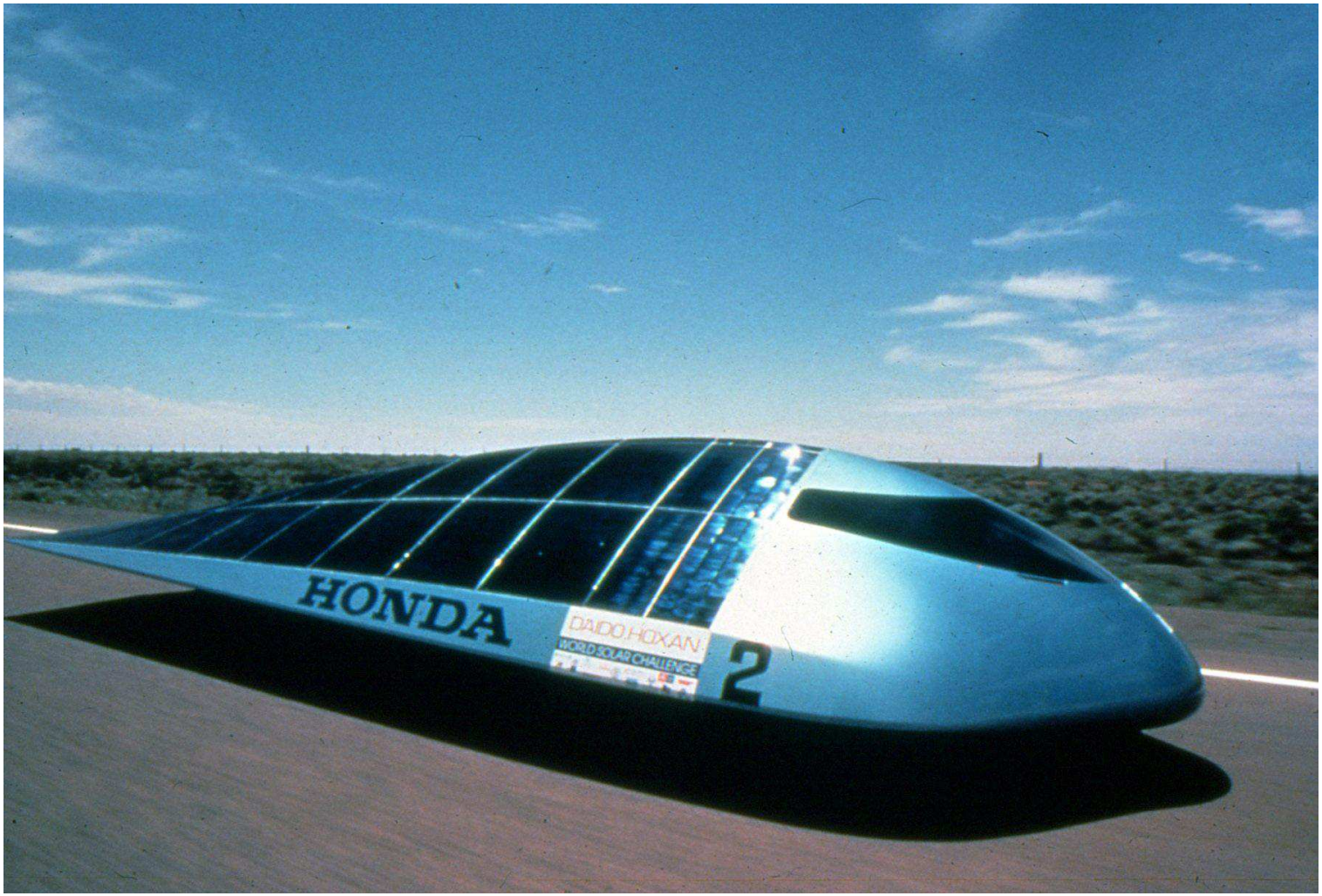
1992 was a bad year

- Sandia Concentrator Initiative Cancelled
- EPRI Contract Cancelled

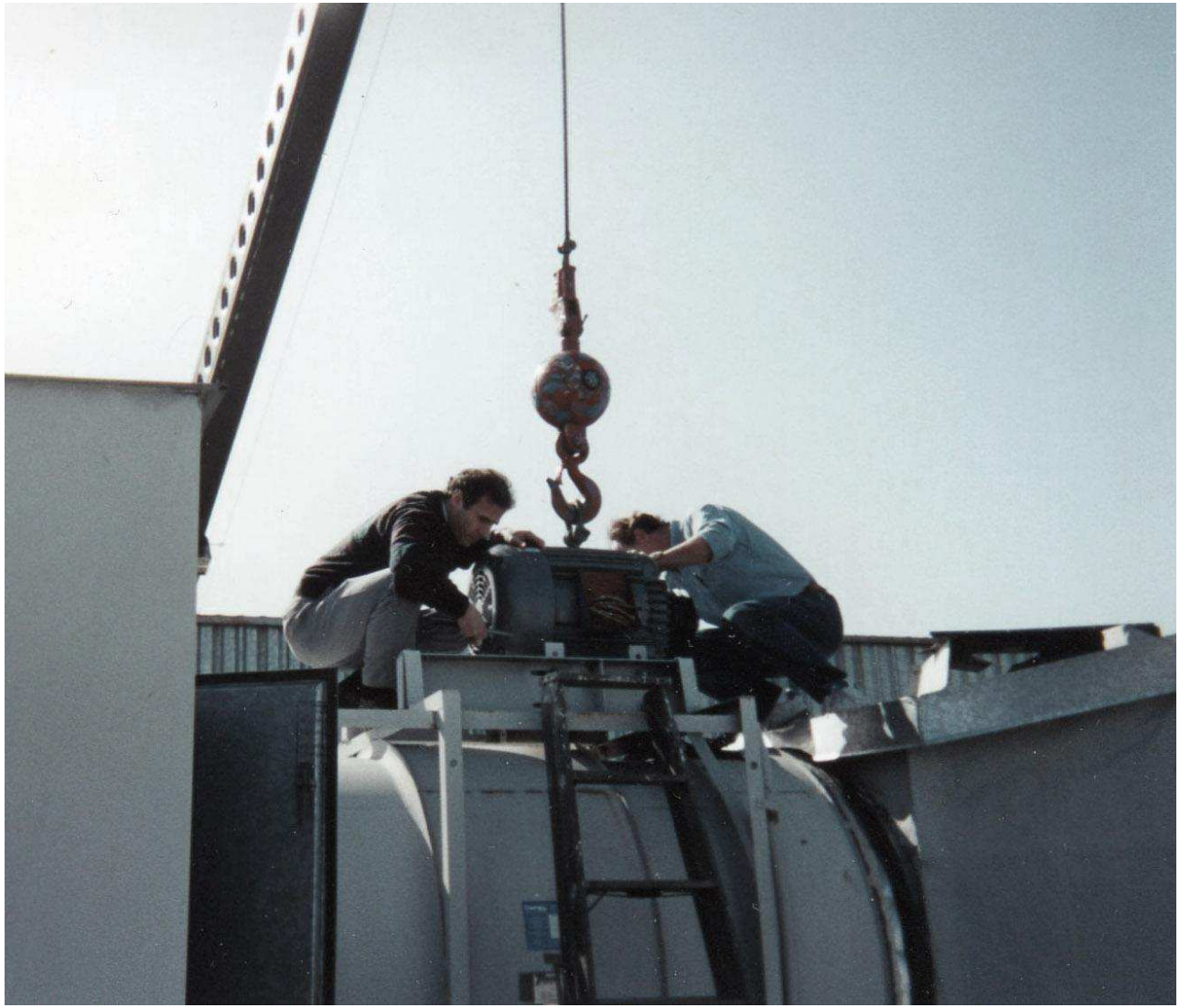
1993 TO 2000
(7 TO 0 BC)

Survival

Honda Dream



Learning a little about manufacturing



Winning 1993 World Solar Challenge

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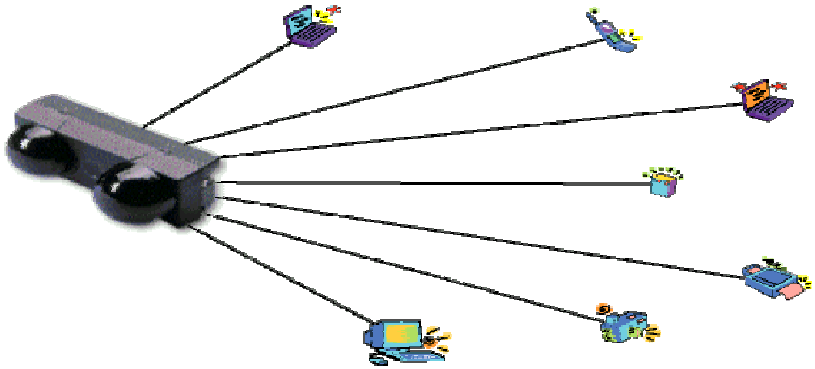
Surviving on Opto Components



NASA/AeroVironment Helios

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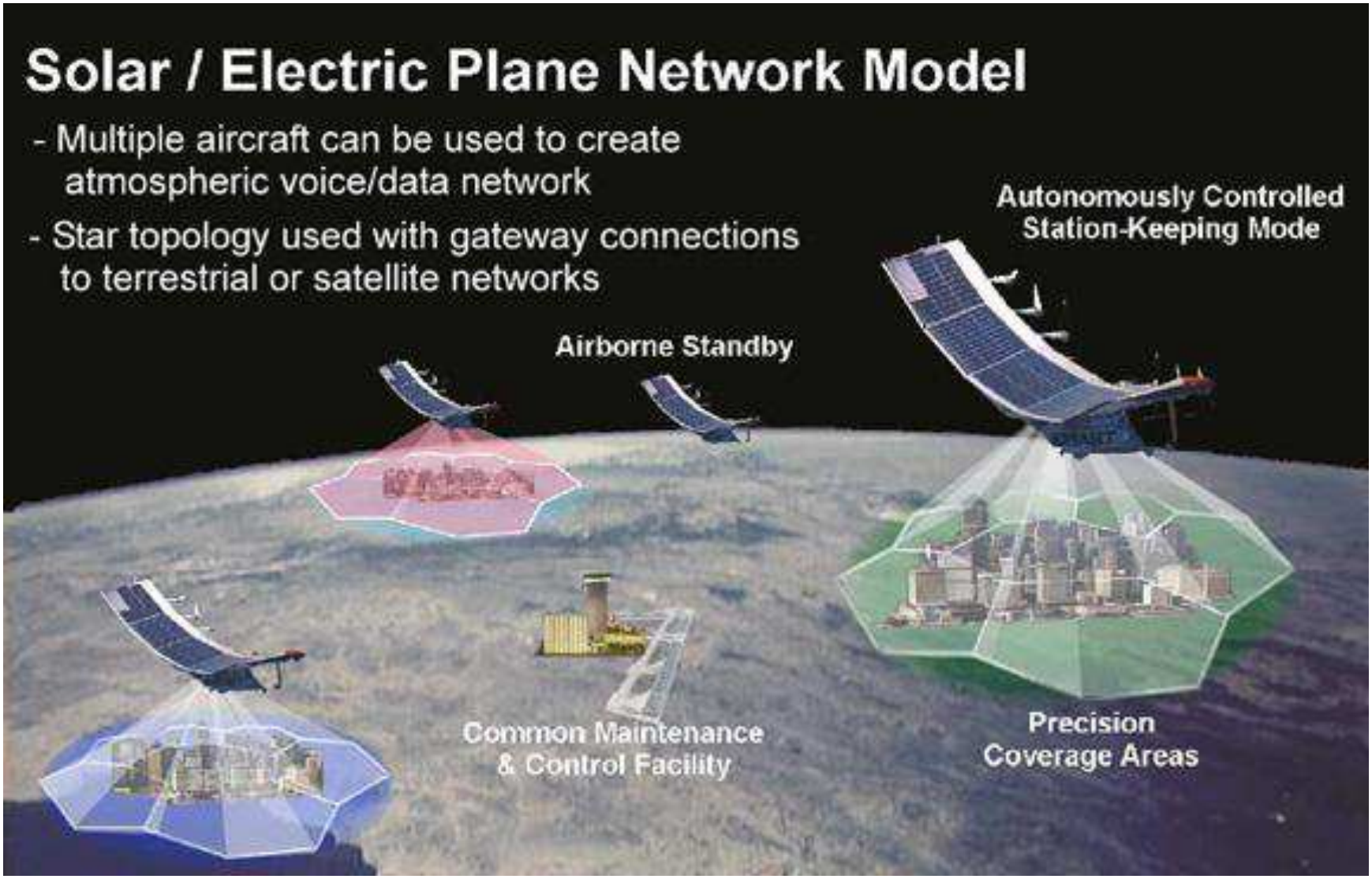
Solar Powered Airplane Communication Platform



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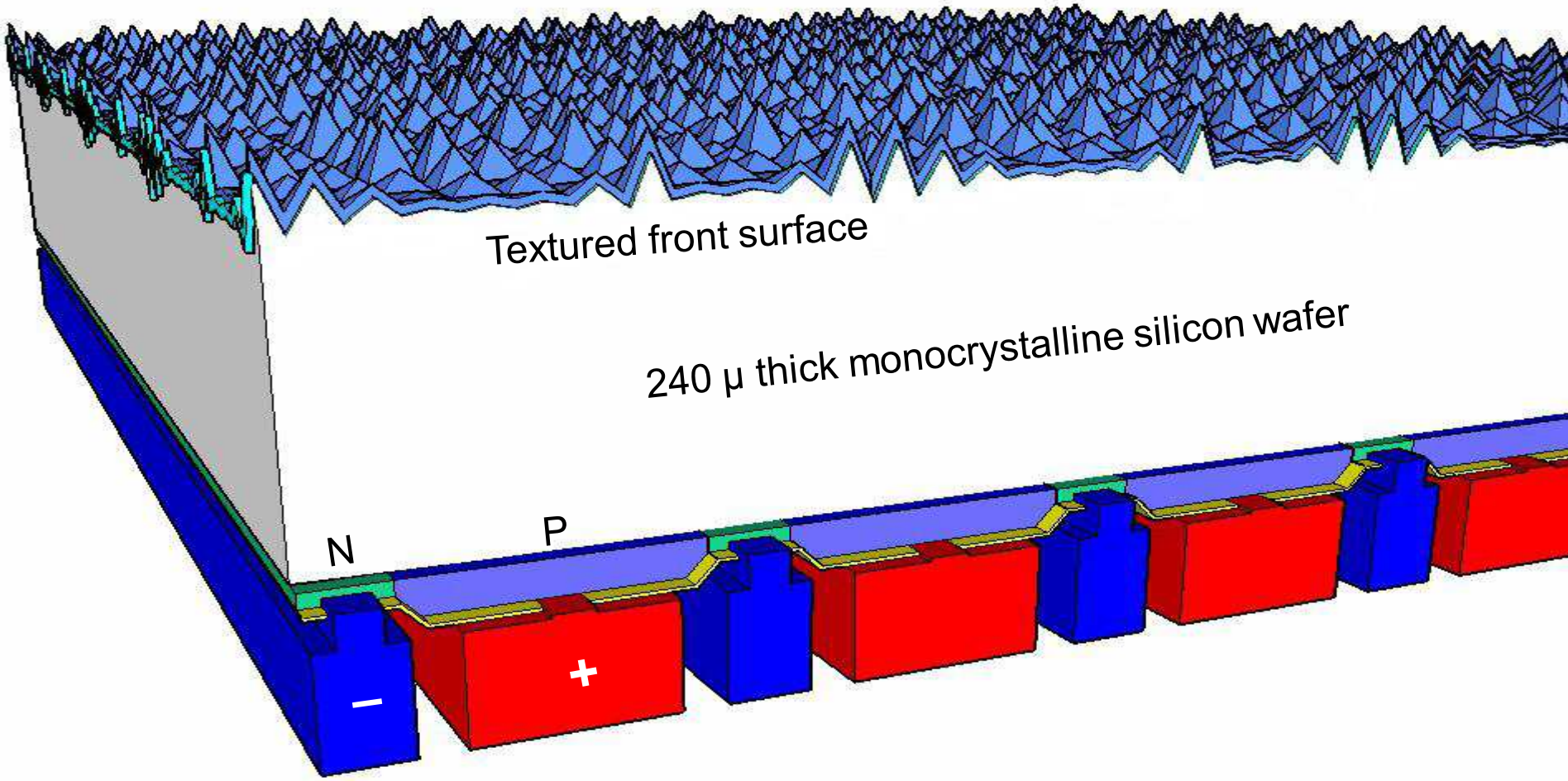
Concentrator Cells for Solar Systems, Pty.

Concentrator Cells for Honda

- Lower Cost
- Higher efficiency
- Higher capacity factor, more kWh/kW
- Easily scalable to the gigawatt level

Fresnel Concentrator System

Project Mercury: Develop a low-cost back-junction cell



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May 1, 2000

Fateful Decision:

Abandon Concentrators and Concentrate on Flat-Plate PV

(Throw away the lens)

Lession: Keep it simple

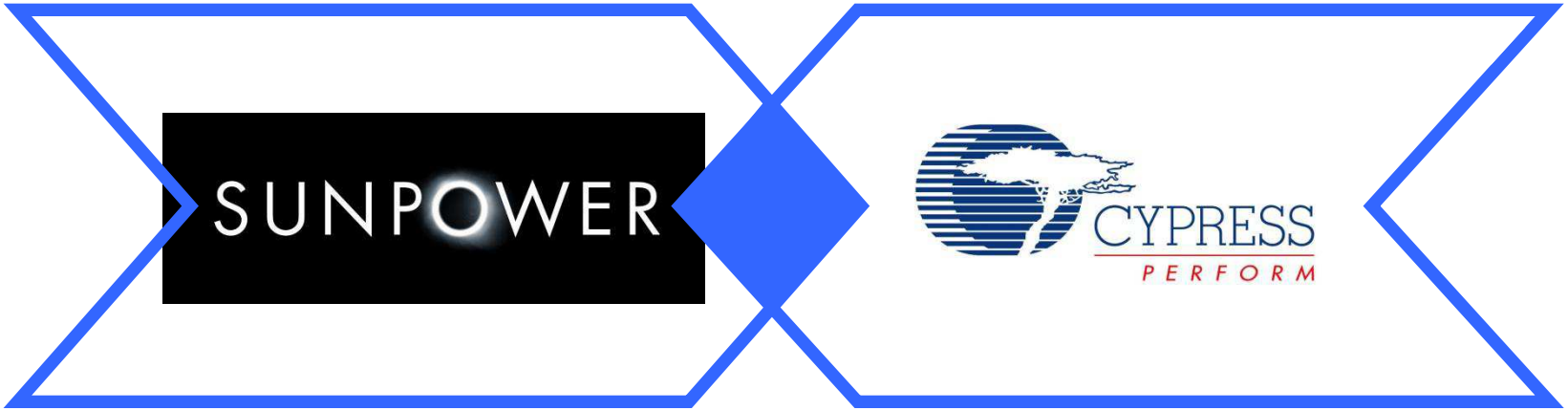
2001 TO 2008

Success

Fundraising 2000

- No VC or investment banks interested in funding SunPower's move to flat-plate cells.
- February, 2001: TJ Rodgers, CEO of Cypress Semiconductor, writes $750,000 personal check to SunPower to keep the company alive
- May, 2002: Cypress buys controlling interest in SunPower
- 2002 to 2005: Cypress invests $150 million to develop cost effective cell process and build manufacturing line-- without knowing if the cell could be manufactured at low cost:
  - high minority carrier lifetime
  - Higher process complexity

Cypress Synergies



Highest efficiency solar cells:

- Strong technical expertise - 15 years of solar cell R&D expertise
- Solar cells and opto-electronics
- World leader in ultra-high efficiency solar cells

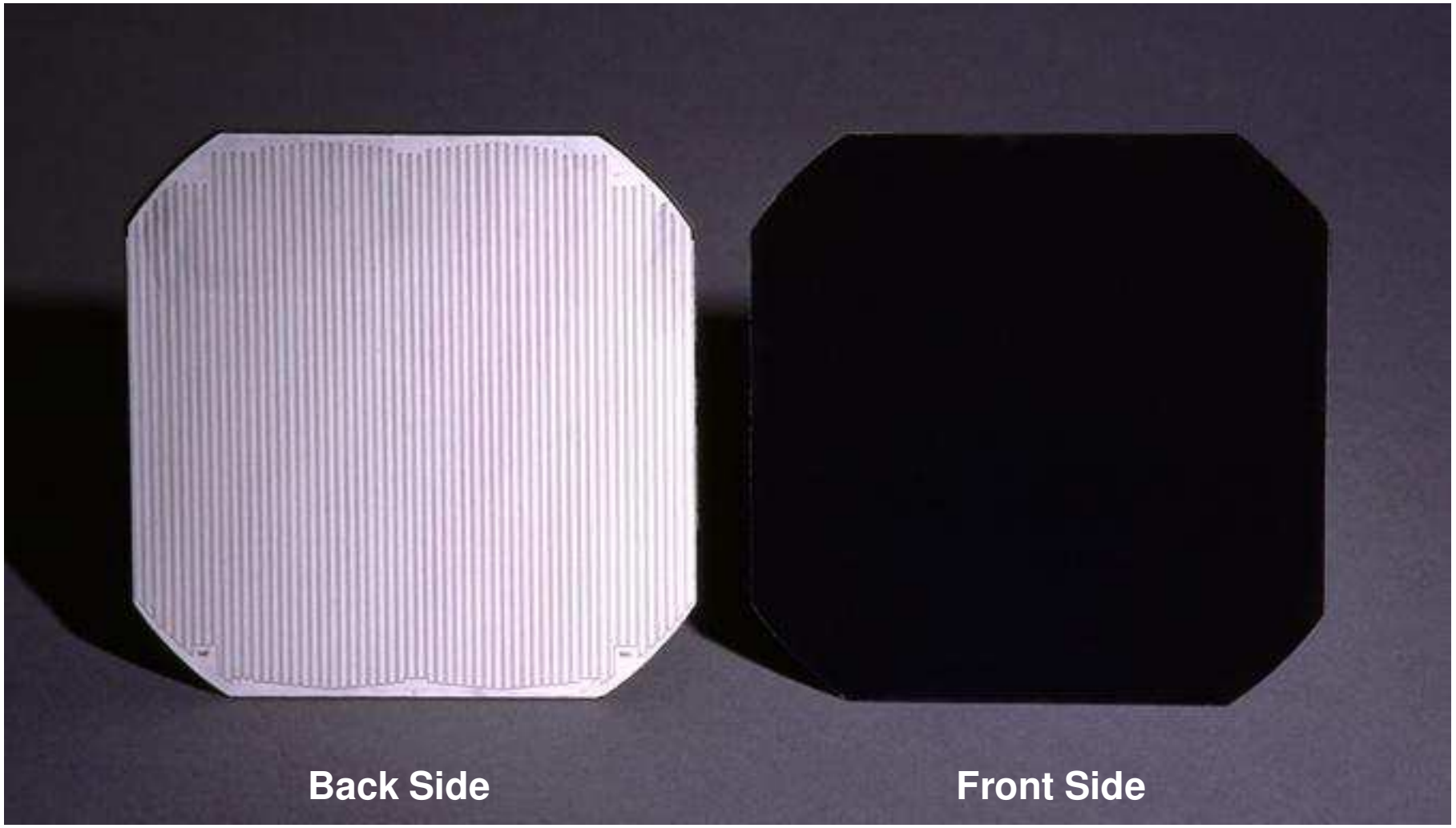
The volume manufacturer:

- Building cost effective products for 20 years
- $1 bn revenue in 2004
- Leading edge, high volume wafer fabs
- Broad portfolio of integrated circuits

2002; SunPower Goes to Texas

A300 Pilot Line

Osaka 2003: Introduced the 20% A-300 Solar Cell



2004; SunPower goes to the Philippines

2005: SunPower goes public

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Pre-trading, every order is for SPWR

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2007 Merger

POWERLIGHT®

SunPower Applications

Residential Retrofit

Power Plants

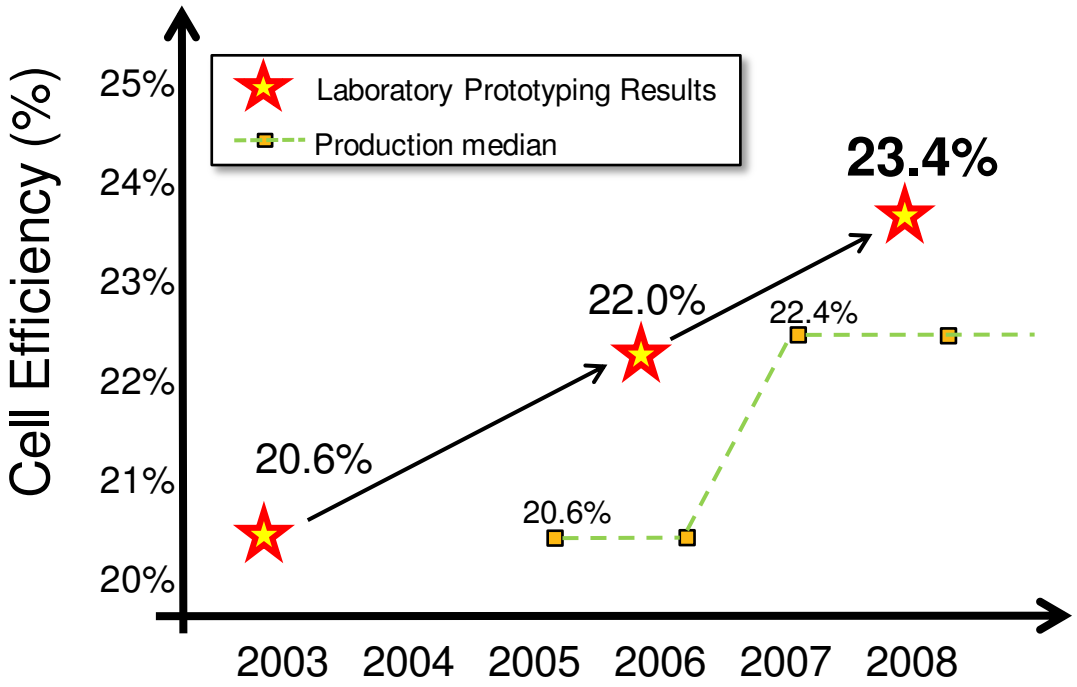
New Production Homes

Commercial & Public

Going forward

- Efficiency up
- Cost down

Breaking News from the Laboratory



23.4%*

Development team with the record solar cell

* Unconfirmed

- Sunpower has steadily improved cell efficiency both in the laboratory and in high scale production since the first all back contact cell prototype in 2003
- The transfer of the >22% Generation 2 product was completed in 2007
- The development team has manufactured a new record device on a 148.58cm^2 full area substrate of 23.4%

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Solaicx Continuous Ingot Growth

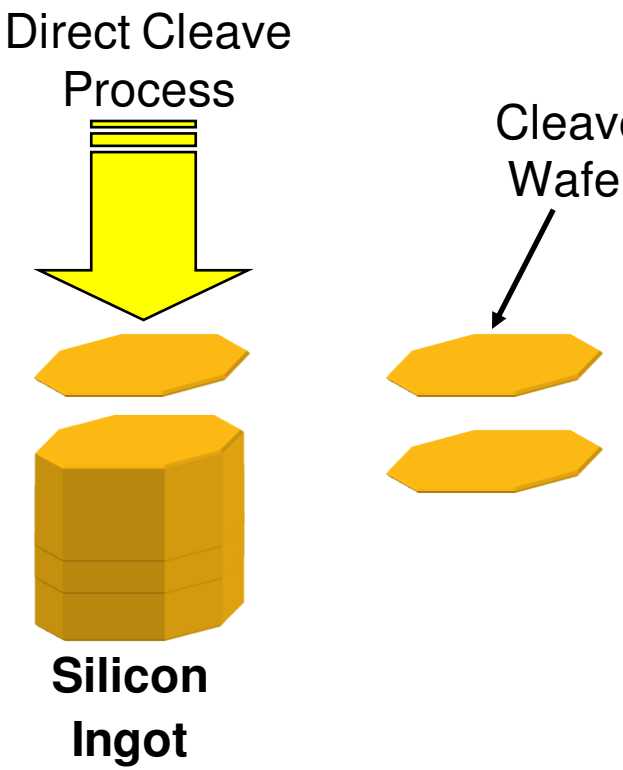
Key Activities:

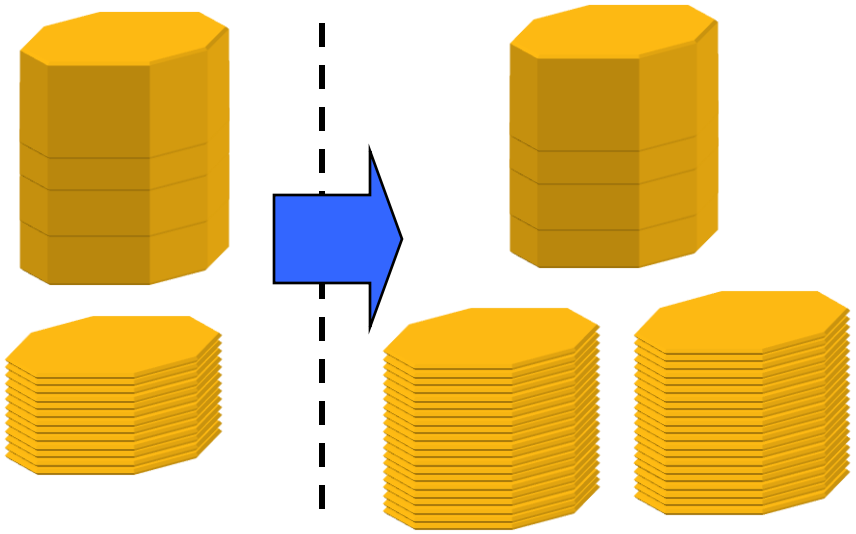
- Continuous Cz ingot growth
- Low-oxygen, high-lifetime material
- Development of hot zone for N-type material
- FBR polysilicon process development and implementation
- Crucible durability

Participants:

Solaicx, Santa Clara, CA

SiGen Direct Cleave Process

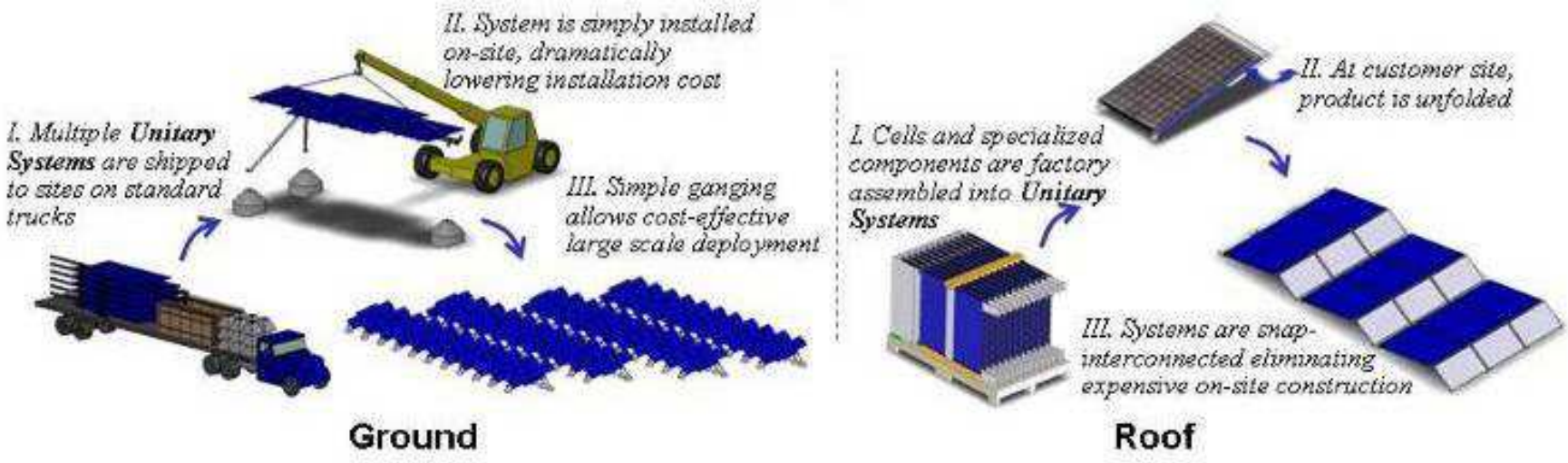




Same material →
2X to 3X more wafers

- c-Si lifetime
- Excellent Edges/Surface
- High strengt

Unitary Products and Systems Reduce Installation Cost



Concept Overview:

- Factory manufactured systems
- Module integrated mounting
- Optimized for automated assembly and rapid deployment

Benefits:

- Lower cost: Leverage standard manufacturing cost reduction practices
- Higher quality: Controlled manufacturing environment
- Scalable: Achieve economies of scale at relatively low volumes; fast installation, more productivity

Factory Assembled Unitary Product Reduces Cost
Tracking improves Energy Delivery

15 MW Plant
Nellis AFB

Installation Rate:
1 MW/day

The Next Big Thing

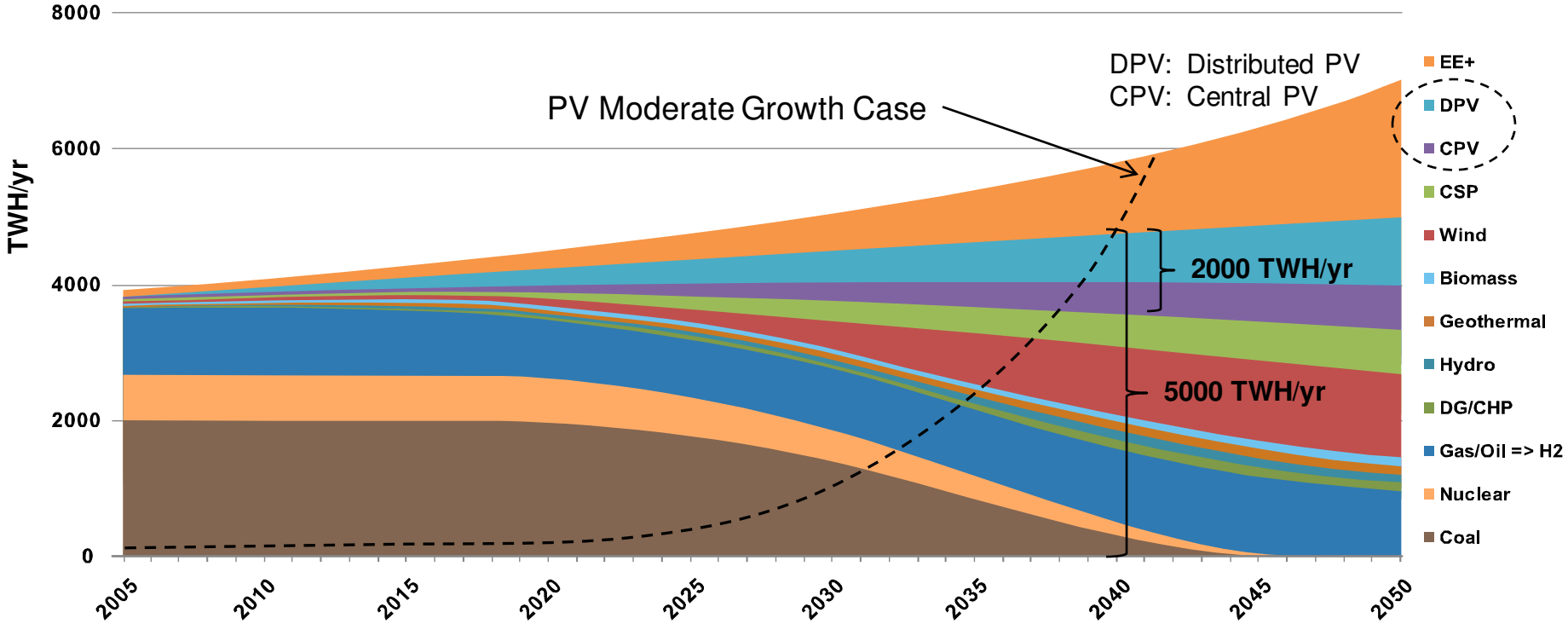
- Large Scale Solar Farms
- PG&E Announces 800 MW of PV Power Purchase Agreements

2050 View

450ppm / 80% CO2 Reductions by 2050

To achieve 80% CO2 reductions by 2050, PV growth needs to be far less than what is possible, given the rise of other renewables and energy efficiency

2040: What is Possible – 5000 TWH/yr PV (Moderate Growth case)
What is Needed – 2000 TWH/yr PV



Sources: McKenzie Report, 2007 for starting points and energy efficiency; AWEA for wind; internal SunPower calculations for DPV, CPV, CSP

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THANK YOU