



Edge-defined film-fed growth silicon (RWE Schott Solar)

PV Manufacturing R&D Project

Welcome to the PV Manufacturing R&D Project— a research and development partnership of the U.S. Department of Energy, National Renewable Energy Laboratory, and Sandia National Laboratories, with members of the U.S. photovoltaic industry.

It is designed to:

- Help U.S. industry improve PV manufacturing processes and equipment
- Accelerate manufacturing cost reductions for PV modules, balance-of-systems components, and integrated systems
- Increase commercial product performance and reliability
- Enhance the investment opportunities for substantially scaling up U.S. manufacturing capacity and increasing U.S. market share.

U.S. Department of Energy • Office of Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Tour of the Display Cases

PV Manufacturing Research & Development Project

The display cases in this hallway give you an historical sweep of the Manufacturing R&D project and the development of PV technologies since the project's inception in 1991. Each case focuses on specific subcontractors' work in the Project, describing the objectives, approaches, and accomplishments, and showing actual samples of products developed. The tour begins with single- and multicrystalline silicon and then moves to thin film technologies. The cases at the end of the hallway cover R&D projects on concentrators, manufacturing support, and systems integration. The two cases in the side hallway describe R&D on balance of systems.

Case	Company	Technology	Year(s)
Modules —Projects that focus on developing better modules of a variety of technologies. Single-crystal Si to very fine-grained Si, with conversion efficiencies decreasing, but manufacturing costs also decreasing.			
1	Shell Solar Industries (formerly Siemens Solar Industries)	Si: single-crystal Cz Si	'91, '92, '94, '98
2	RWE Schott Solar (formerly ASE Americas, Mobil Solar Energy Corp.)	Si: single-crystal EFG Si	'91, '92, '94, '98, '01
3	Evergreen Solar, Inc.	Si: single-crystal ribbon Si	'98, '01
4	BP Solar (formerly BP Solarex, Solarex)	Si: cast polycrystalline Si	'91, '93, '98, '01
5	AstroPower, Inc.	Si: fine crystalline Si	'91, '92, '94, '98, '01
6	Texas Instruments	Si: novel crystalline (spherical) Si	'93
7	Iowa Thin Film Technologies	Thin-film: single-junction a-Si	'94
8	Energy Photovoltaics	Thin-film: multijunction a-Si	'01
9	Energy Conversion Devices	Thin-film: triple-junction a-Si	'91, '92, '98, '01
10	Global Solar Energy (in partnership with ITN Energy, Inc.)	Thin-film: CIGS	'98, '01
11	Shell Solar Industries (formerly Siemens Solar Industries)	Thin-film: CIGS	'01
12	First Solar, LLC. (formerly Solar Cells, Inc.)	Thin-film: CdTe	'91, '93, '98

Case	Company	Technology	Year(s)
Concentrators —Projects that focus on developing better cells and assemblies for concentrator PV systems. Cells are very high efficiency and high cost, but concentrator systems reduce amount of area of cells needed.			
13T	ENTECH, Inc.	Concentrator module	'91, '92
13B	Photovoltaics International	Concentrator module	'94
Manufacturing Support —Projects that focus on feedstock material, assembly, and testing of modules.			
14T	Crystal Systems	Solar-grade Si	'98
14B	STR, Inc. (formerly Springborn Lab, Inc.)	PV encapsulants	'93, '01
15	Spire Corporation	Automated cell assembly	'91, '93, '98, '01
16	Sinton Consulting, Inc.	Monitoring tool for c-Si	'01
Systems Integrators —Projects that focus on putting all the PV components together into a functional system.			
17	PowerLight Corporation	PowerGuard	'98, '01
18T	RWE Schott Solar (formerly Schott Applied Power Corp, Ascension Technology, Inc.)	SunSine	'94, '98, '01
18M	Solar Electric Specialties, Co.	Modular PV system	'94
18B	Solar Design Associates, Inc.	AC PV system	'94
Balance of Systems —Projects that focus on developing better components apart from the modules.			
19	Xantrex Technology, Inc. (formerly Trace Engineering)	Power inverter	'94, '01
20T	Utility Power Group	Solar-tracking subarray	'92, '94, '98
20M	Omnion Power Engineering Corp.	Power conversion	'94, '98
20B	Advanced Energy Systems, Inc.	Inverter	'94



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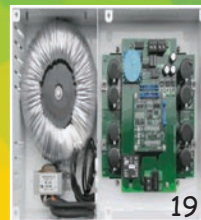
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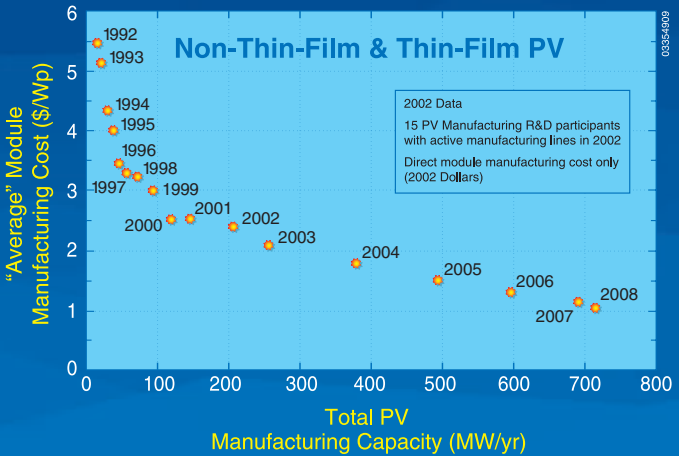


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PV Manufacturing R&D Cost/Capacity



The Photovoltaic Manufacturing R&D Project has existed since 1990, with support from the U.S. Department of Energy (DOE) and the U.S. photovoltaic (PV) industry.

We measure and track the impact of the Project on module cost and production capacity. Our approach is to collect the direct module manufacturing costs and manufacturing capacity—both current and projected—from the Project’s module manufacturing partners.

Through 2002, the graph shows that total module production capacity grew from 13 MW in 1992, at the start of PV Manufacturing R&D subcontracts, to 205 MW in 2002. This represents a 16-fold increase, or a **32% average annual growth in production capacity** among these Project participants.

Direct module manufacturing costs (in 2002 dollars) dropped from \$5.47 per peak watt in 1992 to \$2.42 per peak watt in 2002. This represents a **total cost reduction of about 56%**, or an average annual drop in direct module manufacturing cost of about 8 percent.

From the perspective of technology learning curves, these data reflect **an average 18% drop in direct manufacturing costs for each doubling of production capacity**.



U.S. Department of Energy

Energy Efficiency and Renewable Energy

A Strong Energy Portfolio for a Strong America

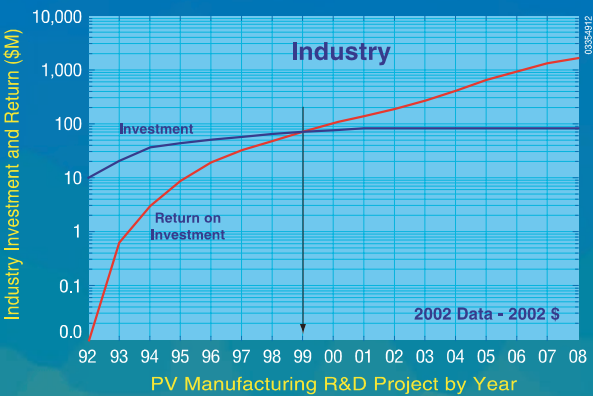
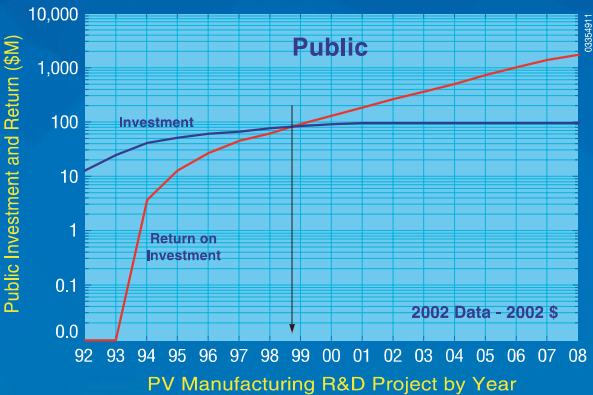
Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America.

Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

Recovering Our Investment in PV Manufacturing R&D

The following analysis is one way to measure the benefits of the PV Manufacturing R&D Project to government, industry, and the public.

Support for the Project has improved PV manufacturing processes and decreased production and product costs. The reduced costs can appear either as **reduced prices to customers** (the public) or as **increased profits to industry**.



The graphs above show the percentage of cumulative “recapture” versus the year of the Project. The curves are based on data from 13 industrial Project subcontractors, some having participated since the beginning of the Project.

At 100% cumulative recapture, the industry and/or public has recovered all funds invested in the Project. The black arrows indicate that the **public recovered its investment by late 1998** and that **industry recaptured the funds it had spent by 1999**. The public recovers its portion of funds spent on research and benefits in the form of price reductions on PV products.

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