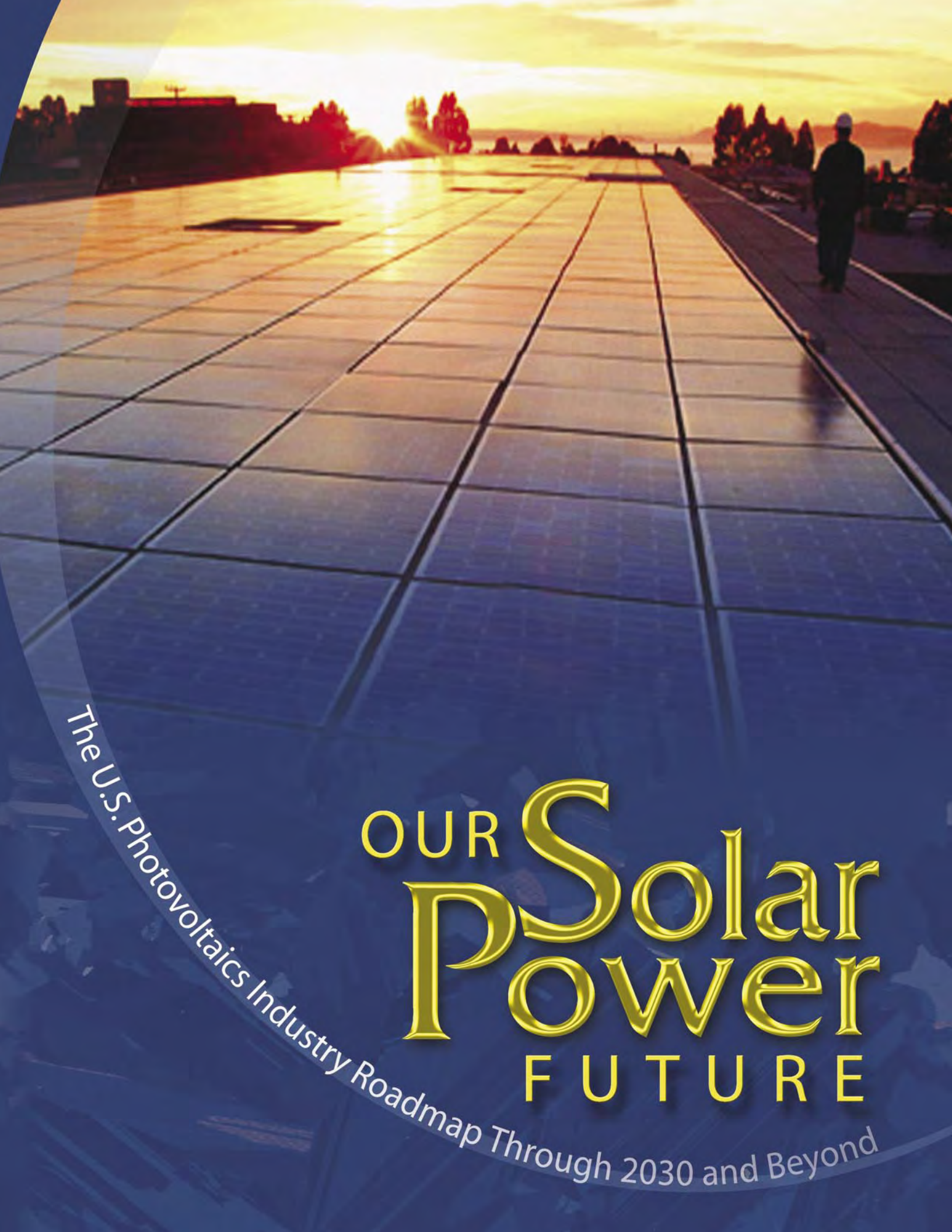


OUR Solar Power FUTURE

The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond

EXECUTIVE summary

The U.S. solar power industry has developed *Our Solar Power Future* as a roadmap through 2030 and beyond. In this document, we briefly discuss the state of solar power today. Next, we look ahead over several decades and set targets for the kind of growth and application of solar power that we think is both possible and vital.

Solar Power Today—World photovoltaic (PV) shipments grew by 32% in 2003, and the industry generated $4.7 billion in revenue. In part, market growth was driven by innovations in both technology and manufacturing that continue to increase efficiency, boost product lifetime and reliability, and make installation easier. As a result, average costs and prices declined

The Goal: Solar provides half of all new U.S. electricity generation by 2025

In 2001, we, the U.S. photovoltaic industry, stated our vision in *Solar Electric Power* as "providing consumers with competitive electricity generation products and services from a thriving, self-sustaining domestic solar power industry." And we laid out a plan to accomplish this vision.

Now, in 2004, we believe our original *Solar Electric Power* roadmap was right. Where investments have been made in technology and market development, the solar power industry has delivered strong growth, has reduced costs, and has improved products—just as predicted.

However, the nations who are proving that these investments truly do lead to the promised benefits are Germany and Japan, not the United States. Their success—coupled with our failure to make similar investments—has resulted in the loss of our competitive edge.

Even our technological advantages through the national laboratories and our R&D investments cannot overcome the amount of capital and experience being generated by the combined strategy of market development and R&D support being advanced by Germany and Japan. And although California is one of the shining stars in the United States regarding solar power growth, its success cannot substitute for a national commitment to market development.

What we are proposing—and have proposed—really does work. And it will deliver the proven benefits of more jobs, a cleaner environment, and more secure domestic energy. A recent analysis of policy options for building solar markets shows that by 2025, half of all new U.S. electricity generation could come from the sun. But this bright future will not happen without solid investment now.

to make solar power more competitive with conventional energy sources, especially as a source of peak power. Unfortunately, the United States has lost its lead in solar power development. In 2003, shipments from U.S. solar power manufacturers fell by over 10% and our overall share of the world market dropped to 14%—the lowest level ever. Meanwhile, shipments from Europe grew by 41% and shipments from Japan grew by 45%. Increasingly, policies in Europe and Japan are driving technology and market development.

Solar Power Tomorrow—The next 10 years are critical for worldwide solar power development. Actions by industry and government will determine whether solar power is catapulted to a new level and whether the United States will regain its position at the forefront of solar power development. Investment decisions over the next decade for research, new manufacturing, and creating new markets will determine where solar power will thrive—and where it will merely survive.

This 7-kW PV awning generates electricity and also provides shading that offsets part of the air-conditioning load. (credit: University of Texas Health Science Center at Houston)

Solar power can provide great value in residential and commercial grid-connected applications, for individual consumers and businesses, as well as for utilities and the communities they serve. Our goals for 2030 are solar power system costs of $2.33 per watt, solar electricity prices of 3.8 cents per kilowatt-hour (kWh) delivered to the customer, installed solar power generation of 200 gigawatts (GW), and direct employment of 260,000 people.

Our Plan for Reaching Tomorrow—For the United States to realize the significant value and economic and employment benefits provided by solar power (see "Solar Power Tomorrow" section for details), we will need sustained, vigorous national leadership in market expansion and research and development (R&D).

Recommended actions for market expansion:

- Enact a residential and commercial tax credit that augments current state and federal support. The first 10 kW installed would receive a 50% tax credit capped at $3 per watt. Any amount above 10 kW would be eligible for a 30% tax credit capped at $2 per watt. Decreasing the caps by 5% per year will encourage a steady decline in prices and ease the transition to a market without tax credits.
- Modify the wind tax credit for solar so that it can be used in concert with the existing 10% investment tax credit.
- Establish uniform net metering and interconnection standards to give solar power owners simple, equitable access to the grid and fair compensation.
- Boost federal government procurement of solar power to $100 million per year to build public-sector markets for solar power.
- Support state public benefit charge programs and other state initiatives to advance solar power and build strategic alliances with public and private organizations to expand solar markets.

Recommended actions for R&D:

- Increase R&D investment to $250 million per year by 2010.

Silent, emission-free solar power brings jobs and energy as easily to a roof in urban Dallas, Texas, as it does to a scenic recreational area in Utah. (credits: top, United Solar Systems Corporation; bottom, Warren Gretz, NREL)

- Strengthen investments in crystalline silicon, thin film, and balance-of-systems components, as well as new system concepts, that are critical to the industry now—reducing the gap between their current cost and performance and their technical potential.
- Support higher-risk, longer-term R&D for all system components that can leapfrog beyond today's technology to new levels of performance and reduce installed system costs.
- Enhance funding for facilities and equipment at centers of excellence, universities, national labs (Sandia National Laboratories and the National Renewable Energy Laboratory)—as well as the Science and Technology Facility at NREL—to shorten by 50% the time between lab discoveries and industry use in manufacturing and products.
- Grow partnerships among industry, universities, and national laboratories to advance PV manufacturing and product technologies.

SOLAR POWER today

The United States is lagging in the competition for solar power's future.

World photovoltaic shipments grew by 32% in 2003, and the industry generated $4.7 billion in revenue. Solar electric systems for homes and businesses dominated the market in the United States, Europe, and Japan as the volume of sales surpassed 740 megawatts (MW). In 2004, the solar power industry expects to surpass the milestone of 1,000 MW of production—enough capacity to power all the households in a city the size of Atlanta, Georgia.

In part, market growth was driven by innovations in both technology and manufacturing that continue to increase efficiency, boost product lifetime and reliability, and make installation easier. As a result, average costs and prices declined to make solar power more competitive with conventional energy sources. Solar electric power has matured into a robust, competitive industry with worldwide markets ready for sustained, rapid growth.

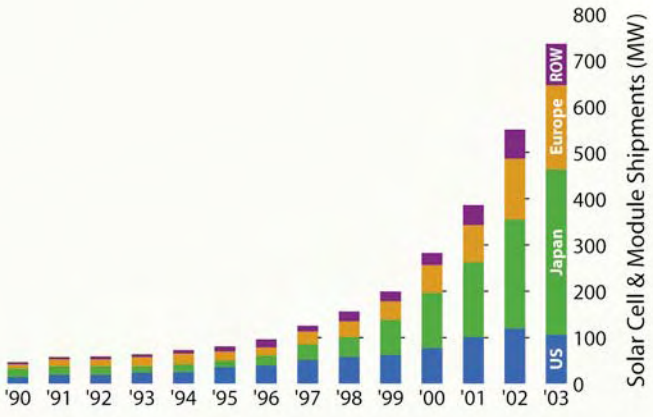
Unfortunately, the United States has lost its lead in solar power development. In 1997, U.S. solar power manufacturers captured 100% of the *domestic* market; in 2003, they captured only 73%. In 1997, U.S. manufacturers captured more than 40% of the *world* market; in 2003, they captured a mere 14%. And after years of growth, shipments in 2003 from U.S. manufacturers fell by more than 10%. Meanwhile, shipments from Europe grew by 41% and shipments from Japan by 45%.

Increasingly, policies in Europe and Japan are driving technology and market development. The U.S. solar industry is compelled to look overseas for markets and to shift critical manufacturing investments away from the United States. Where U.S. solar markets are supported by state policies, a growing share of the installed solar power systems are being imported. And Europe and Japan reap the benefit of manufacturing jobs and local economic development created by solar technology.

"Governor Pataki deserves a tremendous amount of credit for urging Long Island Power Authority (LIPA) to establish its Clean Energy Initiative. … LIPA's Solar Pioneers Program represents the leading edge of an essential change in how we view and use energy. … We want to promote its use here on Long Island to residents and businesses."

– LIPA Chairman Richard Kessel with Gov. George Pataki, February 2002. LIPA is a member of one of the Million Solar Roofs partnerships, a group of 89 organizations that are developing markets for solar energy across the United States.

This solar system, integrated into an awning over the back porch of a residence in California, generates electricity while shading the family's outdoor activities. (credit: GE/AstroPower)



Worldwide solar power shipments in 2003 totaled 744 MW, with the U.S. share at only 14%.

POLICIES MAKING A DIFFERENCE

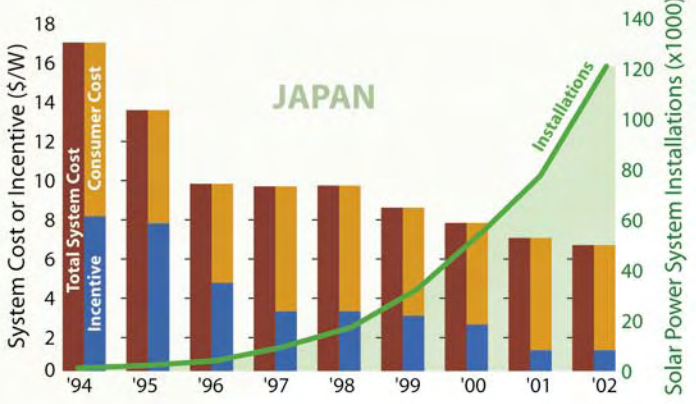
Effective policies sustained over time increase solar power production, dramatically grow markets, improve technology, and reduce costs. Programs in Germany, Japan, and California prove it.

In April 2000, Germany introduced a "feed-in tariff" that offered solar power producers about 50 Euro cents for every kWh fed into the utility grid and guaranteed this price for 20 years. Each year, this guaranteed price is reduced by 5% for new contracts to encourage solar power equipment manufacturers to reduce technology costs. This feed-in tariff, combined with low-cost loans available in the 100,000 Roofs Program, has had a strong, positive impact on Germany's solar power market, expanding it from less than 20 MW per year to 130 MW per year. The long-term commitment of the program attracts investors and gradually creates sustainable solar power markets. The cost is spread over the entire electricity user rate base so that utilities are not negatively impacted and the government does not have to appropriate money annually.

In Japan, nearly all of the recent expansion of the solar power market has been stimulated by the 70,000 Roofs Program. This program, substantially funded by the Japanese government, included an initial 50% cash subsidy for 3- to 4-kW grid-connected residential systems. The program has reduced solar power prices by more than 50% and increased installations from 500 systems to more than 100,000 in just 10 years—while gradually phasing out rebates. The government's investment has fostered internationally competitive mass production.

California set the bar for state solar programs in 1996 when it created a $540 million public benefits fund for renewables. The Emerging Renewables Buy-Down Program oversees a capital subsidy of $3 per watt of installed capacity for solar power systems. Rebate levels are reduced by 20 cents per watt every six months. The California Solar Energy Industries Association (CalSEIA) recently proposed an extension of the program. According to their calculations, the extension would lead to a fully commercial California-based solar power industry serving the global market that would generate $40 billion in sales from 2015 to 2024.

Other states are emulating California's rebates and are experimenting with new programs. Currently, 20 states have government- or utility-sponsored rebates. Another 17 states, including California, have renewable portfolio standards that set goals for increasing supplies of renewable energy. Some, such as Arizona and Nevada, set aside a portion of their portfolio standard for solar power. With a national investment in incentives and programs such as the Million Solar Roofs that augment and encourage state policies like these, our solar industry could succeed like those in Germany and Japan.



Top: *Germany's introduction of the feed-in tariff produced a dramatic jump in installed solar power systems in 2000 and following years.*
Bottom: *Japan's solar power program has reduced solar power system prices by more than 50% and increased the number of installations from 500 systems to more than 100,000 in just 10 years, while gradually phasing out rebates.*

SOLAR POWER tomorrow

The United States wants to attain specific goals for solar power because this technology provides great benefits and value.

The next 10 years are critical for worldwide solar power development. This period will determine which nations reap the economic, environmental, security, and reliability values that solar power offers. Actions by government and industry will determine whether solar power is catapulted to a new level and whether the United States will regain its position at the forefront of solar power development. Investment decisions over the next decade for research, new manufacturing, and creating new markets will determine where solar power will thrive—and where it will merely survive.

OUR TARGETS

At robust growth rates achievable through proven policies for technology and market development, the cumulative capacity of installed solar electric systems in the United States will grow substantially from less than 0.4 GW in 2003 to 200 GW by 2030. For an approximate comparison, a large nuclear power plant is 1,000 MW (1 GW) and is equivalent to about 5 GW of solar power.

In the short term, the annual growth in U.S. solar generation capacity is projected to track growth in worldwide solar power equipment sales, at over 35%. This rate is more aggressive than the original solar power roadmap, based on five years of experience that have demonstrated that greater than 30% annual industry growth rates are practical.

Another major change from the previous roadmap is the amount of U.S. production that is exported. Based on recent experience, manufacturing will likely be moved abroad to serve promising markets in other countries. Exports will likely remain flat, showing little growth. Most U.S. solar power equipment will remain in the United States, and domestic demand will fuel industry growth—if the United States invests in technology and market development programs. By 2020, the U.S. industry should install nearly all of its output—7.2 GW_p per year—in the United States.

After 2015, growth rates will moderate to 26% annually until 2020, as technology and markets mature. Annual growth rates will decline to a

"[The Million Solar Energy Systems on California Homes] proposal is about smart, innovative and environmentally friendly technologies that will help improve the state's ability to meet peak electricity demand while cutting energy costs for homeowners for years to come. Once implemented, it will establish California as a world leader in solar technology."

— Gov. Arnold Schwarzenegger

30,000 ft^2 of PV panels atop the Moscone Convention Center in San Francisco, CA, highlight PV's value as an urban electricity source—easy to site even in areas with limited and expensive real estate, air quality restrictions, and high architectural and aesthetic standards. This is the first project resulting from voter-backed initiatives to finance renewable energy in the city's commercial, residential, and government-owned buildings. The 675-kW system will provide a significant reduction in energy expenses. (credit: PowerLight Corp.)

sustainable 1% to 2% annual increase in 2030—the classic S-shaped market penetration curve for new technologies. By 2030, the industry is targeting cumulative installed solar capacity of 200 GW, and the industry will install 19 GW per year. At that point, solar power will be a substantial share of U.S. peak generating capacity and a major source of electricity.

As soon as 2015, the system selling price is projected at $3.68 per watt if the policies recommended in our plan are implemented. With incentives, the cost of solar electricity will be as low as 5.7 cents per kWh—a level that is lower than current retail rates for many consumers.

In the table below, the Roadmap case summarizes our projection of solar power's future contribution to the United States if the national investments we recommend are enacted and added to continued state support for solar power. The results are expressed in terms of new power capacity; competitive, reliable power for consumers; and thousands of new jobs in manufacturing, installing, building, operating, and maintaining solar power equipment in every state. The Baseline case projects slow growth based on currently available tax credits and accelerated depreciation for systems owned by businesses, with no incentives for homeowners and no investment by states.

Table of Targets and Projections for Solar Power for 2004 to 2050

		2004	2010	2015	2020	2030	2050
System Price and Electricity Cost, Commercial Systems							
Best System Selling Price [a] ($/W)	Baseline	6.10	4.87	4.24	3.76	3.12	2.56
	Roadmap	6.10	4.65	3.68	3.01	2.33	1.93
Electricity Cost [b] (¢/kWh)	Baseline	18.2	13.4	11.5	10.0	8.2	6.8
	Roadmap	10.5	7.4	5.7	4.6	3.8	3.7
U.S. Solar Power Shipments, Installations, and Employment							
Annual U.S. Shipments (MW peak)	Baseline	120	240	480	950	2,400	5,500
	Roadmap	120	510	2,300	7,200	19,000	31,000
Cumulative U.S. Installations (MW peak)	Baseline	340	1,500	3,800	8,200	28,000	100,000
	Roadmap	340	2,100	9,600	36,000	200,000	670,000
Employment [c]	Baseline	20,000	23,000	28,000	37,000	59,000	95,000
	Roadmap	20,000	29,000	62,000	130,000	260,000	350,000
Performance Advances [d]							
Conversion Efficiency (%)	Cell	10–20	15–25	19–28	20–35	22–40+	Ultra-High Efficiency > 40
	Module	8–15	12–17	16–20	18–24	20–30	Ultra-Low Cost > 15
	System	6–12	9–14	13–18	14–20	18–25	

[a] *Year 2004 system selling price represents the price of the 10 lowest-cost commercial systems sold in 2003. Out-year prices calculated using a 90% experience curve, with values rounded to the nearest cent.*

[b] *Customer-side-of-the-meter costs for commercial customers. Residential costs (not shown) are about 50% greater in the Baseline case, and approach parity with commercial costs in the Roadmap case. Baseline case cost calculation assumptions: federal 10% investment tax credit; accelerated depreciation; 7% real discount rate; operation and maintenance (O&M) cost per inverter manufacturers' recommendations. Roadmap Case assumptions: 50% tax credit capped at $3 per watt for the first 10 kW; 30% tax credit capped at $2 per watt for any amount above 10 kW. Caps decrease by 5% per year; federal 10% investment tax credit (basis is after the tax credit reductions); 7.5% state tax credit; 5.8% state depreciation value; 7% real discount rate.*

[c] *Manufacturing, installation, and construction employment are based on how much solar power equipment is manufactured and installed each year. Operation and maintenance employment is based on the total installed capacity of solar equipment that requires O&M in a year. Employment per MW will decline over time as productivity increases. For this analysis, employment per MW was decreased at the same rate as costs are projected to decline. Employment starts at today's current estimate of 20,000. Job creation estimates are only applied to growth.*

[d] *System lifetimes will increase from 25 years today to 30 years by 2010.*

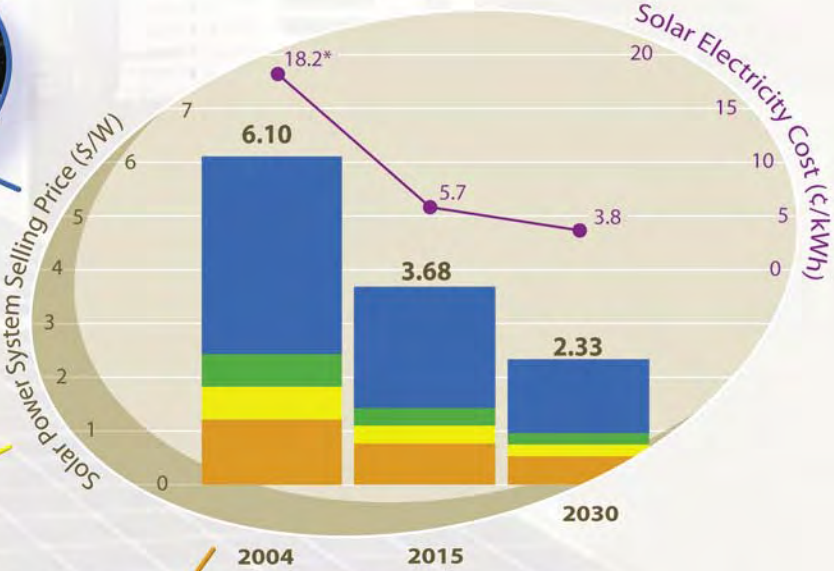
The Goal: Solar provides half of all new U.S. electricity generation by 2025.

As costs decline, solar power in more applications—and

Cost Reduction

Reclaiming Market Leadership will increase solar power sales volumes to more than 7 GW per year in 2020. To do this, the United States must:

- Enact a residential and commercial tax credit that augments current state and federal support. The first 10 kW installed would receive a 50% tax credit capped at $3 per watt. Any amount above 10 kW would be eligible for a 30% tax credit capped at $2 per watt. Decreasing the caps by 5% per year will encourage a steady decline in prices and ease the transition to a market without tax credits.
- Establish uniform net metering and interconnection standards to give solar power owners simple, equitable access to the grid and fair compensation.
- Boost federal government procurement of solar power to $100 million per year, especially in applications that enhance security. State and federal governments are an important market for solar electric systems—the federal government alone consumes more than 54 billion kWh of electricity a year.
- Support state and local efforts to advance solar power by designing federal policies and strengthening deployment programs to leverage existing state programs.

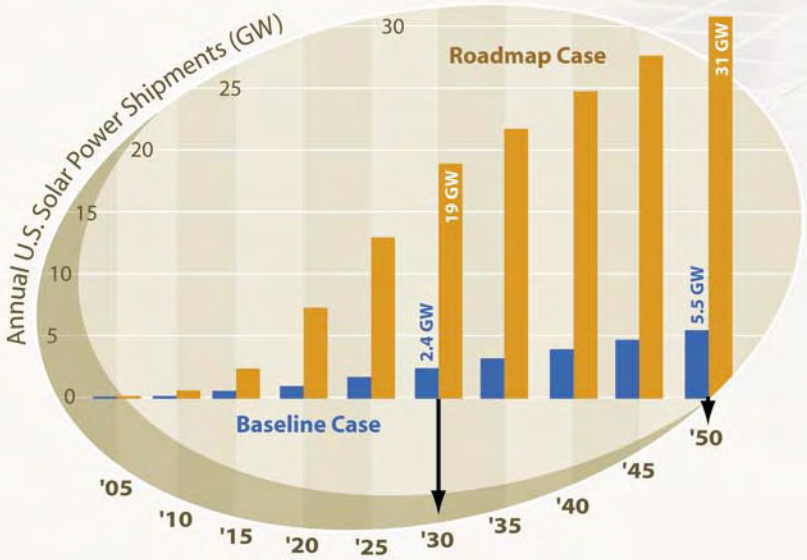


Roadmap case for grid-connected solar system with 30-year lifetime (customer side of meter).

**2004 solar electricity cost is based on present federal policies for a commercial system, investment tax credit, and accelerated depreciation.*

For

is competitive
sales volume increases.



Comparison of annual U.S. solar power shipments under the Baseline and Roadmap cases. Shipments in 2030 and 2050 are 2.4 and 5.5 GW for the Baseline case and 19 and 31 GW for the Roadmap case.

The United States benefits from solar power's success:

- Predictable electricity costs, lower-cost peak power, and less costly distribution expansion.
- Reliable power, improved power quality, and a more stable power grid in the future.
- More American jobs and economic development.
- Abundant, secure domestic energy.
- Less smog, less water used to generate electricity, and lower greenhouse gas emissions.

Maintaining Technology Ownership will reduce solar power costs and make it more competitive by increasing research investments to $250 million per year by 2010.

- Invest in research for crystalline silicon, thin films, and balance-of-systems components that are critical to the industry now—reducing the gap between their current cost and performance and their technical potential.
- Support higher-risk, longer-term R&D for all system components that can leapfrog beyond today's technology to new levels of performance and reduce installed system costs.
- Enhance funding for facilities and equipment at centers of excellence, universities, Sandia, and the Science and Technology Facility at NREL to shorten by 50% the time between lab discoveries and industry use in manufacturing and products.
- Sustain partnerships among industry, universities, and national laboratories to advance PV manufacturing and product technologies.

Market Expansion

every doubling in solar power sales volume, costs decline by at least 10%.

SOLAR POWER'S VALUE IN KEY MARKETS

Japan has installed more than 750 MW of grid-connected systems on homes and businesses in the past decade. In Germany, the 100,000 Rooftop program has resulted in more than 400 MW of installations. And in the United States, about 340 MW of off-grid and grid-connected systems have been installed, with the most rapid growth occurring in the last two years. Solar electricity has transitioned strongly from the remote applications that once dominated sales to generating high-value peaking power for homes and businesses on the grid. The transformation is being driven by strong policies that support the development of solar markets, and by the value that solar electricity delivers to consumers. Progressive municipal utilities, public power companies, and investor-owned utilities around the country are working with state and local governments to promote solar power because it helps their businesses and benefits the communities they serve. Consider the following value offered by solar power.

Predictable Electricity Costs—The fuel for solar systems—light from the sun—is free. Because of this, a solar power system can reliably produce electricity at the same cost for more than 30 years. Contrast the stable costs of solar power with volatile electricity prices experienced by homeowners and businesses recently, caused by natural gas supply problems and power market disruptions.

Easy to Site—Solar power is one of the few generating options that works well almost anywhere—in crowded urban centers like Times Square, a suburban housing development, or a rural farmhouse. On-site solar power has no moving parts, requires no water, has no emissions, and can be integrated into a building structure where it is hardly noticed. These characteristics are ideal for a power source that delivers electricity where it is most valuable—at the point of use.

Reliable Power—The U.S. economy increasingly requires reliable electricity. A solar power system integrated with energy storage can provide backup power during even the worst power outages.

4 Times Square, a 48-story skyscraper in New York City, features a thin-film solar power curtain wall extending from the 35th to the 48th floors on the south and east walls, which replaces traditional glass cladding material. (credit: Andrew Gordon Photography, Fox & Fowle Architects, Energy Photovoltaics)

More American Jobs—Every megawatt of solar power currently supports 32 jobs, with 8 of these jobs in system design, distribution, installation, and service created where the systems are installed. This allows communities that choose solar to reap significant employment benefits along with clean electricity, rather than having their electricity purchases create jobs elsewhere. And because solar can be installed in all 50 states, it can create jobs in all 50 states.

Abundant, Secure Domestic Energy—Every day, the sun shines—for free—on the United States, even as imports of natural gas rise and prices hit record levels. Solar collectors on a 100-by-100-mile area in the Southwest could generate as much electricity as the United States consumes in a year. Alternatively, solar systems on roofs, parking lots, and other developed land across the nation could generate all the electricity we need—now, in 2030, and 2050—without building on the nation's open spaces. At the same time, decentralized

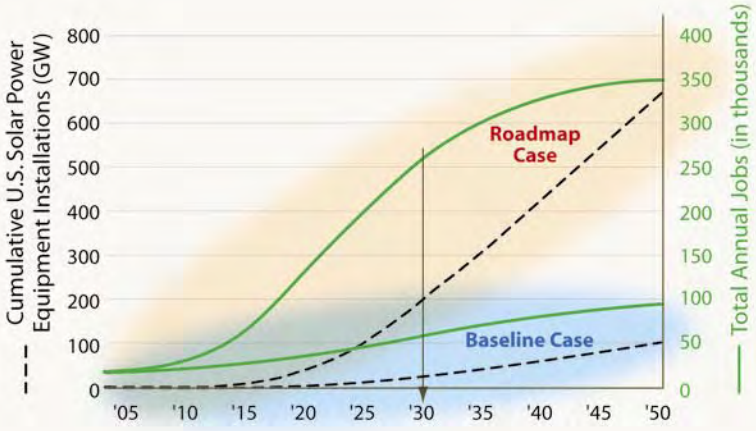
solar power will reduce the vulnerability of our electric system to attack or natural disaster.

Boost to Economic Development—The manufacture and installation of solar systems can provide substantial federal, state, and local tax revenues, and contribute to economic development.

Lower Cost for Peak Power—Solar power generation peaks when demand for electricity peaks—on hot summer afternoons when utilities have trouble meeting demand for air conditioning. During summer peaks when transmission is constrained and utilities are using their most expensive generation (natural gas), solar can substantially increase operating margins and decrease prices.

Greater Grid Stability—Whether in a crowded downtown or a suburban neighborhood, solar power can be sited on customers' roofs to help lower peak demand and avoid expensive upgrades to substations or replacement of buried power lines. In the future, thousands of solar power systems distributed throughout the electrical grid will reduce vulnerability to equipment failures. At a critical moment, thousands of small solar systems are less likely to fail than a single large power plant, transmission line, or transformer.

Less Air Pollution—Solar power produces no on-site air pollution, reducing or avoiding emissions from other sources of generation that increase health care costs and harm the environment. Solar power is even welcome in Los Angeles, where other new power sources are impossible to site because of air quality, noise, or lack of space.



Under the Roadmap case, direct employment in the solar power industry is projected to reach 260,000 jobs by 2030 and 350,000 by 2050. The Baseline case would only reach 59,000 and 95,000 in 2030 and 2050, respectively.

Lower Greenhouse Gas Emissions—Every residential PV system reduces greenhouse gas emissions as much as removing one car from the road.

Lower Water Consumption—Solar power uses 98% less water per MWh generated than the most efficient natural gas generation.

The Sun Shines in Every Community and Congressional District

Modest solar resource—A typical home in Maine needs 291 ft^2 of roof space to meet one-half of its typical electricity needs—only 25% more roof space than needed in sunny Los Angeles.

Outstanding solar resource—A typical home in Los Angeles needs 234 ft^2 of roof space to meet one-half of its typical electricity needs—using a solar power system with a conservative 12% conversion efficiency.

SOLAR POWER

We have a plan that we must actively support and put into action if the United States is to attain its goals for solar power.

our plan to reach tomorrow

In *Our Solar Power Future*, we propose a roadmap that tailors R&D programs to create market solutions, enhances pollution prevention approaches to focus on clean alternatives, ensures customer choice, and provides targeted incentives that seed the market without distorting it. Based on experience in the United States, Japan, and Europe, the actions we propose represent the best and most effective options to achieve these targets. Experience, new analyses, and information also lead to new projections of how the U.S. solar power industry will grow over the coming decades.

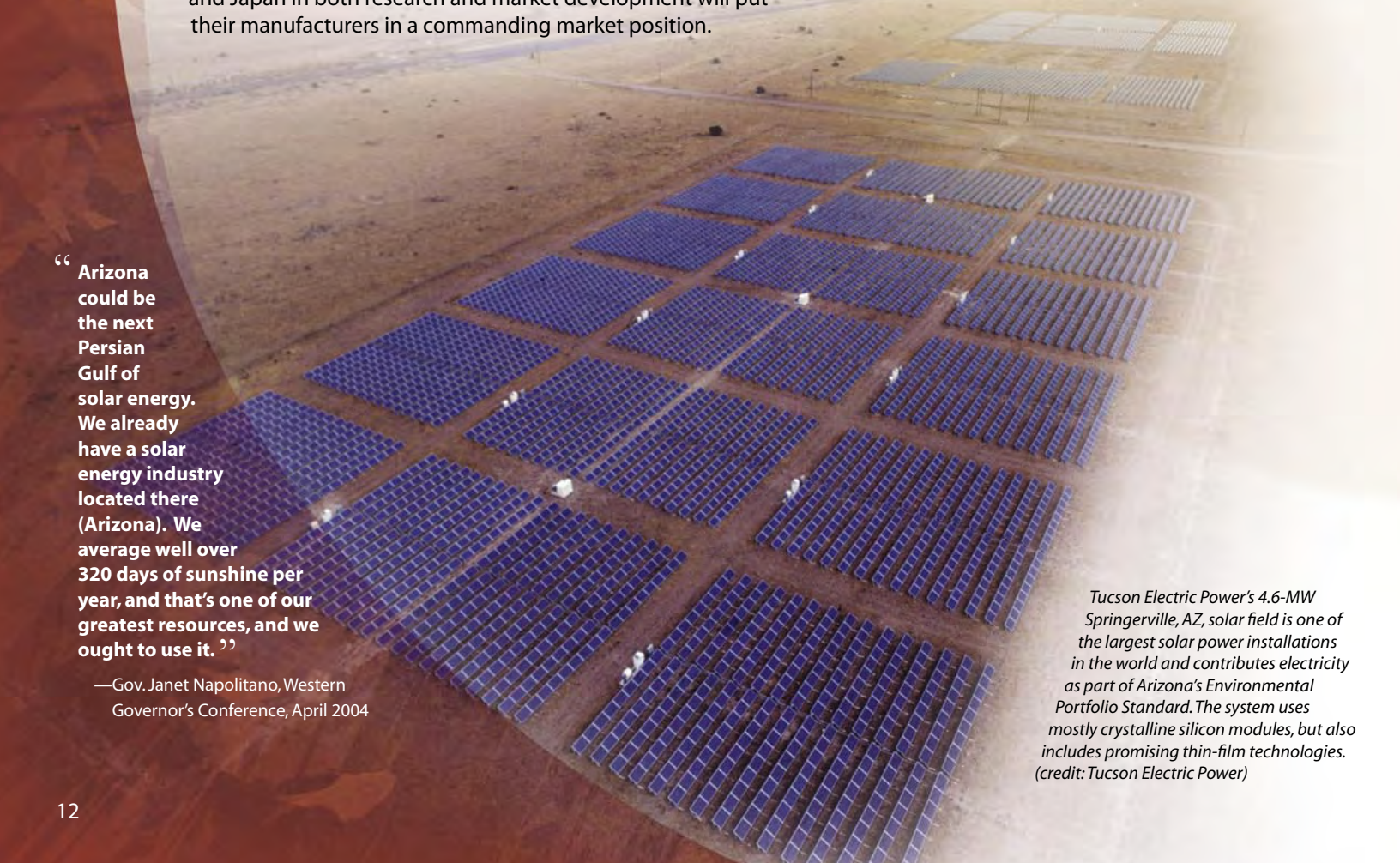
Our projections start with where we are today—with a worldwide industry growing at greater than 30% annually, but increasingly dominated by German and Japanese technology and market development. If the United States continues at current levels of state and federal investment in research and market development, then we will continue to contribute to the growth of world markets, but will import an increasing share of the systems installed here. Investments by Germany and Japan in both research and market development will put their manufacturers in a commanding market position.

However, with robust investments in research and market development, the picture changes dramatically. We would expect growth in shipments in the United States to accelerate from 30% to 38% per year by 2010, then moderate to 26% by 2020 as PV technology and markets mature rapidly. By 2020, total installed PV capacity in the United States could reach 36 GW—a level not expected from the Baseline case until after 2034.

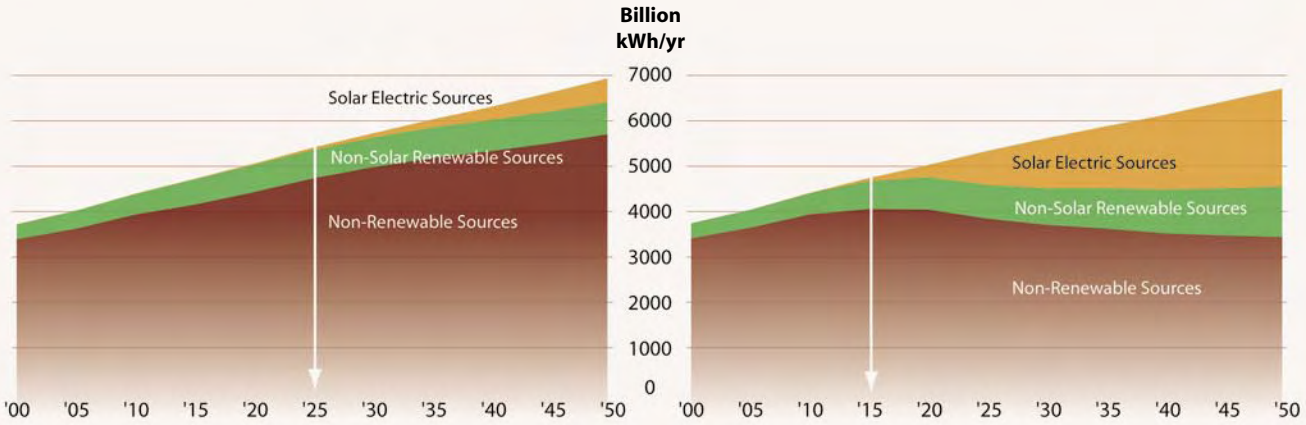
These growth rates sound ambitious, but they are consistent with what is happening today and with experts' assessments of solar power's potential. Solar power companies involved in cost-shared research with the U.S. Department of Energy have reported an 82% "experience curve" in reducing module costs—that is, for every doubling of production, costs decline by 18%. For this roadmap, we assume a 90% experience curve for solar power systems. Expanded support for R&D offers

"Arizona could be the next Persian Gulf of solar energy. We already have a solar energy industry located there (Arizona). We average well over 320 days of sunshine per year, and that's one of our greatest resources, and we ought to use it."

—Gov. Janet Napolitano, Western Governor's Conference, April 2004



Tucson Electric Power's 4.6-MW Springerville, AZ, solar field is one of the largest solar power installations in the world and contributes electricity as part of Arizona's Environmental Portfolio Standard. The system uses mostly crystalline silicon modules, but also includes promising thin-film technologies. (credit: Tucson Electric Power)



In an analysis performed by the National Renewable Energy Laboratory, generation of electricity (in billion kWh/yr) is shown from 2000 to 2050 under the Baseline scenario (left) and Aggressive Policies scenario (right). Generation is broken out for solar electric, non-solar renewable, and non-renewable sources.

considerable opportunities to accelerate cost declines beyond this conservative assumption.

Decreased costs open up new market opportunities, which, in turn, expand solar power shipments and help further reduce costs. Solar power once cost hundreds of dollars per kWh for a few watts of power for satellites. This year, solar power will add 1,000 MW to worldwide generation, cost U.S. commercial customers about 18 cents per kWh, and compete with conventional peaking power for some customers.

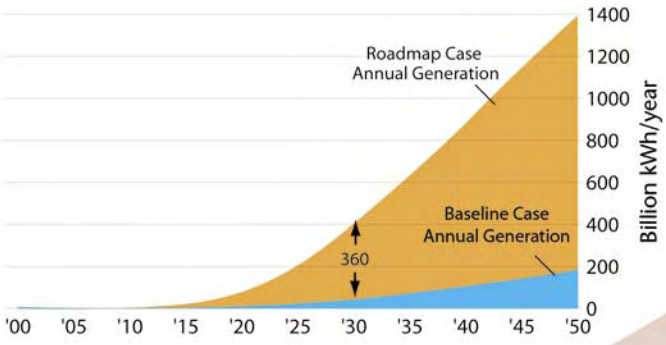
The experience curve is to solar power what Moore's law is to the semiconductor industry—a guide to the industry's long-term potential. And just as with Moore's law, there will be limits to how far the cycle of market expansion, cost reduction, and performance improvement can extend. But all indications are that solar power is still in the early stages of exploiting its potential. Scientists worldwide agree that solar power technologies can become significantly more efficient, more reliable, more durable, and less expensive, as reflected in research plans and technology goals set for their R&D programs.

In technology areas such as plastic solar cells, nanostructured materials, and dye-sensitized solar cells, scientists see the potential to leapfrog far beyond current crystalline silicon and thin films, to dramatically lower cost and raise performance. Ultimately, the potential for cost reduction through both learning and R&D advances is what justifies the robust investments in research and market development called for in our plan, assuring that the dollars will truly be temporary investments, not permanent subsidies.

Our projection of what is possible aligns with other studies using integrated models to investigate possible levels of market penetration for solar power. The two sets of curves above show the results of an analysis by the National Renewable Energy Laboratory (NREL), using a version of the Department of Energy's National Energy Modeling System adapted to investigate solar technologies and potential incentives.

The third chart, to the right, shows solar electricity only and highlights our Baseline and Roadmap case projections developed for this document. The Baseline case projection shows slightly lower early growth than in the NREL analysis, but significantly less growth over time. NREL's Aggressive Policies scenario and our Roadmap case are comparable, although again, our projection assumes slower growth and less total solar energy generation by 2050. Importantly, the two analyses agree that robust investment in research and market development policies today can accelerate the market penetration curve for solar power by more than 10 years. Solar technologies can be a large contributor to U.S. electricity generation much earlier—360 billion kWh more in our Roadmap case by 2030, and about 1,000 billion kWh more in NREL's Aggressive Policies scenario. For comparison, the European Renewable Energy Council projects that by 2040, solar power could be the largest source of renewable energy electricity generation, supplying over one-quarter of worldwide electricity consumption.

With the investments we propose for innovation and market development, solar power can become a major source of electricity—secure, peak-shaving, carbon-free, emission-free, water-saving electricity. Our industry spans the spectrum from Fortune 100 companies to small research ventures. But whatever the size, they are run by entrepreneurs, engineers, scientists, and business people who understand the power of innovation. We are simply asking for the investments in innovation needed to make solar power the technology that helps solve our nation's energy problems sooner, rather than later.



Roadmap projections of solar electricity generation (in billion kWh/yr) from 2000 to 2050 for the Baseline and Roadmap cases. For the Roadmap case, annual solar electricity generation in 2030 is 360 billion kWh—the amount of electricity consumed by 34 million households.

RECLAIMING MARKET LEADERSHIP

Since 1994, Japan has offered major rebates to make solar power cost effective for consumers, despite the worst downturn in its economy since World War II. Here at home, California has been successfully using rebates to build a solar power market since 1997. Despite facing a record state budget deficit, California's new governor, Arnold Schwarzenegger, reasserted the solar rebate program and proposed ambitious goals for installing solar power on new homes. In response, the solar power industry has increased manufacturing, created jobs, and lowered costs to consumers. In the most promising solar markets, the key to success is sustained, strategic leadership to mobilize the public's support for solar power. Policies do exist that have been proven effective for advancing solar power. What we need is sustained national leadership to take the following actions.

Create Incentives for Market Leadership—The United States could ignite explosive, continued growth in the solar industry by enacting tax credits for residential and commercial installations that augment current state and federal support. The first 10 kW installed would receive a 50% tax credit capped at $3 per watt. Any amount above 10 kW would be eligible for a 30% tax credit capped at $2 per watt. Decreasing the caps by 5% per year will encourage a steady decline in prices and ease the transition to a market without tax credits.

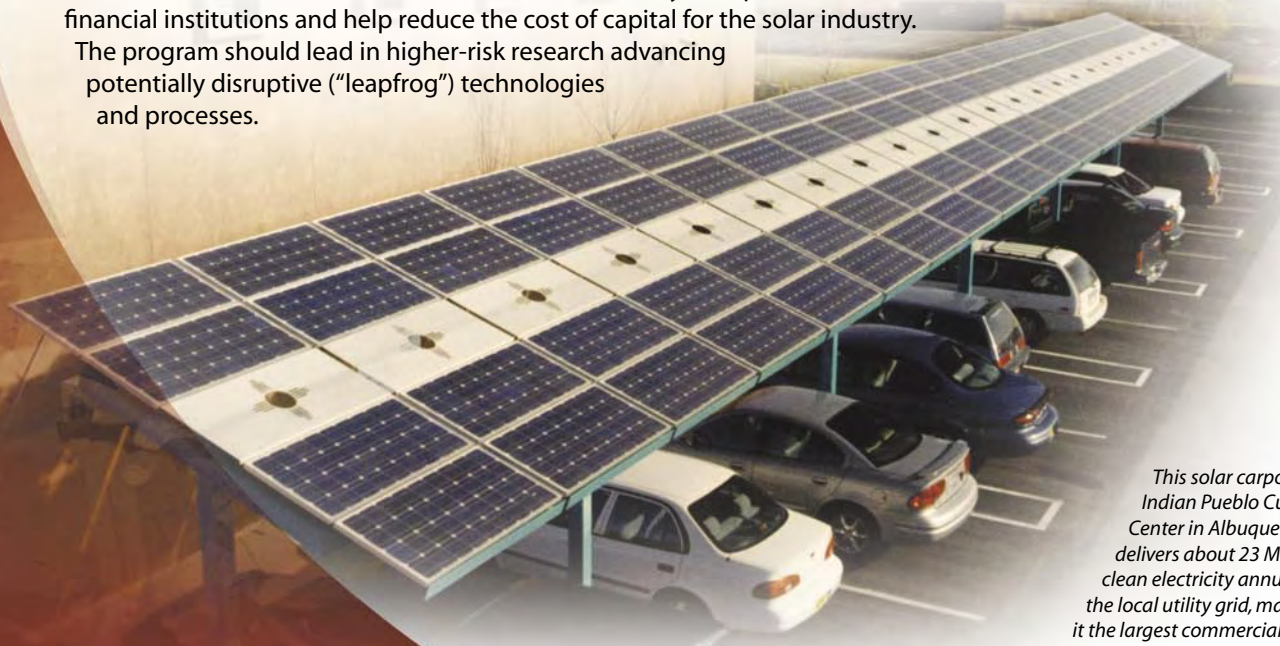
The wind production tax credit for solar power should also be expanded in a manner that allows it to be used in combination with the existing 10% tax credit for businesses that install solar power equipment.

Establish Uniform Net Metering and Interconnection Standards—to give solar power owners everywhere the right to simple, equitable access to the grid and fair compensation for the value of the solar power they supply.

Boost Government Procurement—of solar power to $100 million per year by allowing 20-year Power Purchase Agreements and by appropriating funds for federal agencies to install solar energy. Leaders should dedicate appropriations for green solar power purchases and direct agencies to use solar power equipment where it can increase energy security and emergency preparedness for the largest electricity consumers in the United States—federal and state governments.

Support and Reinforce State and Local Efforts to Advance Solar Power—by designing federal incentives to leverage existing state solar support and encourage other states to adopt solar policies that open new markets, increase sales volume, and help consumers, utilities, and communities benefit from solar electricity.

Increase the DOE Solar R&D Budget to $250 Million Per Year by 2010—to leverage our R&D excellence and thus build solar markets by balanced programs on current crystalline silicon and thin films, manufacturing, reliability, and next-generation PV technologies. Solar power research has helped reduce solar power costs by nearly 50% in a decade and is essential to making solar power broadly competitive in the next decade. DOE and its national laboratories should validate solar system performance to reassure financial institutions and help reduce the cost of capital for the solar industry. The program should lead in higher-risk research advancing potentially disruptive ("leapfrog") technologies and processes.



This solar carport at the Indian Pueblo Cultural Center in Albuquerque, NM, delivers about 23 MWh of clean electricity annually to the local utility grid, making it the largest commercial solar power system in New Mexico. (credit: Sandia National Laboratories)

MAINTAINING TECHNOLOGY OWNERSHIP

The foundation of successful technology is excellent research and development. The U.S. industry recognizes that to reduce solar power system costs, increase the energy delivered from its components and systems, and enhance its manufacturing efficiency (i.e., throughput and yield), the following investments in balanced federal R&D are essential.

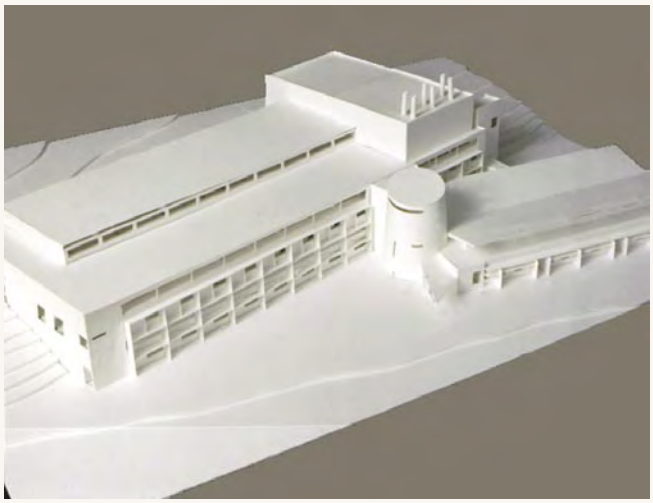
Foster technologies that are now and near, which are critical to our current U.S. industry—this includes crystalline silicon and thin films, as well as balance-of-systems components. This focus will decrease the gaps between where these manufactured technologies are now and what they can realistically achieve, helping to ensure that we meet the roadmap's technical goals over the next 10 years.

Position the United States to own the coming generations of solar power technologies—Investing in R&D for higher-risk, longer-term technology will provide options to leapfrog beyond today's technology to new levels of performance and reduced costs. This R&D includes developing new materials that push current technologies to the next performance level, discovering and demonstrating new devices with ultra-high efficiencies (e.g., nanotechnology approaches, multiple-junction and layered devices), and developing devices with ultra-low costs (e.g., organic or plastic solar cells, ultra-thin films). Investments must also stimulate the next generation of fully integrated solar energy systems. This includes modules and balance-of-systems components, including novel and "smart" electronics, optics, integration, architecture-based energy, storage, hydrogen production, and advanced power electronics.

Enhance support for existing centers of excellence, national labs, and NREL's Science and Technology Facility—critical to improved crystalline silicon and thin films. These centers help to shorten the time between laboratory discovery and industry use by at least 50%, significantly accelerating the transfer of innovation to the marketplace. They also provide rapid response to overcome manufacturing issues and barriers identified by industry.

Continue to develop programs and partnerships among industry, universities, and national laboratories—Partnerships in PV manufacturing R&D and thin-film development have produced unprecedented cost sharing, research collaboration, and publishing that are a model for research that should be expanded and strengthened.

Our previous roadmap identified the doubling of the federal R&D investment as a critical strategy for success. This did not occur, and global competition has advanced and threatens to knock us out of research leadership. To reverse this trend, we call for the United States to gradually increase its annual R&D investment to $250 million by 2010. This moderate investment will accelerate the current U.S. industry's technology strength in capturing near-term markets and will ensure that the United States owns and manufactures the solar products that will serve future generations.



The Science and Technology Facility, a state-of-the-art research facility to be completed in 2006 at the National Renewable Energy Laboratory, is designed to increase collaboration among researchers and shorten the time it takes for new solar power technologies to move from the laboratory bench to commercial manufacturing.

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Cover photo: *This grid-connected 100-kW solar electric system on the roof of PowerLight Corp.'s factory in Berkeley, CA, generates reliable, affordable, clean energy during peak demand times. But it also reduces heating/cooling costs, extends the life of the roof, and produces power that is immune from future price increases of conventional fuels. (credit: PowerLight)*

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