PV Grid Connected Market Potential under a Cost Breakthrough Scenario

Residential Home
Source: Kyocera Solar

September 2004

Toyota Motor Sales, 500 kW.
Source: PowerLight Corporation

Maya Chaudhari
Lisa Frantzis
Dr. Tom E. Hoff

The Energy Foundation
Toward a sustainable energy future
The Energy Foundation

NAVIGANT CONSULTING

CLEAN POWER RESEARCH

This report must be read in its entirety. It is important that the reader understand that no representation is made as to the accuracy or completeness of the content of this report. No person has been authorized by Navigant Consulting Inc. to provide any information or make any representation not contained in this report. Any use which a third party makes of this report, or any reliance upon or decisions to be made based upon this report, are the responsibility of such a third party. Navigant Consulting Inc. does not accept any responsibility for damages, if any, suffered by a third party based upon this report.

Table of Contents

1 » Introduction

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

Table of Contents

1 » **Introduction**

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

The Energy Foundation commissioned this study to evaluate the market potential for PV in 2010 under a cost breakthrough scenario.

- The Energy Foundation believes that PV will play an important role in America's energy future and that the U.S. economic, energy security and environmental benefits are large.
  - The future for the PV industry is bright under either business-as-usual or technology breakthrough scenarios.
- This work was undertaken to develop an estimate of how large the market for PV systems would be under certain assumptions about future installed-cost reductions.
  - One objective was to increase investor confidence in the PV industry, and to encourage state and federal policy makers to continue and expand existing forms of policy and financial support for PV industry expansion.
- Navigant Consulting, Inc. (NCI) assessed the market potential for PV in 2010, if an aggressive investment-led breakthrough in installed system price of $2/Wp[1] is achieved.
  - We emphasize that these cost reductions can only be achieved with strong, continued government support in the near term that creates a positive investment climate for private investors.
- NCI conducted this study in collaboration with Clean Power Research.

1) All data is in $/Wpdc unless otherwise stated.

NAVIGANT CONSULTING

The objective of this study is to answer three key questions:

What is the grid connected[2] market potential for PV under a cost breakthrough scenario and how can this be achieved?

What is the grid connected market potential for PV under a cost breakthrough scenario?

- What is the grid-connected market potential if the average installed price for PV is \$2/Wp (based on a cost breakthrough) in 2010 in the *roof-top* Residential and Commercial sectors? What is the sensitivity for both \$1/Wp and \$3/Wp?
- What is a methodology that can be used to estimate the impact for the Utility[1] sector? What is the potential demand in the utility sector in California under this cost scenario?

How can this market potential be achieved?

- What are the other barriers that need to be addressed to encourage further development of the PV market?

Which are potentially the most attractive states for PV installations in 2010?

- What are the economics of PV in each state, and what favorable incentives exist to support market expansion?

The scope of this study is limited to the grid-connected[3] market in the U.S.

1) The Utility sector refers to PV for central generation or installations at utility substations.
2) Includes both consumer and utility side of the meter; both are addressed in the report using different methodologies. In the U.S., grid connected PV accounted for around 55% of the total market in 2003 and is expected to increase its share over the next decade to 70%.
3) The other markets are off-grid (habitation and industrial) and consumer goods.

Table of Contents

1 » Introduction

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

NAVIGANT CONSULTING

The demand for PV is estimated assuming a breakthrough in installed PV system price by 2010.

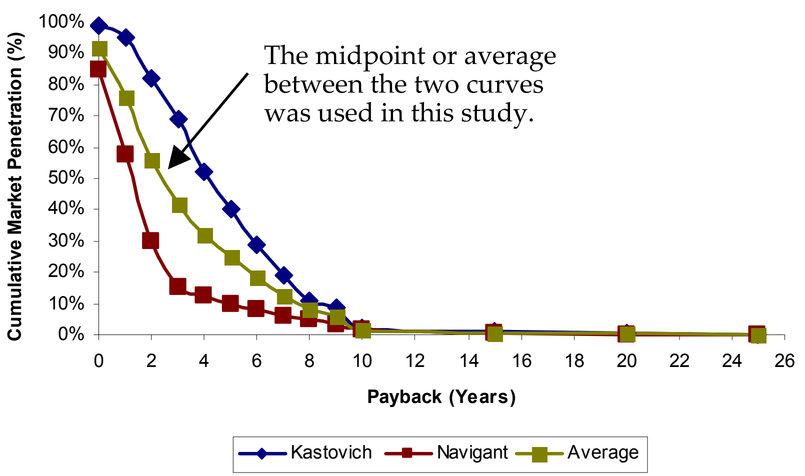
Segment	System Size (kWpdc)[2]	Installed System Price ($/Wpdc) in 2010			Cost Break-through Assumed (Base vs BAU in %)
		Base-case	Sensitivity cases	Business-as-usual (BAU) case [1]	
Residential	2.5 kWp	$2.50	$ 1.25 $ 3.75	$ 5.30	53%
Commercial: Small/ Medium system size	15.0 kWp	$ 2.20	$ 1.10 $ 3.30	$ 4.65	53%
Commercial: Large system size	100 kWp	$ 2.00	$ 1.00 $ 3.00	$ 4.25	53%
Utility Central Plant	5 MWp	$ 2.00	$ 1.00 $ 3.00	$ 4.00	50%

1) BAU is NCI's best estimate of what installed system costs will be in 2010 given recent trends in system cost reductions. NCI has interviewed PV manufacturers, installers, and balance of system suppliers to derive these estimates., 2004. This rate of cost reduction can be achieved with continued government and customer support for PV. No state buy-downs/subsidies are assumed in the 2010 prices shown, but the continued decline in prices in the near term requires continuation of customer incentives in the United States, Europe, and Japan to support plant capacity expansions.

2) Wpdc is the amount of power a PV device will produce at noon on a clear day with sun approximately overhead when the cell is faced directly toward the sun. DC is direct current. The system size was not a constraint on the market size estimated later in the report. The market size was primarily a function of available roof space and project economics. The PV system size is used only to calculate the payback period. The market estimation is driven primarily by roof space, payback and market-penetration rates.

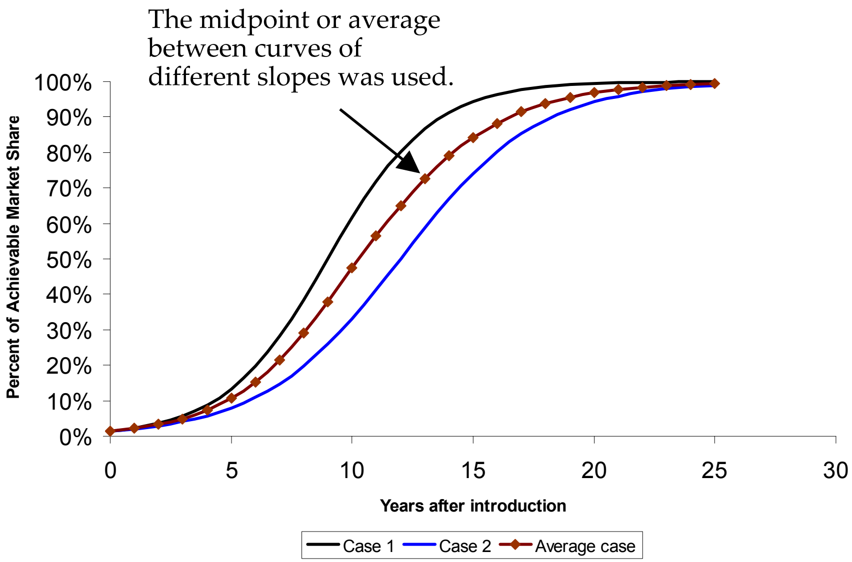
Two curves were used to estimate demand for PV: one links payback to penetration, and the other projects build-up of annual demand.

Payback vs. Cumulative Market Penetration Curves



- The curves provide the cumulative market penetration 10-20 years after product introduction, as a function of payback. These curves were applied to the total technical market potential (available roof space) that can be captured under different payback assumptions.
- The Kastovich curve is more aggressive than the Navigant curve: a midpoint between the two was thus considered in the analysis.

Typical S-Curve



- The S-Curve provides the rate of adoption of technologies, which is a function of the technologies characteristics and market conditions. The curve begins with a slow start, followed by steep growth, and then a plateau which is characteristic of many technological capabilities and product life cycles.
- An average of two curves was used, given the many factors that will impact penetration of PV.

The potential grid-connected residential and commercial sector demand for PV in 2010 at a system price of $2.00-2.50/Wpdc is estimated at 2.9 GWp, valued at ~$6.6 billion annually.

Potential Annual Demand in 2010

Residential

System size = 2.5 kW
Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	5,344	1.39%	6.7
$2.50	958	0.25%	2.4
$3.75	296	0.08%	1.1
$5.30	160	0.04%	0.8

Commercial

Commercial - Small/Medium and Large Total
System size = 15 kWp, 100 kWp
Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	5,941	1.82%	6.5
$ 2.00 - 2.20	1,942	0.60%	4.2
$ 3.00 - 3.30	852	0.26%	2.8
$ 4.25 - 4.65	506	0.16%	2.3

Grid Connected - Total

Technical Market (MW) = 711,864

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	11,285	1.59%	13.1
$ 2.00 - 2.50	2,901	0.41%	6.6
$ 3.00 - 3.75	1,148	0.16%	3.9
$ 4.25 - 5.30	666	0.09%	3.2

Key Comments

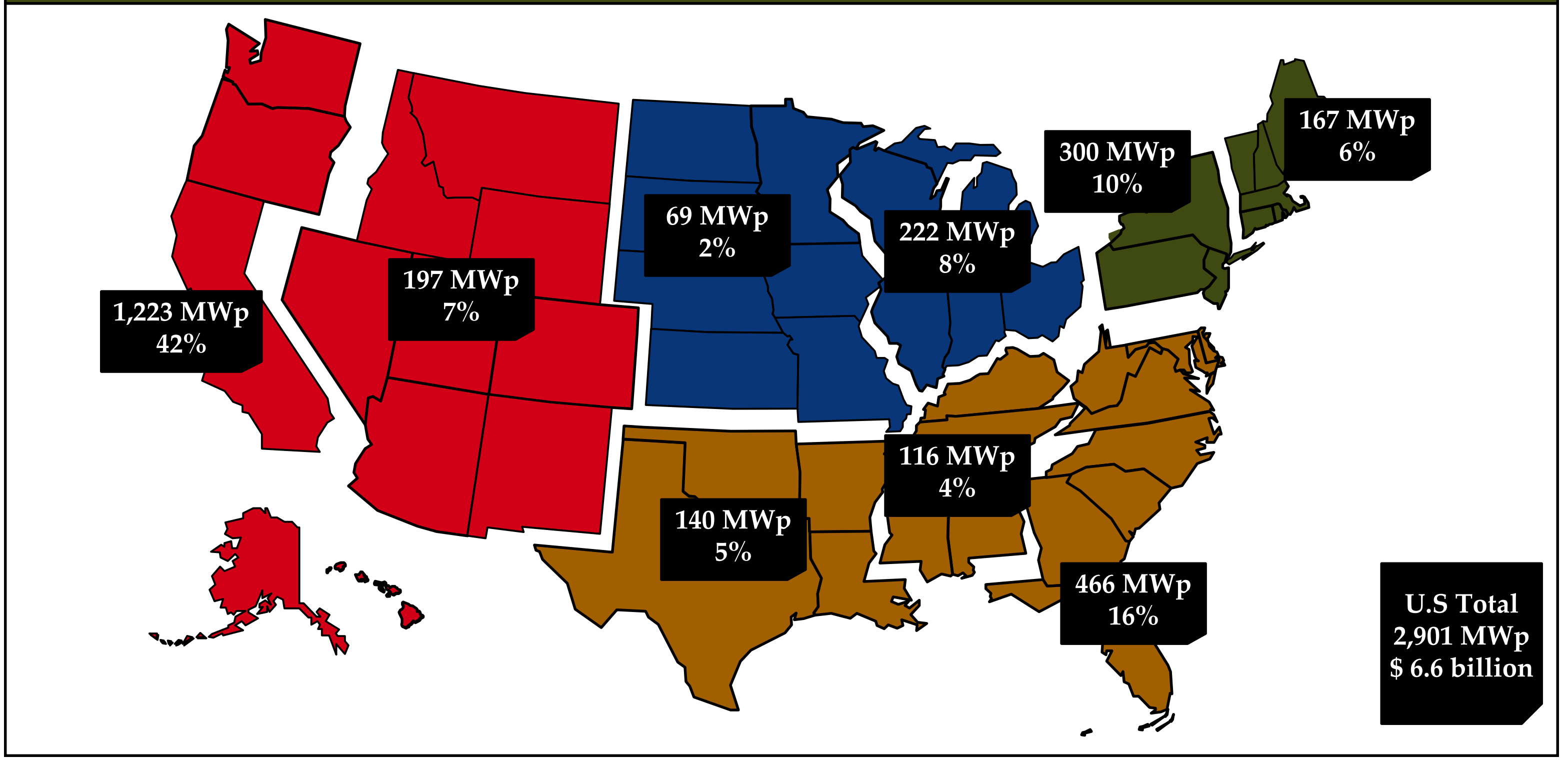
- The annual demand for PV in the year 2010 is calculated by applying the S-curve discussed earlier to the likely cumulative market potential in 2025, and is estimated at around 6% of the same. (see page 36 for further details).
- As can be seen, this demand estimation is highly sensitive to the slope of the S-curve. Moving slightly above or below the S-curve could decrease or increase the 6% share to 3% or 9%.
- The precise position of the PV industry on the S-curve in 2010 is hard to predict, as it depends on many factors including technological developments, investment in manufacturing capacity, market development, consumer behavior and government policies.
- Based on the analysis conducted, it is estimated that the potential demand in 2010 at a system price of $2.00-2.50/Wp is around 2.9GWp[1], assuming the industry can provide the capacity and marketing infrastructure and would have invested in market development prior to 2010 to make it happen. This is orders of magnitude higher than the 2003 estimated demand of 70MWp, valued at around $750-800 million, which may be considered to be constrained due to inadequacy of government incentives (across all states) and funds.[2]

1) This figure is consistent with informal discussions NCI had with a major PV manufacturer who indicated that the total (grid-connected and off-grid) potential PV demand in the U.S at a system price of ~$2.00 (which is expected to happen much later than 2010) is around 3GWp.

2) Note that the business-as-usual case projects almost a ten-fold increase in the PV market by 2010, resulting in an annual value of $3.2 billion.

At a system price of $2.00-2.50/Wpdc, the Pacific and Mid-Atlantic regions together account for 52% of the potential residential and commercial sector demand in 2010[1].

Potential Grid Connected Demand in 2010 By Census Region: MWp/year and % Share
Installed System Price: $2.00 – 2.50/Wpdc



1) Potential demand in 2010 by segment (residential, commercial, total) by state and different system price scenarios is provided in the Appendix. Demand in the Pacific and Mid-Atlantic regions is higher primarily because higher retail electricity prices in these regions shorten the payback period for purchasers of PV systems and, therefore, increase the predicted market demand under the model used in this study.

The potential demand for "central" PV in California in 2010 is estimated at 5-500 MWp annually, depending on natural gas prices and gas turbine (GT) capacity factors.

Central PV Potential Demand in 2010						
Fuel Cost	**$5.0 / MMBTU**			**$3.0 / MMBTU**		
Gas Turbine Capacity Factor	**8%**	**10%**	**15%**	**8%**	**10%**	**15%**
PV System Cost	**Annual Demand in 2010 (MW)**					
$1.00/Wpdc	500	452	312	452	367	201
$2.00/Wpdc	90	20	9	20	12	0
$3.00/Wpdc	5	0	0	0	0	0
$4.00/Wpdc	0	0	0	0	0	0

Demand for central PV is nil when the payback is more than 20 years.

NAVIGANT CONSULTING

The potential demand for PV could be higher than estimated.

Factors That Could Increase the Demand Estimation
Residential and Commercial Segment
1. Only roof-top applications were considered. Other applications such as ground mounted PV, car ports, curtain walls, and awnings were ignored. These applications currently account for a negligible proportion of the market, but is growing. 2. Utility rates could escalate at a rate higher than assumed, which would reduce the payback period for PV systems leading to higher market penetration. 3. The value for Renewable Energy Certificate (RECs) is assumed to be $0.015/kWh in 2010. A higher REC value due to greater demand, particularly for PV RECs, could improve the economics of a PV system and increase demand. 4. The value proposition at any given location may be better than presented in this report. For example, the demand estimate is based on the average consumption by customers in the residential and commercial segments. Customers with higher consumption in some states like California have higher utility rates. For these customers, PV economics would be much better than for the "average" customer, which could lead to higher penetration within the high consumption customer category. 5. The economic analysis did not consider any state incentives or policies that would proactively encourage demand. 6. Time-of-use rates that monetize the value of PV coincidence with utility peak loads would improve PV economics.
Utility Segment
1. The analysis only looked at PV relative to cost of competing generation technologies, but at some sites the PV installation may have additional value in avoiding need for distribution facility capital investment. 2. Value due to factors such as fuel price risk mitigation, intangibles, etc could also lead to better PV economics and hence higher demand. This is again specific to a utility, depending on their generation mix, tariff structure, community relationships, environmental record, etc.

While this study does not analyze the demand taking into account the above, the Appendix does provide some estimate of potential demand under more aggressive market penetration assumptions.

Table of Contents

1 » Introduction

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

3 » Market Potential for Grid Connected PV

Residential and Commercial Segments

Utilities Segment

NAVIGANT CONSULTING

There are many factors that drive the demand for PV in residential and commercial applications…

Factor	Issues
PV Economics *Does PV compare favorably with competing technologies?*	• Grid connected PV competes with retail electricity. Unlike grid power, customers incur a high upfront cost and, depending on the level of customer incentives offered by state or utility programs, a high LCOE[1] over the project life to invest in PV. • This economic disadvantage of PV is reduced significantly through government incentives and a growing market for PV environmental attributes such as green tag (renewable energy certificate or REC) trading. • In terms of a purchase decision, different economic metrics are used, such as: - upfront cost - payback period - internal rate of return - net present value - levelized cost of electricity - years till cumulative positive cash flow
Government Policies *Do government policies encourage PV demand?*	• Supply-related policies encourage or require utilities to invest in PV through Renewable Portfolio Standards (RPS) and cap&trade/allowance-allocation regulations, which help to create a market for green tags. • Demand-related policies encourage customers to purchase PV through incentives such as tax credits, subsidies/buy-downs, low-interest loans, accelerated depreciation, net metering, etc. • The long-term uncertainty surrounding government policies and/or lack of adequate funding often leads to annual variability in PV demand for grid-connected applications.
Customer Behavior *Are there behavioral factors that favor the appeal of PV?*	• 'Green consciousness' due to environmental concerns has been a key driver for early adopters. • Increasingly, PV contributes towards enhancement of public image for commercial customers and has a status symbol for residential customers. • PV also appeals to customers who seek independence in power supply, reduction in risk due to the variability in electricity prices, and peak power reductions.

…of which PV economics, which is a function of system price and government policies, is the most important factor.

1) LCOE = Levelized cost of electricity

NAVIGANT CONSULTING

Measures of payback period and return on investment are the metrics most commonly used to evaluate an investment in PV.

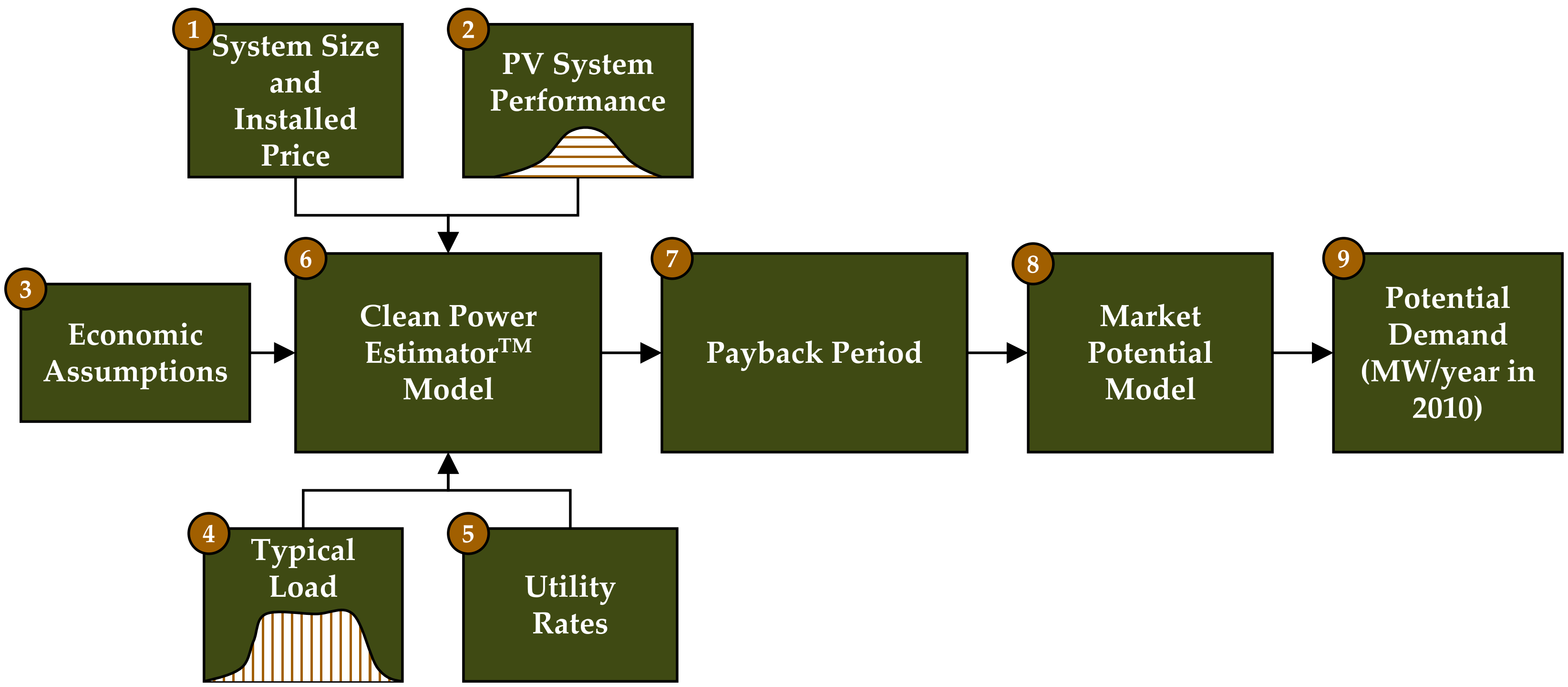
Relevant Economic Metrics[1]	
Residential Segment	• The most common factor considered for residential applications is the ***simple payback period***. • Retrofit applications are implemented by home owners while new construction applications are mainly implemented by home developers and influenced by architects. • In the case of new construction applications, home developers will typically not consider installing PV systems if it costs more than 1-2% of the cost of the house.
Commercial Segment	• Commercial customers tend to take a longer term perspective in considering an investment, and hence take into account a life cycle cost approach. However, budget constraints may adversely impact the decision to invest in PV even if it is a worthwhile investment. • The most common metric used is a measure of ***return on investment***, such as the ***internal rate of return.*** Some customers also consider ***simple payback period.***

We used payback to estimate market potential[2].

1) Source: Discussions with Howard Wenger of PowerLight, and interviews by NCI staff with homebuilders/developers/end-users.
2) For the commercial segment, we did not use a return on investment criteria to calculate the market potential because of a lack of relevant market penetration curves that relate likely market penetration to different rates of return.

NAVIGANT CONSULTING

The approach used to assess the market potential for PV in the residential and commercial segments is illustrated below.



A description of each component of the approach is described in the following pages.

NAVIGANT CONSULTING

A breakthrough in installed system price is assumed, to reach an average of $2/Wp for large commercial systems[1] by 2010.

1 **System Size and Installed Price**

Segment[1]	System Size (kWpdc)[2]	Installed System Price ($/Wpdc) in 2010[3]		
		Base-case	Sensitivity cases	Business-as-usual case
Residential	2.5 kWp	$2.50	$ 1.25 $ 3.75	$ 5.30
Commercial: Small/ Medium system size	15.0 kWp	$ 2.20	$ 1.10 $ 3.30	$ 4.65
Commercial: Large system size	100 kWp	$ 2.00	$ 1.00 $ 3.00	$ 4.25

Key Comments

- For a given PV module price, installed system price in $/Wp is higher for smaller systems due to lower economies of scale associated with Balance of System (BOS) equipment cost, fixed installation costs and transaction costs.
- Residential systems cost 17-33%[4] more than large commercial systems. A 25% average cost premium is thus assumed. Small commercial systems were assumed to be higher by 10%, reflecting some lost economies.
- Sensitivity cases reflect ranges around the base-case.
- Business-as-usual (BAU) case reflects the likely price in 2010, with a 3% decline p.a. from the 2003 price of $5.22/Wpdc for large commercial systems to $4.25/Wpdc in 2010. This rate of cost reduction can be achieved with continued government and customer support for PV. No state buy-downs/subsidies are assumed in the 2010 prices shown, but the continued decline in prices in the near term requires continuation of customer incentives in the United States, Europe, and Japan to support plant capacity expansions. [5]
- The selection of the PV system size does not constrain the demand estimation to those sizes only. The PV system size is used only to calculate the payback period. The market estimation is driven primarily by available roof space, payback and market-penetration rates.

1) The commercial segment was classified into two categories – small/ medium and large, to reflect the differences in system size, system price & market potential.
2) Residential system sizes range between 2-3 kWp, though it could be larger. An average of 2.5 kWp was assumed. Commercial system sizes vary much more, ranging between 1 – 500 kWp. The small/medium sizes tend to range between 10-40kWp while the large systems range from 75-500+kWp. The trend is towards larger commercial systems, with many over 500 MWp. 3)2010 dollar; 4) NCI analysis; 5) This is not to suggest that states may not want to offer incentives at this installed cost level. Rather, it is a simplifying assumption that is likely to be the case in many states. For states that might offer customer incentives, this is an assumption that makes the market estimates conservative.

Note: All system size, price and cost data are per Wpdc or nameplate watts, unless otherwise stated.

NAVIGANT CONSULTING

It is worth noting that the installed price for PV systems depends on many factors…

Drivers of PV Installed System Price

PV Module

Inverter

Mounting Structure
- Function of type of mounting systems
- Varies for retrofit versus new construction installations

Meters, Switches, Panels

Installation Material (electrical, hardware)

System Design and Engineering

Installation Labor
- Varies by location
- Varies for retrofit versus new construction installations

Other
(Inspection, vehicle rental, building permit and review fees, etc.)

→ PV Installed System Price

…for this study, we did not take into account differences between retrofit versus new construction, mounting structures, etc.

NAVIGANT CONSULTING

PV system output assumed: typical installation parameters, x-Si[1] technology, and state capitals for utility rates and insolation levels.

2 **PV System Performance**

Factors Affecting Performance	**Segment**			**Comments**
	Residential	Commercial: Small/Med	Commercial: Large	
PV Technology	Crystalline Silicon			• Crystalline silicon technologies accounted for 92% of module production during 2002. Their share has increased at the expense of thin films during the last decade.
PV System Tilt	18^0 on pitched roof, 0^0 on flat roof	0^0 on flat roof		• Majority of residential homes have pitched roofs, with single family and 2-4 unit homes together accounting for 78% of all residential homes in 2001. • Around 98% of commercial systems are installed with no tilt because of lower installation labor cost and higher roof space utilization[2].
Orientation	South facing			• South facing PV systems provide excellent year-round performance
Tracking System	None assumed			• Tracking helps to increase system output, but also increases cost. Most systems installed do not have tracking systems.
System Location[3]	State Capital			• Location impacts insolation (solar resource) and utility rates for the analysis. The location and utility rates selected were used as representing the state. • California and New York: Two additional locations were selected due to solar resources and/or tiered & wide range of tariff rates.

1) X-Si is crystalline silicon technology, which comprises mono and poly crystalline silicon
2) Systems with 10^o tilt need around 30% more roof space. Source: Interview with PowerLight. 3) The locations by state are provided in the Appendix.

Key economic assumptions include: net metering, RECs with a $.015/kWh value, and minimal Federal incentives.

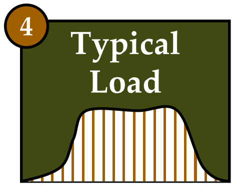
3 Economic Assumptions

Factor[1]	Segment			Comments
	Residential	Commercial: Small/Med	Commercial: Large	
System Life	30 years			• Typical for crystalline silicon technologies.
O&M Cost ($/kW/year)	-	11	11	• O&M cost is not material for residential. Commercial building O&M is mostly labor and is assumed to increase at 2.5% p.a. during project life.
Replacement Expenditure	-			• Inverters will be replaced once during the project life. Cost is negligible and was therefore not incorporated into the analysis.
State Incentives	0			• Purpose of study is to analyze market potential without the support of significant incentives. Only minimal incentives at the federal level is assumed.
Federal Tax Credits (%)	15	10	10	• The 15% residential Tax Credit is being proposed. Commercial Investment Tax Credit has been available for several years and is very likely to continue.
Accelerated Depreciation	-	MACRS 5 year class		• Federal incentive that currently exists and is likely to continue. Applicable only to commercial customers.
REC[2] Value ($/kWh)	0.015			• Assumption reflects the federal cap of $15/MWh. Current PV REC values are much higher, reflecting limited availability in trading system. Value of REC is indexed to inflation at 2.0% p.a. during project life.
Net Metering	Exists			• Assumes no net annual generation by the PV system
Discount Rate	7%	8.5%		• Based on NCI analysis, recommendations by the Department of Energy and Berkeley Lab for air conditioners. • Assumed PV purchase financed by loan/mortgage for residential customers.

1) All data are in 2010 dollars 2) REC = Renewable Energy Certificate

NAVIGANT CONSULTING

We assumed the average monthly consumption by segment in each state to be the same as that in 2001.



Typical Customer Load By Segment, By State[1] (kWh/year, 2001)

State	Residential	Commercial: Small/Med	Commercial: Large
Region: Midwest - East North Central			
Illinois	8,711	87,455	7,394,237
Indiana	11,427	86,112	2,344,113
Michigan	7,788	74,755	2,480,151
Ohio	9,826	70,344	70,344
Wisconsin	8,634	65,732	4,673,847
Region: NorthEast - Middle Atlantic			
New Jersey	7,934	81,329	938,889
New York	6,532	65,638	2,472,830
Pennsylvania	9,081	54,710	1,384,796
Region:			
…			
…			
…			
…			
…			

Key Comments

- A key aspect of determining the economic attractiveness of PV is comparing its output in kWh/year to a typical customer's load (and hence utility bill).
- The typical load is assumed to be the average consumption in kWh/year, as provided by the EIA.
  - Residential: the average residential consumption is considered.
  - Small/ medium commercial: the average commercial sector consumption was used.
  - Large commercial: the average industrial sector consumption was used.
- A typical load profile is mapped on the typical PV load[2] – this enables comparing the load profile with PV output.
- Net metering was assumed, but with no net annual generation value (i.e. if PV system has a net annual export of output to the grid, the customer does not get additional compensation).
- It is assumed that the average load per customer does not change.
- The use of the average consumption in states with tiered rate structures probably understates the potential for PV for these states, because in these states, customers with high consumption and hence high utility rates would see higher returns on PV investment.

1) Source: EIA, US Average Monthly Bill by Sector, Census Division and State, 2001. Details for all states and segments provided in the Appendix.
2) The typical load profile is as provided by the Clean-Power Estimator™ Database, which is described later in the report.

Utility rates are expected to increase at 3.7% per annum from 2003 through 2010, while the rate structure is assumed to remain the same.

5

Utility Rates

Utilities Whose Rates are Assumed[1]

State	Location	Utility
Midwest - East North Central		
Illinois	Chicago	Commonwealth Edison Co.
Indiana	Indianapolis	Indianapolis Power and Light
Michigan	Detroit	Detroit Edison
Ohio	Cleveland	FirstEnergy Corp (The Illuminating Company)
Wisconsin	Milwaukee	We Energies (Wisconsin Electric)
Midwest - West North Central		
Iowa	Cedar Rapids	IES Utilities
Kansas	Topeka	Kansas Power and Light (Western Resources)
Minnesota	St. Paul	Xcel Energy (Northern States Power)
Missouri	Jefferson City	AmerenUE - Missouri (Union Electric)
Nebraska	Lincoln	Lincoln Electric
North Dakota	Bismarck	Montana-Dakota Utilities
South Dakota	Sioux Falls	Xcel Energy (Northern States Power)
NorthEast - Middle Atlantic		
….		
….		
….		
….		
….		

Key Comments

- The utility rates used are those of the largest utility in the locations selected, which as mentioned earlier is the state capital, as well as two additional locations in California and New York. The actual rate structures of the utilities selected were used in the analysis, rather than an average rate structure for the country.
- For the analysis, assumptions need to be made about the utility rates during the project life, which is from 2010 (the year in which low cost systems will be available) till 2040, given that PV systems have an operating life of 30 years.
  - It is assumed that the rate *structure* during the period of analysis remains the same as in 2003.
  - The *rates* increase at an average rate of 3.7% per annum from 2003 till 2010, and at 2% per annum thereafter for the project life[2].
- It must be noted that there may be utilities other than those selected for this study whose utility rates are higher, which could result in higher returns for a PV investment.

1) Full list of utilities is provided in the Appendix.
2) NCI analysis, based on forecast regarding electricity prices (as provided in the EIA's Annual Energy Outlook 2003) and inflation assumptions.

NAVIGANT CONSULTING

The Clean Power Estimator™ model conducts the PV output and payback analysis by state and segment.

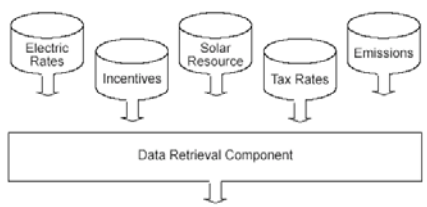
6

Clean Power Estimator™ Model

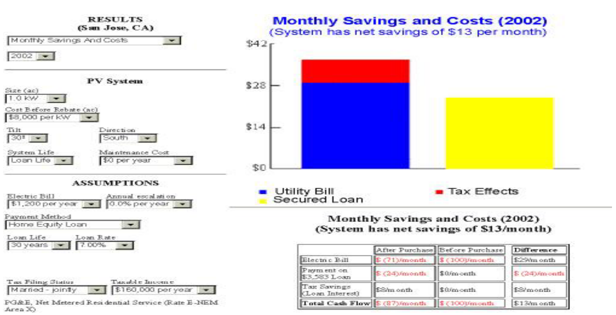
Model Overview[1]

The three key components of the model…

The Data component of the model…



An illustration of one of the model outputs…



Key Comments

- The Estimator is a suite of Internet based applications designed to help consumers evaluate the cost effectiveness of clean energy systems, including PV.
- It provides an estimate of the costs and benefits of a system for residential or commercial customers. It takes into account system size, system installation, system price, financial assumptions, utility rates and solar resources across locations.
- There are three critical components of the Estimator: Data, Analysis and Applications.
- With the Data component, amongst other information, the Estimator has data on the solar resource for 237 locations and includes the utility rates for more than 400 locations (with over 1500 rate schedules, covering residential and commercial customers).
- It produces several outputs. We have used the payback calculation in our analysis to estimate the market potential for PV.

1) Brief description provided in the Appendix. Complete model documentation is available at http://www.clean-power.com

NAVIGANT CONSULTING

The weighted[1] average payback in 2010 is 9-12 years for a system price of $2.00-2.50/Wpdc, and 13-19 years for a price of $4.25-$5.30/Wpdc.

7

Payback Period[2]

Payback : U.S.

Residential

System size = 2.5 kW

System Price ($/Wpdc)	Payback (years)		
	Wt. Av.	Max	Min
$1.25	7	11	4
$2.50	12	18	7
$3.75	15	22	10
$5.30	19	27	13

Commercial - Small/Medium

System size = 15 kW

System Price ($/Wpdc)	Payback (years)		
	Wt. Av.	Max	Min
$1.10	6	9	3
$2.20	9	13	5
$3.30	11	16	7
$4.65	13	17	9

Commercial - Large

System size = 100 kW

System Price ($/Wpdc)	Payback (years)		
	Wt. Av.	Max	Min
$1.00	6	11	3
$2.00	9	15	6
$3.00	11	17	8
$4.25	13	19	9

Key Comments

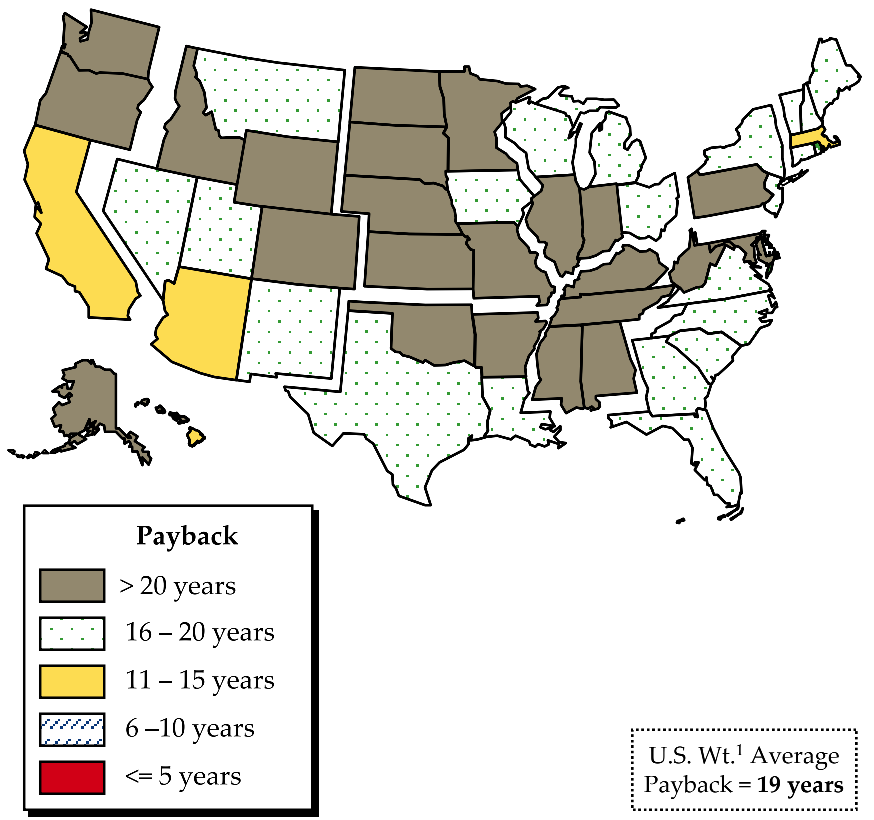
- Payback is calculated taking into account net system price and first year savings.
- The net system price assumes a federal Tax Credit of 15% for residential systems (which is proposed) and 10% Investment Tax Credit for commercial (which currently exists). In addition, the federal accelerated depreciation incentive provided to commercial customers is considered.
- Savings during the first year take into account after-tax utility bill savings, first year loan interest tax savings, and the value of Renewable Energy Certificate (RECs) at $0.015/kWh, less first year O&M costs.
- Payback is calculated by segment, by state for each installed system price scenario.
- An installed system price 50% less than the business-as-usual price (i.e. $2.00-2.50/Wpdc instead of $4.25-5.30/Wpdc) leads to a 40% reduction in payback for residential customers (from 19 years to 12 years) and to ~30% reduction for commercial customers (from 13 years to 9 years)
- At low system prices, payback in some states can be as low as 3-4 years. However, there are some states where the payback will still be 9-11 years.
- Payback is not directly proportional to system price because the value of loan interest tax savings are considered – thus, a 50% reduction in system price does not correspond to a 50% reduction in payback, because the first year savings change as well due to tax deductibility of loan interest.

1) Weighting is done by number of customers by state, by segment. Data source: EIA, 2001 data. Data on number of customers is provided in the Appendix.
2) Data on payback by state and segment for different installed system price is provided in the Appendix.

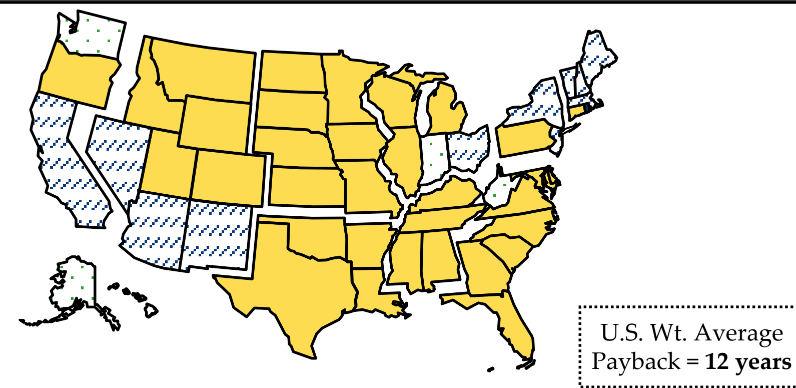
NAVIGANT CONSULTING

At $2.50/Wpdc for residential systems in 2010, payback for some states is 6-10 years, while under the BAU case it is >10 years for all states.

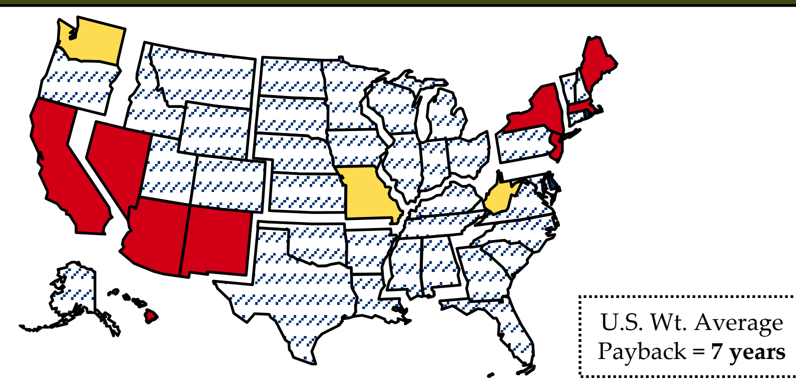
Payback in 2010, Residential @ $5.30/Wpdc



Payback in 2010, Residential @ $2.50/Wpdc



Payback in 2010, Residential @ $1.25/Wpdc



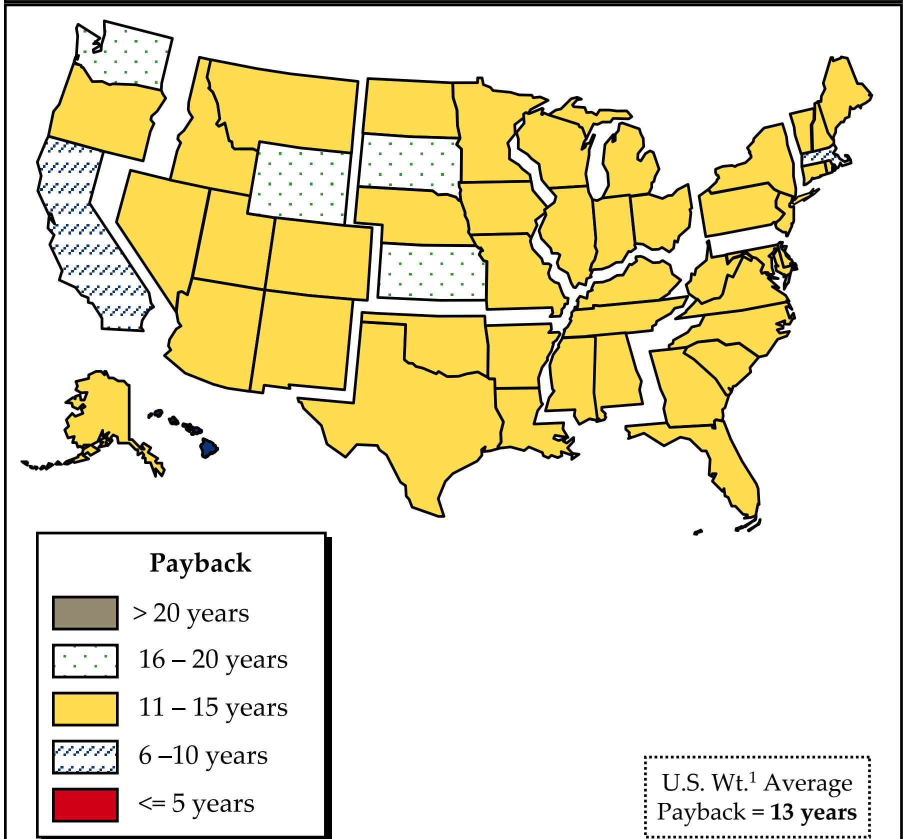
At $1.25/Wpdc, most of the U.S. has a payback of <=10 years, with some states at <=5 years.

1) Weighting is done by number of customers by state, by segment.

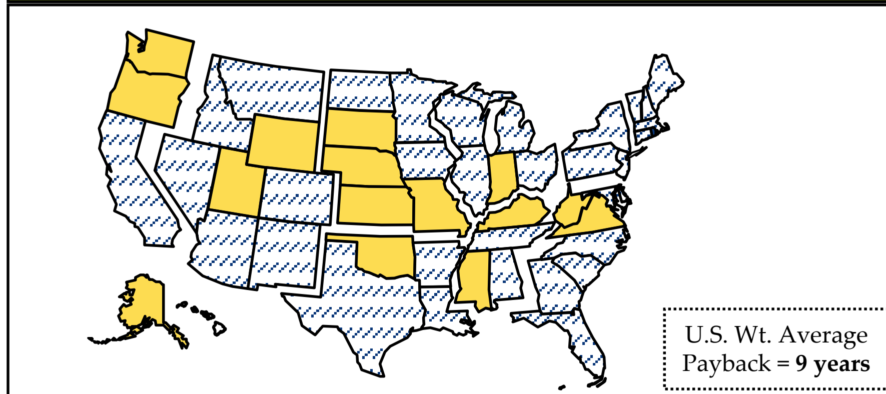
NAVIGANT CONSULTING

At $2.20/Wpdc for medium commercial systems in 2010, many states have a payback of 6-10 years, compared to only CA under BAU case.

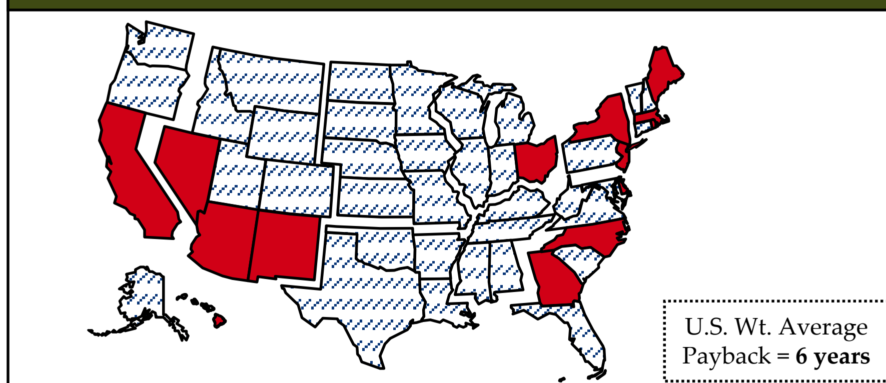
Payback in 2010, Commercial Small/Med @ $4.65/Wpdc



Payback in 2010, Commercial Small/Med @ $2.20/Wpdc



Payback in 2010, Commercial Small/Med @ $1.10/Wpdc

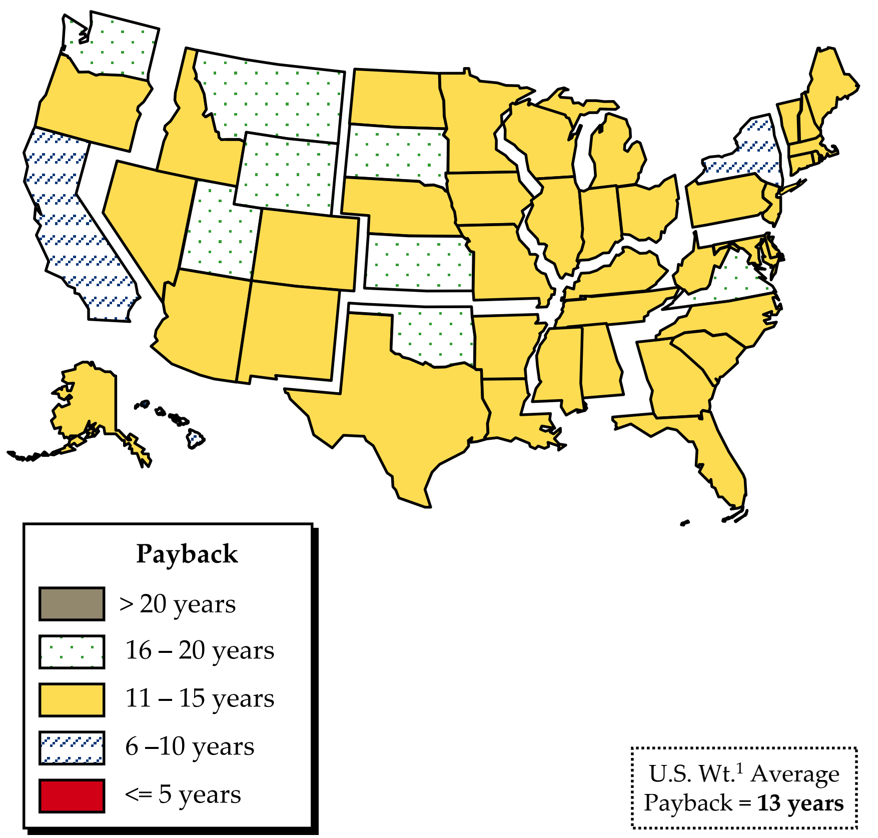


At $1.10/Wpdc, the entire country has a payback of <=10 years, with several states having a payback of <= 5 years.

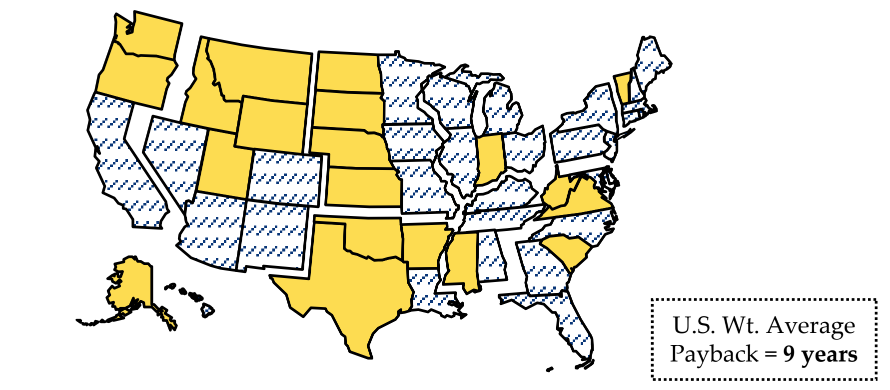
1) Weighting is done by number of customers by state, by segment.

The overall payback trend for large commercial systems is similar to that for medium sized systems, though paybacks are slightly higher…

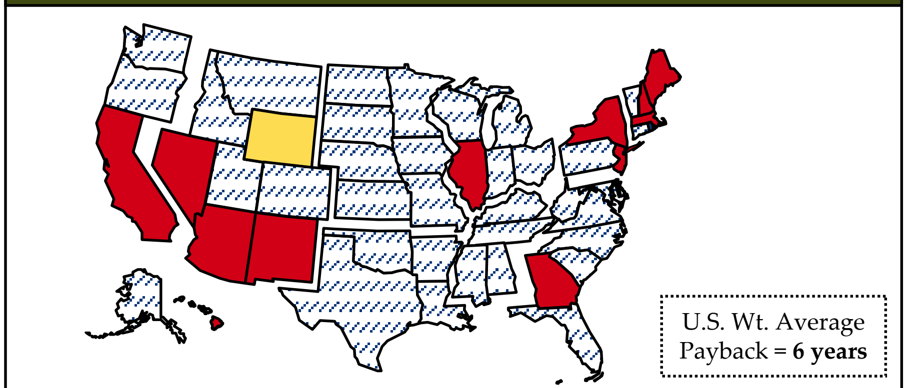
Payback in 2010, Commercial Large @ $4.25/Wpdc



Payback in 2010, Commercial Large @ $2.00/Wpdc



Payback in 2010, Commercial Large @ $1.00/Wpdc



…reflecting the lower utility rates for large commercial customers.

1) Weighting is done by number of customers by state, by segment.

The logic and main components in the model to estimate the potential grid-connected demand for PV in 2010 is as follows:

8 **Market Potential Model**

Key Components of Market Potential Model

8.1 Roof Space Available for PV in 2025 (Mln. sq. ft)
X
8.2 PV Power Density in 2025 (Wp/sq. ft)
=
8.3 Technical Market in 2025 (MWp)
X
8.4 Cumulative Market Penetration in 2025 (%)
=
8.5 Potential Cumulative Market in 2025 (MWp)
X
8.6 Technology Adoption S-Curve from 2003-2025 (%)
=
8.7 Potential Annual Demand in 2010 (MWp)

Note:

- The objective of this project is to estimate the potential demand in 2010.
- Market penetration curves provide the cumulative market penetration ~15 years after a product has been introduced. These curves are thus used to calculate the cumulative market in 2025.
- The likely demand in 2010 is then calculated using an S-curve, which predicts the rate of technology adoption.

NAVIGANT CONSULTING

Total roof space available for PV in 2025 is estimated at 84.5 billion ft^2, compared to 62.4 billion ft^2 in 2003, with a residential share at 53%.

8.1 Roof Space Available for PV in 2025 (Mln. sq. ft)

Roof Space: U.S. [1]

Roof Area Available for PV Systems			2003	2010	2025
Total, by segment					
	Residential	Mln. Sq. Ft.	33,969	37,616	45,005
	Commercial - Small/Medium	Mln. Sq. Ft.	24,463	27,302	33,982
	Commercial - Large	Mln. Sq. Ft.	4,003	4,492	5,556
	Total	Mln. Sq. Ft.	62,436	69,409	84,544
As % of total roof area					
	Residential	%	22%	22%	22%
	Commercial	%	65%	65%	65%
As % of total floor area					
	Residential	%	16%	16%	16%
	Commercial	%	60%	60%	60%

Roof Available for PV in 2025		Residential		Commercial - (Small/Medium & Large)		Total	
		Mln Sq. Ft.	% share	Mln Sq. Ft.	% share	Mln Sq. Ft.	% share
Midwest							
	East North Central	6,659	15%	5,244	13%	11,903	**14%**
	West North Central	3,205	7%	2,646	7%	5,851	**7%**
NorthEast							
	Middle Atlantic	4,202	9%	3,117	8%	7,319	**9%**
	New England	1,710	4%	1,430	4%	3,140	**4%**
South							
	East South central	3,642	8%	3,650	9%	7,293	**9%**
	South Atlantic	9,004	20%	8,394	21%	17,397	**21%**
	West South Central	6,309	14%	4,492	11%	10,801	**13%**
West							
	Mountain	3,065	7%	3,609	9%	6,674	**8%**
	Pacific	7,210	16%	6,957	18%	14,166	**17%**
Total		**45,005**	100%	**39,538**	100%	**84,544**	**100%**
	% share of total	**53%**		**47%**		**100%**	

Key Comments

- Total roof space available for PV systems is defined as:
  Total roof space available for PV =Total roof space of buildings
  less
  Roof unavailable due to solar access issues
- The total roof space available for PV due to solar access issues differs by type of roof, and is as follows:
  Pitched roof = 18%[2]
  Flat roof = 65%[2]
- The total roof space available by segment is estimated as follows:

	Commercial[2]	**Residential[2]**
Total roof space by type		
- % pitched roof area	0%	92%
- % flat roof area	100%	8%
Total available roof space		
- % of total roof space	65%	22%

Note : Amongst residential buildings, it is assumed that single family homes and 2-4 unit apartments have pitched roofs while 5+ unit apartments and mobile homes have flat roofs.

1) The methodology and data used to calculate available roof space by state and segment is provided in the Appendix.
2) Details provided in the Appendix.

NAVIGANT CONSULTING

Space available for PV installations depends on roof type, orientation, shading and other factors, collectively called 'solar access' issues.

Roof Type

The roof type determines the potential tilt of PV systems that can be installed.

There are two primary roof types:
- Flat
- Pitched

Structural Adequacy

PV systems add load to roofs. As such, the structural adequacy of roofs and building codes needs to be taken into consideration, though it is typically not an issue.

Material Compatibility

Roof building materials should support PV system installations, and most do support PV installations. There may be cases where PV may not be aesthetically compatible, but this issue is not considered.

Shading

Shading reduces the output of PV systems and hence reduces eligible roof area available. Shading occurs from:
- Trees
- HVAC, other equipment
- Vent stacks, chimneys, other roof structures

Orientation

PV systems are most productive when oriented from southeast clockwise around to west.

The orientation of pitched roofs determines the eligible roof space.

The impact of the above issues on roof space available for PV systems is discussed in the Appendix.

Power density of PV *systems* is estimated at 10.2 and 12.3 Wp/sq. ft. in 2010 and 2025 respectively, compared to 8.7 Wp/sq. ft. in 2003.

8.2 **PV Power Density in 2025 (Wp/sq. ft)**

Key Assumptions

- Crystalline silicon (x-Si) technology, which comprises mono crystalline and poly crystalline silicon is the most efficient PV technology and also the most dominant in the market, with a 92% share of PV module production in 2002.
- During 2003, the weighted average power density of crystalline silicon *modules* was 10.8 Wp/sq. ft. PV system installations require an area approximately 1.25 times the area of PV modules, to provide space between modules, wiring, access to modules etc. The *system* power density is thus lower than the module power density.
- Assuming the same distribution in production between mono and poly crystalline silicon, it is estimated that due to efficiency improvements, the PV module power density in 2010 will be around 12.8 Wp/sq. ft, or an increase of 2.4% per annum, resulting in a PV system density of 10.2 Wp/sq. ft.
- Assuming that due to scientific and engineering constraints the rate of improvement in efficiency is slower by half beyond 2010, the power density of PV modules in 2025 is estimated at 15.3 Wp/dc, or a PV system power density of 12.3 Wp/sq. ft.

Technology	*% share in x-Si production*	*Module power density (Wp/sq. ft).*	*System power density (Wp/sq. ft.)*		
			2003	*2010*	*2025*
Mono crystalline	41%	12.2			
Poly-crystalline	59%	9.9			
Weighted average		10.8	8.7	10.2	12.3

Source: NCI analysis

NAVIGANT CONSULTING

The technical market for grid-connected PV in 2025 is estimated at ~1,000 GWp, an average increase of 3% p.a. from ~ 540 GWp in 2003…

8.3

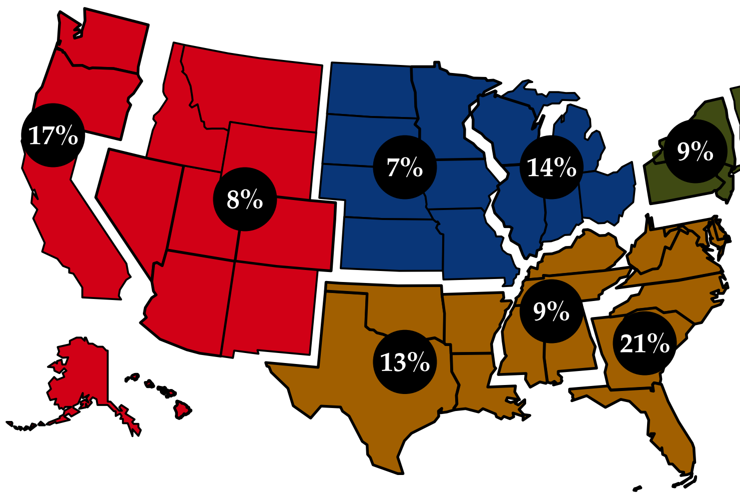
Technical Market in 2025 (MWp)

Technical Market in U.S. [1]

Technical Ultimate Potential (MWp)	2025		2003	
	MWp	% share	MWp	% share
Residential	552,307	53%	294,855	54%
Commercial - Small/ Medium	417,032	40%	212,343	39%
Commercial - Large	68,181	7%	34,750	6%
Total	**1,037,519**	**100%**	**541,948**	**100%**

- The technical potential is almost equally split between residential and commercial segments.
- Region wise, West-Pacific and South-Atlantic account for the highest technical potential in 2025 at 17% and 21% respectively, driven by roof space available for PV.

Technical Market By Census Region: 2025
% share of total



…driven by growth in building stock and an increase in power density of PV systems.

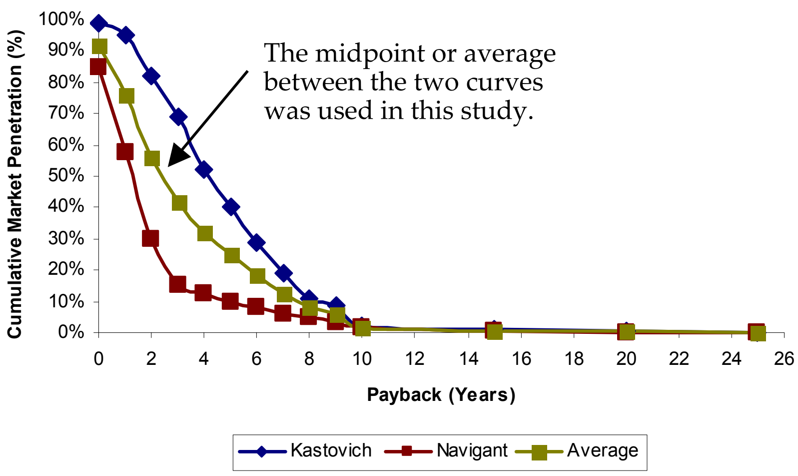
1) State-wise details of technical potential in 2025 provided in the Appendix.

NAVIGANT CONSULTING

This analysis did not assume a higher penetration rate (e.g., that experienced by hi-tech products) for the following reasons.

8.4 Cumulative Market Penetration in 2025 (%)

Payback vs. Cumulative Market Penetration Curves[1]



Key Comments

- The curves provide the cumulative market penetration 10-20 years after product introduction, as a function of payback.
- The Kastovich[1] (for replacement market) and Navigant[2] curves are considered to be the most appropriate curves to calculate the market potential for PV, because they reflect investments in electric products, with a focus on the replacement market, which is analogous to the retrofit market (new construction accounts for less than 2% of building stock).
- Rapid penetration rates of hi-tech products is not considered to be comparable to PV because of the following:
  - Comparatively high upfront cost and payback of > 5 years associated with PV, even with low system price
  - 'Green' attribute does not drive the main market
  - The 'network' effect and high adoption rates of products such as computers and cell phones where the value of being a customer increases as the network grows is not relevant to PV
  - Investment of significant time and resources is needed to develop the manufacturing and marketing infrastructure required to serve a market of more than 100 MWp/year[3].
- The Kastovich curve is more aggressive than the Navigant curve: a midpoint between the two was thus considered in the analysis.

1) Kastovich, J.C., Lawrence, R.R., Hoffman, R.R., and Pavlak, C., 1982, "Advanced Electric Heat Pump Market and Business Analysis.". The curves apply simple payback as the criteria, and were developed for the residential market.

2) Proprietary data belonging to Navigant Consulting. Developed by the Navigant team while at Arthur D. Little, based on HVAC penetration experience for the Building Equipment Division, Office of Building Technologies, U.S. Department of Energy (DoE) in 1995. The Navigant curve is used by the DoE in its evaluation of energy efficiency and distributed energy technologies, which was confirmed in an interview with Steve Wade in January 2004.

3) Sales of PV in the U.S. during 2003 is estimated at 70 MWp.

NAVIGANT CONSULTING

The potential cumulative grid-connected PV market in 2025 is estimated at 47 GWp, at a PV system price of $2.00-2.50/Wpdc in 2010.

8.5 Potential Cumulative Market in 2025 (MWp)

Potential Cumulative Market in 2025

Residential		
System size =	2.5 kWp	
Technical Market (MWp) =	552,307	
System Price ($/Wpdc)	**MWp**	**% mkt share**
$1.25	86,641	15.69%
$2.50	15,538	2.81%
$3.75	4,793	0.87%
$5.30	2,593	0.47%
Commercial		
Commercial - Small/Medium and Large Total		
System size =	15 kWp, 100 kWp	
Technical Market (MWp) =	485,213	
System Price ($/Wpdc)	**MWp**	**% mkt share**
$ 1.00 - 1.10	96,314	19.85%
$ 2.00 - 2.20	31,487	6.49%
$ 3.00 - 3.30	13,816	2.85%
$ 4.25 - 4.65	8,205	1.69%
Grid Connected - Total		
Technical Market (MWp) =	1,037,519	
System price ($/Wpdc)	**MWp**	**% mkt share**
$ 1.00 - 1.25	182,955	17.63%
$ 2.00 - 2.50	47,025	4.53%
$ 3.00 - 3.75	18,609	1.79%
$ 4.25 - 5.30	10,798	1.04%

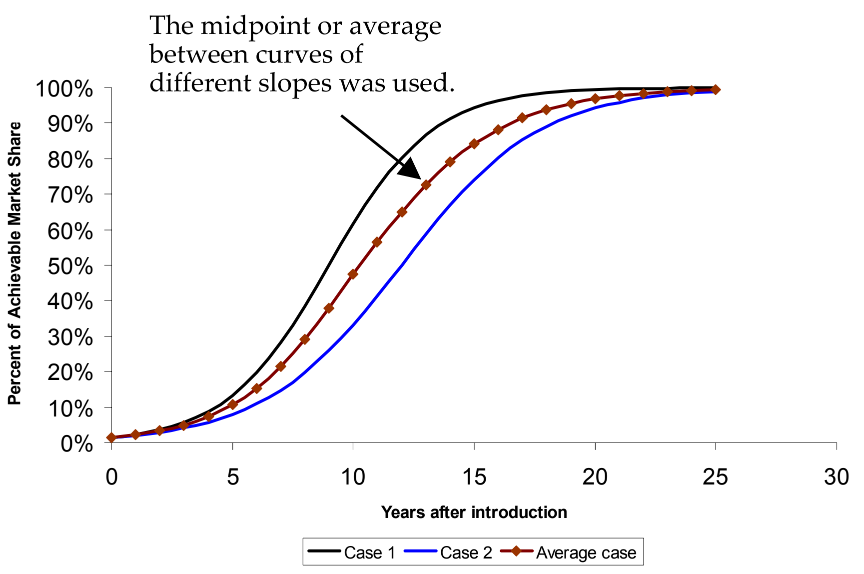
Key Comments

- The potential cumulative market potential is calculated on a state-by-state basis and summed to arrive at the total for the U.S.
- As can be seen from the table on the left, if a PV system in the $2.00-2.50/Wpdc is introduced in 2010, a cumulative of 47 GWp could be achieved by 2025, assuming investment is made in manufacturing and marketing infrastructure to support this level of penetration, with appropriate market development efforts (awareness, training, interconnection, net metering in all states, etc).
- A system price of $1.00-1.25/Wpdc dramatically increases the potential cumulative market, because as shown earlier in the report, the payback becomes fairly attractive.
- The importance of appropriate market development efforts cannot be underestimated. To put the projected cumulative market potential in 2025 in perspective, it must be noted that the estimated cumulative grid connected PV in the U.S. is currently ~200 MWp.

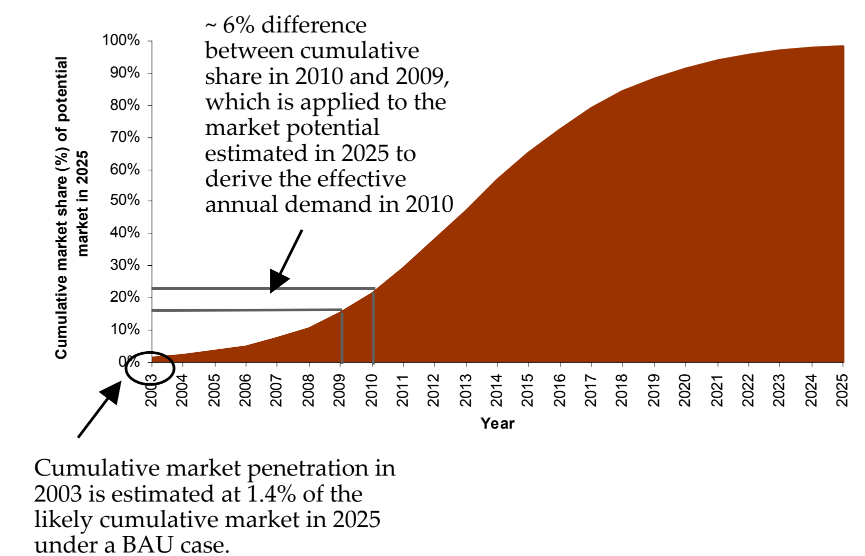
The typical technology adoption S-curve is used to calculate back the market penetration for the year 2010 from 2025.

8.6 Technology Adoption S-Curve from 2003-2025 (%)

Typical S-Curve



S-Curve to Calculate Potential Demand in 2010



NAVIGANT CONSULTING

The potential grid-connected annual demand for PV in 2010 at a system price of $2.00-2.50/Wpdc is estimated at 2.9 GWp, valued at ~$6.6 billion.

8.7 **Potential Annual Demand in 2010 (MWp)**

Potential Annual Demand in 2010

Residential			
System size =	2.5 kW		
Technical Market (MWp) =	385,790		
System Price ($/Wpdc)	**MWp**	**% mkt share**	**$ billion**
$1.25	5,344	1.39%	6.7
$2.50	958	0.25%	2.4
$3.75	296	0.08%	1.1
$5.30	160	0.04%	0.8
Commercial			
Commercial - Small/Medium and Large Total			
System size =	15 kWp, 100 kWp		
Technical Market (MW) =	326,074		
System Price ($/Wpdc)	**MWp**	**% mkt share**	**$ billion**
$ 1.00 - 1.10	5,941	1.82%	6.5
$ 2.00 - 2.20	1,942	0.60%	4.2
$ 3.00 - 3.30	852	0.26%	2.8
$ 4.25 - 4.65	506	0.16%	2.3
Grid Connected - Total			
Technical Market (MW) =	711,864		
System Price ($/Wpdc)	**MWp**	**% mkt share**	**$ billion**
$ 1.00 - 1.25	11,285	1.59%	13.1
$ 2.00 - 2.50	2,901	0.41%	6.6
$ 3.00 - 3.75	1,148	0.16%	3.9
$ 4.25 - 5.30	666	0.09%	3.2

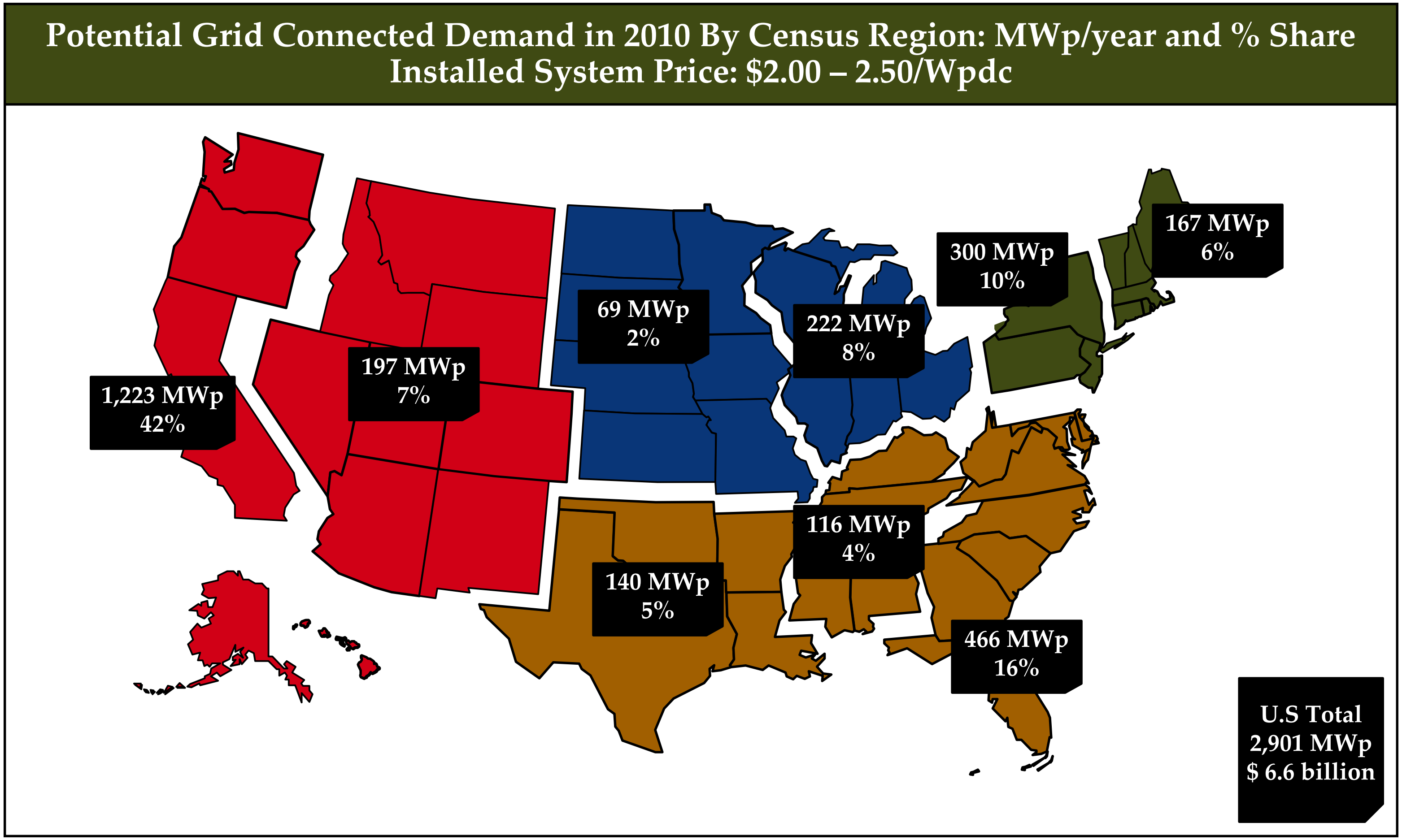
Key Comments

- The demand for PV in the year 2010 is calculated by applying the S-curve discussed earlier to the likely cumulative market potential in 2025, and is estimated at around 6% of the same.
- As can be seen, this demand estimation is highly sensitive to the slope of the S-curve. Moving slightly above or below the S-curve could decrease or increase the 6% share to 3% or 9%.
- The precise position of the PV industry on the S-curve in 2010 is hard to predict, as it depends on many factors including technological developments, investment in manufacturing capacity, market development, consumer behavior and government policies.
- Based on the analysis conducted, it is estimated that the potential demand in 2010 at a system price of $2.00-2.50/Wp is around 2.9GWp[1], assuming the industry can provide the capacity and marketing infrastructure and would have invested in market development prior to 2010 to make it happen. This is orders of magnitude higher than the 2003 estimated demand of 70MWp, valued at around $750-800 million, which may be considered to be constrained due to inadequacy of government incentives (across all states) and funds.[2]

[1]Discussions with a major PV manufacturer indicate that the total (grid-connected and off-grid) potential PV demand in the U.S at a system price of ~$2.00 (which is expected to happen much later than 2010) is around 3GWp. [2]Note that the business-as-usual case projects almost a ten-fold increase in the PV market by 2010, resulting in an annual value of $3.2 billion.

NAVIGANT CONSULTING

At a system price of $2.00-2.50/Wpdc, the Pacific and Mid Atlantic regions together account for 52% of the potential annual demand in 2010[1].

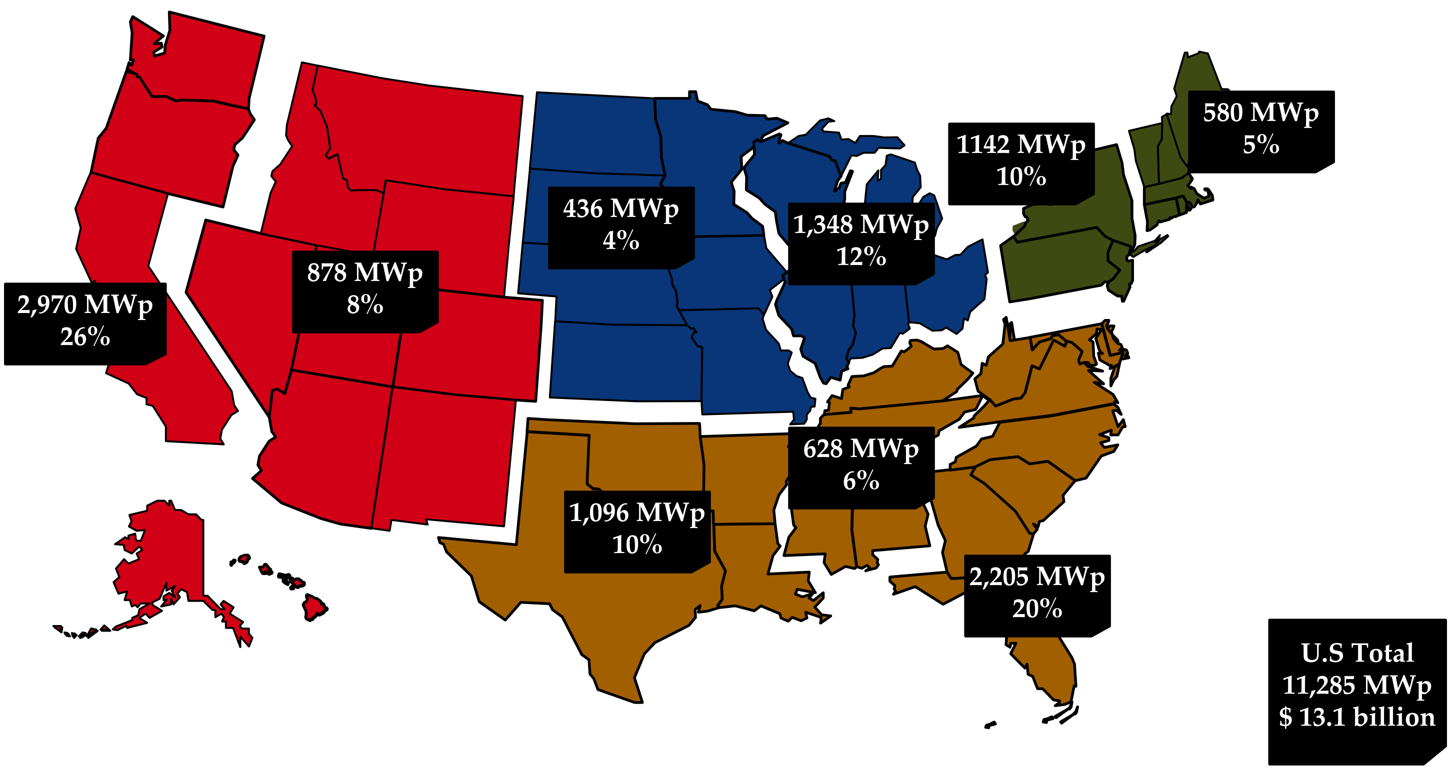


1) Potential demand in 2010 by segment (residential, commercial, total) by state and different system price scenarios is provided in the Appendix.

NAVIGANT CONSULTING

At a system price of $1.00-1.25/Wpdc, the potential in the Midwest and West South Central increases more than in other regions.

Potential Grid Connected Annual Demand in 2010 By Census Region: MWp/year and % Share -- Installed System Price: $1.00 – 1.25/Wpdc

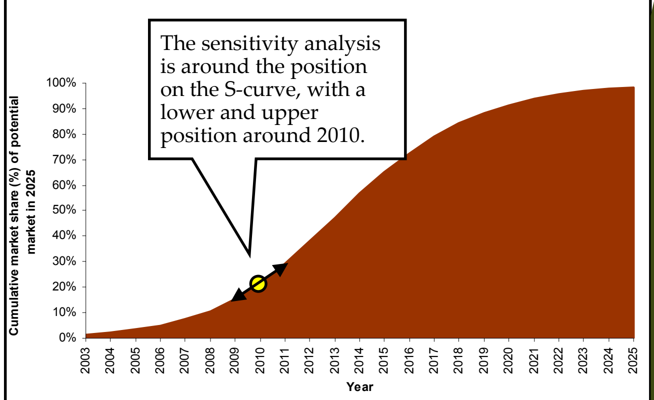


1) Potential demand in 2010 by segment (residential, commercial, total) by state and different system price scenarios is provided in the Appendix.

A sensitivity analysis around the position on the S-curve yields a potential grid-connected demand for PV in 2010 of 2.2–3.6 GWp.

8.7 Potential Annual Demand in 2010 (MWp)

S-Curve to Calculate Potential Demand in 2010



Potential Annual Demand in 2010-Low

Residential

System size = 2.5 kW

Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	4,053	1.05%	5.1
$2.50	727	0.19%	1.8
$3.75	224	0.06%	0.8
$5.30	121	0.03%	0.6

Commercial

Commercial - Small/Medium and Large Total

System size = 15 kWp, 100 kWp

Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	4,506	1.38%	4.9
$ 2.00 - 2.20	1,473	0.45%	3.2
$ 3.00 - 3.30	646	0.20%	2.1
$ 4.25 - 4.65	384	0.12%	1.8

Grid Connected - Total

Technical Market (MW) = 711,864

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	8,559	1.20%	10.0
$ 2.00 - 2.50	2,200	0.31%	5.0
$ 3.00 - 3.75	871	0.12%	2.9
$ 4.25 - 5.30	505	0.07%	2.4

Potential Annual Demand in 2010-High

Residential

System size = 2.5 kW

Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	6,622	1.72%	8.3
$2.50	1,188	0.31%	3.0
$3.75	366	0.09%	1.4
$5.30	198	0.05%	1.1

Commercial

Commercial - Small/Medium and Large Total

System size = 15 kWp, 100 kWp

Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	7,361	2.26%	8.0
$ 2.00 - 2.20	2,407	0.74%	5.2
$ 3.00 - 3.30	1,056	0.32%	3.4
$ 4.25 - 4.65	627	0.19%	2.9

Grid Connected - Total

Technical Market (MW) = 711,864

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	13,983	1.96%	16.3
$ 2.00 - 2.50	3,594	0.50%	8.2
$ 3.00 - 3.75	1,422	0.20%	4.8
$ 4.25 - 5.30	825	0.12%	3.9

1) Discussions with a major PV manufacturer indicate that the total (grid-connected and off-grid) potential PV demand in the U.S at a system price of ~$2.00 (which is expected to happen much later than 2010) is around 3GWp.

2) Market share is relative to the technical market of available roof space.

The potential demand for grid-connected PV in residential and commercial segments could potentially be higher than estimated.

Factors That Could Increase the Demand Estimation for Grid Connected Applications
1. Only roof-top applications were considered. Other applications such as ground mounted PV, car ports, curtain walls, and awnings were ignored. These applications account for a negligible proportion of the market, but is growing. 2. Utility rates could escalate at a rate higher than assumed, which would reduce the payback period for PV systems leading to higher market penetration. 3. The value for Renewable Energy Certificate (RECs) is assumed to be $0.015/kWh in 2010. A higher REC value due to greater demand, particularly for PV RECs, could improve the economics of a PV system and increase demand. 4. The demand estimate is based on the average consumption by customers in the residential and commercial segments. Customers with higher consumption in some states like California have higher utility rates. For these customers, PV economics would be much better than for the "average" customer, which could lead to higher penetration within the high consumption customer category. 5. The economic analysis did not consider any state incentives or policies that would proactively encourage demand. 6. Time-of-use rates that monetize the value of PV coincidence with utility peak loads would improve PV economics.

Source: NCI analysis

Additional analysis of the potential demand for grid-connected PV, as listed below is presented in the Appendix.

- Estimation of the annual demand in 2015, based on assumptions discussed earlier in this report.
- Estimation of the annual demand in 2010, based on the Kastovich market penetration curve and the higher slope S-curve.

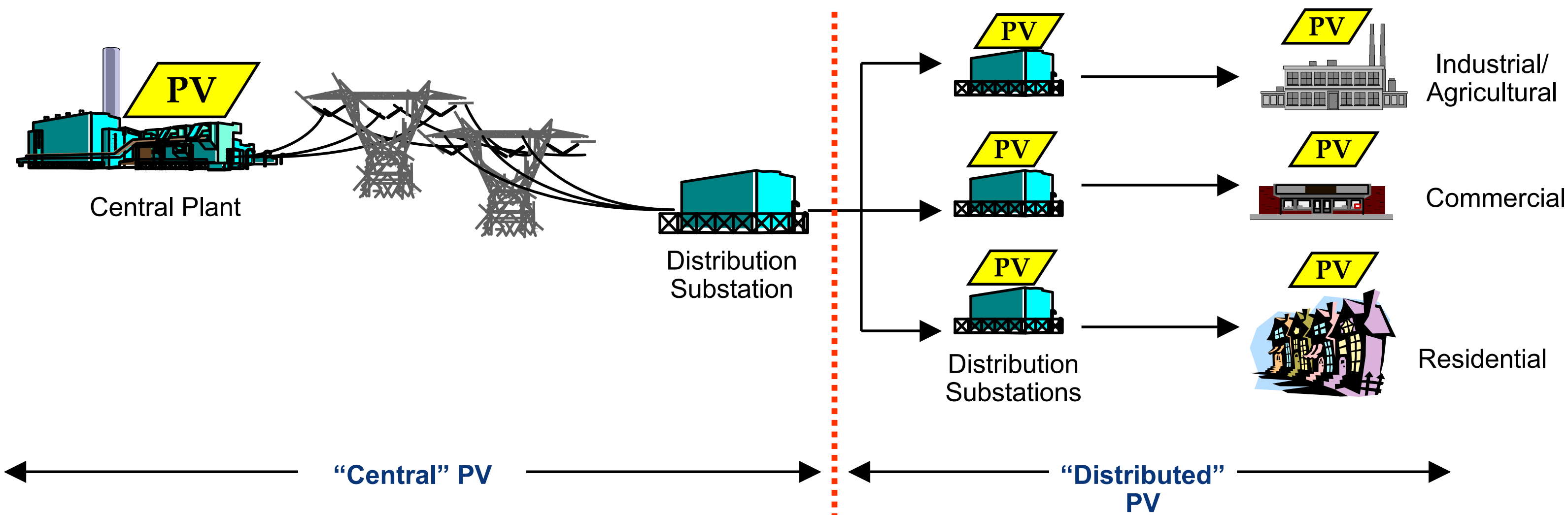
3 » Market Potential for Grid Connected PV

Residential and Commercial Segments

Utilities Segment

From a utility's perspective, PV can be used at either the central plant location on the power grid or on the distribution part of the system.

Applications of PV on the Power Grid



- "Central" PV plants are of large size (several MW) and connect at the transmission level
- Central PV applications compete against conventional fossil fuel power plants as well as alternative energy sources (wind, biomass, geothermal)

- "Distributed" PV plants are smaller in size and connect to the grid at the substation level or further downstream
- Distributed PV applications compete against other distributed generation technologies such as internal combustion and steam turbines, reciprocating engines, etc.

NAVIGANT CONSULTING

There are many sources of value from PV, with relatively higher value accruing to "distributed" rather than "central" applications.

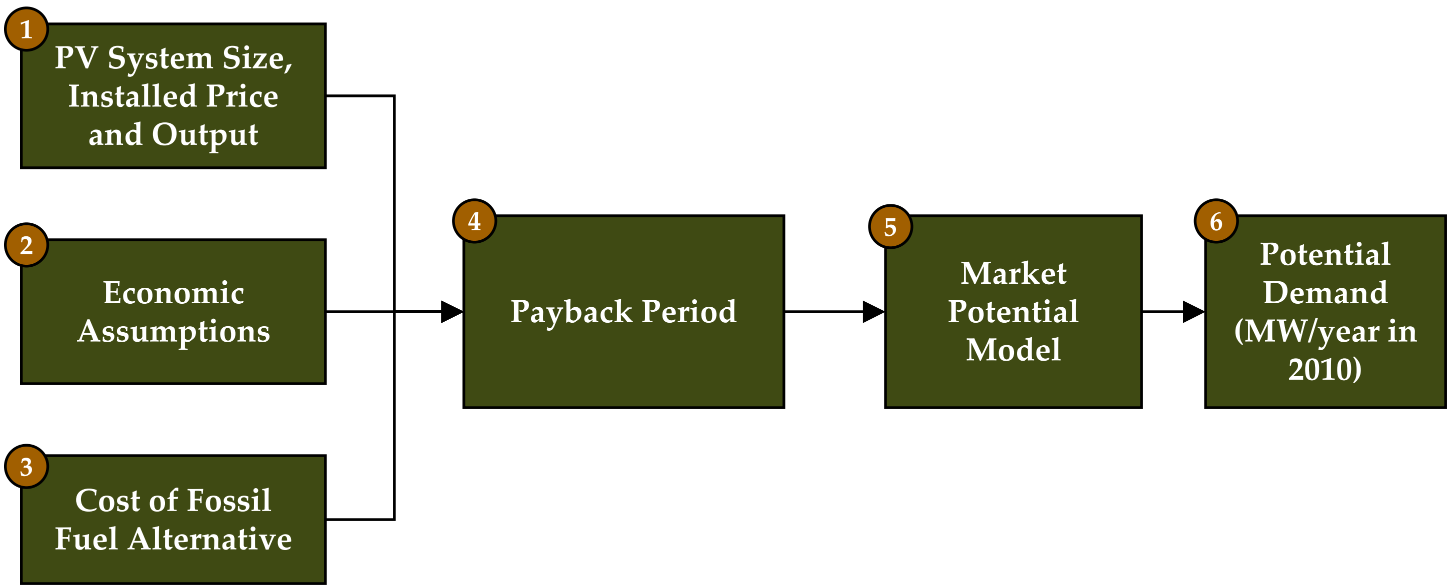
Value Source	Comments	Application	
		"Central"	"Distributed"
Energy Value and Capacity Credit	• Energy produced by PV plant can be used either on site or transmitted to loads. • PV output often coincides with peak demand, though this differs by location due to variations in solar resource and load profile • PV is an intermittent energy source, and thus has low dispatchability.	•Low Value -Competes with low cost fossil alternatives -Value from peak shaving -Intermittency	•High value to customer -Competes with high price of retail energy -Value from peak shaving -Saves energy loss •Low value to utility (lost revenues)
T&D Deferral	• PV plants at or near the load reduce the need to upgrade or expand T&D system • The value of deferral is site specific within a utility system, depending on rate of load growth, existing T&D capacity and system condition, etc.	•Low value -Does not provide any deferral value	•Medium-High value -Value accrues to utility whether PV system is owned by it or not -No value if load & system do not have the required profile
Emission Allowance & REC	• PV has practically no emissions • PV is an eligible technology for most RPS requirements • Value of PV meeting RPS mandate depends on whether the mandate has solar set asides, or minimum requirements by class of technology	•Medium – High value -Provides value	•Medium value -Many customers don't need emission allowance or RECs -Can market this value to utilities, but market not fully developed
Other	• Value from fuel price risk mitigation, because PV does not use fuel • Value from intangibles (public relations, "feel good" by community, etc)	•Medium value	•Low – Medium value -Depends on customer profile

NAVIGANT CONSULTING

The focus of the demand analysis in the utility segment is for "central" applications.

- Utilities take a life cycle cost-benefit perspective, the analysis of which is impacted by factors such as equipment cost, O&M cost including fuel cost, deferred investment in T&D, fuel price risk mitigation, value of emission allowances, impact on power reliability & quality, etc.
  - In selecting a technology, utilities need to consider all potential technologies.
  - The selection of a technology also needs to take into account utility and site specific conditions and requirements.
- The regulation which most impacts PV demand is RPS requirement. However, most RPS do not mandate PV (except in very few states, through solar set-asides), and hence PV has to compete with other renewable energy sources such as wind and biomass, when utilities seek to comply with RPS regulations.
- PV installation on residential and commercial rooftops provides a utility with more benefits than a central plant, including T&D deferral and saving of energy losses
- Estimating the demand from a utility for PV in "distributed" applications must thus take into account PV installation in the residential and commercial segments within a utility's territory, whether owned by the utility or not in order to avoid double counting.
- The scope of this study does not permit an analysis of the demand of PV from the utility segment taking into account all the above issues.
- This study has evaluated the potential demand from the residential and commercial segments. It is unlikely that there will be an additional demand from the utilities for PV in the distribution part of the system.
- As such, the focus of the analysis in the utility segment is on estimating the demand for "central" applications of PV.

The approach used to analyze the potential demand in the utility segment is illustrated below.



- **The analysis is conducted for only one state, namely California.**
- **A description of each component of the approach is described in the following pages.**

A breakthrough in installed system price is assumed, to reach an average of $2/Wp for large central plant PV systems by 2010.

1 PV System Size, Installed Price and Output

Utility Central PV Application		
System Size (kWpdc)		5 MWp
Installed System Price ($/Wpdc) in 2010 (2010 dollars)	Base-case	$ 2.00
	Sensitivity cases	$ 1.00 and $ 3.00
	Business-as-usual case	$ 4.00
System Capacity Factor		20% and 27%

Key Comments

- The large central system sizes currently installed worldwide range between 3.3-5MWp. An average system size of 5MWp is considered reasonable during 2010.
- Central PV systems typically have a tracking system, which while it increases system cost, also results in higher PV system output.
- In addition to the PV cost components for residential and commercial systems, central PV systems also incur land procurement and land development cost. Typically this cost is not large, at 1% of the total project cost.
- In 2004, it is estimated that the installed system cost for a single axis tracking system is around $5.5-7.0/Wpac (or an average of $5.2/Wpdc). This is expected to decline to around $4.00/Wpdc by 2010.
- Two alternative insolation locations in California are assumed, with resulting capacity factors of 20% and 27%. A single tracking system leads to an increase of 20-25% in system output compared to a system without tracking.

NAVIGANT CONSULTING

Key economic assumptions include: O&M expenses, RECs with a $.015/kWh value, and minimal Federal incentives.

2 Economic Assumptions

Factor[1]	Assumption	Comments
System Life	30 years	• Typical for crystalline silicon technologies.
O&M Cost ($/kW/year)	$ 27/ kW/ year	• Central systems incur O&M expenses to ensure PV panels are clean and maintenance of the tracking system which has moving parts.
Replacement Expenditure	Yes	• Inverters will be replaced once during Year 10 of the project life. Cost of inverter is assumed at around $210/W based on current prices and trends.
State Incentives	No	• No state incentives are assumed.
Federal Tax Credits (%)	10	• Federal Investment Tax Credit of 10% has been available for several years and does not have an expiration. Assumed that this will be applicable to central PV.
Accelerated Depreciation	MACRS 5 year class	• Federal incentive that currently exists and is likely to continue. Applicable to commercial customers.
REC[2] Value ($/kWh)	0.015	• Assumption reflects the federal cap of $15/MWh. Current PV REC values are much higher, reflecting limited availability in trading system.
Net Metering	Not relevant	• Not relevant for central PV systems.
Discount Rate	6.35%	• Assumes debt equity ratio of 3:1, cost of debt at 7.5%, cost of equity at 12%, marginal federal income tax at 34% and state income tax at 6.5%.

1) All data are in 2010 dollars 2) REC = Renewable Energy Certificate

NAVIGANT CONSULTING

The competing technology considered is a gas turbine peak generation plant.

3

Cost of Fossil Fuel Alternative

Fossil Fuel Alternative: Gas Turbine[1]	
Capital Cost	$71.92/kW/year (Fully loaded cost)
O&M Expenses (non-fuel)	$2.00 / MWh
Fuel Cost	$/MMBTU: $5 and $3 Heat rate: 10,500 BTU/kWh
Capacity Factor	8%, 10% and 15% (range for a peak plant)

1) NCI Estimates

Key Comments

- A PV central plant will compete most effectively with a peaking plant, given the characteristics of PV system output, which matches peak demand. Cost and performance of a GT generator peak plant is assumed for comparison.
- A range of values has been considered for two key assumptions, i.e. fuel cost and capacity factor

While utilities do not typically use the payback metric in their decision, this was used to provide an estimate of demand[1].

4 **Payback Period**

Payback Period						
Fuel Cost	**\$5.0 / MMBTU**			**\$3.0 / MMBTU**		
GT Capacity Factor	**8%**	**10%**	**15%**	**8%**	**10%**	**15%**
PV System Cost	**Payback Period (Years)**					
\$1.00/Wpdc	3	4	5	4	5	6
\$2.00/Wpdc	8	11	16	11	14	25
\$3.00/Wpdc	19	28	>50	28	50	N/A
\$4.00/Wpdc	>50	>50	N/A	>50	N/A	N/A

Key Comments

- Utilities use investment metrics such as IRR and NPV to make investment decisions. However, there is limited data available to estimate market potential based on these metrics. Hence, the payback metric was used to provide an estimate of demand.
- The payback period is calculated by taking into account the initial capital investment required for the PV system, the differential in the levelized cost of energy (LCOE) between the PV system and the fossil fuel alternative, value of RECs, and the output of the PV system. In addition, values associated with PV system for emission allowance and fuel price risk mitigation are estimated at around \$50/kW/year.[2]
- In the case where the LCOE of PV plant and consideration of REC results in a cost higher than that of the fossil fuel alternative, payback is not calculated.

1) A curve that relates financial return (IRR) or comparative cost difference between two energy sources (in %) and market penetration by a technology is not available within NCI or in the public domain. Hence the payback curve was used to provide an estimate of demand in the utilities sector.
2) NCI estimates based on NOx + CO_2 at \$10/ton and 800lb/MWh; and Austin Energy's green fixed price premium

NAVIGANT CONSULTING

The market potential model used for the utility segment is similar to that for the residential/commercial segments, with some differences.

5

Market Potential Model

Key Comments	
Technical Market Potential - 2025	• The technical market potential is the total demand for peak power in 2025. • In California, peak demand during 2025 is estimated at 67,529 MW
Cumulative Market Penetration - 2025	The cumulative market penetration by PV of the peak power market in 2025 is calculated using the average of the Kastovich and NCI curves (payback versus market penetration) as discussed in the section on residential and commercial demand.
S-Curve	The S curve used for the utility segment is similar to that for the residential segment, with a small difference in that for the residential and commercial segment, PV had penetrated the market by 2003, albeit to a very small percentage, while for the utility segment, the market penetration is for practical purposes, nil.

NAVIGANT CONSULTING

The potential demand for central PV in California in 2010 is estimated at 9-500 MWp, depending natural gas price and GT capacity factor.

6

Potential Demand in 2010

Central PV Potential Demand in 2010						
Fuel Cost	**$5.0 / MMBTU**			**$3.0 / MMBTU**		
GT Capacity Factor	**8%**	**10%**	**15%**	**8%**	**10%**	**15%**
PV System Cost	**Annual Demand in 2010 (MW)**					
$1.00/Wpdc	500	452	312	452	367	201
$2.00/Wpdc	90	20	9	20	12	0
$3.00/Wpdc	5	0	0	0	0	0
$4.00/Wpdc	0	0	0	0	0	0

Demand for central PV is nil when the payback is more than 20 years.

NAVIGANT CONSULTING

Table of Contents

1 » Introduction

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » **Market Barriers**

5 » Attractive States for PV

6 » Appendix

NAVIGANT CONSULTING

To realize the market potential for PV, technological, institutional and market infrastructure barriers need to be addressed.

Market Barriers for PV

Technological

- High manufacturing and total installed system cost

Institutional

- Lack of consistent and long-term funds for buy-down programs
- Lack of interconnection standards
- Wide-spread net metering policies for all sizes of PV
- Uncertainty about the value of Renewable Energy Certificates in the marketplace

Market Infrastructure

- Installer training
- Building inspector and code official training
- Consumer education about the technology

The industry must address the barriers taking into account their impact and the resources and time required to redress them.

Barriers	Impact of Barrier		Ease of Redress	
	Rating	Comments	Rating	Comments
High manufacturing and total installed system cost	●	• High first cost is the most significant barrier to PV adoption	○	• Manufacturing improvements have been incremental over the past decade
Lack of interconnection standards	◒	• Interconnection costs or penalties can result in uneconomic installations of PV	◒	• Many states are moving to establish quicker and cheaper processes for PV interconnection
Wide-spread net metering policies for all sizes of PV	●	• Lack of net metering policies can ruin the economics of a PV system	◒	• Over 35 states in the U.S. currently have net metering policies for small PV systems
Uncertainty about RECs values	○	• Many owners of PV systems currently do not receive value from the sale of RECs	●	• MA has implemented a program already to guarantee payment on RECs for 10 years
Lack of long-term funds for buy-down programs	◒	• Without buy-downs, the grid-connected PV market would probably not exist in the U.S.	●	• Creative business models or phasing out of buy-downs can help to overcome this barrier
Installer training	○	• Poor installations result in reduced output, but does not prevent the system from working	●	• Many state programs are focusing on installer training activities
Building inspector and code official training	◒	• Lack of knowledge about PV can hinder inspection approvals	●	• As volumes and knowledge of PV increases, this issue should resolve itself
Consumer education	◒	• Many consumers still associate PV with the poor performance of solar hot water systems in the 1980s	●	• Educational campaigns can help overcome this barrier

○ = Low ◒ = Medium ● = High

Potential solutions to the key barriers include:

Barriers	Potential Solutions
High manufacturing and total installed system cost	Provide funding support to manufacturers to expand R&D and manufacturing capacities or establish stable customer incentive "buy-down" funding to encourage investment in manufacturing plant.
Lack of interconnection standards	Work with state agencies to develop interconnection standards.
Wide-spread net metering policies for all sizes of PV	Work with state agencies to develop net metering policies that are for residential and commercial size PV systems.
Uncertainty about RECs values	Try to replicate MA model of REC value guarantees in other states and with other state renewable energy funds.
Lack of long-term funds for buy-down programs	Develop other creative business models so there is not complete reliance on state buy-down programs. If buy-downs are implemented, ensure that they are phased out over time to create a sustainable market. Review Japanese buy-down program.
Installer training	Several states have implemented very good installer training programs that can be replicated in other states.
Building inspector and code official training	Use Clean Energy States Alliance (CESA) or individual state funds to help educate and train building inspectors and code officials about PV.
Consumer education	Provide more TV adds or educational campaigns to educate consumers about the high reliability of PV and the benefits to the environment.

NAVIGANT CONSULTING

Table of Contents

1 » Introduction

2 » Executive Summary

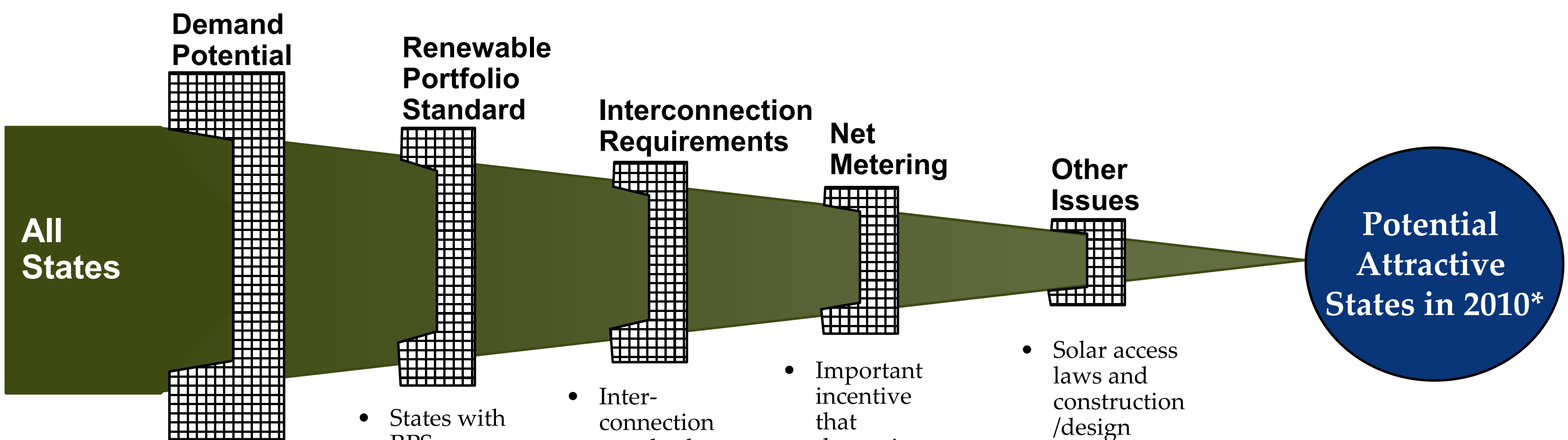
3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

Potentially attractive states for grid connected PV systems were identified by taking into account five criteria.



Demand Potential

- Assessment based on utility rates, solar resources and roof space availability
- Large markets are attractive!
- Focus on demand from the roof-top residential and commercial market segments.

Renewable Portfolio Standard

- States with RPS encourages consideration of PV, and provides impetus for development of REC market

Interconnection Requirements

- Inter-connection standards and streamline processes for PV systems

Net Metering

- Important incentive that determines PV economics

Other Issues

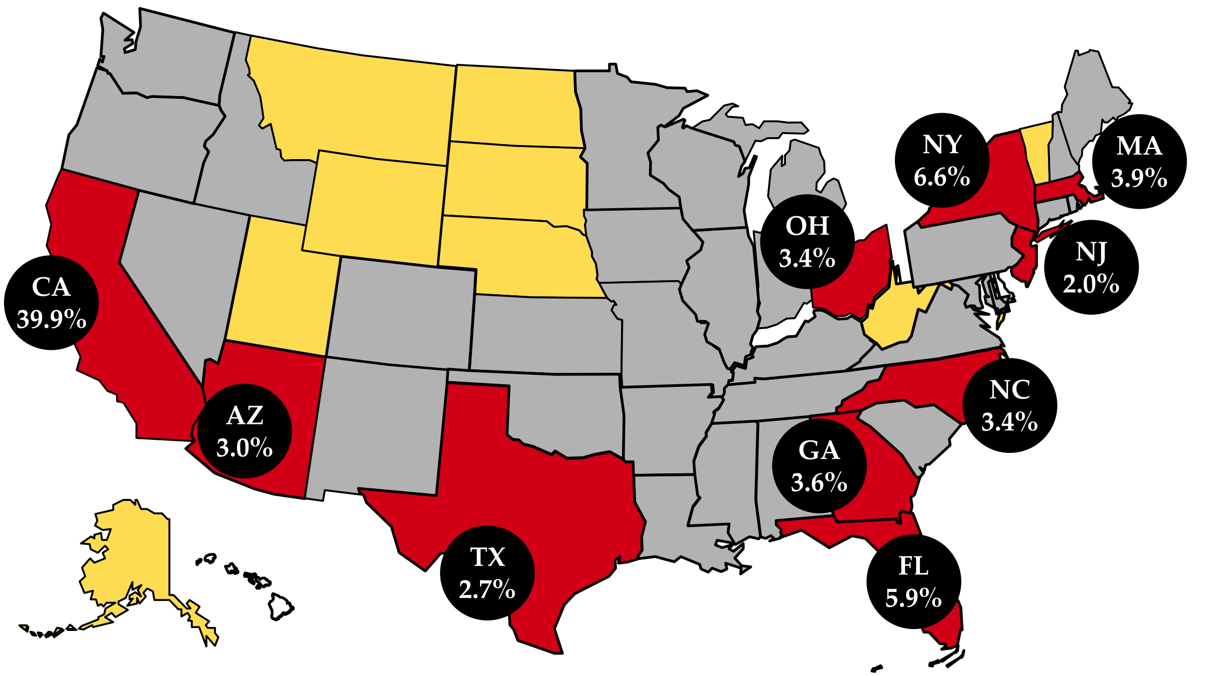
- Solar access laws and construction /design policies can impact customer choice

*This is not indicative of the best current state markets for PV in the U.S., that are largely driven by state buy-down programs and rebates.

NAVIGANT CONSULTING

The top ten states together account for 74% of the total potential demand of 2,901 MWp in 2010 at a system price of $2.00-2.50/Wpdc.

Potential Grid Connected Demand in 2010 By State: % Share of Total



Ranking

1. CA
2. NY
3. FL
4. MA
5. GA
6. NC
7. OH
8. AZ
9. TX
10. NJ

= Top Ten States = Bottom Ten States = 'In-between' States

U.S Total 2,901 MWp

Note: Based on analysis conducted for this study. See earlier part of report. Potential demand in 2010 by segment (residential, commercial, total) by state and different system price scenarios is provided in the Appendix. This is not indicative of the best current state markets for PV in the U.S., that are largely driven by state buy-down programs and rebates.

Amongst the top ten states identified by demand potential, seven have or are considering RPS.

#	State	RPS Status			Rating		
		% Required	By Year	Other Issues/ Comments	High	Medium	Low
1	California	20%	2017	Minimum 1% increase every year	√		
2	New York			Currently implementing an RPS with Solar set-aside		√	
3	Florida	No state RPS standard					√
4	Massachusetts	4%	2009		√		
5	Georgia	No RPS standard					√
6	Ohio	No RPS standard					√
7	North Carolina			Considering RPS		√	
8	Arizona	1.1%*	2007	Solar should be 60%	√		
9	Texas	2.2% or 2,000 MW	2009		√		
10	New Jersey	6.5%	2012	Minimum of 4% from Class-I sources, which includes solar	√		

* RPS requirement is 0.8% in 2004. If PV does not reach a cost – benefit status agreeable to by the Commission by 2004, RPS standard will not increase beyond 2004.

NAVIGANT CONSULTING

Five states have interconnection standards that make it easy for customers to install PV systems of a reasonable size.

#	State	Interconnection Status			Rating		
		State Standards	Maximum System Size Eligibility	Other Issues	High	Medium	Low
1	California	√	≤ 10 MW		√		
2	New York	√	≤ 300 kVA	Developing standby changes (except for residential systems of ≤ 10 kW)	√		
3	Florida	√ (for IOUs, not munis or coops)	≤ 10 kW	Requires $100K liability insurance by customer		√	
4	Massachusetts	√	≤ 60 kW			√	
5	Georgia	√	≤ 10 kW Residential ≤ 100 kW Commercial			√	
6	Ohio	√	≤ 300 kVa		√		
7	North Carolina						√
8	Arizona	√ (by major utilities)			√		
9	Texas	√	≤ 10 MW at 60 kV or less		√		
10	New Jersey	√			√		

NAVIGANT CONSULTING

Nine states offer net metering, though some states restrict the PV system size eligible for net metering.

#	State	Net Metering Status				Rating		
		Applicable	System Size Eligibility	Cumulative PV Installation Eligibility	Other Issues	High	Medium	Low
1	California	√ (state wide)		Up to 0.5% utility peak demand	No exit fees	√		
2	New York	√ (state wide)	<10kW	Up to 0.1% utility peak demand		√		
3	Florida	√ (by each utility)				√		
4	Massachusetts	√	≤ 60 kW				√	
5	Georgia	√	≤ 10 kW Residential ≤ 100 kW Commercial	Up to 0.2% of utility peak demand			√	
6	Ohio	√				√		
7	North Carolina							√
8	Arizona	√	≤ 10 kW (APS) ≤ 500 kW (TEP)			√		
9	Texas	√	≤ 50 kW				√	
10	New Jersey	√	≤ 100 kW	Up to 0.1% utility peak demand			√	

NAVIGANT CONSULTING

Six states allow solar easements which ensures optimal PV system operation during the system life.

#	State	Other Issues		Rating		
		Solar Access Laws/ Guidelines	Construction & Design Issues	High	Medium	Low
1	California	• Solar easements allowed* • Restrictive covenants prohibited** • Cities have specific requirements, e.g, encouraging buildings oriented for PV, relaxing building height restrictions if PV installed, etc.	Solar to be installed on all state buildings where feasible by January 1, 2007, as well as on new state buildings and park constructions	√		
2	New York	• Solar easements allowed • Local zoning districts can make own rules		√		
3	Florida	• Prohibits covenants restricting access/use of solar energy			√	
4	Massachusetts	• Solar easements allowed • Prohibits restrictive covenants		√		
5	Georgia	• Solar easements allowed • Prohibits restrictive covenants		√		

* Easements provide assured access to solar resource after PV system is installed.
** Covenants that restrict installation of PV system by building owner, associations, etc.

NAVIGANT CONSULTING

Six states allow solar easements which ensures optimal PV system operation during the system life. *(Continued)*

#	State	Other Issues		Rating		
		Solar Access Laws/ Guidelines	Consideration & Design Issues	High	Medium	Low
6	Ohio	• Solar easements allowed		√		
7	North Carolina					√
8	Arizona	• Restrictive covenants prohibited	New state buildings should follow solar design and install PV if payback ≤ 8 years		√	
9	Texas		State government to evaluate PV			√
10	New Jersey	• Solar easements allowed		√		

NAVIGANT CONSULTING

Seven states are the most attractive for PV, namely California, New York, Massachusetts, Ohio, Arizona, Texas and New Jersey.

#	State	Attractiveness Based on Criteria					Overall Attractiveness*
		Demand Potential	RPS	Interconnection Requirement	Net Metering	Other Issues	
1	California	●	●	●	●	●	●
2	New York	●	◒	●	●	●	●
3	Florida	●	○	◒	●	◒	◒
4	Massachusetts	●	●	◒	◒	●	●
5	Georgia	●	○	◒	◒	●	◒
6	Ohio	●	○	●	●	●	●
7	North Carolina	●	◒	○	○	○	○
8	Arizona	●	●	●	●	◒	●
9	Texas	●	●	●	◒	○	●
10	New Jersey	●	●	●	◒	●	●

○ = Unfavorable ◒ = Medium ● = Favorable

* High if rated Favorable on at least three criteria, Medium if rated Favorable on at least two criteria, Low if rated Favorable on one or no criteria.

NAVIGANT CONSULTING

Table of Contents

1 » Introduction

2 » Executive Summary

3 » Market Potential for Grid Connected PV

4 » Market Barriers

5 » Attractive States for PV

6 » Appendix

List of Appendices

6 » Appendix

A1 » Census Regions

A2 » Locations and Utilities Selected for Analysis

A3 » Average Customer Load

A4 » Number of Customers

A5 » Clean-Power Estimator™ Model

A6 » Payback

A7 » Available Roof Area

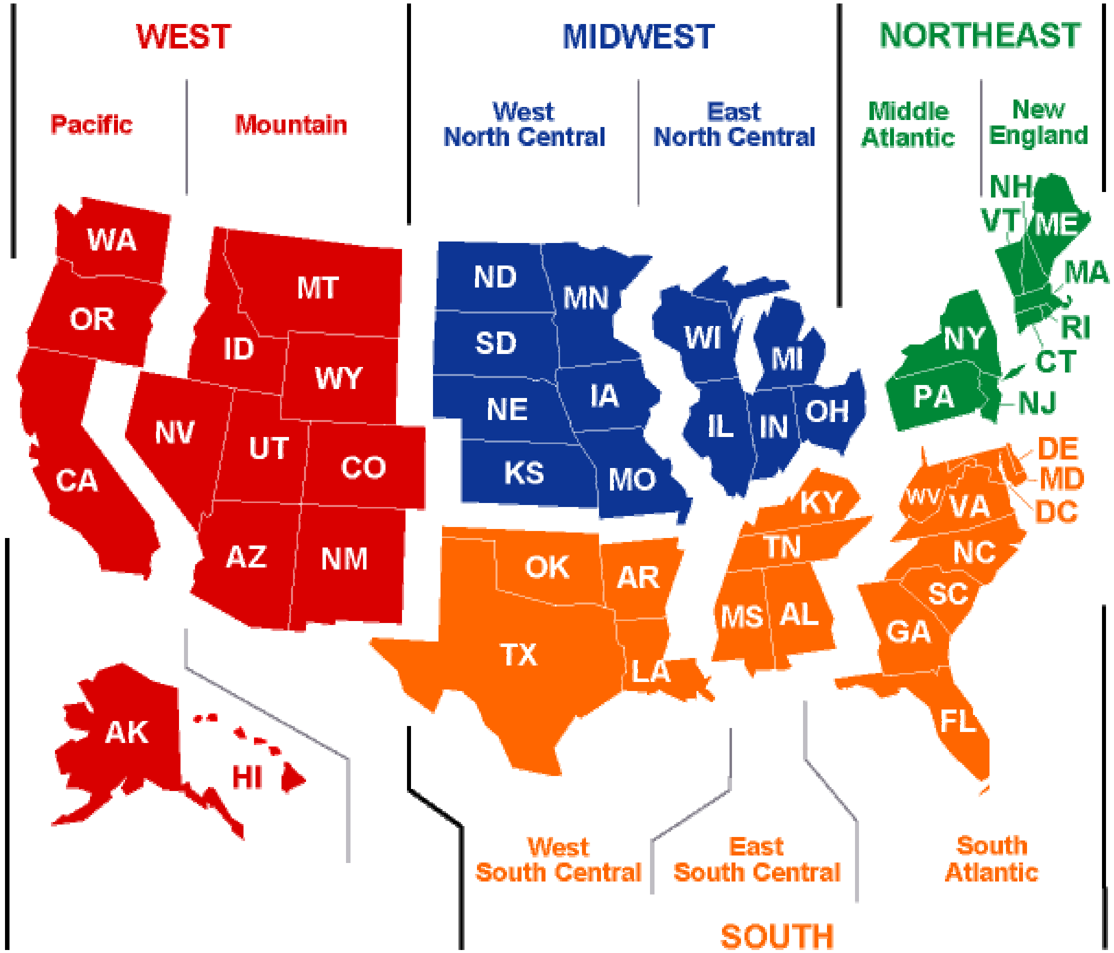
A8 » Technical Market for PV

A9 » Annual Demand in 2010

A10 » Annual Demand in 2015

A11 » Annual Demand in 2010 with Alternative Curves

There are nine Census regions.



NAVIGANT CONSULTING

The locations and utilities selected determine the insolation and utility rates used to represent the entire state in our analysis.

State	Location	Utility
Midwest - East North Central		
Illinois	Chicago	Commonwealth Edison Co.
Indiana	Indianapolis	Indianapolis Power and Light
Michigan	Detroit	Detroit Edison
Ohio	Cleveland	FirstEnergy Corp (The Illuminating Company)
Wisconsin	Milwaukee	We Energies (Wisconsin Electric)
Midwest - West North Central		
Iowa	Cedar Rapids	IES Utilities
Kansas	Topeka	Kansas Power and Light (Western Resources)
Minnesota	St. Paul	Xcel Energy (Northern States Power)
Missouri	Jefferson City	AmerenUE - Missouri (Union Electric)
Nebraska	Lincoln	Lincoln Electric
North Dakota	Bismarck	Montana-Dakota Utilities
South Dakota	Sioux Falls	Xcel Energy (Northern States Power)
NorthEast - Middle Atlantic		
New Jersey	Trenton	PSE&G (Public Service Electric and Gas Co.)
New York -1	Albany	Niagara Mohawk
New York -2	New York	Consolidated Edison
New York -3	New York	Long Island Power Authority
Pennsylvania	Harrisburg	PPL Electric Utilities
NorthEast - New England		
Connecticut	Hartford	Connecticut Light and Power
Maine	Augusta	Central Maine Power
Massachusetts	Boston	NSTAR (Boston Edison)
New Hampshire	Manchester	Public Service of New Hampshire
Rhode Island	Providence	Narragansett Electric
Vermont	Montpelier	Green Mountain Power
South - East South Central		
Alabama	Montgomery	Alabama Power Co.
Kentucky	Frankfort	American Electric Power (Kentucky Power)
Mississippi	Jackson	Entergy Mississippi (Mississippi Power and Light)
Tennessee	Nashville-Davidson	Nashville Electric Service

State	Location	Utility
South - South Atlantic		
Delaware	Newark	Conective (Delmarva Power)
Florida	Miami	Florida Power & Light Co.
Georgia	Atlanta	Georgia Power
Maryland	Annapolis	BGE (Baltimore Gas and Electric)
North Carolina	Charlotte	Duke Power
South Carolina	Columbia	South Carolina Electric and Gas
Virginia	Richmond	Dominion (Virginia Electric and Power)
Washington, DC	Washington	PEPCO
West Virginia	Charleston	American Electric (Appalachian Power)
South - West South Central		
Arkansas	Little Rock	Entergy Arkansas
Louisiana	New Orleans	Entergy (Louisiana Power & Light)
Oklahoma	Tulsa	AEP (Public Service Company of Oklahoma)
Texas	Dallas	TXU Electric
West - Mountain		
Arizona	Phoenix	APS
Colorado	Denver	Public Service Company of Colorado
Idaho	Boise City	Idaho Power
Montana	Helena	Northwestern Energy (Montana Power Company)
Nevada	Las Vegas	Nevada Power
New Mexico	Santa Fe	PNM (Public Service Company of New Mexico)
Utah	Salt Lake City	PacifiCorp (Utah Power & Light)
Wyoming	Casper	PacifiCorp (Pacific Power)
West - Pacific		
Alaska	Anchorage	Chugach
California -1	Long Beach	Southern California Edison (SCE)
California -2	Sacramento	Sacramento Municipal Utility District (SMUD)
California -3	San Jose	Pacific Gas and Electric Company (PG&E)
Hawaii	Honolulu	Hawaiian Electric Company (Oahu)
Oregon	Portland	PacifiCorp (Pacific Power)
Washington	Olympia	Puget Sound Energy

Note:
- State capitals typically have the highest population, and largest building stock for both commercial and residential buildings in the state.
- Solar resource data is available for all state capitals.
- In the case of California and New York, because of the combination of good solar resource and different tiered or wide range of electricity tariff structures, we took into account two additional cities.

Average customer load in kWh/year, by state and segment[1].

Average consumption (kWh/year)			
State	**Residential**	**Commercial: Small/Med**	**Commercial: Large**
Midwest - East North Central			
Illinois	8,711	87,455	7,394,237
Indiana	11,427	86,112	2,344,113
Michigan	7,788	74,755	2,480,151
Ohio	9,826	70,344	70,344
Wisconsin	8,634	65,732	4,673,847
Regional Weighted Average	**9,157**	**76,979**	**3,282,208**
Midwest - West North Central			
Iowa	9,945	49,110	4,050,919
Kansas	10,543	67,023	729,050
Minnesota	9,333	85,583	3,963,724
Missouri	12,246	80,681	1,685,644
Nebraska	11,797	59,104	729,961
North Dakota	11,939	64,680	64,680
South Dakota	10,928	56,212	1,048,383
Regional Weighted Average	**10,830**	**70,492**	**2,148,511**
NorthEast - Middle Atlantic			
New Jersey	7,934	81,329	938,889
New York -1	6,532	65,638	2,472,830
New York -2	6,532	65,638	2,472,830
New York -3	6,532	65,638	2,472,830
Pennsylvania	9,081	54,710	1,384,796
Regional Weighted Average	**7,694**	**64,599**	**1,760,078**
NorthEast - New England			
Connecticut	8,573	92,465	947,327
Maine	7,208	60,283	2,777,927
Massachusetts	7,126	76,125	809,128
New Hampshire	6,934	45,206	754,247
Rhode Island	6,464	77,338	547,171
Vermont	7,028	46,124	46,124
Regional Weighted Average	**7,412**	**72,109**	**970,213**
South - East South Central			
Alabama	14,281	59,196	5,258,472
Kentucky	13,229	59,565	6,186,238
Mississippi	14,222	60,206	3,449,249
Tennessee	15,177	67,016	16,902,980
Regional Weighted Average	**14,312**	**62,111**	**9,128,569**

Average consumption (kWh/year)			
State	**Residential**	**Commercial: Small/Med**	**Commercial: Large**
South - South Atlantic			
Delaware	10,895	90,209	5,872,970
Florida	13,806	81,344	817,951
Georgia	12,716	88,536	3,425,552
Maryland	11,910	115,183	834,362
North Carolina	12,649	71,434	71,434
South Carolina	13,883	68,368	5,889,721
Virginia	13,227	92,524	3,630,781
Washington, DC	8,605	267,426	279,693,635
West Virginia	11,917	56,477	969,271
Regional Weighted Average	**13,053**	**84,136**	**4,596,780**
South - West South Central			
Arkansas	12,702	61,779	663,524
Louisiana	14,140	79,578	1,876,633
Oklahoma	12,984	65,414	65,414
Texas	14,059	77,049	77,049
Regional Weighted Average	**13,818**	**74,664**	**358,665**
West - Mountain			
Arizona	12,891	101,067	1,851,363
Colorado	7,930	72,581	1,383,645
Idaho	12,712	68,638	1,134,733
Montana	9,454	46,956	46,956
Nevada	11,602	57,780	5,887,283
New Mexico	6,824	62,123	3,688,728
Utah	8,671	94,240	857,299
Wyoming	9,557	58,139	58,139
Regional Weighted Average	**10,166**	**74,737**	**2,020,298**
West - Pacific			
Alaska	8,060	59,096	1,188,636
California - 1	6,528	64,240	520,152
California - 2	6,528	64,246	520,167
California - 3	6,528	64,246	520,157
Hawaii	7,473	57,092	5,794,191
Oregon	12,035	70,322	1,061,215
Washington	12,808	83,901	1,062,193
Regional Weighted Average	**8,008**	**67,167**	**791,503**
National Weighted Average	**10,520**	**72,893**	**2,783,283**

1) Source: EIA, US Average Monthly Bill by Sector, Census Division and State, 2001. Assumption made that load per customer remains constant with time.
2) Note 1: The EIA commercial segment data is assumed for small/medium commercial while EIA industrial segment data is assumed for large commercial.
3) Note 2: Weighting is done by number of customers by segment, by state (EIA data, 2001), which is provided in the appendix.

NAVIGANT CONSULTING

For the purpose of analysis, NCI used the 2001[1] EIA data on number of customers by segment in each state.

Number of Customers (2001)					
State	Residential Total	Commercial Total	Total	% share of U.S Total	% share of Residential
Midwest - East North Central					
Illinois	4,801,256	501,175	5,302,431	4%	90.5%
Indiana	2,574,672	296,676	2,871,348	2%	89.7%
Michigan	4,147,897	466,654	4,614,551	4%	89.9%
Ohio	4,817,008	561,554	5,378,562	4%	89.6%
Wisconsin	2,364,921	284,113	2,649,034	2%	89.3%
Regional subtotal	**18,705,754**	**2,110,172**	**20,815,926**	**16%**	**89.9%**
Midwest - West North Central					
Iowa	1,249,933	173,308	1,423,241	1%	87.8%
Kansas	1,144,180	190,752	1,334,932	1%	85.7%
Minnesota	2,078,775	231,313	2,310,088	2%	90.0%
Missouri	2,463,550	322,570	2,786,120	2%	88.4%
Nebraska	732,255	122,346	854,601	1%	85.7%
North Dakota	291,483	47,468	338,951	0%	86.0%
South Dakota	327,661	51,852	379,513	0%	86.3%
Regional subtotal	**8,287,837**	**1,139,609**	**9,427,446**	**7%**	**87.9%**
NorthEast - Middle Atlantic					
New Jersey	3,204,881	418,567	3,623,448	3%	88.4%
New York -1	1,820,572	244,402	2,064,974	2%	88.2%
New York -2	3,641,144	488,804	4,129,948	3%	88.2%
New York -3	1,281,143	171,986	1,453,130	1%	88.2%
Pennsylvania	5,097,755	803,274	5,901,029	5%	86.4%
Regional subtotal	**15,045,495**	**2,127,033**	**17,172,528**	**13%**	**87.6%**
NorthEast - New England					
Connecticut	1,395,720	134,542	1,530,262	1%	91.2%
Maine	657,079	74,250	731,329	1%	89.8%
Massachusetts	2,520,474	328,099	2,848,573	2%	88.5%
New Hampshire	546,402	86,516	632,918	0%	86.3%
Rhode Island	417,355	48,207	465,562	0%	89.6%
Vermont	285,905	42,435	328,340	0%	87.1%
Regional subtotal	**5,822,935**	**714,049**	**6,536,984**	**5%**	**89.1%**
South - East South Central					
Alabama	1,946,833	318,692	2,265,525	2%	85.9%
Kentucky	1,791,468	240,678	2,032,146	2%	88.2%
Mississippi	1,185,264	188,617	1,373,881	1%	86.3%
Tennessee	2,433,410	387,520	2,820,930	2%	86.3%
Regional subtotal	**7,356,975**	**1,135,507**	**8,492,482**	**7%**	**86.6%**

Number of Customers (2001)					
State	Residential Total	Commercial Total	Total	% share of U.S Total	% share of Residential
South - South Atlantic					
Delaware	342,747	40,267	383,014	0%	89.5%
Florida	7,343,128	908,971	8,252,099	6%	89.0%
Georgia	3,490,148	427,323	3,917,471	3%	89.1%
Maryland	2,016,667	220,320	2,236,987	2%	90.2%
North Carolina	3,652,769	528,310	4,181,079	3%	87.4%
South Carolina	1,791,811	255,700	2,047,511	2%	87.5%
Virginia	2,816,818	313,888	3,130,706	2%	90.0%
Washington, DC	194,925	27,307	222,232	0%	87.7%
West Virginia	824,784	120,134	944,918	1%	87.3%
Regional subtotal	**22,473,797**	**2,842,220**	**25,316,017**	**20%**	**88.8%**
South - West South Central					
Arkansas	1,189,161	148,144	1,337,305	1%	88.9%
Louisiana	1,824,750	222,671	2,047,421	2%	89.1%
Oklahoma	1,524,652	207,143	1,731,795	1%	88.0%
Texas	8,344,840	1,144,915	9,489,755	7%	87.9%
Regional subtotal	**12,883,403**	**1,722,873**	**14,606,276**	**11%**	**88.2%**
West - Mountain					
Arizona	2,032,358	218,170	2,250,528	2%	90.3%
Colorado	1,824,528	246,447	2,070,975	2%	88.1%
Idaho	543,244	95,318	638,562	0%	85.1%
Montana	410,997	77,615	488,612	0%	84.1%
Nevada	828,100	115,820	943,920	1%	87.7%
New Mexico	732,626	110,147	842,773	1%	86.9%
Utah	771,928	87,659	859,587	1%	89.8%
Wyoming	224,499	50,134	274,633	0%	81.7%
Regional subtotal	**7,368,280**	**1,001,310**	**8,369,590**	**6%**	**88.0%**
West - Pacific					
Alaska	234,646	38,282	272,928	0%	86.0%
California -1	3,947,048	519,753	4,466,801	3%	88.4%
California -2	3,947,048	519,753	4,466,801	3%	88.4%
California -3	3,947,048	519,753	4,466,801	3%	88.4%
Hawaii	375,015	54,804	429,819	0%	87.2%
Oregon	1,454,426	210,665	1,665,091	1%	87.3%
Washington	2,468,000	284,113	2,752,113	2%	89.7%
Regional subtotal	**16,373,231**	**2,147,122**	**18,520,353**	**14%**	**88.4%**
Total	**114,317,707**	**14,939,895**	**129,257,602**	**100%**	**88.4%**

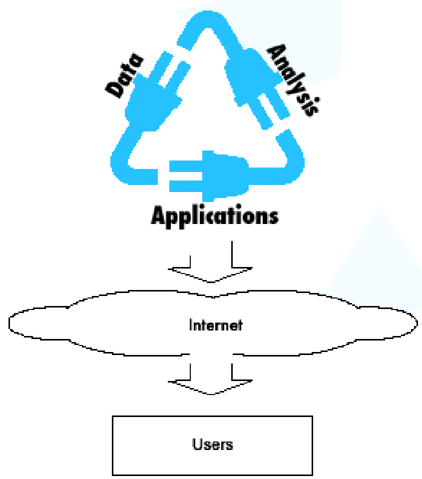
Notes:

- Source: EIA, US Average Monthly Bill by Sector, Census Division and State, 2001. Building data is available by Census regions and not be states. The number of customers data is used as weights in calculating the roof area by state. The implicit assumption in our analysis is that the percent share of customers within the states in a region will not change with time.
- Commercial Total = Total of Commercial Small/Medium and Commercial Large
- Total number of customers for New York and California are distributed across the three locations based on the percentage share of customers of the three relevant utilities.

NAVIGANT CONSULTING

Overview

The Estimator is a suite of Internet-based applications designed to help consumers evaluate the cost-effectiveness of clean energy systems. It provides a personalized estimate of the costs and benefits of a system for a specific residential or commercial customer. The Estimator's three critical components are data, analysis, and applications. The applications can be used to support the objectives of equipment manufacturers, resellers and dealers, utilities and state agencies, and the federal government.



Users

Equipment Manufacturers

- Expand Web Presence
- Generate Quality Sales Leads
- Assess New Markets
- Offer Targeted Incentives

Resellers and Dealers

- Screen Potential Customers
- Produce Professional Sales Quotations
- Meet with Customers
- Assess Site Feasibility

State Agencies and Utilities

- Educate Consumers
- Support Incentive Programs
- Assist in Rebate Processing
- Evaluate System Performance

Federal Government

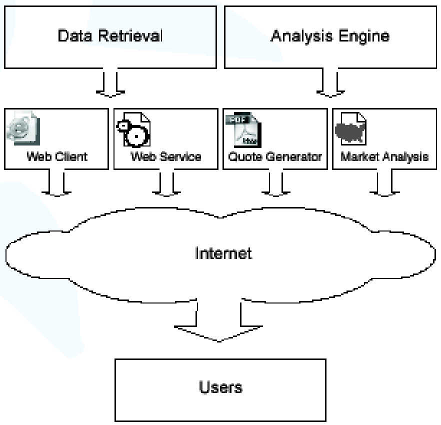
- Promote Clean Energy Technologies
- Evaluate Potential New Incentives
- Answer Complex Research Questions

Applications

Estimator applications inclue the Web Client, Web Service, Quote Generator, and Market Analysis programs. All of these programs make use of the Estimator databases and analysis engine.

The databases include information about electric rate tariffs, incentive programs, solar resource, load profiles, emissions factors and tax information.

The analysis engine contains the algorithms, based on many years of research, necessary to calculate cost-effectiveness.



NAVIGANT CONSULTING

Payback in 2010 by state, segment and at different system prices is shown below.

STATE	PAYBACK (years) IN 2010											
	Residential				Commercial Small/Med				Commercial Large			
System price in 2010 ($/Wpdc) >>	$1.25	$2.50	$3.75	$5.30	$1.10	$2.20	$3.30	$4.65	$1.00	$2.00	$3.00	$4.25
Midwest - East North Central												
Illinois	7	13	17	21	7	10	12	14	5	8	10	12
Indiana	11	18	22	26	8	12	14	15	7	11	13	15
Michigan	7	12	16	20	6	10	12	14	6	9	11	13
Ohio	6	10	14	17	5	8	10	12	6	9	11	13
Wisconsin	7	12	16	20	6	9	11	13	6	9	11	12
Regional Weighted Average	**7**	**13**	**16**	**20**	**6**	**10**	**12**	**13**	**6**	**9**	**11**	**13**
Midwest - West North Central												
Iowa	7	12	15	19	6	9	11	12	6	9	10	12
Kansas	8	14	18	22	9	13	14	16	9	13	15	16
Minnesota	8	13	17	21	7	10	12	13	7	10	11	13
Missouri	8	14	18	22	8	11	13	14	6	9	11	13
Nebraska	9	14	19	22	8	11	13	14	8	11	13	14
North Dakota	8	14	17	21	7	10	12	13	9	12	13	14
South Dakota	8	14	18	22	8	12	14	16	8	12	14	16
Regional Weighted Average	**8**	**13**	**18**	**21**	**8**	**11**	**13**	**14**	**7**	**10**	**12**	**14**
NorthEast - Middle Atlantic												
New Jersey	5	10	13	16	5	8	10	12	5	8	10	11
New York - 1	7	12	15	19	5	8	10	11	4	7	9	10
New York - 2	4	8	11	14	5	8	10	11	4	6	8	10
New York - 3	5	9	12	16	4	7	9	11	3	6	8	9
Pennsylvania	8	13	18	22	6	9	11	12	6	9	11	13
Regional Weighted Average	**6**	**11**	**14**	**18**	**6**	**8**	**10**	**12**	**5**	**8**	**10**	**11**
NorthEast - New England												
Connecticut	7	11	15	19	6	9	11	12	6	9	11	13
Maine	5	9	13	16	5	8	10	11	4	7	9	11
Massachusetts	5	9	12	15	4	7	8	10	5	7	9	11
New Hampshire	6	10	14	18	6	9	11	13	5	8	10	12
Rhode Island	6	10	13	17	5	8	10	11	6	9	11	12
Vermont	6	10	14	17	6	9	11	12	9	12	14	15
Regional Weighted Average	**5**	**10**	**13**	**17**	**5**	**8**	**10**	**11**	**5**	**8**	**10**	**12**
South - East South Central												
Alabama	8	13	17	21	6	9	11	13	7	10	12	14
Kentucky	9	15	19	23	8	12	13	14	7	10	12	13
Mississippi	9	14	19	23	7	11	13	14	8	11	13	15
Tennessee	8	14	18	22	6	10	12	13	6	9	11	12
Regional Weighted Average	**8**	**14**	**18**	**22**	**7**	**10**	**12**	**14**	**6**	**10**	**12**	**13**

Source: Analysis by Clean-Power Research and NCI

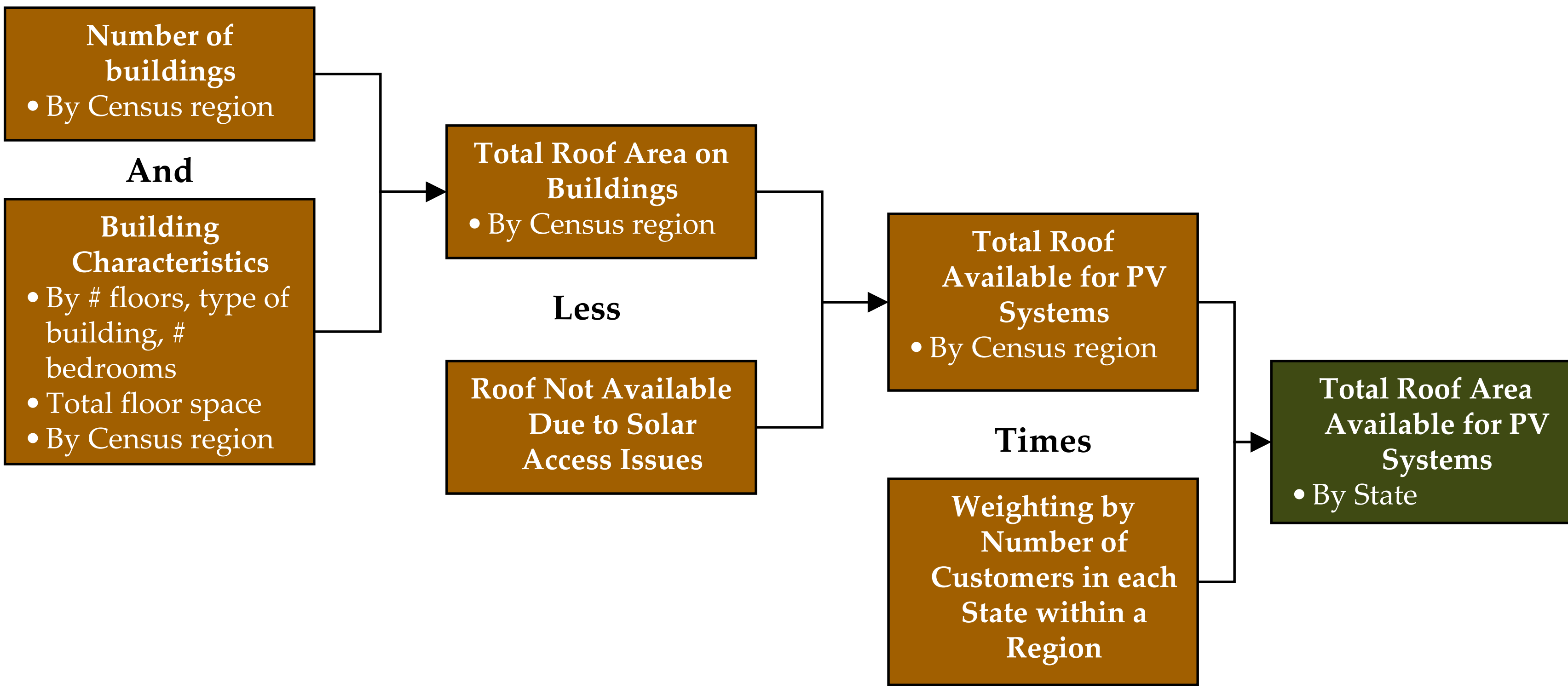
Payback in 2010 by state, segment and at different system prices is shown below (continued).

STATE	PAYBACK (years) IN 2010											
	Residential				Commercial Small/Med				Commercial Large			
System price in 2010 ($/Wpdc) >>	$1.25	$2.50	$3.75	$5.30	$1.10	$2.20	$3.30	$4.65	$1.00	$2.00	$3.00	$4.25
South - South Atlantic												
Delaware	7	12	16	19	5	8	10	12	6	9	11	12
Florida	6	11	15	19	6	9	11	12	6	9	11	13
Georgia	7	12	16	20	5	8	10	12	5	8	10	12
Maryland	7	13	17	21	6	10	12	13	7	10	12	13
North Carolina	7	12	16	19	5	8	10	12	7	10	12	14
South Carolina	7	11	15	19	6	9	11	13	8	12	14	15
Virginia	7	13	17	20	7	11	12	14	9	13	14	16
Washington, DC	6	11	15	18	6	9	10	12	5	8	10	11
West Virginia	11	17	22	25	8	11	13	14	9	12	13	14
Regional Weighted Average	**7**	**12**	**16**	**20**	**6**	**9**	**11**	**12**	**7**	**10**	**12**	**13**
South - West South Central												
Arkansas	8	13	17	21	7	10	12	14	9	12	14	15
Louisiana	6	11	14	18	6	9	10	12	6	9	11	12
Oklahoma	8	14	18	22	8	11	13	15	10	13	15	16
Texas	7	12	16	20	7	10	12	14	8	11	13	15
Regional Weighted Average	**7**	**12**	**16**	**20**	**7**	**10**	**12**	**14**	**8**	**11**	**13**	**15**
West - Mountain												
Arizona	5	9	12	15	5	8	10	12	5	8	10	12
Colorado	8	13	17	21	7	10	12	14	7	10	12	14
Idaho	8	14	18	21	7	10	11	13	8	12	13	14
Montana	7	12	16	20	7	10	12	13	10	13	15	16
Nevada	5	10	13	17	5	8	11	13	4	7	9	11
New Mexico	5	9	13	16	5	8	10	12	5	7	9	11
Utah	7	12	16	20	8	12	14	15	10	13	15	16
Wyoming	8	14	19	23	9	13	15	17	11	15	17	19
Regional Weighted Average	**6**	**11**	**15**	**18**	**6**	**10**	**12**	**13**	**7**	**10**	**12**	**13**
West - Pacific												
Alaska	9	16	20	25	9	12	13	14	8	11	12	14
California - 1	4	7	10	13	4	6	8	9	4	6	8	10
California - 2	6	11	14	17	5	8	9	11	5	8	10	11
California - 3	4	8	11	13	3	5	7	9	4	6	8	9
Hawaii	4	7	10	13	4	6	8	10	3	6	8	9
Oregon	9	14	18	22	9	12	14	15	8	11	13	15
Washington	11	17	22	27	9	13	16	17	8	12	15	16
Regional Weighted Average	**6**	**10**	**13**	**16**	**5**	**8**	**9**	**11**	**5**	**8**	**9**	**11**
U.S. weighted average	**7**	**12**	**15**	**19**	**6**	**9**	**11**	**13**	**6**	**9**	**11**	**13**

Source: Analysis by Clean-Power Research and NCI

NAVIGANT CONSULTING

The methodology to calculate roof area available for PV systems is:



NAVIGANT CONSULTING

Key sources of data and assumption used for the analysis of total roof area available for PV systems:

Key Sources of Data

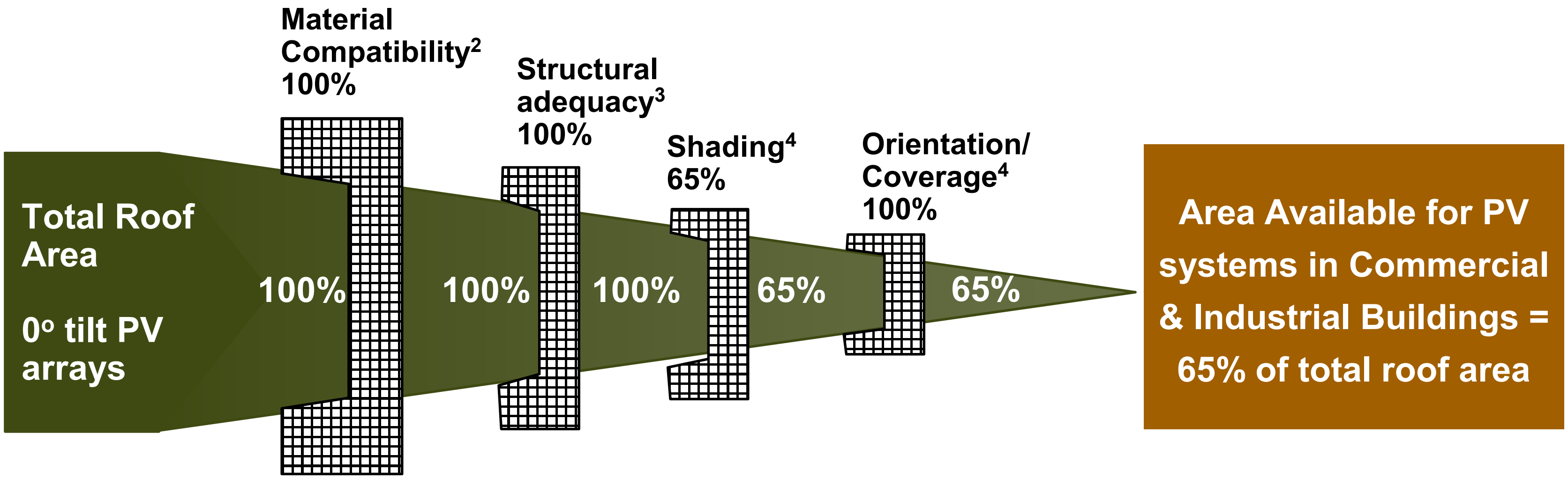
- EIA's Residential Energy Consumption Survey (RECS) 2001
- EIA's Commercial Buildings Energy Consumption Survey (CBECS) 1999
- Building data used by the EIA for its Annual Energy Outlook 2003, made available to NCI
  - Commercial buildings: Total floor space forecast by Census region for each year till 2025
  - Residential buildings: Total number of buildings by type of building for each year till 2025; Total floor space for each year till 2025

Key Assumptions / Analysis Notes

- Building characteristics (distribution by number of floors or bedrooms, average number of floors, etc) remain the same as provided in the 2001 RECS and 1999 CBECS.
- Percent of roof space available due to solar access issues remains the same over time (though it is likely that some newly constructed buildings may take into account solar access issues, where possible and viable).
- Commercial roof space available for PV was distributed into space available for small/medium PV systems and large PV systems by taking into account the following:
  - Number of buildings distributed by range of roof area per building
  - Size of PV system that can be installed by range of roof area per building

NAVIGANT CONSULTING

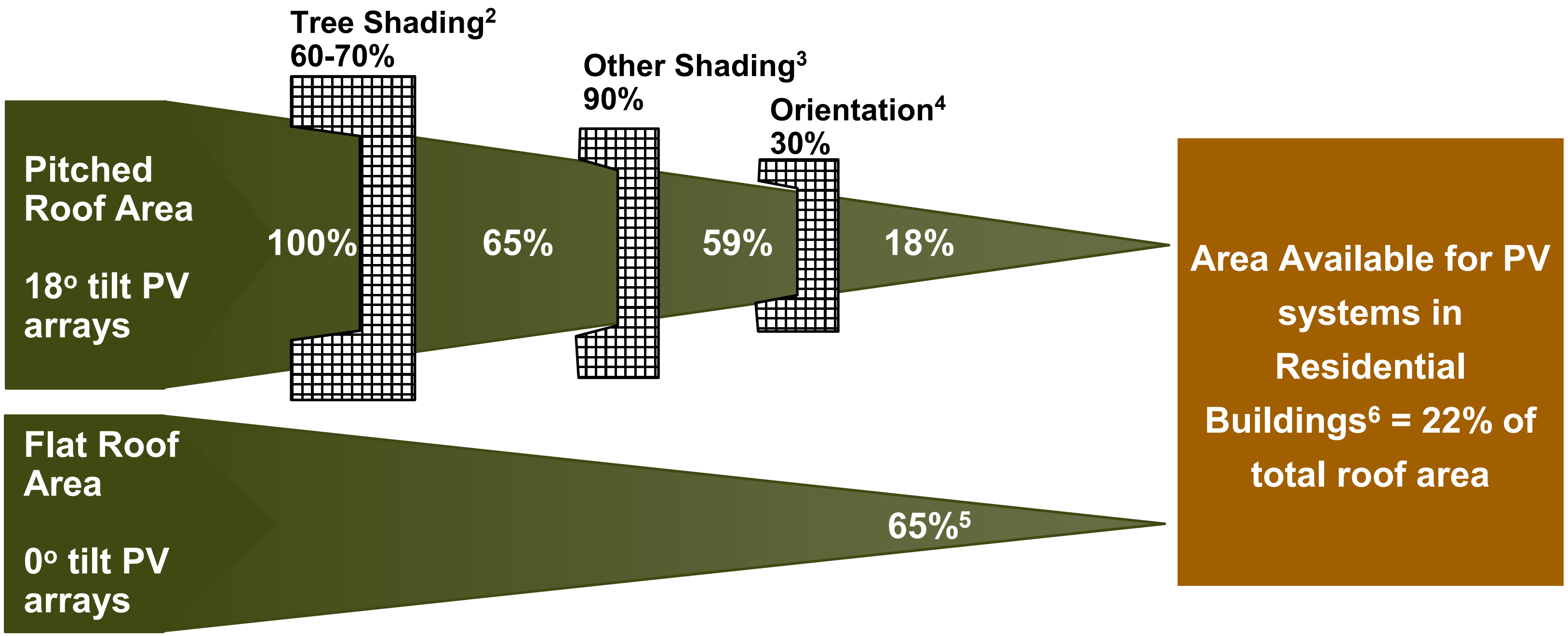
The roof space available in commercial buildings for PV installations is around 65% of total roof area[1].



1) Includes roof space over enclosed garages.
2) Roofing material is predominantly built up asphalt or EPDM, both of which are suitable for PV and therefore there are no compatibility issues for flat roof buildings.
3) Structural adequacy is a function of roof structure (type of roof, decking and bar joists used ,etc.) and building code requirements (wind loading, snow loading which increases the live load requirements). For most buildings, this is not expected to be an issue.
4) An estimated 5% of commercial building roofing space is occupied by HVAC and other structures. Small obstructions create problems with mechanical array placement while large obstructions share areas up to 7x that of the footprint. Hence, around 35% of roof area is considered to be unavailable due to shading. In some commercial buildings such as shopping center, rooftops tend to be geometrically more complex than in other buildings and the percentage of unavailable space may be slightly higher.
5) Flat arrays are assumed. If tilted arrays were assumed, then more space would be required per PV panel due to panel shading issues, which would reduce the roof space available.

Note: The data is based on a study conducted by the Navigant Consulting team while at Arthur D. Little (data is proprietary to Navigant Consulting). New construction may have higher availability, as solar access issues are taken into account in designing new buildings.

The roof space available in residential buildings for PV installations is around 22% of total roof area[1].



1) Includes roof space over enclosed garages.
2) Roof area available due to tree shading is around 60% for single homes and higher at 70% for townhouses and other residential buildings. Closely packed homes in high density neighborhoods allow little room for large trees to grow and shade roofs, compared to larger homes in low density neighborhoods.
3) Other shading may be due to chimneys, vent stacks and other roof obstructions.
4) Based on assumptions made for single homes, which account for 70% of the building stock in the country. Assume that orientations from southeast clockwise around to west are appropriate for PV installations. For gable ended roofs with one long ridge line, assume that one of the pitched surfaces will face in the proper direction for 75% of the residences. If each surface is half the roof, 38% of the roof area can accommodate PV arrays. For hip roof buildings, one of four roof area will be facing in the right direction, or 25% of the roof area. The average of 38% and 25% is around 30%, which is what is assumed as the percentage of roof area with acceptable orientation.
5) See analysis of roof area availability for flat roof buildings on previous page.
6) Assumes single home and 2-4 unit apartments have pitched roof, which accounts for 92% of total roof space, the balance 8% being flat roof space on 5+ unit apartments and mobile homes.

Note: The data is based on a study conducted by the Navigant Consulting team while at Arthur D. Little (data is proprietary to Navigant Consulting). New construction may have higher availability, as solar access issues are taken into account in designing new buildings.

Estimated roof area available for PV in 2025, by state and segment:

2025 Roof Available for PV (Mln. Sq.ft)							
State	Residential Total	Commercial: Small/Med	Commercial: Large	Commercial Total	Total	% share of U.S Total	% share of Residential
Midwest - East North Central							
Illinois	1,709	1,133	113	1,246	2,955	3%	58%
Indiana	917	670	67	737	1,654	2%	55%
Michigan	1,477	1,055	105	1,160	2,636	3%	56%
Ohio	1,715	1,269	127	1,396	3,110	4%	55%
Wisconsin	842	642	64	706	1,548	2%	54%
Regional subtotal	**6,659**	**4,769**	**476**	**5,244**	**11,903**	**14%**	**56%**
Midwest - West North Central							
Iowa	483	365	38	402	886	1%	55%
Kansas	442	402	41	443	885	1%	50%
Minnesota	804	487	50	537	1,341	2%	60%
Missouri	953	679	70	749	1,702	2%	56%
Nebraska	283	258	27	284	567	1%	50%
North Dakota	113	100	10	110	223	0%	51%
South Dakota	127	109	11	120	247	0%	51%
Regional subtotal	**3,205**	**2,399**	**248**	**2,646**	**5,851**	**7%**	**55%**
NorthEast - Middle Atlantic							
New Jersey	895	544	69	613	1,508	2%	59%
New York -1	508	318	40	358	867	1%	59%
New York -2	1,017	636	81	716	1,733	2%	59%
New York -3	358	224	28	252	610	1%	59%
Pennsylvania	1,424	1,045	132	1,177	2,601	3%	55%
Regional subtotal	**4,202**	**2,766**	**351**	**3,117**	**7,319**	**9%**	**57%**
NorthEast - New England							
Connecticut	410	233	37	269	679	1%	60%
Maine	193	128	20	149	342	0%	56%
Massachusetts	740	568	89	657	1,397	2%	53%
New Hampshire	160	150	24	173	334	0%	48%
Rhode Island	123	83	13	97	219	0%	56%
Vermont	84	73	12	85	169	0%	50%
Regional subtotal	**1,710**	**1,235**	**194**	**1,430**	**3,140**	**4%**	**54%**
South - East South Central							
Alabama	964	698	327	1,024	1,988	2%	48%
Kentucky	887	527	247	774	1,661	2%	53%
Mississippi	587	413	193	606	1,193	1%	49%
Tennessee	1,205	848	397	1,246	2,451	3%	49%
Regional subtotal	**3,642**	**2,486**	**1,164**	**3,650**	**7,293**	**9%**	**50%**

2025 Roof Available for PV (Mln. Sq.ft)							
State	Residential Total	Commercial: Small/Med	Commercial: Large	Commercial Total	Total	% share of U.S Total	% share of Residential
South - South Atlantic							
Delaware	137	106	13	119	256	0%	54%
Florida	2,942	2,387	297	2,684	5,626	7%	52%
Georgia	1,398	1,122	140	1,262	2,660	3%	53%
Maryland	808	579	72	651	1,459	2%	55%
North Carolina	1,463	1,388	173	1,560	3,024	4%	48%
South Carolina	718	672	84	755	1,473	2%	49%
Virginia	1,129	824	103	927	2,055	2%	55%
Washington, DC	78	72	9	81	159	0%	49%
West Virginia	330	316	39	355	685	1%	48%
Regional subtotal	**9,004**	**7,465**	**929**	**8,394**	**17,397**	**21%**	**52%**
South - West South Central							
Arkansas	582	312	74	386	969	1%	60%
Louisiana	894	469	112	581	1,474	2%	61%
Oklahoma	747	436	104	540	1,287	2%	58%
Texas	4,086	2,410	575	2,985	7,071	8%	58%
Regional subtotal	**6,309**	**3,627**	**865**	**4,492**	**10,801**	**13%**	**58%**
West - Mountain							
Arizona	845	684	102	786	1,632	2%	52%
Colorado	759	773	116	888	1,647	2%	46%
Idaho	226	299	45	344	570	1%	40%
Montana	171	243	36	280	451	1%	38%
Nevada	344	363	54	417	762	1%	45%
New Mexico	305	345	52	397	702	1%	43%
Utah	321	275	41	316	637	1%	50%
Wyoming	93	157	24	181	274	0%	34%
Regional subtotal	**3,065**	**3,139**	**470**	**3,609**	**6,674**	**8%**	**46%**
West - Pacific							
Alaska	103	109	15	124	227	0%	45%
California -1	2,346	1,992	281	2,273	4,620	5%	51%
California -2	261	221	31	253	513	1%	51%
California -3	2,607	2,214	312	2,526	5,133	6%	51%
Hawaii	165	156	22	178	343	0%	48%
Oregon	640	598	84	683	1,323	2%	48%
Washington	1,087	807	114	921	2,007	2%	54%
Regional subtotal	**7,210**	**6,097**	**860**	**6,957**	**14,166**	**17%**	**51%**
Total	**45,005**	**33,982**	**5,556**	**39,538**	**84,544**	**100%**	**53%**

Source: Analysis by Clean-Power Research and NCI

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

Estimated roof area available for PV in 2010, by state and segment:

2010 Roof Available for PV (Mln. Sq.ft)							
State	Residential Total	Commercial: Small/med	Commercial : Large	Commercial Total	Total	% share of U.S Total	% share of Residential
Midwest - East North Central							
Illinois	1,428	994	99	1,093	2,521	4%	57%
Indiana	766	588	59	647	1,413	2%	54%
Michigan	1,234	925	92	1,018	2,252	3%	55%
Ohio	1,433	1,114	111	1,225	2,658	4%	54%
Wisconsin	704	563	56	620	1,323	2%	53%
Regional subtotal	**5,565**	**4,184**	**417**	**4,602**	**10,167**	**15%**	**55%**
Midwest - West North Central							
Iowa	404	321	33	354	757	1%	53%
Kansas	369	353	36	389	759	1%	49%
Minnesota	671	428	44	472	1,143	2%	59%
Missouri	795	597	62	659	1,454	2%	55%
Nebraska	236	226	23	250	486	1%	49%
North Dakota	94	88	9	97	191	0%	49%
South Dakota	106	96	10	106	212	0%	50%
Regional subtotal	**2,676**	**2,109**	**218**	**2,326**	**5,002**	**7%**	**53%**
NorthEast - Middle Atlantic							
New Jersey	749	515	65	581	1,330	2%	56%
New York -1	426	301	38	339	764	1%	56%
New York -2	851	602	76	678	1,529	2%	56%
New York -3	299	212	27	239	538	1%	56%
Pennsylvania	1,192	989	125	1,114	2,306	3%	52%
Regional subtotal	**3,517**	**2,618**	**332**	**2,950**	**6,467**	**9%**	**54%**
NorthEast - New England							
Connecticut	343	205	32	237	580	1%	59%
Maine	161	113	18	131	292	0%	55%
Massachusetts	619	499	78	577	1,197	2%	52%
New Hampshire	134	132	21	152	287	0%	47%
Rhode Island	103	73	12	85	187	0%	55%
Vermont	70	65	10	75	145	0%	48%
Regional subtotal	**1,431**	**1,086**	**171**	**1,257**	**2,687**	**4%**	**53%**
South - East South Central							
Alabama	805	570	267	838	1,643	2%	49%
Kentucky	741	431	202	633	1,374	2%	54%
Mississippi	490	338	158	496	986	1%	50%
Tennessee	1,006	694	325	1,019	2,025	3%	50%
Regional subtotal	**3,043**	**2,032**	**952**	**2,984**	**6,027**	**9%**	**50%**

2010 Roof Available for PV (Mln. Sq.ft)							
State	Residential Total	Commercial: Small/med	Commercial : Large	Commercial Total	Total	% share of U.S Total	% share of Residential
South - South Atlantic							
Delaware	115	76	10	86	201	0%	57%
Florida	2,457	1,726	215	1,941	4,398	6%	56%
Georgia	1,168	812	101	913	2,080	3%	56%
Maryland	675	418	52	471	1,145	2%	59%
North Carolina	1,222	1,003	125	1,128	2,351	3%	52%
South Carolina	600	486	60	546	1,146	2%	52%
Virginia	942	596	74	670	1,613	2%	58%
Washington, DC	65	52	6	58	124	0%	53%
West Virginia	276	228	28	257	533	1%	52%
Regional subtotal	**7,520**	**5,398**	**672**	**6,070**	**13,590**	**20%**	**55%**
South - West South Central							
Arkansas	487	281	67	349	835	1%	58%
Louisiana	747	423	101	524	1,271	2%	59%
Oklahoma	624	394	94	487	1,111	2%	56%
Texas	3,414	2,175	519	2,694	6,108	9%	56%
Regional subtotal	**5,271**	**3,274**	**781**	**4,054**	**9,325**	**13%**	**57%**
West - Mountain							
Arizona	707	474	71	545	1,252	2%	56%
Colorado	635	536	80	616	1,251	2%	51%
Idaho	189	207	31	238	427	1%	44%
Montana	143	169	25	194	337	0%	42%
Nevada	288	252	38	290	578	1%	50%
New Mexico	255	239	36	275	530	1%	48%
Utah	268	191	29	219	488	1%	55%
Wyoming	78	109	16	125	203	0%	38%
Regional subtotal	**2,563**	**2,177**	**326**	**2,503**	**5,066**	**7%**	**51%**
West - Pacific							
Alaska	86	79	11	90	176	0%	49%
California -1	1,963	1,445	204	1,649	3,612	5%	54%
California -2	218	161	23	183	401	1%	54%
California -3	2,181	1,606	226	1,833	4,014	6%	54%
Hawaii	138	113	16	129	267	0%	52%
Oregon	536	434	61	495	1,031	1%	52%
Washington	909	585	83	668	1,577	2%	58%
Regional subtotal	**6,032**	**4,423**	**624**	**5,047**	**11,078**	**16%**	**54%**
U.S Total	**37,616**	**27,302**	**4,492**	**31,793**	**69,409**	**100%**	**54%**

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

Technical market for PV (MWp) in 2025 – by state and segment.

2025 Technical Ultimate Potential (MWp)					
State	Residential Total	Commercial Total	Total	% share of U.S Total	% share of Residential
Midwest - East North Central					
Illinois	20,976	15,285	36,261	3%	58%
Indiana	11,248	9,048	20,296	2%	55%
Michigan	18,121	14,232	32,353	3%	56%
Ohio	21,045	17,126	38,171	4%	55%
Wisconsin	10,332	8,665	18,997	2%	54%
Regional subtotal	**81,722**	**64,356**	**146,078**	**14%**	**56%**
Midwest - West North Central					
Iowa	5,931	4,939	10,870	1%	55%
Kansas	5,429	5,436	10,865	1%	50%
Minnesota	9,864	6,592	16,456	2%	60%
Missouri	11,690	9,193	20,882	2%	56%
Nebraska	3,475	3,487	6,961	1%	50%
North Dakota	1,383	1,353	2,736	0%	51%
South Dakota	1,555	1,478	3,032	0%	51%
Regional subtotal	**39,326**	**32,477**	**71,804**	**7%**	**55%**
NorthEast - Middle Atlantic					
New Jersey	10,985	7,527	18,511	2%	59%
New York -1	6,240	4,395	10,635	1%	59%
New York -2	12,480	8,790	21,270	2%	59%
New York -3	4,391	3,093	7,484	1%	59%
Pennsylvania	17,473	14,445	31,917	3%	55%
Regional subtotal	**51,568**	**38,249**	**89,817**	**9%**	**57%**
NorthEast - New England					
Connecticut	5,029	3,306	8,335	1%	60%
Maine	2,368	1,824	4,192	0%	56%
Massachusetts	9,083	8,062	17,144	2%	53%
New Hampshire	1,969	2,126	4,095	0%	48%
Rhode Island	1,504	1,185	2,688	0%	56%
Vermont	1,030	1,043	2,073	0%	50%
Regional subtotal	**20,983**	**17,545**	**38,528**	**4%**	**54%**
South - East South Central					
Alabama	11,828	12,573	24,401	2%	48%
Kentucky	10,884	9,495	20,379	2%	53%
Mississippi	7,201	7,441	14,642	1%	49%
Tennessee	14,785	15,288	30,073	3%	49%
Regional subtotal	**44,699**	**44,797**	**89,495**	**9%**	**50%**

2025 Technical Ultimate Potential (MWp)					
State	Residential Total	Commercial Total	Total	% share of U.S Total	% share of Residential
South - South Atlantic					
Delaware	1,685	1,459	3,144	0%	54%
Florida	36,103	32,943	69,046	7%	52%
Georgia	17,159	15,487	32,646	3%	53%
Maryland	9,915	7,985	17,900	2%	55%
North Carolina	17,959	19,147	37,106	4%	48%
South Carolina	8,810	9,267	18,077	2%	49%
Virginia	13,849	11,376	25,225	2%	55%
Washington, DC	958	990	1,948	0%	49%
West Virginia	4,055	4,354	8,409	1%	48%
Regional subtotal	**110,493**	**103,007**	**213,501**	**21%**	**52%**
South - West South Central					
Arkansas	7,146	4,740	11,886	1%	60%
Louisiana	10,966	7,124	18,090	2%	61%
Oklahoma	9,162	6,627	15,790	2%	58%
Texas	50,149	36,630	86,779	8%	58%
Regional subtotal	**77,423**	**55,121**	**132,544**	**13%**	**58%**
West - Mountain					
Arizona	10,375	9,650	20,025	2%	52%
Colorado	9,314	10,901	20,215	2%	46%
Idaho	2,773	4,216	6,989	1%	40%
Montana	2,098	3,433	5,531	1%	38%
Nevada	4,227	5,123	9,350	1%	45%
New Mexico	3,740	4,872	8,612	1%	43%
Utah	3,941	3,877	7,818	1%	50%
Wyoming	1,146	2,217	3,364	0%	34%
Regional subtotal	**37,614**	**44,289**	**81,904**	**8%**	**46%**
West - Pacific					
Alaska	1,268	1,522	2,790	0%	45%
California -1	28,794	27,899	56,693	5%	51%
California -2	3,199	3,100	6,299	1%	51%
California -3	31,993	30,999	62,992	6%	51%
Hawaii	2,026	2,179	4,206	0%	48%
Oregon	7,859	8,376	16,236	2%	48%
Washington	13,337	11,297	24,633	2%	54%
Regional subtotal	**88,477**	**85,371**	**173,848**	**17%**	**51%**
Total	**552,307**	**485,213**	**1,037,519**	**100%**	**53%**

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

Technical market for PV (MWp) in 2010 – by state and segment.

2010 Technical Ultimate Potential (MWp)					
State	**Residential Total**	**Commercial: Total**	**Total**	**% share of U.S Total**	**% share of Residential**
Midwest - East North Central					
Illinois	14,650	11,209	25,859	4%	57%
Indiana	7,856	6,635	14,492	2%	54%
Michigan	12,657	10,437	23,094	3%	55%
Ohio	14,698	12,559	27,258	4%	54%
Wisconsin	7,216	6,354	13,571	2%	53%
Regional subtotal	**57,078**	**47,195**	**104,273**	**15%**	**55%**
Midwest - West North Central					
Iowa	4,139	3,629	7,767	1%	53%
Kansas	3,789	3,994	7,782	1%	49%
Minnesota	6,883	4,843	11,726	2%	59%
Missouri	8,157	6,754	14,911	2%	55%
Nebraska	2,425	2,562	4,986	1%	49%
North Dakota	965	994	1,959	0%	49%
South Dakota	1,085	1,086	2,171	0%	50%
Regional subtotal	**27,443**	**23,860**	**51,303**	**7%**	**53%**
NorthEast - Middle Atlantic					
New Jersey	7,683	5,954	13,636	2%	56%
New York - 1	4,364	3,476	7,841	1%	56%
New York - 2	8,728	6,953	15,681	2%	56%
New York - 3	3,071	2,446	5,517	1%	56%
Pennsylvania	12,220	11,426	23,646	3%	52%
Regional subtotal	**36,066**	**30,255**	**66,321**	**9%**	**54%**
NorthEast - New England					
Connecticut	3,517	2,428	5,945	1%	59%
Maine	1,656	1,340	2,996	0%	55%
Massachusetts	6,351	5,922	12,273	2%	52%
New Hampshire	1,377	1,562	2,938	0%	47%
Rhode Island	1,052	870	1,922	0%	55%
Vermont	720	766	1,486	0%	48%
Regional subtotal	**14,672**	**12,889**	**27,561**	**4%**	**53%**
South - East South Central					
Alabama	8,258	8,591	16,849	2%	49%
Kentucky	7,599	6,488	14,087	2%	54%
Mississippi	5,028	5,084	10,112	1%	50%
Tennessee	10,322	10,446	20,768	3%	50%
Regional subtotal	**31,207**	**30,609**	**61,815**	**9%**	**50%**

2010 Technical Ultimate Potential (MWp)					
State	**Residential Total**	**Commercial: Total**	**Total**	**% share of U.S Total**	**% share of Residential**
South - South Atlantic					
Delaware	1,176	882	2,058	0%	57%
Florida	25,198	19,910	45,109	6%	56%
Georgia	11,977	9,360	21,337	3%	56%
Maryland	6,920	4,826	11,746	2%	59%
North Carolina	12,535	11,572	24,107	3%	52%
South Carolina	6,149	5,601	11,750	2%	52%
Virginia	9,666	6,875	16,542	2%	58%
Washington, DC	669	598	1,267	0%	53%
West Virginia	2,830	2,631	5,462	1%	52%
Regional subtotal	**77,120**	**62,256**	**139,376**	**20%**	**55%**
South - West South Central					
Arkansas	4,990	3,575	8,565	1%	58%
Louisiana	7,657	5,374	13,031	2%	59%
Oklahoma	6,398	4,999	11,397	2%	56%
Texas	35,016	27,631	62,647	9%	56%
Regional subtotal	**54,061**	**41,580**	**95,640**	**13%**	**57%**
West - Mountain					
Arizona	7,249	5,593	12,843	2%	56%
Colorado	6,508	6,318	12,826	2%	51%
Idaho	1,938	2,444	4,381	1%	44%
Montana	1,466	1,990	3,456	0%	42%
Nevada	2,954	2,969	5,923	1%	50%
New Mexico	2,613	2,824	5,437	1%	48%
Utah	2,753	2,247	5,001	1%	55%
Wyoming	801	1,285	2,086	0%	38%
Regional subtotal	**26,283**	**25,671**	**51,953**	**7%**	**51%**
West - Pacific					
Alaska	887	923	1,809	0%	49%
California - 1	20,132	16,915	37,047	5%	54%
California - 2	2,237	1,879	4,116	1%	54%
California - 3	22,369	18,794	41,163	6%	54%
Hawaii	1,417	1,321	2,738	0%	52%
Oregon	5,495	5,078	10,573	1%	52%
Washington	9,324	6,849	16,173	2%	58%
Regional subtotal	**61,860**	**51,760**	**113,620**	**16%**	**54%**
U. S. Total	**385,790**	**326,074**	**711,864**	**100%**	**54%**

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

Potential annual demand for grid-connected PV in 2010 for residential segment, by state and installed system price scenario (1 of 2).

Residential: Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$1.25	$2.50	$3.75	$5.30	$1.25	$2.50	$3.75	$5.30
Midwest - East North Central								
Illinois	150	16	8	4	2.8%	1.7%	2.8%	2.7%
Indiana	11	4	1	0	0.2%	0.4%	0.5%	0.0%
Michigan	140	15	8	4	2.6%	1.6%	2.6%	2.7%
Ohio	274	22	13	7	5.1%	2.3%	4.3%	4.6%
Wisconsin	80	8	4	3	1.5%	0.9%	1.5%	1.6%
Regional sub-total	**654**	**65**	**34**	**19**	**12.2%**	**6.8%**	**11.6%**	**11.6%**
Midwest - West North Central								
Iowa	55	5	3	2	1.0%	0.5%	0.9%	1.0%
Kansas	25	3	2	1	0.5%	0.3%	0.6%	0.5%
Minnesota	60	7	4	2	1.1%	0.7%	1.2%	1.3%
Missouri	52	7	4	2	1.0%	0.7%	1.2%	0.9%
Nebraska	15	2	1	0	0.3%	0.2%	0.3%	0.3%
North Dakota	6	1	0	0	0.1%	0.1%	0.2%	0.2%
South Dakota	8	1	0	0	0.1%	0.1%	0.2%	0.1%
Regional sub-total	**220**	**25**	**14**	**7**	**4.1%**	**2.7%**	**4.6%**	**4.3%**
NorthEast - Middle Atlantic								
New Jersey	152	23	8	4	2.8%	2.4%	2.6%	2.7%
New York -1	62	6	3	2	1.2%	0.6%	0.9%	1.1%
New York -2	226	62	12	7	4.2%	6.4%	4.0%	4.6%
New York -3	68	16	4	2	1.3%	1.7%	1.2%	1.2%
Pennsylvania	106	12	6	3	2.0%	1.2%	2.0%	1.7%
Regional sub-total	**613**	**118**	**32**	**18**	**11.5%**	**12.3%**	**10.8%**	**11.3%**
NorthEast - New England								
Connecticut	50	5	2	1	0.9%	0.5%	0.8%	0.9%
Maine	35	6	2	1	0.6%	0.7%	0.6%	0.6%
Massachusetts	156	36	8	4	2.9%	3.7%	2.6%	2.6%
New Hampshire	27	2	1	1	0.5%	0.2%	0.4%	0.4%
Rhode Island	21	2	1	1	0.4%	0.2%	0.3%	0.4%
Vermont	13	1	1	0	0.3%	0.1%	0.2%	0.2%
Regional sub-total	**302**	**51**	**14**	**8**	**5.7%**	**5.4%**	**4.9%**	**5.1%**
South - East South Central								
Alabama	78	8	4	2	1.5%	0.8%	1.4%	1.4%
Kentucky	35	5	3	1	0.6%	0.5%	1.0%	0.5%
Mississippi	30	4	2	1	0.6%	0.4%	0.7%	0.5%
Tennessee	73	9	5	2	1.4%	0.9%	1.6%	1.1%
Regional sub-total	**216**	**26**	**14**	**6**	**4.0%**	**2.7%**	**4.7%**	**3.5%**

NAVIGANT CONSULTING

Potential annual demand for grid-connected PV in 2010 for residential segment, by state and installed system price scenario (2 of 2).

Residential: Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$1.25	$2.50	$3.75	$5.30	$1.25	$2.50	$3.75	$5.30
South - South Atlantic								
Delaware	15	1	1	0	0.3%	0.2%	0.2%	0.3%
Florida	385	34	17	10	7.2%	3.5%	5.6%	6.3%
Georgia	123	13	7	4	2.3%	1.4%	2.3%	2.5%
Maryland	65	7	4	2	1.2%	0.8%	1.3%	1.3%
North Carolina	165	15	8	5	3.1%	1.6%	2.6%	3.0%
South Carolina	87	8	4	3	1.6%	0.8%	1.4%	1.6%
Virginia	91	11	5	3	1.7%	1.1%	1.8%	1.8%
Washington, DC	10	1	0	0	0.2%	0.1%	0.2%	0.2%
West Virginia	4	1	1	0	0.1%	0.2%	0.2%	0.0%
Regional sub-total	**946**	**92**	**46**	**27**	**17.7%**	**9.6%**	**15.7%**	**17.0%**
South - West South Central								
Arkansas	47	5	3	1	0.9%	0.5%	0.9%	0.9%
Louisiana	125	11	6	4	2.3%	1.2%	2.1%	2.3%
Oklahoma	41	5	3	1	0.8%	0.5%	1.0%	0.8%
Texas	387	41	20	11	7.2%	4.2%	6.7%	6.7%
Regional sub-total	**600**	**62**	**32**	**17**	**11.2%**	**6.4%**	**10.7%**	**10.7%**
West - Mountain								
Arizona	179	44	9	5	3.3%	4.5%	3.0%	3.0%
Colorado	61	7	3	2	1.2%	0.7%	1.2%	1.1%
Idaho	13	2	1	0	0.2%	0.2%	0.3%	0.3%
Montana	14	2	1	1	0.3%	0.2%	0.3%	0.3%
Nevada	58	7	3	2	1.1%	0.7%	0.9%	1.0%
New Mexico	52	10	3	2	1.0%	1.0%	0.9%	1.0%
Utah	28	3	2	1	0.5%	0.3%	0.5%	0.6%
Wyoming	5	1	0	0	0.1%	0.1%	0.1%	0.1%
Regional sub-total	**411**	**74**	**22**	**12**	**7.7%**	**7.7%**	**7.3%**	**7.4%**
West - Pacific								
Alaska	4	1	0	0	0.1%	0.1%	0.1%	0.0%
California - 1	642	206	46	22	12.0%	21.5%	15.6%	13.7%
California - 2	37	3	2	1	0.7%	0.3%	0.6%	0.7%
California - 3	608	211	32	21	11.4%	22.0%	10.9%	13.2%
Hawaii	45	14	3	1	0.8%	1.5%	1.1%	0.9%
Oregon	33	4	2	1	0.6%	0.5%	0.8%	0.7%
Washington	13	5	2	0	0.3%	0.5%	0.5%	0.0%
Regional sub-total	**1,382**	**445**	**88**	**47**	**25.9%**	**46.4%**	**29.7%**	**29.2%**
U. S. Total	**5,344**	**958**	**296**	**160**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

NAVIGANT CONSULTING

Potential annual demand for grid-connected PV in 2010 for commercial segment, by state and installed system price scenario (1 of 2).

Commercial Total:Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$ 1.00-1.10	$ 2.00- $ 2.20	$ 3.00-3.30	$ 4.25-4.65	$ 1.00-1.10	$ 2.00- $ 2.20	$ 3.00-3.30	$ 4.25-4.65
Midwest - East North Central								
Illinois	158	22	13	10	2.7%	1.1%	1.5%	1.9%
Indiana	47	8	6	4	0.8%	0.4%	0.7%	0.8%
Michigan	156	26	12	9	2.6%	1.3%	1.4%	1.7%
Ohio	244	78	18	15	4.1%	4.0%	2.1%	2.9%
Wisconsin	88	24	8	6	1.5%	1.2%	0.9%	1.3%
Regional sub-total	**694**	**157**	**57**	**44**	**11.7%**	**8.1%**	**6.6%**	**8.7%**
Midwest - West North Central								
Iowa	50	16	5	4	0.8%	0.8%	0.6%	0.8%
Kansas	20	4	3	2	0.3%	0.2%	0.3%	0.5%
Minnesota	52	7	6	5	0.9%	0.4%	0.7%	0.9%
Missouri	60	10	6	5	1.0%	0.5%	0.8%	1.0%
Nebraska	17	3	3	2	0.3%	0.2%	0.3%	0.4%
North Dakota	9	1	1	1	0.1%	0.1%	0.1%	0.2%
South Dakota	9	1	1	1	0.1%	0.1%	0.1%	0.1%
Regional sub-total	**216**	**44**	**25**	**20**	**3.6%**	**2.2%**	**2.9%**	**3.9%**
NorthEast - Middle Atlantic								
New Jersey	105	35	8	7	1.8%	1.8%	1.0%	1.3%
New York -1	66	23	6	4	1.1%	1.2%	0.7%	0.8%
New York -2	156	61	21	9	2.6%	3.2%	2.5%	1.8%
New York -3	58	24	12	4	1.0%	1.2%	1.5%	0.8%
Pennsylvania	143	38	14	11	2.4%	2.0%	1.6%	2.2%
Regional sub-total	**529**	**182**	**62**	**35**	**8.9%**	**9.4%**	**7.3%**	**6.9%**
NorthEast - New England								
Connecticut	37	12	3	3	0.6%	0.6%	0.4%	0.5%
Maine	28	9	3	2	0.5%	0.5%	0.3%	0.3%
Massachusetts	157	76	34	12	2.6%	3.9%	4.0%	2.4%
New Hampshire	25	7	2	2	0.4%	0.4%	0.2%	0.3%
Rhode Island	18	7	2	1	0.3%	0.4%	0.2%	0.2%
Vermont	13	4	1	1	0.2%	0.2%	0.1%	0.2%
Regional sub-total	**278**	**116**	**45**	**20**	**4.7%**	**6.0%**	**5.3%**	**4.0%**
South - East South Central								
Alabama	138	32	11	9	2.3%	1.6%	1.3%	1.7%
Kentucky	57	9	7	6	1.0%	0.5%	0.8%	1.1%
Mississippi	48	7	5	4	0.8%	0.4%	0.6%	0.8%
Tennessee	171	43	14	11	2.9%	2.2%	1.7%	2.2%
Regional sub-total	**413**	**90**	**38**	**29**	**6.9%**	**4.6%**	**4.4%**	**5.8%**

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

Potential annual demand for grid-connected PV in 2010 for commercial segment, by state and installed system price scenario (2 of 2).

Commercial Total:Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$ 1.00-1.10	$ 2.00- $ 2.20	$ 3.00-3.30	$ 4.25-4.65	$ 1.00-1.10	$ 2.00- $ 2.20	$ 3.00-3.30	$ 4.25-4.65
South - South Atlantic								
Delaware	20	6	2	1	0.3%	0.3%	0.2%	0.2%
Florida	452	136	33	26	7.6%	7.0%	3.9%	5.1%
Georgia	236	91	24	14	4.0%	4.7%	2.8%	2.7%
Maryland	79	12	7	5	1.3%	0.6%	0.8%	1.1%
North Carolina	265	82	20	16	4.5%	4.2%	2.3%	3.2%
South Carolina	99	27	8	6	1.7%	1.4%	1.0%	1.2%
Virginia	76	11	9	6	1.3%	0.6%	1.0%	1.3%
Washington, DC	13	4	1	1	0.2%	0.2%	0.1%	0.2%
West Virginia	19	4	3	2	0.3%	0.2%	0.4%	0.5%
Regional sub-total	**1,259**	**374**	**106**	**78**	**21.2%**	**19.3%**	**12.4%**	**15.4%**
South - West South Central								
Arkansas	31	5	4	3	0.5%	0.2%	0.4%	0.5%
Louisiana	97	30	7	6	1.6%	1.5%	0.9%	1.2%
Oklahoma	28	6	4	3	0.5%	0.3%	0.5%	0.6%
Texas	340	39	30	22	5.7%	2.0%	3.5%	4.4%
Regional sub-total	**496**	**79**	**45**	**34**	**8.4%**	**4.0%**	**5.2%**	**6.8%**
West - Mountain								
Arizona	133	43	10	8	2.2%	2.2%	1.2%	1.6%
Colorado	86	11	9	6	1.5%	0.6%	1.0%	1.3%
Idaho	39	8	4	3	0.7%	0.4%	0.4%	0.6%
Montana	30	5	3	2	0.5%	0.3%	0.3%	0.4%
Nevada	78	25	6	4	1.3%	1.3%	0.8%	0.8%
New Mexico	77	25	8	4	1.3%	1.3%	1.0%	0.9%
Utah	17	3	2	2	0.3%	0.2%	0.3%	0.3%
Wyoming	7	2	1	1	0.1%	0.1%	0.1%	0.2%
Regional sub-total	**468**	**122**	**43**	**31**	**7.9%**	**6.3%**	**5.1%**	**6.1%**
West - Pacific								
Alaska	7	1	1	1	0.1%	0.1%	0.1%	0.2%
California - 1	652	298	165	72	11.0%	15.3%	19.3%	14.3%
California - 2	53	20	8	3	0.9%	1.0%	0.9%	0.6%
California - 3	761	419	235	126	12.8%	21.6%	27.5%	24.9%
Hawaii	52	25	13	5	0.9%	1.3%	1.6%	1.0%
Oregon	32	7	5	4	0.5%	0.3%	0.6%	0.8%
Washington	32	8	5	4	0.5%	0.4%	0.6%	0.8%
Regional sub-total	**1,588**	**778**	**432**	**215**	**26.7%**	**40.1%**	**50.7%**	**42.5%**
U. S. Total	**5,941**	**1,942**	**852**	**506**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Note: Commercial Total = Total of Commercial Small/Medium and Commercial Large

NAVIGANT CONSULTING

Potential annual demand for total grid-connected PV in 2010, by state and installed system price scenario (1 of 2).

Grid Connected Total:Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$ 1.00-1.25	$ 2.00- $ 2.50	$ 3.00-3.75	$ 4.25-5.30	$ 1.00-1.25	$ 2.00- $ 2.50	$ 3.00-3.75	$ 4.25-5.30
Midwest - East North Central								
Illinois	308	37	21	14	2.7%	1.3%	1.8%	2.1%
Indiana	58	12	7	4	0.5%	0.4%	0.6%	0.6%
Michigan	296	41	20	13	2.6%	1.4%	1.7%	2.0%
Ohio	518	100	31	22	4.6%	3.4%	2.7%	3.4%
Wisconsin	168	32	12	9	1.5%	1.1%	1.1%	1.4%
Regional sub-total	**1,348**	**222**	**91**	**62**	**11.9%**	**7.7%**	**7.9%**	**9.4%**
Midwest - West North Central								
Iowa	105	21	8	6	0.9%	0.7%	0.7%	0.9%
Kansas	45	7	5	3	0.4%	0.3%	0.4%	0.5%
Minnesota	111	14	9	7	1.0%	0.5%	0.8%	1.0%
Missouri	111	17	10	7	1.0%	0.6%	0.9%	1.0%
Nebraska	32	5	4	2	0.3%	0.2%	0.3%	0.4%
North Dakota	15	2	2	1	0.1%	0.1%	0.1%	0.2%
South Dakota	16	2	1	1	0.1%	0.1%	0.1%	0.1%
Regional sub-total	**436**	**69**	**38**	**27**	**3.9%**	**2.4%**	**3.3%**	**4.0%**
NorthEast - Middle Atlantic								
New Jersey	256	59	16	11	2.3%	2.0%	1.4%	1.7%
New York -1	128	28	9	6	1.1%	1.0%	0.8%	0.9%
New York -2	382	123	33	16	3.4%	4.2%	2.9%	2.5%
New York -3	126	40	16	6	1.1%	1.4%	1.4%	0.9%
Pennsylvania	249	50	20	14	2.2%	1.7%	1.7%	2.1%
Regional sub-total	**1,142**	**300**	**94**	**53**	**10.1%**	**10.3%**	**8.2%**	**8.0%**
NorthEast - New England								
Connecticut	87	17	6	4	0.8%	0.6%	0.5%	0.6%
Maine	62	15	4	3	0.6%	0.5%	0.4%	0.4%
Massachusetts	314	112	42	16	2.8%	3.9%	3.7%	2.5%
New Hampshire	52	9	3	2	0.5%	0.3%	0.3%	0.3%
Rhode Island	39	8	3	2	0.3%	0.3%	0.2%	0.3%
Vermont	26	5	2	1	0.2%	0.2%	0.1%	0.2%
Regional sub-total	**580**	**167**	**60**	**28**	**5.1%**	**5.8%**	**5.2%**	**4.3%**
South - East South Central								
Alabama	216	40	16	11	1.9%	1.4%	1.4%	1.7%
Kentucky	91	14	10	6	0.8%	0.5%	0.9%	1.0%
Mississippi	78	11	7	5	0.7%	0.4%	0.7%	0.7%
Tennessee	244	52	19	13	2.2%	1.8%	1.6%	1.9%
Regional sub-total	**628**	**116**	**52**	**35**	**5.6%**	**4.0%**	**4.5%**	**5.3%**

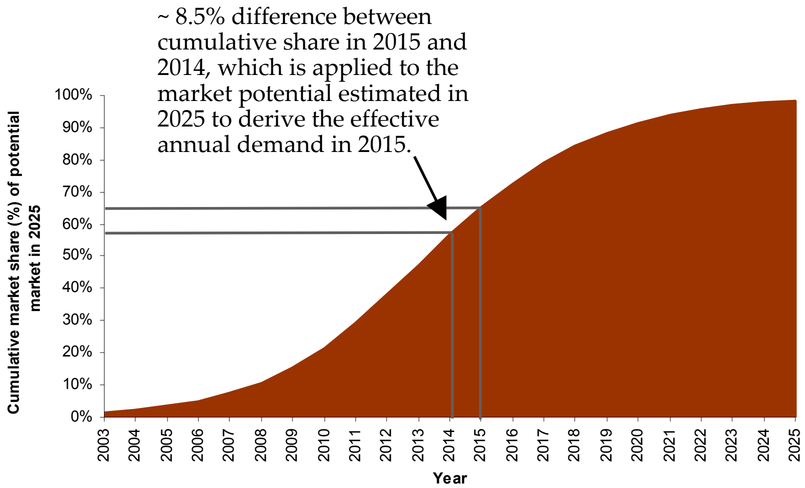
NAVIGANT CONSULTING

Potential annual demand for total grid-connected PV in 2010, by state and installed system price scenario (2 of 2).

Grid Connected Total:Demand in 2010								
State	Annual demand (MWp) in 2010				% share of annual demand in 2010			
System price ($/Wpdc) >>	$ 1.00-1.25	$ 2.00- $ 2.50	$ 3.00-3.75	$ 4.25-5.30	$ 1.00-1.25	$ 2.00- $ 2.50	$ 3.00-3.75	$ 4.25-5.30
South - South Atlantic								
Delaware	36	8	2	2	0.3%	0.3%	0.2%	0.3%
Florida	837	170	50	36	7.4%	5.9%	4.3%	5.4%
Georgia	359	104	31	18	3.2%	3.6%	2.7%	2.6%
Maryland	144	20	11	7	1.3%	0.7%	0.9%	1.1%
North Carolina	430	97	27	21	3.8%	3.4%	2.4%	3.1%
South Carolina	186	35	12	9	1.6%	1.2%	1.1%	1.3%
Virginia	167	22	14	9	1.5%	0.7%	1.2%	1.4%
Washington, DC	23	5	2	1	0.2%	0.2%	0.1%	0.2%
West Virginia	23	5	4	2	0.2%	0.2%	0.3%	0.4%
Regional sub-total	**2,205**	**466**	**152**	**105**	**19.5%**	**16.1%**	**13.3%**	**15.8%**
South - West South Central								
Arkansas	78	10	6	4	0.7%	0.3%	0.5%	0.6%
Louisiana	222	41	13	10	2.0%	1.4%	1.2%	1.4%
Oklahoma	68	11	7	5	0.6%	0.4%	0.6%	0.7%
Texas	727	79	50	33	6.4%	2.7%	4.3%	5.0%
Regional sub-total	**1,096**	**140**	**76**	**51**	**9.7%**	**4.8%**	**6.7%**	**7.7%**
West - Mountain								
Arizona	312	86	19	13	2.8%	3.0%	1.6%	2.0%
Colorado	148	18	12	8	1.3%	0.6%	1.0%	1.2%
Idaho	52	10	5	3	0.5%	0.3%	0.4%	0.5%
Montana	44	7	4	3	0.4%	0.2%	0.3%	0.4%
Nevada	136	32	9	5	1.2%	1.1%	0.8%	0.8%
New Mexico	129	35	11	6	1.1%	1.2%	1.0%	0.9%
Utah	45	6	4	3	0.4%	0.2%	0.3%	0.4%
Wyoming	13	2	1	1	0.1%	0.1%	0.1%	0.1%
Regional sub-total	**878**	**197**	**65**	**42**	**7.8%**	**6.8%**	**5.7%**	**6.4%**
West - Pacific								
Alaska	11	2	1	1	0.1%	0.1%	0.1%	0.1%
California - 1	1,294	504	211	94	11.5%	17.4%	18.4%	14.1%
California - 2	89	23	10	4	0.8%	0.8%	0.9%	0.6%
California - 3	1,369	630	267	147	12.1%	21.7%	23.3%	22.1%
Hawaii	97	40	17	6	0.9%	1.4%	1.4%	1.0%
Oregon	65	11	7	5	0.6%	0.4%	0.7%	0.8%
Washington	46	12	7	4	0.4%	0.4%	0.6%	0.6%
Regional sub-total	**2,970**	**1,223**	**520**	**262**	**26.3%**	**42.1%**	**45.3%**	**39.3%**
U. S. Total	**11,285**	**2,901**	**1,148**	**666**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Potential annual demand for total grid-connected PV in 2015, based on the assumptions discussed in the report is estimated at 4.0 GWp.

S-Curve to Calculate Potential Demand in 2015



Potential Demand in 2015

Residential

System size = 2.5 kW
Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	7,407	1.92%	9.3
$2.50	1,328	0.34%	3.3
$3.75	410	0.11%	1.5
$5.30	222	0.06%	1.2

Commercial

Commercial - Small/Medium and Large Total
System size = 15 kWp, 100 kWp
Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	8,234	2.53%	8.9
$ 2.00 - 2.20	2,692	0.83%	5.9
$ 3.00 - 3.30	1,181	0.36%	3.9
$ 4.25 - 4.65	701	0.22%	3.2

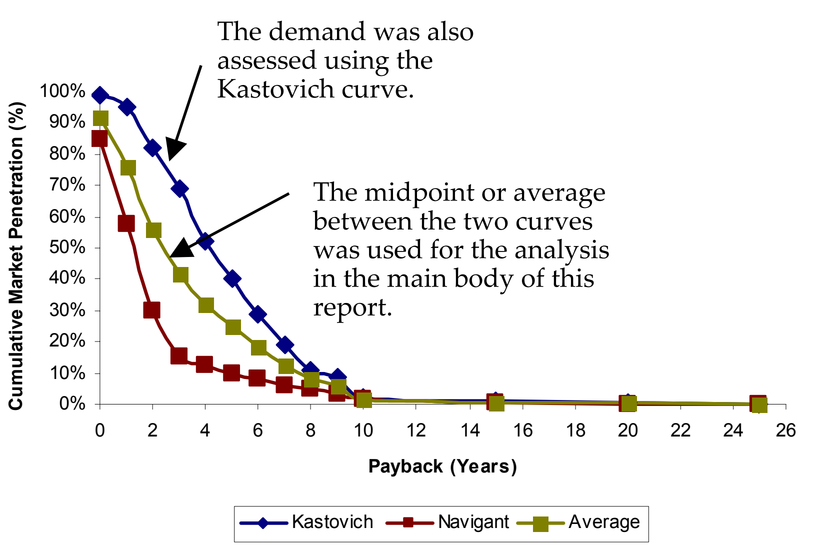
Grid Connected - Total

Technical Market (MW) = 711,864

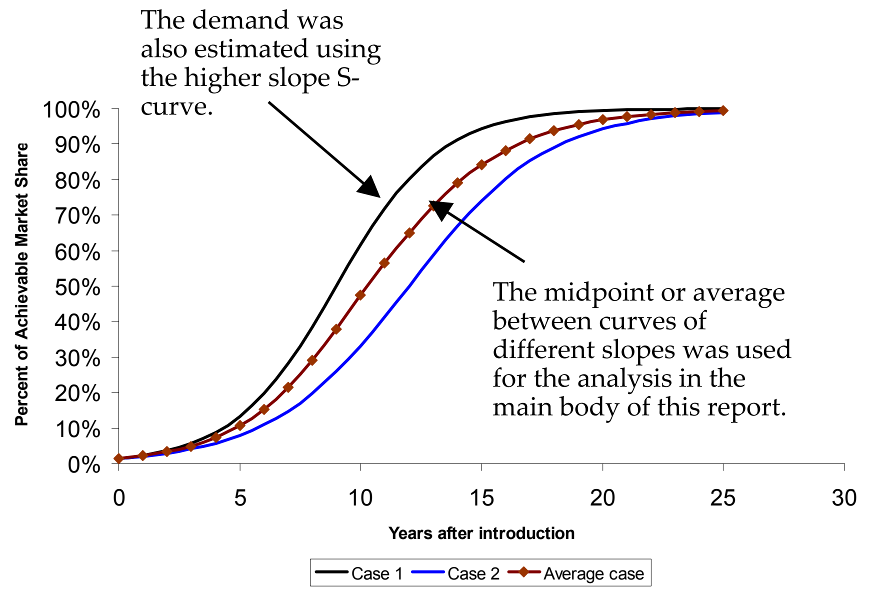
System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	15,641	2.20%	18.2
$ 2.00 - 2.50	4,020	0.56%	9.2
$ 3.00 - 3.75	1,591	0.22%	5.4
$ 4.25 - 5.30	923	0.13%	4.4

As an additional analysis, the Kastovich penetration curve and higher slope S-curves were used to estimate demand.

Payback vs. Cumulative Market Penetration Curves[1]



Typical S-Curve



- **NCI believes that using the higher penetration curve and higher slope S-curve is aggressive, given the market development efforts needed to grow and realize the PV market (e.g., additional manufacturing and infrastructure development).**
- **However, the additional analysis was conducted at the request of The Energy Foundation. It does not represent the view of NCI.**

1) Kastovich, J.C., Lawrence, R.R., Hoffman, R.R., and Pavlak, C., 1982, "Advanced Electric Heat Pump Market and Business Analysis.". The curves apply simple payback as the criteria, and were developed for the residential market. The Navigant curve: Proprietary data belonging to Navigant Consulting. Developed by the Navigant team while at Arthur D. Little, based on HVAC penetration experience for the Building Equipment Division, Office of Building Technologies, U.S. Department of Energy (DoE) in 1995. The Navigant curve is used by the DoE in its evaluation of energy efficiency and distributed energy technologies, which was confirmed in an interview with Steve Wade in January 2004.

NCI believes that using the higher penetration curve and higher slope S-curve is aggressive, but conducted the analysis at the request of EF.

Potential Annual Demand in 2010

Residential

System size = 2.5 kW
Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	5,344	1.39%	6.7
$2.50	958	0.25%	2.4
$3.75	296	0.08%	1.1
$5.30	160	0.04%	0.8

Commercial

Commercial - Small/Medium and Large Total
System size = 15 kWp, 100 kWp
Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	5,941	1.82%	6.5
$ 2.00 - 2.20	1,942	0.60%	4.2
$ 3.00 - 3.30	852	0.26%	2.8
$ 4.25 - 4.65	506	0.16%	2.3

Grid Connected - Total

Technical Market (MW) = 711,864

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	11,285	1.59%	13.1
$ 2.00 - 2.50	2,901	0.41%	6.6
$ 3.00 - 3.75	1,148	0.16%	3.9
$ 4.25 - 5.30	666	0.09%	3.2

Potential Annual Demand in 2010 – Higher Curves

Residential

System size = 2.5 kW
Technical Market (MWp) = 385,790

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$1.25	11,350	2.94%	14.2
$2.50	1,796	0.47%	4.5
$3.75	515	0.13%	1.9
$5.30	284	0.07%	1.5

Commercial

Commercial - Small/Medium and Large Total
System size = 15 kWp, 100 kWp
Technical Market (MW) = 326,074

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.10	12,840	3.94%	8.8
$ 2.00 - 2.20	3,862	1.18%	5.8
$ 3.00 - 3.30	1,574	0.48%	3.8
$ 4.25 - 4.65	892	0.27%	3.2

Grid Connected - Total

Technical Market (MW) = 711,864

System Price ($/Wpdc)	MWp	% mkt share	$ billion
$ 1.00 - 1.25	24,190	3.40%	23.0
$ 2.00 - 2.50	5,657	0.79%	10.3
$ 3.00 - 3.75	2,090	0.29%	5.7
$ 4.25 - 5.30	1,176	0.17%	4.7

The demand estimated using the alternative curves is almost twice.

NAVIGANT CONSULTING

Contact Information

Lisa Frantzis | Director
77 South Bedford Street
Burlington, MA 01803
lfrantzis@navigantconsulting.com
781-564-9614 direct

Dr. Tom E. Hoff | Principal
Clean Power Research
10 Glen Court
Napa, CA 94558
tomhoff@clean-power.com
707-224-9992 direct