May 2000 • NREL/CP-520-28426

Conference Paper

Customer Sited PV — U.S. Markets Developed from State Policies

C. Herig and H. Thomas
National Renewable Energy Laboratory: Golden, Colorado

R. Perez
ASRC: The University at Albany; New York

H. Wenger
AstroPowerWest: Concord, California

Presented at the 16th European Photovoltaic Solar Energy Conference and Exhibition
Glasgow, Scotland, U.K.
May 1-5, 2000

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

NOTICE

The submitted manuscript has been offered by an employee of the Midwest Research Institute (MRI), a contractor of the US Government under Contract No. DE-AC36-99GO10337. Accordingly, the US Government and MRI retain a nonexclusive royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for US Government purposes.

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at http://www.doe.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: reports@adonis.osti.gov

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

CUSTOMER SITED PV—U.S. MARKETS DEVELOPED FROM STATE POLICIES

Christy Herig & Holly Thomas
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO USA 80401- 3393
christy_herig@nrel.gov

Richard Perez
ASRC
The University at Albany 251 Fuller Rd
Albany, NY 12203
perez@asrc.cestm.albany.edu

Howard Wenger
AstroPowerWest
5036 Commercial Circle, Suite B
Concord, CA 94520
hwenger@astropower.com

Abstract: The customer-sited PV market in the United States depends on state policies emerging from electric utility industry restructuring. These policies, most of which have appeared since 1996, reduce both the first cost and improve operating benefits. This analysis determines the breakeven turnkey cost of a PV system, from the customer ownership perspective, on a state-by-state basis. The results of this work are used by industry to target high-value markets and by policy makers to identify options that will result in the greatest economic and market development. Still intangible external PV benefits, such as environmental value, are also analyzed and gauged against existing/potential policy actions.

1. INTRODUCTION

The U.S. market for customer-sited photovoltaics (CSPV) has historically been off-grid systems where the capital cost of the distribution-line extension offsets the CSPV cost. With residential energy prices ranging from 5¢-14¢/kWh, a consumer's values must extend beyond economics to make a grid-connected CSPV investment. PV system installed costs have declined from $6.21/W in 1996 to $3.90/W in 2000,[1] with levelized energy costs of 17¢-12¢/kWh,[2] respectively [5]. Additionally, the PV industry has developed products targeted at the grid-tied residential market and developed financing packages to alleviate the up-front cost burden to the consumer. The gap between consumer value and cost for CSPV is close, but not close enough for most U.S. consumers. However, as part of the electric industry restructuring, many states have included grid-tied CSPV market development policies for the purposes of resource diversity and economic development. The initial customer-sited PV niche market analysis completed in 1996 [1] resulted in only 5 states with a breakeven turnkey cost (BTC) greater than $4 per watt. In 1999, 15 states had BTCs greater than $4 per watt, and four states were above $7 per watt. This increase in consumer market value is fully attributed to policies emerging from state restructuring activities. These include:

- 9 state income tax rebates
- 30 states with net metering [6]
- 12 buy-down or grant programs
- 11 property tax exemptions
- 2 state interconnection standards.

Including these incentives in a life-cycle value analysis for CSPV provides industry with geographic market targets.

[1] These costs are the result of an aggregate long-term purchase for the Sacramento Municipal Utility District Pioneer PV program and represent the lowest reported residential installed costs. These are representitive of commercial PV systems of 30 kW or more. The year 2000 cost was estimated from the committed contract price.

[2] Levelized costs are for residential systems with 1st mortgage financing and retail rate compensation for energy production at 10¢/kWh.

2. APPROACH

The state-by-state database was developed to determine a breakeven turnkey cost for each state and is presented in Table 1. The consumer breakeven turnkey cost (BTC) is the value per kW that a consumer can pay for a PV home energy system and neither gain nor lose money over the life of the system. The energy, tax, and policy benefits, as well as the capital (included in the home mortgage), operation, and maintenance costs over the life of the system are forced to a net present worth of zero, using an 8% discount rate, by varying the initial cost of the PV system.

2.1 Assumptions

With comparisons made later in the paper between the 1996 analysis and 1999 analysis, it should be noted that many of the assumptions for the life-cycle value analysis were more conservative for the 1999 analysis. The electricity price inflation rate has been lowered from 3.5% to 2%, consistent with market realities. This change decreased the BTC 5%-10%. However, operation and maintenance costs are still inflated at 3.5%. An inflation rate was not applied to the environmental externality benefits over the life of the system, because this is still an intangible value. Also consistent with the 1996 analysis is the 1-kW installed PV system basis, taking advantage of full residential retail electric rate benefits. The mortgage financing is at 90% debt, 30-year term, but the interest rate is set at 7%, down from 8%, which results in an increased BTC.

2.2 Database Development

Next to capital cost reduction policy incentives, the analysis is most sensitive to changes in the residential rates. The current residential rates are based on annual residential revenue and consumption [3], resulting in lower, more conservative rates. Of the 50 states, only 21 rates changed from the initial study by one- or two-tenths of a cent.

Table 1: State-By-State Attributes and Incentives

State	Res. Rank 1999	Res. Rate [3]	Res. Tax Credit [4],[5]	Net Meter [6]	Prop-erty Tax [3]	Sales Tax [3]	Buy Down, Grant[5], [7],[8],[9]	SOX-#/kW-yr [10]	NOX-#/kW-yr [10]	CO2-#/kW-yr [10]	Cap Factor [11]	Res. BTC ($/kW) 1999	Ext. - NPV ($/kW) 1999	Res. BTC ($/kW) 1996
Alabama	37	6.7						16	8	2937	19	$2,497	$664	$2,440
Alaska	39	11.4						5	10	2644	12	$2,462	$413	$1,793
Arizona	14	8.8	25%/$1K	Y		Y		7	10	2957	24	$4,590	$456	$4,788
Arkansas	34	7.8						7	7	2791	19	$2,542	$434	$3,423
California	4	11.5		Y	Y		$3/W,50%	2	4	1389	22	$7,402	$286	$4,873
Colorado	10	7.4		Y			25%	10	16	4122	23	$5,196	$687	$2,789
Connecticut	19	12.1		Y				6	4	2062	18	$3,531	$319	$3,707
Delaware	21	9.2						28	10	3503	18	$3,497	$987	$2,910
Florida	11	8.1				Y	$2/W	14	8	2739	19	$5,016	$592	$2,544
Georgia	30	7.7						17	7	3090	19	$2,798	$687	$2,287
Hawaii	3	14.8	35%/$1750					15	9	4356	24	$7,911	$737	$7,500
Idaho	49	5.2						2	1	644	21	$1,690	$110	$2,189
Illinois	2	10.4			Y		60%/$5k	17	8	1962	18	$8,411	$612	$3,057
Indiana	29	6.9		Y	Y			24	18	4401	17	$2,815	$1,037	$2,231
Iowa	23	8.2		Y				16	15	3497	19	$2,995	$759	$1,915
Kansas	26	7.7						9	12	3350	21	$2,894	$576	$2,858
Kentucky	42	5.6						27	11	2976	17	$2,323	$930	$1,476
Louisiana	28	7.4						19	8	3206	20	$2,828	$735	$2,143
Maine	22	12.8		Y				8	3	2767	16	$3,462	$423	$3,158
Maryland	7	8.3		Y			$2.94/W	17	9	2876	18	$6,133	$693	$2,744
Massachusetts	13	11.6	15%/$1K	Y	Y	Y		9	5	2408	18	$4,647	$433	$4,321
Michigan	40	8.6						11	8	2198	16	$2,414	$481	$1,983
Minnesota	44	7.2		Y	Y	Y		7	10	2909	17	$2,217	$469	$1,885
Mississippi	36	7.0						11	9	3228	19	$2,502	$581	$2,737
Missouri	31	7.1						17	12	3165	19	$2,681	$730	$2,509
Montana	48	6.4			Y			3	6	2017	19	$1,919	$263	$1,771
Nebraska	43	6.4						8	11	2384	20	$2,222	$453	$2,066
Nevada	17	8.9		Y				8	13	3714	24	$3,610	$578	$3,021
New Hamp.	18	13.7		Y	Y			8	2	1230	16	$3,540	$294	$3,571
New Jersey	6	12.1		Y		Y	$2.94/W	4	6	1912	18	$6,719	$289	$3,608
New Mexico	16	8.9		Y				9	17	4447	25	$3,860	$684	$3,666
New York	1	14.1	25%/$3750	Y			50%	6	4	1540	18	$10,257	$289	$4,372
N. Carolina	5	8.0	40%/$1500	Y			$2.94/W	14	7	2409	19	$7,042	$563	$3,714
North Dakota	20	6.3	5%-3yrs	Y	Y			15	12	3630	19	$3,519	$710	$2,393
Ohio	25	8.6						27	11	2714	16	$2,956	$925	$2,354
Oklahoma	35	6.6		Y				9	12	3509	21	$2,538	$578	$3,429
Oregon	47	5.6	.40/kWh, $1K					1	1	415	18	$2,042	$55	$2,344
Pennsylvania	8	9.9		Y			$2.94/W	16	6	1854	16	$6,092	$548	$3,052
Rhode Island	15	12.1		Y			$1/W	1	9	2262	18	$4,564	$264	$3,541
S. Carolina	41	7.5						11	5	1738	19	$2,403	$416	$2,598
South Dakota	46	7.1			Y			5	4	947	19	$2,065	$215	$2,544
Tennessee	45	6.0						18	7	2223	18	$2,191	$652	$1,582
Texas	27	7.8		Y	Y			6	9	3166	22	$2,892	$453	$3,250
Utah	12	6.9	25%/$2K					3	15	4705	24	$4,907	$710	$2,588
Vermont	32	11.5		Y				0	0	293	16	$2,614	$21	$3,198
Virginia	9	7.8		Y			$2.94/W	12	6	2443	18	$5,753	$513	$2,744
Washington	50	5.0		Y				2	1	412	15	$1,020	$81	$1,084
West Virginia	33	6.3						29	12	3353	17	$2,605	$1,014	$2,105
Wisconsin	24	6.9		Y	Y		$0.5/kWh	14	10	2896	16	$2,994	$630	$1,770
Wyoming	38	6.2						8	16	4151	21	$2,477	$641	$1,887

Net metering [6], property tax, and sales tax [4] incentives are included in the table, but not in the analysis. Full residential electric rate benefits are assumed, due to the BTC per kW installed basis.

The state buy-downs and grants are all new policies that have developed since the original study. The authors have chosen to include two state (Florida and Illinois) buy-down policies and programs, which are not yet, but will soon be, available. However, the actual buy-down may change upon availability. Additionally, the authors were unable to verify the availability of the Colorado Solar Energy Association 25% system cost rebate, but the rebate is included in the analysis.

The California SBC provides $54 million over 4 years for buy-downs of "emerging renewables," which include residential CSPV. The California Energy Commission administers the fund, which started in March of 1998. The buy-down provides $3/W, up to 50% of the installed cost. It was designed to decline on an annual basis, but is currently still available at the $3/W value [12].

The Photovoltaic Buildings in Florida program will apply the major portion of $600,000 worth of funding from the Florida Energy Office / Department of Community Affairs toward system buy-downs. The residential CSPV buy-down is proposed at $2/W [8]. The program will be administered by the Florida Solar Energy Center.

The Illinois SBC will collect $5 million annually targeted towards renewable energy resources [5]. The Renewable Energy Resources Program, under the Department of Commerce and Community Affairs, is expected to administer grants to fund 60% of CSPV costs up to $5,000.

The Virginia Alliance for Solar Energy (VASE) is currently offering a $2.94/W buy-down for residential CSPV in five states (Maryland, New Jersey, North Carolina, Pennsylvania and Virginia) through a request for proposal [7]. A minimum aggregate of 10 kWac is required by the request for proposal.

The New York State Energy Research and Development Authority (NYSERDA) will administer the SBC fund, expected to collect over $234 million in the next three years [5]. Currently, NYSERDA has a program opportunity notice (PON) to deploy $1 million funds toward residential CSPV [9]. The PON limits the cost share at 50%.

The pounds per kilowatt-hour emission mitigation for SO_X, NO_X, and CO_2 externalities were determined using the total industry generation and total industry emissions for each state [10]. Due to disclosure conflicts and externalities conflicts, six states (Arizona, Kentucky, Mississippi, Nebraska, North Dakota, and Wyoming) are calculated using utility generation and total industry emissions. The emissions mitigated for each kW of PV installed are then calculated using the state average PV capacity factor [11]. The value of the emissions mitigation by PV is based on the cost of control [15] versus the value of environmental damages.

TABLE 2: Emissions Cost-of-Control Values

	National [14]	CA [16]	WI [16]	MA 16]
SO_X $/#	$2.03	$2.20-11.00	NA	$0.75
NO_X $/#	$0.82	$4.50-$15.00	$1.35	$3.25
CO_2 $/ton	$13	$9	$15	$22

3 RESULTS

As shown in Figure 1, fifteen states now have BTCs above $4/W. In just four years, 12 new state policies, either buy-downs, grants, or state income tax rebates, have been instituted, all of which reduce the initial cost of the CSPV system, increasing the BTC. Figure 2 examines the top fifteen states for other potential policies, such as environmental externalities and real-time pricing.

FIGURE 1 Breakeven Turnkey Cost 1996 & 1999

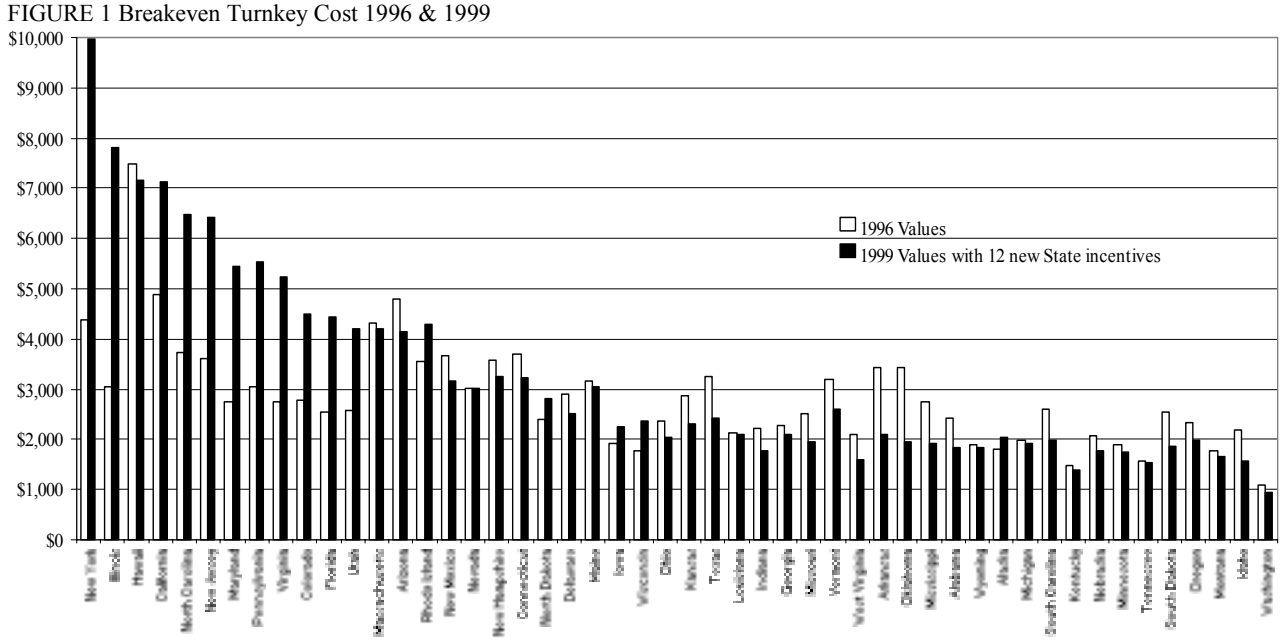
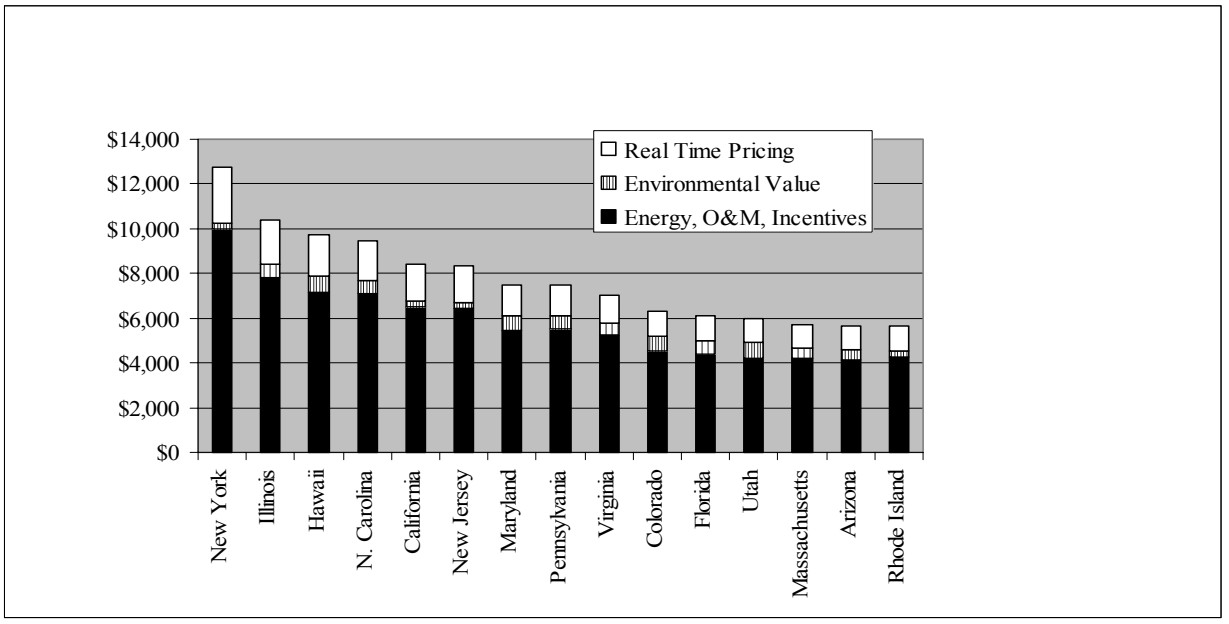


Figure 2: 1999 BTC with Environmental Externalities and Real Time Pricing



4 CONCLUSIONS

The economics indicate policies do effectively fill the gap between consumer value and price. The most active deployment areas in the country are the states with high BTCs.

Though many of the incentives used in the analysis have changed or sunseted, there is potential for new incentives. Currently, 23 states have initiated or implemented restructuring policies and 16 have renewables provisions. The system benefits charges (SBC), included in 13 state restructuring policies, are a source of funding for consumer incentives. Thus far, only 7 of the 13 state SBCs have been implemented, leaving potential for more near-term incentives. Additionally, 9 state renewable portfolio standards, the Million Solar Roofs initiative, 40+ community partnerships working on consumer awareness, reducing infrastructure barriers and municipal policies, and the fifty utility green-pricing programs either offered or under development are potentially new arenas for consumer incentives.

With the potential for market stimulation through policy incentives established by analyzing the increased consumer value, the next step is to determine the effectiveness as measured by participation in the various incentives programs.

REFERENCES

[1] Wenger, H., Herig, C., Taylor, R., Eiffert, P., and R. Perez, "Niche Markets For Grid-Connected Photovoltaics", IEEE Photovoltaic Specialists Conference, Washington, D.C., 10/96

[2] Osborn, D., "Sustained Orderly Development and Commercialization of Grid-Connected Photovoltaics: SMUD as a Case Example", A pre-print from Advances in Solar Energy XIV, 2000, Ver. 02/24/2000

[3] Energy Information Administration, "Electric Sales and Revenue 1997"

[4] Database of State Incentives for Renewable Energy-DSIRE, (1998). NCSC-IREC @ http://www-solar.mck.ncsu.edu/dsire.htm

[5] Sprately, W. A., "Consumer Charges Power Solar Financing", Public Utilities Fortnightly, Dec. 1998

[6] Starrs, T. (Feb. 1999), Personal Communications, "Summary of State Net Metering Programs (current)", version 2/15/99, Kelso Starrs and Assoc., Vashon, WA

[7] VASE Request for Proposal Phase 3, Virginia Alliance for Solar Energy (VASE) @ http://www.vase.org/index.html, (1999)

[8] Ventre, G. (1999), Personal Communication, Florida Solar Energy Center, Cocoa, FL

[9] Program Opportunity Notice (PON) No. 448-98, "Residential Photovoltaics Market Development", New York Solar Energy Research and Development Authority (NYSERDA) @ http://www.nyserda.org/448pon.html, 1999

[10] Energy Information Administration, "State Electricity Profiles", DOE/EIA-0629, March 1999

[11] QuickScreen software, Pacific Energy Group @ http://www.pacificenergy.com/software.htm

(12) Masri, M. (1999): Personal Communications, California Energy Commission, Sacramento, CA

[13] Osborn, D., "Commercialization and Business Development of Grid-Connected PV at SMUD", Proc. ASES Solar '98 Conference, Albuquerque, NM, June 1998

[14] Buchanan, C., P. Chernick, A. Krupnik, U. Fritsche, (1991) Environmental Costs of Electricity, Oceana

[16] Energy Information Administration, "Electricity Generation and Environmental Externalities: Case Studies", DOE/EIA-0598, March 1999

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE May 2000	3. REPORT TYPE AND DATES COVERED conference paper

4. TITLE AND SUBTITLE Customer-Sited PV—U.S. Markets Developed from State Policies	5. FUNDING NUMBERS C TA: PV008102
6. AUTHOR(S) C. Herig, H. Thomas, R. Perez, and H. Wenger	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401-3393	10. SPONSORING/MONITORING AGENCY REPORT NUMBER CP-520-28426
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161	12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The customer-sited PV market in the United States depends on state policies emerging from electric utility industry restructuring. These policies, most of which have appeared since 1996, reduce both the first cost and improve operating benefits. This analysis determines the breakeven turnkey cost of a PV system, from the customer ownership perspective, on a state by state basis. The results of this work are used by industry to target high-value markets and by policy makers to identify options which will result in the greatest economic and market development. Still intangible external PV benefits, such as environmental value, are also analyzed and gauged against existing/potential policy actions.

14. SUBJECT TERMS photovoltaics ; PV markets ; PV systems ; customer-sited PV ; state policies ; break-even turnkey cost	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL