COMMENTS SUBMITTED TO THE FLORIDA PUBLIC SERVICE COMMISSION:
UNDOCKETED WORKSHOP ON FLORIDA RENEWABLE
TECHNOLOGIES ASSESSMENT
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Residential Photovoltaic Program Development for Florida

I. Executive Summary

This testimony assesses the potential of rooftop solar photovoltaic (PV) systems to gain market acceptance and provide part of the electrical requirement of Florida over the next decade. The attractiveness of rooftop PV systems to individual customers will depend upon a comparison consumers make between the cost per kilowatt-hour (kWh) from the PV systems and the expected cost per kWh from tariffed electric service. Consumers will install PV systems if they think the cost of PV electricity is comparable to the expected cost of electricity from their utility provider.

With policy changes and modest capital buydowns, it is reasonable to expect that PV could provide competitively priced electricity. Based on the analysis presented in these comments, it is reasonable to expect a ten-year PV development program could lead 100,000 Florida households to install 1 kilowatt (kW) or 2 kW grid-connected systems. More aggressive policy and financial support could increase the number of rooftop PV systems installed.

In order to assess the economics of a solar PV program for Florida, a number of variables, including the size and duration of the program, the capital cost, lifetime, generating capacity, and

capacity factor of the PV technology, the cost of credit, the availability of tax deductions, the present utility rate structure and estimated tariff escalation rates, and the size of any incentives are specified.

We begin by examining the basic economics of PV in Florida. The analysis is performed both for the case where PV-generated electricity is valued at regular residential electricity tariff rates, and also where it is valued at peak tariff rates. We then estimate the potential cost of PV generated electricity in Florida under a state or utility-run residential rooftop PV installation program. We suggest policies to develop such a program in Florida, and provide a comparison of the levelized cost of grid electricity to the levelized cost of PV under the program to show under what conditions costs would be reasonable enough for the program to succeed.

II. Economic Analysis

We begin the analysis by assessing the economics per installed kilowatt (kW) of PV under a set of economic and technical assumptions. In this hypothetical example, one kW of PV is installed on a residential rooftop in Florida and the installed system cost is rolled into a 25-year home mortgage at a 7% interest rate. Interest on loan principal is claimed as a deduction on Federal income taxes. A hypothetical capital buydown mechanism is included to allow incentivization of customer or contractor system purchase. While changing the values of these assumptions will change numerical results, the basic methodology is straightforward.

A sensitivity analysis is performed to assess the impact of rate structure and future rate change assumptions, resulting in two cases. In the first case, the starting average residential tariff is 8.5 cents/kWh, the peak residential tariff is 13 cents/kWh, and the annual tariff growth rate is 3%. This is denoted as the "low peak tariff/ low tariff escalation" case. In the second case, the starting average residential tariff is again 8.5 cents/kWh, but the peak residential tariff is two cents/kWh higher at 15 cents/kWh, and a more rapid annual tariff growth rate of 4% is assumed. This is denoted the "high peak tariff/ high tariff escalation" case.

The full set of assumptions for the two cases are provided in Table 1 below.

Table 1. Assumptions for Economic Analysis of a Hypothetical 1 kW PV System Under Two Different Tariff Scenarios

Assumption	low peak tariff/ low tariff escalation	high peak tariff/ high tariff escalation
Product size (kW)	1	1
Product lifetime (years) [1]	25	25
Capacity Factor [2]	23.4%	23.4%
Installed capital cost ($/kW) [3]	$ 8,000	$ 8,000
Hypothetical buydown incentive ($/kW) [4]	$ 4,000	$ 4,000
Hypothetical installed cost to consumer ($/kW)	$ 4,000	$ 4,000
Mortgage interest rate (%)	7%	7%
Federal incremental tax rate (%) [5]	27.5%	27.5%
Effective interest rate after tax deductions [6]	5.08%	5.08%
Residential Electricity Tariff, 2002 ($/kWh)	$ 0.085	$ 0.085
Peak Load Electricity Tariff, 2002 ($/kWh) [7]	$ 0.130	$ 0.150
Tariff growth rate (%/year)	3%	4%

1. Twenty-five year lifetime as specified in testimony the Florida 2020 Commission, Tallahassee, FL, April 19, 2001, by David L. Block, Ph.D., Director, Florida Solar Energy Center.
2. Annual average PV capacity factor for Florida as reported in Powering the South, Renewable Energy Policy Project, January 2002. This capacity factor was calculated using 40-km resolution satellite data supplied by the Department of Energy's National Renewable Energy Laboratory (NREL).
3. Personal communication with the Florida Solar Energy Center, June 24, 2002. The $8000/kW value represents the installed cost of utility-installed PV found in a recent study of Florida's PV programs. Costs for independent contractor-installed PV tend to be $2000/kW or higher than this.
4. This initial level of capital buydown is comparable to PV buydown incentives in other states. For example, the Los Angeles Department of Water and Power (LADWP) offers a buydown incentive of $4.50 to $6.00 per installed watt for qualified PV systems, and the Long Island Power Authority Solar Pioneer program offers a buydown incentive of $6.00 per installed watt of PV, which will be reduced to $4.00 per installed watt beginning August 1, 2002. Sources: Los Angeles Department of Water and Power, http://www.greenla.com/solar/incentives/, Database of State Incentives on Renewable Energy, http://www.dsireusa.org.
5. From IRS 2001 Tax Rate Schedules. This is the most common Federal tax bracket, representing lower middle-income households. Because Florida has no state tax, state tax deductions cannot be used to improve the economics of PV installation costs.
6. Use of an effective interest rate over the course of the loan results in costs approximately 1% lower than would result from calculating tax deductions separately for each year.
7. REPP estimate, based on personal communication with the Florida Solar Energy Center, June 24, 2002.

A simple economic analysis based on these assumptions shows that the levelized cost of photovoltaic power to the consumer over the 25 year lifetime of the PV system, after a hypothetical $4000/kW buydown incentive is accounted for, is 14.0 cents/kWh. As shown by Table 2, the levelized value of electricity generation avoided at the central station over the same 25 years, valued at the standard residential tariff rate and taking into account tariff escalation, is 12.4 cents/kWh under the low peak tariff/ low tariff escalation scenario, and 14.2 cents/kWh under the high peak tariff/ high tariff escalation scenario. The difference between these levelized costs represents any remaining additional per KWh cost the consumer would pay for the electricity generated from the PV system as compared to what they would have paid for grid electricity. In the low peak tariff/ low tariff escalation scenario, this difference (cost) is 1.6 cents/kWh, while in the high peak tariff/ high tariff escalation scenario the customer saves 0.2 cents/kWh by using the PV system to generate electricity.

Table 2. Results of Economic Analysis for Hypothetical 1 kW PV System With Standard Residential Pricing

Description	low peak tariff/ low tariff escalation		high peak tariff/ high tariff escalation	
Annual payment ($/kW/year)	$	286	$	286
Net PV system cost to consumer ($/kW)	$	7,149	$	7,149
Electricity saved over 25-year lifetime (MWh/kW)		51.2		51.2
Value of electricity saved over 25 years ($/kW)	$	6,353	$	7,256
Levelized value of electricity ($/kWh)	$	0.124	$	0.142
Levelized cost of PV electricity ($/kWh)	$	0.140	$	0.140
Levelized Cost Difference ($/kWh)	**$**	**0.016**	**$**	**(0.002)**

Table 3 (below) shows the results of the same levelized electricity cost analysis as in shown in Table 2, expect that in this case it is assumed that a net metering policy with peak pricing opt-in is in effect, and that all kWh generated by the PV system are valued at peak price. The levelized cost of PV electricity is unchanged at 14.0 cents/kWh. The levelized value of electricity

generation avoided at the central station over the 25 year PV system lifetime, valued at the peak tariff rate and taking into account tariff escalation, is 19.0 cents/kWh under the low peak tariff/ low tariff escalation scenario, and 25.0 cents/kWh under the high peak tariff/ high tariff escalation scenario. Again the difference between these levelized costs represents any remaining additional per KWh cost the consumer would pay for the electricity generated from the PV system as compared to what they would have paid for grid electricity. In the low peak tariff/ low tariff escalation scenario, this difference represents a savings to the consumer of 5.0 cents/kWh, while in the high peak tariff/ high tariff escalation scenario the customer saves 11.0 cents/kWh by using the PV system to generate electricity.

Table 3. Results of Economic Analysis for Hypothetical 1 kW PV System With Peak Pricing Opt-in

Description	low peak tariff/ low tariff escalation		high peak tariff/ high tariff escalation	
Annual payment ($/kW/year)	$	286	$	286
Net PV system cost to consumer ($/kW)	$	7,149	$	7,149
Electricity saved over 25-year lifetime (MWh/kW)		51.2		51.2
Value of electricity saved over 25 years ($/kW)	$	9,716	$	12,805
Levelized value of electricity ($/kWh)	$	0.190	$	0.250
Levelized cost of PV electricity ($/kWh)	$	0.140	$	0.140
Levelized Cost Difference ($/kWh)	**$**	**(0.050)**	**$**	**(0.110)**

III. Program Development

Using that basic framework, the economics of a multi-year residential rooftop PV program for Florida under a set of economic, technical, and policy assumptions are assessed. The first policy we recommend is regulatory reform to provide residential net metering with peak pricing opt-in. As shown in the hypothetical example above, valuation of PV-generated electricity at peak price improves the economics of PV significantly.

We propose a PV program goal of 100,000 1-kW systems to be installed over a period of 10 years. [1] While this is an average of 10,000 systems per year, fewer systems than this would be installed in earlier years as systems are sourced, contractors trained and certified, and program elements put in place. An increasing number of systems would be installed each year as the program ramps up.

In addition, the procurement of a long-term contract for a large number of PV system installations under competitive bidding is assumed to reduce the installed capital cost by $1000/kW, to $7000/kW. Because our goal is the minimization of program costs, we choose a buydown incentive level that minimizes the difference between the levelized value of grid peak power offset by PV and the levelized cost of the PV systems.

A sensitivity analysis assesses the impact of rate structure and rate escalation, resulting in two cases. In the first case, the peak residential tariff is 13 cents/kWh, and the annual tariff growth rate is 3%. This is denoted as the "low peak tariff/ low tariff escalation" case. In the second case, the peak residential tariff is two cents/kWh higher at 15 cents/kWh, and a more rapid annual tariff growth rate of 4% is assumed. This is denoted the "high peak tariff/ high tariff escalation" case.

The full set of assumptions for the two cases are provided in Table 4 below.

A simple economic analysis based on these assumptions shows that the levelized cost of photovoltaic power to the consumer after buydown incentives are accounted for and the levelized peak tariff value of electricity generation avoided at the central station under the low peak tariff/ low tariff escalation scenario over the 25 year program lifetime are identical at 19.0 cents/kWh. (See Table 5). As Table 6 shows, the level of capital buydown required to bring the difference in levelized costs to this zero value is $1565/kW. In the high peak tariff/ high tariff escalation

[1] The goal of 100,000 systems installed in Florida over the next 10 years is the same size as the goal set by the Los Angeles Department of Water and Power (LADWP) Solar Rooftop Incentive for Residential and Commercial Customers. LADWP's goal is to have 100,000 systems on rooftops in the City of Los Angeles by the year 2010. Further information on this program is found at LADWP's website: http://www.ladwp.com/whatnew/solaroof/solaroof.htm

scenario the levelized cost of photovoltaic power is 24.4 cents/kWh and the levelized peak tariff value of electricity generation is 25.0 cents/kWh, resulting in a customer savings of 0.6 cents/kWh through PV electricity generation. (See Table 5 below.) As Table 6 shows, this customer savings is achieved with no buydown requirement.

Table 4. Assumptions for Economic Analysis of a Multi-Year PV Program Under Two Different Tariff Scenarios

Assumption [1]	low peak tariff/ low tariff escalation	high peak tariff/ high tariff escalation
Participants (average installations/yr)	10,000	10,000
Program duration (years)	10	10
Product lifetime (years)	25	25
Product size (kW)	1	1
Capacity Factor	23.4%	23.4%
Installed capital cost ($/kW)	$ 7,000	$ 7,000
Hypothetical buydown incentive ($/kW)	$ 1,565	$ -
Hypothetical installed cost to consumer ($/kW)	$ 5,435	$ 7,000
Mortgage interest rate (%)	7%	7%
Federal incremental tax rate (%)	27.5%	27.5%
Effective interest rate after tax deductions	5.08%	5.08%
Peak Load Electricity Tariff, 2002 ($/kWh)	$ 0.130	$ 0.150
Tariff growth rate (%/year)	3%	4%

1. All assumptions in Table 3 are the same as detailed in Table 1 notes above, with the exceptions that installed PV system capital cost is reduced through competitive bidding and buydown incentives are reduced to minimize program costs.

Table 5. Results of Economic Analysis of a Multi-Year PV Program With Peak Pricing Opt-in

Description	low peak tariff/ low tariff escalation		high peak tariff/ high tariff escalation	
Annual payment for PV System ($/year)	$	3,88,304	$	5,004,072
Net PV system cost to consumers ($)	$	97,132,612	$	125,101,800
Electricity saved over 25-year lifetime (MWh)		512,460		512,460
Value of electricity saved over 25 years ($)	$	97,156,356	$	128,051,173
Levelized value of electricity ($/kWh)	$	0.190	$	0.250
Levelized cost of PV electricity ($/kWh)	$	0.190	$	0.244
Levelized Cost Difference ($/kWh)	**$**	**(0.000)**	**$**	**(0.006)**

Table 6. Buydown Required For Levelized Cost Break Even For a Multi-Year PV Program With Peak Pricing Opt-in

	low peak tariff/ low tariff escalation		high peak tariff/ high tariff escalation	
Required buydown incentive ($/kW)	**$**	**1,565**	**$**	**0**

IV. Other Considerations

There are a number of benefits that could result from offsetting a portion of Florida's current central-station power generation with clean, distributed, solar PV that are not accounted for in this analysis. The PV systems will generate electricity and save the water consumed in traditional generating units. This water use reduction provides both environmental and economic benefits. In addition, PV will provide benefits to the grid from distributed generation, including distribution grid support and increased effective load carrying capacity, public health and environmental benefits from the avoidance of NOx, SOx, HC, CO2, and heavy metal air emissions. Further study of these benefits, including quantification and monetization, may well improve the economics of solar PV generation beyond that which has been shown above.

APPENDIX A:

ADDENDUM TO

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Table A1: Buydown Required For Levelized Cost Break Even For a Multi-Year PV Program With Peak Pricing Opt-in Under Different Capacity Factor Assumptions

PV Capacity Factor	Reference	low peak tariff/ low tariff escalation	high peak tariff/ high tariff escalation
23.4%	Powering the South Report	$ 1,565	$ 0
19.2%	Florida Solar Energy Center	$ 2,545	$1,120
18.1%	NREL (1999)	$2,800	$1,450

"Low" tariff scenario assumes 13.0 cent/kWh peak and 3% escalation,
"High" tariff scenario assumes 15.0 cent/kWh peak and 4% escalation.