DRAFT

Solar Electricity (Photovoltaics): Opportunities in Florida

The direct conversion of solar energy to electricity using the photovoltaic (PV) effect (solar cell) is a form of renewable energy. The PV industry is in its infancy, and although small compared to mature generation technologies (e.g., fossil fuels, nuclear) it has been one of the world's fastest growing industries during the past 10 years. In 2009, 7.2GWp of new PV capacity was installed world-wide, and generated $38.5 billion in global revenues[1]. By comparison the total electricity generation capacity in Florida is 59.1GW[2,3]. It is estimated that generating 10% of the world's electricity using PV would require at steady state an annual production rate of ~250GWp. Thus, only a very small fraction of the existing manufacturing capacity is in place (<1%). It is further estimated that each installed MWp created 42 jobs in 2008 and will create 19 in 2025[4]. *The long term opportunity for Florida is to become an exporter of PV systems to the Southeast US, Caribbean, Americas, and beyond, and thus create direct and indirect jobs related to manufacturing, assembly, design, and research.* The levelized cost of PV, however, is still more expensive than that based on fossil fuels (~ $0.17/kWhr[5]), but the cost has been declining steadily with grid parity expected in Florida in ~2015[6.] A key question for Florida is: Will any of this manufacturing and related capacity be located in Florida?

The answer to this question depends on several factors, but locations with a secure market for PV installations, low manufacturing costs, and a skilled workforce have been important factors to date. The industry consists of PV module manufacturers (mostly small start-up companies), supply chain providers (mostly large companies), and systems integrators who design, construct and sometimes operate systems (mostly small companies). PV systems have large upfront costs but extremely low operating costs since fuel (sunlight) is free and there are only minimal operating costs. Aside from materials costs, the major panel manufacturing cost is capitalization, and thus financing costs are critical for small companies. To obtain reasonable financing, new manufacturing facilities must demonstrate ~5 years demand for their product. Of course other location-dependent costs exist, including those associated with workforce availability and wages, taxes, and transportation.

It is argued that the State of Florida has the potential to attract a significant PV manufacturing industry through creation of a sustainable market. The arguments include:

- Very high solar radiation (23.4% capacity factor with unobstructed 1D tracking)

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[1]http://www.epia.org/fileadmin/EPIA_docs/public/Global_Market_Outlook_for_Photovoltaics_until_2014.pdf

[2] http://www.eia.doe.gov/cneaf/electricity/epa/fig1p1.html

[3] Note that a W of electrical power is ~4W_p since the solar cell is not receiving direct solar insolation for all 24 hours in a day. The annual average PV capacity factor for Florida is 23.4% 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). http://rredc.nrel.gov/solar/pubs/redbook/

[4] New Energy Finance, 2009; note this calculation uses an I/O model and includes direct, indirect, and induced jobs but neglects lost opportunity jobs. The location of the jobs is also not predicted.

[5] http://www.solarbuzz.com/SolarIndices.htm; 500 kW_p flat roof mounted Solar System, connected to the grid and excluding back up power for a sunny climate.

[6] www1.eere.energy.gov/**solar**/pdfs/dpw_lushetsky.pdf

- Large coastal population and available interior land in southern half of State, thus minimizing average transmission distance.
- High per capita residential electricity use with potential for significant distributed deployment (reduce transmission need, increase resilience to catastrophic events).
- PV electricity production well matched to demand, particularly in South Florida.
- Our current cost of electricity is relatively high (~12 ¢/kWhr), thus making PV more attractive.
- PV manufacturing in nearby regions (SE US, Caribbean[7], South and Central America) is minimal and thus represents an export potential.

For these reasons the State is in a position for significant deployment of PV as illustrated in the map below, which is taken from a recent NREL study.[8] This U.S. map compares the residential PV breakeven cost ($\$/W_p$) projected for 2015 considering only time-of-use rate structure. It is predicted grid parity will be realized in Florida when the cost ($\$/W_p$) reaches the $6 to $8 range. It is also noted that Florida's per capita residential electricity demand is among the highest in the country[9,] due in part to high summer air-conditioning and winter heating using electricity. Fortunately, the timing between PV generation and demand is relatively well matched during the high demand summer time.

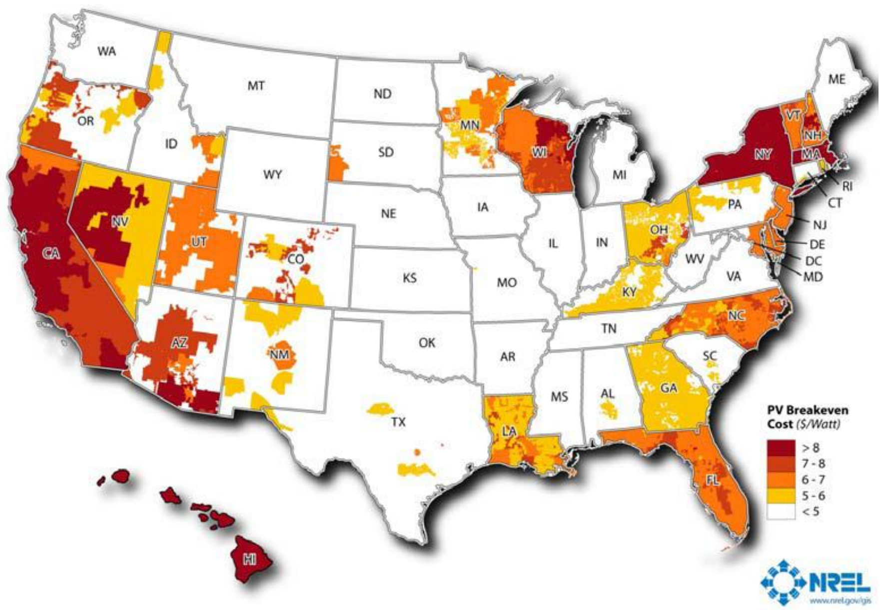

Figure 1. Residential solar PV break-even cost ($/W) in 2008 using the most common rate structure and all incentives.

The deployment of PV can be made at variable scales ranging from the utility level (~1 to 100 MW_p) to widely distributed residential scale (few kW_p). There is a strong rationale for utility scale deployment, and the lower installed cost is the leading argument[10]. Additionally, utility scale installations are less expensive to operate and, depending on location, easier to connect to the grid. At low penetration levels, Florida is well positioned to minimize distribution costs and losses given the high population density and available locations. Florida is the 4th most populous state (18.5M

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[7] The high cost of electricity in the Caribbean and the intermittency of PV makes distributed generation with storage a very viable option, and thus immediate market for export.

[8] Breakeven Cost for Residential Photovoltaics in the United States: Key Drivers and Sensitivities, NREL/PR-6A2-47248, December 2009, http://www.nrel.gov/docs/fy10osti/47248.pdf

[9] http://www.eia.doe.gov/state/state_energy_profiles.cfm?sid=FL

[10] Site shows difference between residential, commercial, and industrial scale costs: http://www.solarbuzz.com/SolarIndices.htm

persons), with its citizens residing primarily along its long coastline. The interior of the state, however, is primarily zoned agriculture with significant land area available for utility-scale PV installations. As an example, FPL began operation of the largest U.S. PV facility in 2009 (25 MW, DeSoto Next Generation Solar Energy Center). Furthermore, the large front-end installation costs are not borne by the utility, but rather spread over time to the rate payer.

Although residential installation and commercial costs are more expensive than that for utility scale (up to double the cost), there is also motivation for the State to add distributed PV generation. In particular, a more distributed model would better mitigate risk, for example due to natural disasters such as hurricanes. A distributed generation model as compared to a utility scale one also reduces transmission and distribution costs as well as system losses[11]. Rooftop PV also reduces heat gain into buildings, which reduces cooling costs. Rooftop PV also minimizes environmental impact through more efficient land use. According to the Florida Public Service Commission, Florida had only ~13MW of installed residential PV capacity at the end of 2009. The optimal distribution between utility, commercial, and residential installation, however, depends upon the relative importance of the various factors.

PV generation and load demand, however, are intermittent and conventional generation capacity must match the power needs. Thus at significant penetration[12] of energy in the State will benefit from storage integration. This need is compounded by the fact the Florida has no elevation variation for pumped hydroelectric storage or suitable geology for compressed air storage. As a 500 mile long peninsula, Florida is further limited in its potential to buy and transmit electricity from neighboring regions. These storage/trading limitations can be partially addressed through optimal distribution of PV generation sites and demand side management approaches.

The State has invested heavily in the preparation of a qualified workforce, including its community college and university systems. As testimony, Florida was ranked number one in the nation in 2010 for its workforce by CNBC in a study of all 50 states that examines 10 different categories, including workforce, to measure each state's ability to attract businesses[13]. Current opportunities include the imminent availability of ~6500 NASA employees with a skill set well suited to PV manufacturing.

Strategies to Establish PV Industry in Florida

Create significant demand for PV in the State

a. Authorization of utilities with rate increase to recover costs
b. Promote residential PV installation through programs that support up-front cost
    i. Property Assessed Clean Energy (PACE) Financing

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[11] Caamaño-Martín, E., Laukamp, H., Jantsch, M., Erge, T., Thornycroft, J., Moor, H. D., et al.. Interaction between photovoltaic distributed generation and electricity networks. Progress in Photovoltaics: Research and Applications, 16(7), 629–643 (2008).

[12] The critical penetration level is not known as it depends on many factors including specific distribution of sites and utility systems.

[13] http://www.cnbc.com/id/37516706

        1. Benefits: allows access to PV by more consumers, transfer of lien reduces risk to homeowner, couples with energy efficiency investment to give better ROI, produces scale attractive to financial market, easy to measure effectiveness.
        2. Challenges: Savings to investment ratio must >1 and depends on several factors, ensuring full transfer of value upon sale, impact when mortgage occurs. The program is now in jeopardy as Fanny Mae and Freddy Mac have demanded 1st position on defaulted loan.
    ii. Solar Lease Program
        1. Benefits: allows access to PV by more consumers, economies of scale offered by leaser, potential increase in use of tax benefits, rebates, RECs
        2. Challenges: new owner assumes payment upon sale, pay for system not power generated, better investment is owner owned
    iii. Residential Power Purchase Agreement
        1. Benefits: allows access to PV by more consumers, economies of scale offered by leaser, potential increase in use of tax benefits, rebates, RECs, pay only for power generated
        2. Challenges: new owner assumes payment upon sale, better investment is owner owned
    iv. Solar Rebate Program
        1. Benefits: allows access to PV by more consumers
        2. Challenges: pay for part of system not power generated, may be resistance in Florida due to experience with previous program of not fully funding rebates.
c. Promote PV installation through programs that increase rate of return
    i. Feed-in-Tariff Programs
        1. Benefits: Target PV, encourage distributed deployment, simple to administrate (pay for generated electricity), pay only for power generated
        2. Challenges: A subsidy that imposes a higher cost consumers, uncertainties in rate setting
    ii. Renewable Energy Certificates
        1. Benefits: Tangible asset that can be sold to entities that need to meet renewable energy generation standards.
        2. Challenges: Program not limited to solar PV, although ‘carve-outs’ for solar are possible. Program requires administration and regulation.

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