Solar Accounting: Measuring the Costs and Benefits of Going Solar

As public awareness and concern over energy price volatility, national energy security, and the environmental consequences associated with conventional forms of electricity generation continue to grow, so too will the need for citizens, business and industry leaders, and governmental entities to make the switch to bountiful, domestic clean energy. Counties and municipalities in the U.S. are no exception. The large number of buildings and other electricity-consuming properties controlled by local governments makes the cost of powering these facilities a significant expenditure for local governments.[1] By adopting renewable energy sources like solar, local governments can lock in stable electric rates for several decades into the future and reduce emissions that jeopardize public health and environmental quality. Furthermore, installing a solar energy system on municipal or county property can demonstrate local government leadership in pursuing a clean energy future.

Installing solar energy systems on municipal or county property can also deliver long-term cost savings for a local government. Whether a particular solar energy system will hold a positive or negative net value for a local government, along with the magnitude of this value, is subject to a number of cost and benefit factors. This short paper is designed to inform local government budget and finance officers and analysts on the factors influencing a solar energy system's economic viability and outlines the various costs and benefits associated with going solar (and how they may be properly estimated). Finally, this paper explores the different ways in which these costs and benefits may be compared in order to determine whether solar energy will be an attractive investment for a local government.

The Costs of Going Solar

The costs associated with investing in solar energy largely depend on which system ownership model the local government chooses to pursue. This section outlines the costs associated with both direct system ownership and ownership by a third party. The financial benefits of going solar are covered in the following section.

Direct Ownership

Until just a few years ago, direct ownership was the sole means by which local governments (as well as consumers and businesses) adopted solar energy. Under this ownership model, the system host is also the system owner, covering all the up-front costs associated with installing a solar energy system, and laying claim to all the clean electricity and environmental benefits these systems deliver. As of the first quarter of 2012, the average weighted installed cost of solar for a non-residential, non-utility solar energy system was $4.63/watt.[2] However, this number represents much more than the purchase price of the components of a solar energy system. A breakdown of the various costs contributing to the final price tag of a solar energy system (as well as some incentives that can serve to bring these costs down) are listed on the following pages.[i]

[i] **NOTE:** All financial and technical figures cited in this brief are averages or estimates obtained from recent market research and are included only to provide "rule-of-thumb" guidance. Figures used in actual cost-benefit analyses should be based on quotes received from respondents during the RFP process and/or on other figures that more accurately reflect your local government's unique circumstances.

- Equipment costs are those associated with purchasing the hardware necessary for installing a solar energy system. For a rooftop photovoltaic (PV) system, hardware components include the PV modules, solar power inverters, mounting and racking hardware, meters, disconnect devices, and system wiring.[3, 4]
- Non-hardware costs make up just over half the total installed cost of a solar energy system.[5] Most of these non-hardware costs come from installation labor and hardware profit. The remainder of these costs (approximately one-fourth of total installed costs) are "soft costs", which include the cost of:
    - *Obtaining Permits* – Installing a solar energy system often requires obtaining a number of approvals, including building and electrical permits. Completing the paperwork and compiling the documents required to obtain these permits can be time consuming (and therefore expensive) and permitting fees can sometimes add significantly to the cost of a solar energy system. It is common practice for local governments to require installers to bear the responsibility for obtaining all necessary permits.[ii]
    - *System Inspections* – Once permits for the system are obtained and installation is completed, systems must be inspected and approved by a permitting official, who ensures the system was installed according to the requirements of local codes.
    - *Securing Interconnection Approvals* – Before a solar energy system can be connected to the electric grid, the project must be reviewed by the local utility to ensure the solar energy system will have no negative impacts on the grid. Obtaining these approvals can require collecting and submitting copies of system diagrams, proof that the property on which the system is installed is adequately insured, and copies of signed building permits.[iii] As with the permitting process, securing interconnection approval can be costly in terms of the time it takes to collect and submit the required documents, and may involve processing fees. Applying for and executing an interconnection agreement with the local utility should be the responsibility of the contractor installing the system.

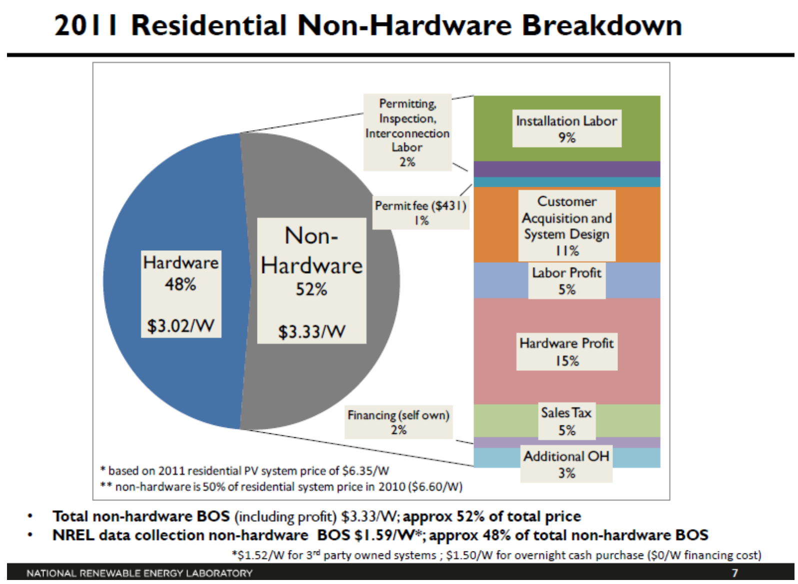

Figure 1: Non-Hardware Costs of Going Solar
Source: Ardani, K., (2012) National Renewable Energy Laboratory

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[ii] To make this an easier and less costly process for solar contractors operating in the community, local governments should consider standardizing and streamlining their permitting processes. For the latest best practices on improving the local permitting process, please see the Interstate Renewable Energy Council's report entitled *Sharing Success: Emerging Approaches to Efficient Rooftop Solar Permitting*, available at www.irecusa.org/wp-content/uploads/Sharing-Success-final-version.pdf

[iii] A sample interconnection agreement application is available through PG&E, online at www.pge.com/includes/docs/pdfs/shared/newgenerator/netenergymetering/form79-1101_interconnection30kw.pdf

- *Project Financing* – Covering the cost of capital needed to finance a solar installation should also be included in a local government's calculation of total installed costs. A common means for a local government to finance the purchase and installation of a solar energy system is for it to leverage its bond issuing authority. Solar installations are typically financed by a local government through either voter-approved *general obligation bonds*, the principal and interest on which are typically repaid through future tax revenues, or by borrowing via *revenue bonds*, which rely on project revenues or savings generated through avoided energy costs to repay bondholders.[iv] In addition to these bonds, local governments can finance solar energy systems through the use of *Qualified Energy Conservation Bonds (QECBs)*, a type of tax credit bond in which bondholders receive federal tax credits instead of interest on their investment, allowing these bonds to be issued at a low effective interest rate.[v] Finally, some states or local governments have set up revolving loan funds or grants to capitalize energy improvements on government property. Find out what loan programs might be available for local governments in your state at www.dsireusa.org/solar.
- *Customer Acquisition and System Design* – Obtaining and following up on customer leads, providing customers with price quotes, and producing the designs and technical documents that illustrate the details of the systems these customers will ultimately receive, are all costs that are borne by a solar installation contractor that are recouped through final installed costs.
- *Covering Installer Overhead* – Additionally, contractors cover the fixed and variable costs of operating their business through the final prices offered to customers.
- *Sales Taxes* – Sales taxes constitute, on average, approximately 5% of the total installed cost of a solar energy system. Recognizing that these taxes represent a notable portion of installed costs, many states have taken action to overcome this additional cost burden by exempting the purchase of solar energy equipment from state sales taxes. Currently, 22 states and Puerto Rico offer state sales tax incentives for solar energy equipment, and two states (New York and Colorado) give local governments the ability to exempt these purchases from local sales taxes as well. Sales taxes will likely not figure into a local government's calculation of total costs, as these entities are eligible for exclusion from them.

Again, some of these costs may not apply to a local government's procurement of a solar energy system, but are included here in the interest of creating a complete picture of the costs of direct system ownership. The actual amounts of hardware, labor, and applicable soft costs will be dictated by the nature of the proposals received during the RFP process.[vi] In addition to installed costs, direct ownership of a solar energy system involves relatively small, though not insignificant, operations and maintenance (O&M) costs. This includes the cost of panel maintenance, managing encroaching vegetation or wildlife, servicing and inspection of hardware and monitoring systems, along with inverter replacement, over the system's useful life (estimated to be between 25 and 40 years). According to the Electric Power Research Institute, these annual O&M costs can range from between \$6 and \$27 per kilowatt.[6]

[iv] More information on state and local government bonds, along with a general outline of the bond issuing process, can be found in the report published by the National Renewable Energy Laboratory (NREL) entitled *Solar Photovoltaic Financing: Deployment on Public Property by State and Local Governments* at www.nrel.gov/docs/fy08osti/43115.pdf

[v] More information on QECBs can be found online at www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US51F&re=1&ee=1

[vi] For tips on improving the quantity and quality of responses received to RFPs for solar energy systems, please see The Solar Foundation's issue brief entitled "Steps to a Successful Solar RFP", available online at www.thesolarfoundation.org/education/sunshot-solar-outreach-partnership

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The need to acquire and maintain supplemental *insurance* – in the form of general liability (protecting against damage to third-party property or personal injury or death), property risk (protecting the system itself against loss or damage), or other forms of insurance – can add another layer of costs to a solar energy project.[7] Though local governments typically self-insure systems they own, some utilities may require supplemental insurance.[8] Therefore, the annual premiums for this additional insurance coverage (if any) will vary by jurisdiction, but are typically between 0.25% and 0.5% of total installed costs.[9] Learn more about additional insurance requirements at www.irecusa.org/irec-programs/connecting-to-the-grid/interconnection.

In some states, local government can take advantage of incentive programs that help reduce the overall cost of going solar. As of May 2012, 22 states, along with the District of Columbia, Puerto Rico, and the U.S. Virgin Islands provide direct cash incentives for solar. In addition, utilities within most states operate their own incentive programs.[10]
These incentives, such as cash rebates and grants, are tailored to promote the use of solar energy in one or more sectors (e.g., residential, commercial, industrial, etc.). In many cases, local governments are eligible for these incentives as well. You can determine whether rebates, grants, loans or other financial incentives exist in your state or through your electric utility, and whether your local government qualifies for these incentives, by visiting the Database of Incentives for Renewables and Efficiency (DSIRE) at www.dsireusa.org/solar and selecting your state on the map.

Third-Party Ownership

The mid- to late- 2000's witnessed the rise of an important alternative to the direct ownership of solar energy systems. Under a third-party ownership arrangement, a local government (or private sector customer) serves as the host for, but does not own, the solar energy system installed by the contractor. A *power purchase agreement (PPA)* is a popular way of structuring third-party ownership agreements. Under a PPA, the contractor entering into the agreement assumes responsibility for the costs of installing, operating, and maintaining the system. In exchange, the host (in this case the local government) provides the owner with a down payment and agrees to purchase the electricity generated by the system through a long-term contract, often at a rate that is lower than that paid to the utility for electricity derived from traditional sources.[11] These PPA rates can remain *fixed* over the term of the agreement, or can include *price escalators* that increase the price paid for the electricity delivered at a predetermined rate (typically between 2-5% per year).[12] In states that do not allow PPAs, third-party ownership arrangements can be structured as a *solar lease*, which can be very similar to a PPA, but involve making regular lease payments rather than purchasing the electricity the system generates.

There are many benefits and drawbacks to third-party ownership models, and though it is important to consider these carefully before deciding to enter into one of these agreements, most of these are outside the scope of this paper.[vii] However, two of the advantages of third-party ownership are important from a cost-benefit analysis standpoint. First, distilling the numerous installation and O&M costs down to a simple electric rate (in dollars per kilowatt hour) or lease payment can make calculating the cost side of the equation much easier. Second, and more importantly, because the installer (a taxable entity) retains ownership of the system under these agreements, he or she will qualify for the

[vii] For a discussion of the advantages and disadvantages of PPAs, see the NREL report entitled *Solar Photovoltaic Financing: Deployment on Public Property by State and Local Governments*, available at www.nrel.gov/docs/fy08osti/43115.pdf; a similar discussion on the pros and cons of solar leases can be found in the NREL report, *Solar PV Project Financing: Regulatory and Legislative Challenges for Third-Party PPA System Owners*, available at www.nrel.gov/docs/fy10osti/46723.pdf

30% Federal Investment Tax Credit (ITC) and for the Modified Accelerated Cost-Recovery System (MACRS)[viii], two key federal benefits that help to significantly reduce the installed cost of solar, but have traditionally been unavailable to local governments. The installer that claims these benefits can pass along the savings to the local government host.

Table 1: Summary of the Costs of Going Solar: Direct v. Third-Party Ownership

Direct Ownership	***Third-Party Ownership***
(+) Installed Costs	***Power Purchase Agreements***
Hardware	**(+) PPA Down Payment**
Non-Hardware	**(+) PPA Rate**[ix]
Labor and Profit	*Fixed Price?*
Soft Costs	*Price Escalator?*
(+) Operations and Maintenance Costs	
System Cleaning, Monitoring, and Servicing	***Solar Leases***
Inverter Replacement	**(+) Solar Lease Down Payment**
Insurance	**(+) Solar Lease Payments**
(-) Incentives for Solar Energy	

The Benefits of Going Solar

From a local government's perspective, the long term energy cost savings delivered by solar energy systems provide the most obvious benefit of going solar. However, policies exist in many states that help ensure system owners benefit from all the electricity their systems produce (i.e., that owners still benefit from the electricity they do not immediately consume) and that monetize the environmental attributes of solar energy, helping make solar a more economically sound investment.

Avoided Energy Consumption Costs

When used, the electricity generated by a solar energy system offsets the consumption of electricity provided by the local utility. By foregoing the use of this electricity, solar customers avoid paying retail rates for the generation and delivery of, and any other incidental costs associated with, electricity obtained from a utility. However, the use of solar electricity only allows a customer to avoid those costs based on the number of kilowatt-hours (kWh) consumed; fixed costs and demand charges[x] (a charge associated with the highest peak demand in a billing period) will likely be unaffected by any avoided electricity consumption.[13]

[viii] More information is available through the DSIRE website on the ITC www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=1 and MACRS www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F&re=1&ee=1

[ix] PPA rates often already account for all available incentives, and sometimes also include some of the monetized benefits of going solar (e.g., proceeds from the sale of Solar Renewable Energy Credits). Local governments should review the PPA carefully and note how ownership of these benefits are assigned.

[x] For a clear and concise discussion on why demand charges are typically unaffected by solar electricity, see Section 4 of NREL Technical Report NREL/TP-6A2-43537, *Rate Analysis of Two Photovoltaic Systems in San Diego*, available at www.nrel.gov/analysis/pdfs/43537.pdf

Because the amount of utility-sourced electricity offset by solar depends on how much electricity the solar system produces, the first step in calculating avoided electricity costs is to estimate the amount of electricity generated by a solar energy system. A simple estimate of annual electricity output can be calculated by finding the product of two figures: the solar energy system's *capacity rating* and the number of *peak sun hours* received at a location.

- *Capacity Rating* is a measure of the size of a solar energy system, typically measured in watts (W) or kilowatts (kW). The higher a system's capacity rating, the more electricity it can produce. To accurately estimate a system's output, it is important to recognize the distinction between direct current (DC) and alternating current (AC) ratings. The capacity rating listed on a solar panel is its *DC rating* - a measure of the amount of direct current electricity the system produces under "standard test conditions". However, before this electricity can be used to power buildings and appliances, it must be converted into alternating current. This conversion process is not 100% efficient, resulting in the loss of some of this electricity. These total losses are measured by a *derate factor*, the final product of all the factors that affect a system's conversion efficiency.[14] Multiplying a system's DC rating by the derate factor will yield the *AC rating*; it is this capacity rating that should be used in system output calculations.
- *Peak Sun Hours* is a measure of the number of hours per day that solar irradiance (the amount of solar radiation falling on a particular area) is at its maximum (i.e., 1,000 W/m^2).[15] This measure effectively compresses the solar irradiance available throughout the day into a number of hours of maximum sunlight. Calculating peak sun hours is simple: determine the solar irradiance of the location a solar energy system will be installed,[xi] and divide this figure by the peak sun estimate of 1000 W/m^2. For example, the National Renewable Energy Laboratory's (NREL) "PV Watts Viewer" (see footnote below) indicates that Springfield, Massachusetts receives an average of 4.23 kilowatt-hours (kWh) of solar radiation per square meter (m^2) per day. Because one kilowatt-hour is equal to one thousand watt-hours, we can write this as 4,230 Wh/m^2/day. Dividing this figure by our peak sun estimate of 1,000 W/m^2 yields 4.23 peak sun hours per day.

Once a system's *AC rating* and the *peak sun hours* for the site on which the system will be installed have been determined, annual energy output can be estimated. Using the Massachusetts example above, the annual energy output for a 5 kW (DC rating) system with a derate factor of 0.77 can be estimated as:

$$\underbrace{\underset{\text{DC Rating}}{5\text{ kW}} \times \underset{\text{Derate Factor}}{0.77}}_{\text{AC Rating}} \times \underset{\text{Peak Sun Hours (per day)}}{4.23} \times \underset{\text{Days in a Year}}{365} = \underset{\text{Annual Energy Output}}{5{,}944\text{ kWh/year}}$$

It should be understood that this method only provides a rough estimate of a solar energy system's output. More sophisticated estimates can be obtained by visiting NREL's "PV Watts Calculator", available at rredc.nrel.gov/solar/calculators/PVWATTS/version1/, or from installers during the RFP process.

[xi] Solar irradiance for your location can be estimated by visiting the National Renewable Energy Laboratory's "PV Watts Viewer", available at mapserve3.nrel.gov/PVWatts_Viewer/index.html

Once an electricity output estimate has been obtained, annual avoided electricity costs can be calculated. Again, to determine these energy savings, a local government should apply the total electricity produced by the solar energy system to utility costs that are based on the number of kilowatt-hours consumed. Figure 2 below illustrates some service and supply charges for electricity delivered by a utility serving western Massachusetts. The charges highlighted in blue are those that are based on the amount of electricity consumed every billing period, and are those that should be included in a local government's estimate of avoided electricity costs. The charges in orange, however, are the fixed costs and demand charges that are not likely to be reduced through the use of solar electricity.

While calculating annual cost savings for the first year is as simple as the process outlined above, determining the value of avoided energy costs for subsequent years is slightly more complicated and involves consideration of two additional elements. The first of these is a solar energy system's *degradation factor*. As time goes on, the efficiency with which PV systems convert sunlight into electricity diminishes by between 0.5-1.0 percent each year.[16] Production in years after the first should be adjusted by this factor. The second issue that must be considered in producing the most accurate solar cost-benefit analysis possible is *projected growth in electricity prices*. In its "Annual Energy Outlook 2012", the U.S. Energy Information Administration (EIA) projects that electricity prices across all sectors will grow at an annual rate of 2 percent.[17]

Delivery Services Detail	Rate	Charge
Customer Charge		$30.00
Distribution Demand Charge	4.00KW x $10.220000	$40.88
Distribution Energy Charge	1500.00KWH x $0.001780	$2.67
Transmission Energy Charge	1500.00KWH x $0.006310	$9.47
Transmission Demand Charge	4.00KW x $4.020000	$16.08
Net Metering Recovery Surcharge	1500.00KWH x $0.000070	$0.11
Solar Program Cost Adjustment	1500.00KWH x $0.000320	$0.48
Electricity Supply Detail	**Rate**	**Charge**
Generation Service Charge	1500.00KWH x $0.082380	$123.57

Figure 2: Some Typical Electricity Charges
Adapted from a sample bill from Western Massachusetts Electric (www.wmeco.com)

A Note on Net Metering and the Value of Net Excess Generation

Net metering policies and related equipment provide solar energy system owners the means to feed unused solar electricity back into the grid. By installing meters that run in the opposite direction when electricity is exported to the grid, customers will only be billed by the utility for the *net* electricity they consume. In some cases, however, solar energy systems produce more electricity than system owners can use in a single billing period. Though details vary across the 43 states that have adopted net metering policies,[18] in general, this *net excess generation* is stored as credits that (in many of these states) can be used to offset consumption in a later billing period (either within the same 12-month period or indefinitely), with any credits remaining after this "roll-over" cycle purchased by the utility at its retail, avoided-cost, or other rates.[19] Payments made at avoided cost rates or at another rate less than the retail rate can reduce the monetary value of some of the electricity generated by a solar energy system. Unless your local government has a strong reason to believe it will have credits remaining at the end of a roll-over period, it may not be necessary or even practical to estimate the portion of the electricity generated by your system that should be valued at your state's unused net excess generation rate.

Again, there is still considerable variation between net metering policies and, in some states, these policies aren't as beneficial to customers as the process outlined above. You can learn more about your state's net metering policy by

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visiting the Database of Incentives for Renewables and Efficiency at www.dsireusa.org/solar, and see how your state ranks in terms of the quality of these policies by viewing the "Freeing the Grid" report at www.newenergychoices.org/uploads/FreeingTheGrid2011.pdf

Solar Renewable Energy Credits

A Renewable Portfolio Standard (RPS) is a policy enacted at the state level that mandates a certain percentage of a utility's electricity sales be obtained from renewable sources by a certain date. Sixteen of these states go one step further, requiring that a percentage of this electricity come from distributed solar resources (known as a "carve-out" or "set-aside") or apply a multiplier to the electricity generated by these systems for purposes of satisfying the RPS.[20] Seven of these solar carve-out states, along with the District of Columbia, allow for in-state markets for the creation, sale, and purchase of Solar Renewable Energy Credits (SRECs). Some other states with solar carve-outs, but still lacking robust SREC markets, are able to generate credits and sell them into markets in other states.[21]

An SREC represents the environmental benefits of generating one megawatt-hour (MWh; equal to 1,000 kWh) of solar electricity, allowing for these benefits to be monetized. In states where SRECs can be generated and sold by a local government owning a solar energy system, these credits can significantly affect the economics of going solar. Figure 3 below shows the price for Massachusetts SRECs sold at auction in August 2012. At this price, the 5kW system from our earlier example will bring in over $1,200 in additional revenue in the project's first year. Those seeking to use SRECs to further offset the costs of going solar are cautioned that SREC prices can vary greatly between states, over time, and depending on the type of SREC sale in question.[xii]

Additionally, third-party ownership arrangements will typically assign the system owner (rather than the local government) the rights to the SRECs produced by a solar energy system.[22] Thus, the PPA rates or monthly lease payments made under these agreements will often already reflect the value of SRECs, as well as other incentives for which system owners are eligible.

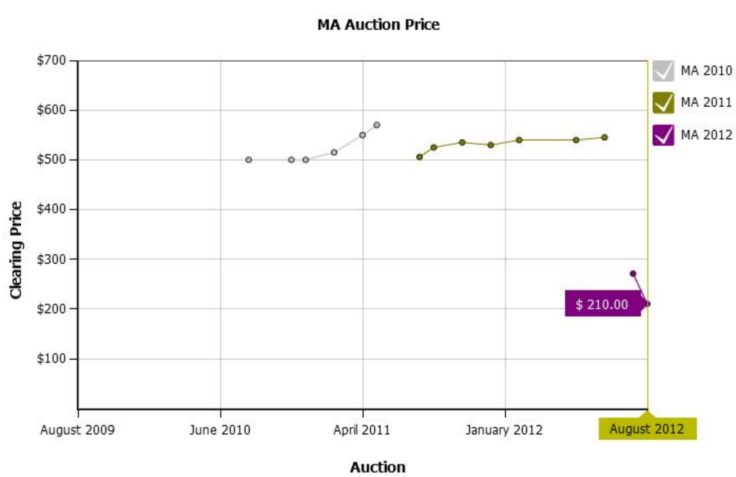

Figure 3: Auction Prices for Massachusetts SRECs, August 2012
Source: SRECTrade (www.srectrade.com)

Table 2: Summary of the Benefits of Going Solar

Direct Ownership	***Third-Party Ownership***
(+) Avoided Energy Costs	**(+) Avoided Energy Costs**
(+) Value of Net Excess Generation	**(+) Value of Net Excess Generation**
(+) Value of SRECs (where available)	

[xii] Learn more about SRECs and how they are priced and sold at www.srectrade.com or at www.flettexchange.com

Measuring the Value of Going Solar

Net Present Value Analysis

Once each of the costs and benefits discussed in the previous sections have been determined for the project proposed for your local government, the net present value (the difference between the future value of benefits and costs) of the 5 kW project in Massachusetts described above can be estimated as shown in the tables below. In general, projects with a positive net present value (i.e., those that provide a net benefit) are deemed worthwhile investments. Assumptions and additional explanations of each of these costs and benefits follow on the next page.

Table 3: Net Present Value Analysis - Direct Ownership Project; Springfield, Massachusetts

	Costs					***Benefits***			
Year	**Installed Costs**	**O&M Costs**	**Insurance**	**Total Costs**	**Present Value of Costs**	**Avoided Electricity Costs**	**SREC Revenue**	**Total Benefits**	**Present Value of Benefits**
1	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,631.73)	$540.07	$1,248.24	$1,788.31	$1,788.31
2	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,524.98)	$545.36	$1,235.76	$1,781.12	$1,664.60
3	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,425.22)	$550.65	$1,223.28	$1,773.93	$1,549.42
4	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,331.98)	$555.93	$1,210.79	$1,766.73	$1,442.18
5	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,244.84)	$561.21	$1,198.31	$1,759.52	$1,342.33
6	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,163.40)	$566.47	$1,185.83	$1,752.30	$1,249.36
7	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,087.29)	$571.72	$1,173.35	$1,745.06	$1,162.81
8	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($1,016.16)	$576.95	$1,160.86	$1,737.81	$1,082.22
9	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($949.68)	$582.16	$1,148.38	$1,730.54	$1,007.19
10	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($887.55)	$587.35	$1,135.90	$1,723.25	$937.33
11	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($829.49)	$592.51	$1,123.42	$1,715.93	$872.29
12	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($775.22)	$597.65	$1,110.93	$1,708.58	$811.73
13	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($724.51)	$602.75	$1,098.45	$1,701.20	$755.35
14	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($677.11)	$607.82	$1,085.97	$1,693.79	$702.86
15	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($632.81)	$612.85	$1,073.49	$1,686.33	$653.99
16	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($591.41)	$617.84	$1,061.00	$1,678.84	$608.49
17	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($552.72)	$622.78	$1,048.52	$1,671.30	$566.13
18	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($516.56)	$627.67	$1,036.04	$1,663.71	$526.69
19	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($482.77)	$632.51	$1,023.56	$1,656.07	$489.97
20	($1,392.23)	($135.00)	($104.50)	($1,631.73)	($451.19)	$637.29	$1,011.07	$1,648.37	$455.79
21	$0.00	($135.00)	($104.50)	($239.50)	($61.89)	$642.01	$998.59	$1,640.61	$423.96
22	$0.00	($135.00)	($104.50)	($239.50)	($57.84)	$646.67	$986.11	$1,632.78	$394.34
23	$0.00	($135.00)	($104.50)	($239.50)	($54.06)	$651.25	$973.63	$1,624.88	$366.76
24	$0.00	($135.00)	($104.50)	($239.50)	($50.52)	$655.76	$961.14	$1,616.91	$341.08
25	$0.00	($135.00)	($104.50)	($239.50)	($47.22)	$660.19	$948.66	$1,608.85	$317.18
	($27,844.62)	($3,375.00)	($2,612.50)	($33,832.12)	($18,768.17)	$15,045.42	$27,461.28	$42,506.70	$21,512.35

Net Present Value: $2,744.18

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Assumptions and Explanations for Table 3:

Year – The year in which costs and benefits occur. A 25-year horizon was used, as this figure represents the lower bound of a solar energy system's useful life, and is typically the length of manufacturers' warranties for solar panel power output.

Installed Costs – The values in this field represent the costs of system installation and interest payments. Installed costs were determined for a 5 kW system at the average installed cost rate of $4.63/W. This $23,150 price tag was reduced by $2,250, the maximum rebate amount allowed under the "Commonwealth Solar II Rebate" offered by the state of Massachusetts.[23] The project estimated here is financed through a 20-year municipal bond at an interest rate of 3.25%, with payments occurring at the beginning of each year. Using these parameters, annual bond payment values were determined using the PMT function in Microsoft Excel.

O&M Costs – Annual costs for operations and maintenance were estimated at a rate of $27/kW.

Insurance – Annual premiums for supplemental insurance were estimated as 0.5% of total installed costs.

Total Costs – Represents the sum of installed, O&M, and insurance costs.

Present Value of Costs – Represents the value of the costs occurring in each year, adjusted to reflect a 7% discount rate.[xiii]

Avoided Electricity Costs – Represents the product of annual system electric output (adjusted annually to reflect a 1% decrease in output each year) and a retail electricity rate of $0.09086/kWh (adjusted annually to reflect a 2% increase in retail electricity rates each year). Recall that these avoided costs are a function of the amount of electricity produced by a solar energy system, which in turn depends primarily upon the number of peak sun hours the system receives.

SREC Revenue – Values here are based on the creation of one SREC per MWh, multiplied by an SREC auction price of $210 (the August 2012 auction price for Massachusetts SRECs). It should be noted that SRECs have been prone to price fluctuations over time and between markets. Analysts should be cautioned that future fluctuations can have a significant impact on project economics.

Total Benefits – Represents the sum of avoided electricity costs and SREC revenues.

Present Value of Benefits – Represents the value of the benefits occurring in each year, adjusted to reflect a 7% discount rate.

A similar, though simpler, analysis can be produced to assess the economic benefits of a power purchase agreement or solar lease, in which a third party retains ownership of a solar energy system. The cost side of the equation will consist of either the value of annual lease payments or solar electricity purchased at PPA rates (adjusted each year to reflect any price escalators), along with any down payments. The benefits side will consist of avoided electricity costs, as calculated above. SREC revenue should only be included if ownership of the SRECs is assigned to the local government. Otherwise, the value of SRECs should already be reflected in the lease payment or PPA rate paid to the owner.

Benefit-Cost Ratio

Once a net present value analysis has been conducted, a benefit-cost ratio can be obtained. This metric is exactly what its name implies, and is calculated by dividing the present value of a project's benefits by the present value of its costs. The benefit-cost ratio for the example above is $21,512.35/$18,768.17 = 1.15. This figure can be used to easily make comparisons between different proposed solar projects. The general decision criterion is to select the project with the highest benefit-cost ratio.

[xiii] For more on discount rates and how they can be calculated, please see *Net Present Value Analysis: A Primer for Finance Officers*, available at www.gfoa.org/services/dfl/budget/documents/NetPresentValueAnalysis.pdf

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Simple Payback Period

A payback period is a measure of the number of years it takes for cumulative annual cash flows to equal the cost of the project. As noted at the bottom of Table 3, installed costs for the 5 kW example project totaled $27,844.62. Table 4 below illustrates net cash inflows for each year of the project and tracks cumulative cash inflows. As the table shows, the payback period for this project is between 18 and 19 years.

Table 4: Payback Period Analysis - Direct Ownership Project; Springfield, Massachusetts

	Installed Costs: $27,844.62							
Year	**O&M Costs**	**Insurance**	**Total Annual Outflow**	**Avoided Electricity Costs**	**SREC Revenue**	**Total Annual Inflow**	**Net Cash Inflow**	**Cumulative Cash Inflow**
1	($135.00)	($104.50)	($239.50)	$540.07	$1,248.24	$1,788.31	$1,548.81	$1,548.81
2	($135.00)	($104.50)	($239.50)	$545.36	$1,235.76	$1,781.12	$1,541.62	$3,090.43
3	($135.00)	($104.50)	($239.50)	$550.65	$1,223.28	$1,773.93	$1,534.43	$4,624.86
4	($135.00)	($104.50)	($239.50)	$555.93	$1,210.79	$1,766.72	$1,527.22	$6,152.08
5	($135.00)	($104.50)	($239.50)	$561.21	$1,198.31	$1,759.52	$1,520.02	$7,672.10
6	($135.00)	($104.50)	($239.50)	$566.47	$1,185.83	$1,752.30	$1,512.80	$9,184.90
7	($135.00)	($104.50)	($239.50)	$571.72	$1,173.35	$1,745.07	$1,505.57	$10,690.47
8	($135.00)	($104.50)	($239.50)	$576.95	$1,160.86	$1,737.81	$1,498.31	$12,188.78
9	($135.00)	($104.50)	($239.50)	$582.16	$1,148.38	$1,730.54	$1,491.04	$13,679.82
10	($135.00)	($104.50)	($239.50)	$587.35	$1,135.90	$1,723.25	$1,483.75	$15,163.57
11	($135.00)	($104.50)	($239.50)	$592.51	$1,123.42	$1,715.93	$1,476.43	$16,640.00
12	($135.00)	($104.50)	($239.50)	$597.65	$1,110.93	$1,708.58	$1,469.08	$18,109.08
13	($135.00)	($104.50)	($239.50)	$602.75	$1,098.45	$1,701.20	$1,461.70	$19,570.78
14	($135.00)	($104.50)	($239.50)	$607.82	$1,085.97	$1,693.79	$1,454.29	$21,025.07
15	($135.00)	($104.50)	($239.50)	$612.85	$1,073.49	$1,686.34	$1,446.84	$22,471.91
16	($135.00)	($104.50)	($239.50)	$617.84	$1,061.00	$1,678.84	$1,439.34	$23,911.25
17	($135.00)	($104.50)	($239.50)	$622.78	$1,048.52	$1,671.30	$1,431.80	$25,343.05
18	($135.00)	($104.50)	($239.50)	$627.67	$1,036.04	$1,663.71	$1,424.21	$26,767.26
19	($135.00)	($104.50)	($239.50)	$632.51	$1,023.56	$1,656.07	$1,416.57	$28,183.83
20	($135.00)	($104.50)	($239.50)	$637.29	$1,011.07	$1,648.36	$1,408.86	$29,592.69
21	($135.00)	($104.50)	($239.50)	$642.01	$998.59	$1,640.60	$1,401.10	$30,993.79
22	($135.00)	($104.50)	($239.50)	$646.67	$986.11	$1,632.78	$1,393.28	$32,387.07
23	($135.00)	($104.50)	($239.50)	$651.25	$973.63	$1,624.88	$1,385.38	$33,772.45
24	($135.00)	($104.50)	($239.50)	$655.76	$961.14	$1,616.90	$1,377.40	$35,149.85
25	($135.00)	($104.50)	($239.50)	$660.19	$948.66	$1,608.85	$1,369.35	$36,519.20

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It is important to note, however, that though simple payback periods are relatively easy to calculate and are a commonly cited metric of a solar project's economic viability, this measurement has two significant shortcomings.[24] First, payback periods do not illustrate a project's long term profitability, but focus only on how quickly the project delivers a return on investment. With this measure, a solar project's key benefit – its ability to offset electricity derived from conventional fuels over the entirety of its useful life – will be lost in this overly simplified measure. Using the simple payback period as the primary decision criterion will likely result in the rejection of solar projects with long payback periods, though these projects will deliver significant economic and environmental benefits over the long term. Secondly, simple payback periods do not account for the time value of money (captured through the use of discount rates), and as such will overvalue cash inflows and outflows in later years.

Given these limitations, it is not recommended that the economic viability of solar energy projects be measured by simple payback period alone. A net present value analysis should be the primary means by which these projects are evaluated, with simple payback period used to provide additional information on a local government's investment in solar.

Conclusion

Measuring the value of going solar can be a complex and time consuming undertaking, requiring both the collection of accurate and often unfamiliar information and its evaluation according to specialized methods. However, most local government budget or finance officers will already possess the required methodological know-how to properly assess the value of investing in equipment purchases, infrastructure upgrades, or policies. The above discussions of the costs and benefits particular to investments in *solar energy* are meant to provide these analysts with an understanding of the other half of this process, helping them to make the best and most accurate decisions possible.

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