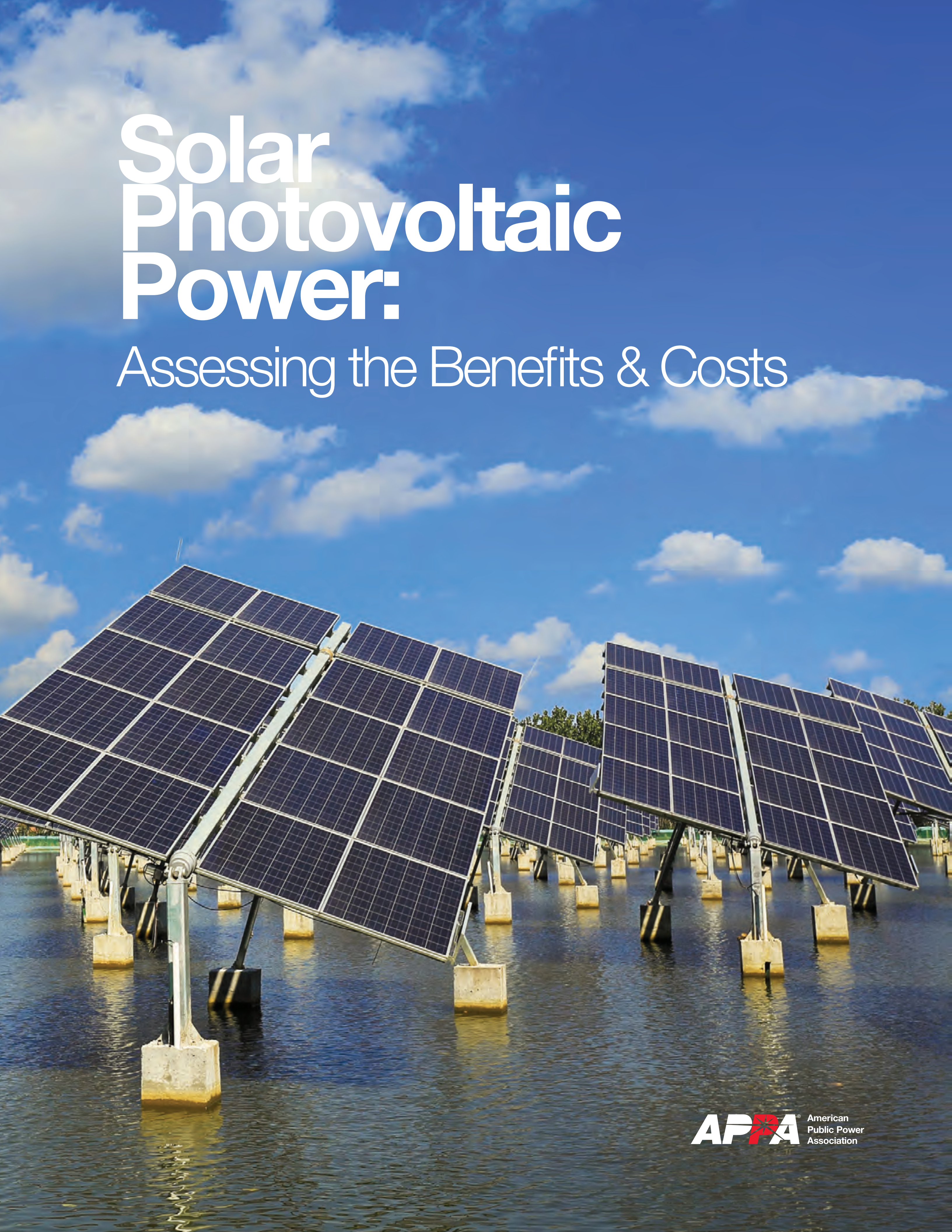
Solar Photovoltaic Power:

Assessing the Benefits & Costs



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I - Introduction

Solar photovoltaic (PV) makes up only a small fraction of the nation's electric generation capacity, but it has grown rapidly over the last several years. According to a report by the Solar Energy Industries Association (SEIA), PV installations in the U.S. grew by 76 percent (3.3 GW) in 2012, after doubling in 2011, bringing the total amount of PV operating in the U.S. as of year-end 2012 to 7.2 GW.

Despite the growth, questions remain about the efficacy of solar PV as a power resource. Issues such as benefit-cost profile, the nature and magnitude of subsidies, impact on electric rates, and the degree of cost shifting among utility customers — all engender considerable debate.

A balanced assessment of solar PV requires an examination of all these components keeping in mind that parochial interests and stakeholder perspectives can affect the measurement and treatment of key variables, and hence the conclusions. Utilities considering solar PV because of mandated net metering programs, renewable portfolio standard requirements, customer interest, or integrated resource plan considerations, might find it difficult to reconcile conflicting benefit-cost claims.

This paper uses simple analytical models to highlight the key dynamics underpinning solar PV. The intent is not to offer a final assessment on the merits of solar PV as a power resource, but rather to present an analytical framework that may help decision makers assess the benefits and costs, and manage the trade-offs inherent in the use of this technology.

II – Basic Framework

Conceptually, the fundamental question of whether solar PV makes economic sense as a power resource can be addressed with a basic economic benefit-cost (B/C) analysis, in which the levelized cost of electricity produced with a PV system is compared to the levelized value of its output. There are numerous ways to think about project economics, but one common approach is to derive a B/C ratio with the net present value (NPV) of project benefits in the numerator and the NPV of project costs in the denominator.

$$\text{B/C Ratio} = \frac{\text{Net present value of project benefits}}{\text{Net present value of project costs}}$$

B/C ratio>1 means the project is economic, as benefits exceed costs.
B/C ratio<1 means the project is uneconomic, as costs exceed benefits.

The relative cost-effectiveness of projects can be assessed by comparing their benefit-cost ratios — the higher the B/C ratio, the greater "bang for the buck."

Although the conceptual framework is simple, there is no single, standard modeling approach that would be accepted by all for this purpose. The results and conclusions can differ depending on how the analysis is conducted. There are at least three key elements of the modeling that will crucially affect the results:

(1) Structure of the benefit-cost ratio in terms of the variables included and how they are arranged
(2) Values assigned to the variables
(3) Perspective from which the analysis is conducted (and how cash flows rebound to stakeholders)

Similar to energy efficiency and some other types of utility projects, the economics of solar PV can be viewed from at least three broad perspectives — of solar customers, non-solar customers, and society as a whole. The benefit-cost assessment can differ across the stakeholder groups because the specific terms included in the respective benefit-cost equations vary across the groups. As discussed below, there are a number of reasons for this, but one factor is the presence of subsidies, and/or cost shifting among customers.

III - Subsidies and Cost Shifting

Many solar projects benefit from various types of "societal" subsidies. These include federal and state tax credits, grants, renewable energy credits, local property tax relief and more. In addition, solar net metering projects can benefit from de facto subsidization in the form of cross-customer cost shifting. Larger scale, utility-owned projects are effectively subsidized by all customers, through higher utility rates, whenever project costs exceed the economic value of the output. Currently, these subsidies are crucial for the development of solar PV.

The purpose of this paper is not to challenge the policy initiatives behind the subsidies, or to suggest that the solar PV is the only category of energy resource that enjoys subsidies or gives rise to cost shifting. The purpose is simply to show that subsidies exist for solar PV, and to understand how they might affect the B/C analysis. As seen in the illustrative benefit-cost analysis presented in the next section, the impact of the "societal" subsidies is generally straightforward, simply offsetting certain costs incurred by those who receive them. However, the subsidization that results from cross-customer cost shifting and higher electric rates deserves more explanation.

Cost-shifting issues are particularly pronounced with net metered projects where subsidization arises because the solar output displaces utility production and sales. In a given time frame, the electric output from the PV system will be less than, equal to, or greater than the host customer's electric load (usage). When the output is less than or equal to the customer's usage, utility sales drop, causing both revenues and costs to decline. But, whenever volumetric electric rates exceed unitized avoided costs, revenues fall by more than costs and the utility faces a net revenue loss unless it makes up the shortfall by raising rates and shifting costs to its non-solar customers .

When customer output is less than or equal to customer usage

Decline in utility revenue = Project output x Volumetric rate per unit ($/kWh or $kW)
Decline in utility cost = Project output x Marginal cost per unit ($/kWh or $/kW)
Decline in net revenue = Project output x (Rate – unitized marginal cost)

If the output from a net energy metering (NEM) system exceeds the customer's usage, he or she can "sell" the excess power to the utility. The NEM payments are often based on the utility's volumetric rates, but they might also be based on average rates, or determined on some other basis such as the estimated "value" of the output. Rather than actual sales transactions, this typically involves crediting NEM production from a given period against customer usage in another period, but the utility is, in effect, purchasing the net output of the project. The incremental costs of this purchase will be offset to some degree because the utility avoids the costs of procuring the output from a different source. If the NEM payments exceed avoided costs, the utility's total net cost will rise and the non-solar customers will end up subsidizing the project because higher total costs translate into higher electric rates.

When customer output is greater than customer usage

Increase in utility cost = Net output x Net metering payment per unit
Avoided utility cost = Net output x Marginal cost per unit
Net increase in utility cost = Net output x (Payment – avoided cost)

In this model, the basic dynamic -- non-solar customers subsidize the solar customers whenever the volumetric electric rate, or NEM payment, exceeds the unitized, avoided cost -- holds both when solar production is below the customer's usage and the customer simply avoids the volumetric charge, and, when production exceeds usage, allowing the customer to sell the excess.

One should expect volumetric charges to exceed avoided costs in many net metering arrangements because volumetric rates are often used to recover not only marginal energy and generation capacity costs, but also, transmission, distribution, and other embedded costs of providing retail electric service, while the costs avoided through NEM projects usually include marginal energy and generation capacity, perhaps some transmission, but very little, if any, distribution or other fixed costs. Net metering customers continue to rely on the utility's distribution system to meet their needs when the solar panels are not producing, when usage exceeds output and when selling excess power to the grid. So, for the most part, distribution costs are not avoided through solar net metering projects and solar customers are simply not carrying their corresponding share of distribution and other embedded costs when they avoid, or are paid, volumetric rates designed to recover those costs.

Two factors affect the change in rates paid by the non-solar customers on account of solar NEM programs - reduction in utility sales and the relationship between the NEM payments and the actual costs avoided by the utility as a result of the NEM production. For a utility,

Average rate = Total Cost
kWh Sales

NEM programs will affect both components, and hence average rates, in different ways depending on the scale and structure of the program.

To illustrate, consider a hypothetical utility with an initial year peak load of 500 MW and sales of 3 million MWh per year, assumed to grow at 0.5% per year over a 20-year period. The total cost of service in the first year is assumed to be $360 million, which yields an average retail rate in the first year of $.12/kWh. The total retail rate contains a variable component of $.07/kWh and a fixed component of $.05/kWh, both of which escalate at an assumed 2.5% annual inflation rate. The variable component reflects all the costs avoided by the utility as a result of the NEM production, and the fixed component contains all remaining costs, including distribution system costs not avoided through NEM production. Given these assumptions the 20-year levelized rate for the base case is $.144/kWh.

TABLE 1

20-Year Leveled Rate Impacts, Percent Change

	NEM Payment $/Kwh	NEM Payment $/Kwh	NEM Payment $/Kwh	NEM Payment $/Kwh
NEM as % of Load	$0.120	$0.150	$0.090	$0.070
5.00%	1.95%	1.55%1	1.03%	0.00%
10.00%	3.90%	3.11%	2.06%	0.00%
15.00%	5.85%	4.66%	3.09%	0.00%
20.00%	7.80%	6.22%	4.13%	0.00%

Table 1 shows rate impacts on the utility's non-solar customers for different levels of NEM production and payments. We start by deriving a base 20-year levelized rate assuming no NEM programs. Then, NEM programs of different scales and costs are introduced and the associated levelized rates are calculated and compared to the base rate. The rate impacts are expressed in terms of percentage change in levelized rates relative to no NEM, base case.

In Table 1, the rows designate project scale and the columns indicate the level of NEM payments. Each entry shows the percent change to the 20-year levelized rate for the indicated combination of scale and NEM payment. For example, the first entry of 1.95% shows that if the NEM project is 5% of load and the volumetric payment equals the levelized total rate of $.12/kWh, the rates to non-solar customers will rise by 1.95% as a result of the NEM project. Reading across the first row, one can see that as the NEM payment declines toward the variable component of the rate, the rate impact is smaller. Reading down the first column, one can see that for the given NEM payment, the rate impact increases as the project scale increases. The rate impacts in the last column are all zero because the NEM payment of $.07/kWh is equal to the assumed value for avoided cost.

Table 1 not only shows how NEM programs can affect rates paid by non-solar customers, but it also demonstrates that rate design can be an effective tool to address cost shifting. As volumetric rates get closer to avoided costs, rate impacts are mitigated and cost shifting diminishes.

IV – Illustrative Benefit-Cost Analysis

Along with the effects of cost shifting, other key variables — direct project costs, cash flows associated with wholesale market products, societal subsidies and external factors — can cause the economics of solar PV to vary across stakeholder groups.

For example, projects that qualify for a federal investment tax credit (ITC) can yield cash flow benefits to the stakeholder group that invests, but not to society or other stakeholders. Global environmental benefits might appear as positive cash flows for society but not for utility customers — at least not the full amount — because customers will garner only a negligible fraction of the societal benefit. The value of renewable energy credits (RECs) flows to the stakeholder groups that hold the rights, but not to groups that don't. And, alternative procurement models — net metering, utility ownership, or community projects — will affect stakeholder groups differently.

The tables and graphs below use benefit-cost analysis to illustrate how the economics of an NEM project can vary across three principal stakeholder groups — solar customers, non-solar customers, and society, depending on stakeholder perspectives and the treatment of crucial variables. Tables 2 and 3 are laid out in the same way, but they depict different scenarios. It is important to do a scenario analysis because there is uncertainty regarding the values of the key inputs and ambiguity concerning the proper assignment of the variables to stakeholder groups.

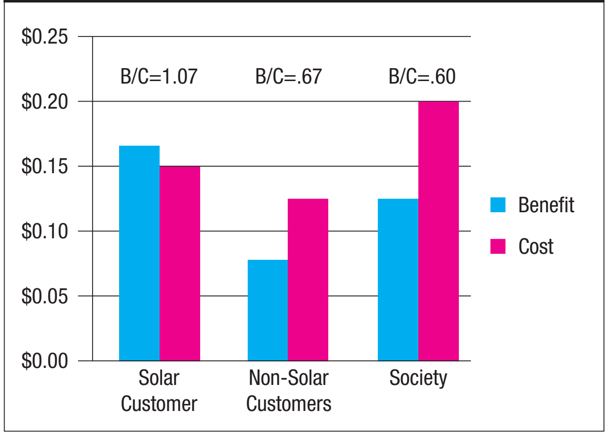
Table 2 - Costs

	(1) Project Cost $/Kwh	(2) ITC & Other $/Kwh	(3) NEM Payment $/Kwh	(4) Total Net Cost $/Kwh
Solar Customer	$0.20	($0.05)	$0.00	$0.15
Non-Solar Customers	$0.00	$0.00	$0.12	$0.12
Society	$0.20	$0.00	$0.00	$0.20

Table 2 - Benefits

	(5) Loss & TOU Leveled Energy $/Kwh	(6) Leveled Capacity $/Kwh	(7) Leveled REC $/Kwh	(8) Leveled Transmission $/Kwh	(9) Leveled Distribution $/Kwh	(10) Leveled Externalities $/Kwh	(11) Leveled NEM Revenue $/Kwh	(12) Leveled Total Benefits $/Kwh	(13) B/C Ratio
Solar Customer	$0.00	$0.00	$0.04	$0.00	$0.00	$0.00	$0.12	$0.16	1.07
Non-Solar Customers	$0.05	$0.01	$0.00	$0.02	$0.00	$0.00	$0.00	$0.08	0.67
Society	$0.05	$0.01	$0.00	$0.02	$0.00	$0.04	$0.00	$0.12	0.60

Graph 2



The presentation is meant to be illustrative, but the base case values shown in Table 2 are reasonable and within ranges used by others. Given the assumptions underlying Table 2, the NEM project appears to be economic from the perspective of the solar customers, but uneconomic for the non-solar customers and society.

Columns 1–3 in the top section of Table 2 depict individual costs, any one of which may or may not apply to a particular stakeholder group. Costs include the all-in costs to install and maintain the PV system; incentives (federal ITC, grants, etc.) , which are treated as cost offsets to the recipients; and NEM payments to solar customers, which are treated as costs to the utility and hence costs to non-solar customers.

Columns 5-11 of the bottom section depict individual benefits, which might include avoided energy, capacity, transmission and distribution costs; REC proceeds; avoided environmental external factors; and NEM payments to solar customers . It is assumed that the project produces marketable RECs, the proceeds of which flow to solar customers. The existence and market value of RECs can vary widely across jurisdictions, and also within jurisdictions over time. NEM programs may also be set up so that REC proceeds flow to the utility, and hence to non-solar customers, as opposed to the solar customers.

Solar customers incur the total PV system costs (column 1), but these costs are partially offset by the societal subsidies (federal ITC, accelerated tax depreciation, state tax concessions, grants and other incentives) shown in column 2. The benefits flowing to solar customers include NEM payments (column 11) and REC proceeds (column 7). The NEM payment is set at $0.12/kWh, which represents the nationwide average retail rate for residential electric customers . In reality, these payments may, depending on the structure of the NEM program and the utility's rate design practices, be higher or lower than the utility's average rate, so this value can vary widely with significant impacts on the B/C ratios. For non-solar customers, total cost, based on the NEM payment made by the utility to the solar customers (column 3), exceeds the total benefits, which comprise avoided

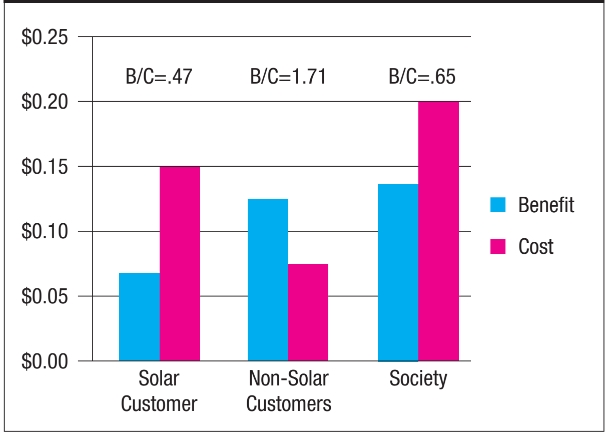
Table 3 - Costs

	(1) Project Cost $/Kwh	(2) ITC & Other $/Kwh	(3) NEM Payment $/Kwh	(4) Total Net Cost $/Kwh
Solar Customer	$0.20	($0.05)	$0.00	$0.15
Non-Solar Customers	$0.00	$0.00	$0.07	$0.07
Society	$0.20	$0.00	$0.00	$0.20

Table 2 - Benefits

	(5) Loss & TOU Leveled Energy $/Kwh	(6) Leveled Capacity $/Kwh	(7) Leveled REC $/Kwh	(8) Leveled Transmission $/Kwh	(9) Leveled Distribution $/Kwh	(10) Leveled Externalities $/Kwh	(11) Leveled NEM Revenue $/Kwh	(12) Leveled Total Benefits $/Kwh	(13) B/C Ratio
Solar Customer	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.07	$0.07	0.47
Non-Solar Customers	$0.05	$0.01	$0.04	$0.02	$0.00	$0.00	$0.00	$0.12	1.71
Society	$0.05	$0.01	$0.00	$0.02	$0.00	$0.05	$0.00	$0.13	0.65

Graph 3



energy, capacity and transmission costs (columns 5, 6 and 8). Consistent with the cost shifting discussion in Section III, it is assumed that the solar customers continue to rely on the utility's distribution system to consume electricity when their facilities are not producing, and to sell electricity during periods of excess production, so the benefits do not include avoided distribution costs.

Society, via the solar customers, incurs the PV system costs, which are not offset by the tax incentives and grants because these items merely represent transfer payments from a societal perspective. Along with avoided energy, capacity and transmission costs, the societal benefits include an environmental component shown in column 10, which represents the expected reduction in environmental costs when solar production reduces the output of fossil resources. In this scenario, the environmental benefit happens to equal the assumed REC value, but this will not necessarily be the case. Because society incurs the PV system costs without offsetting subsidies, societal costs exceed the net costs to the solar customers. At the same time, societal benefits in the form of avoided production costs are assumed to be below the NEM payment, and the societal environmental benefit is equal to the solar customers' REC benefit. Thus, relative to the solar customers, societal costs are higher and benefits are lower, so the project appears uneconomic for society but economic for solar customers.

As shown by the B/C ratios (column 13) Table 2 indicates that in this scenario, the NEM project is cost effective (B/C 1.07) only for solar customers. The project is not cost-effective for non-solar customers (B/C 0.67) and for society as a whole (B/C 0.60). The project is least cost effective from a societal perspective.

An alternative scenario is presented on Table/Graph 3. In this case, the project appears economic for non-solar customers but not for solar customers or society.

In Table 3, the NEM payment is set equal to the utility's avoided cost ($0.07/kWh versus $0.12/kWh in Table 2). The REC proceeds are allocated to the utility, and hence to the non-solar customers. The social environmental benefit

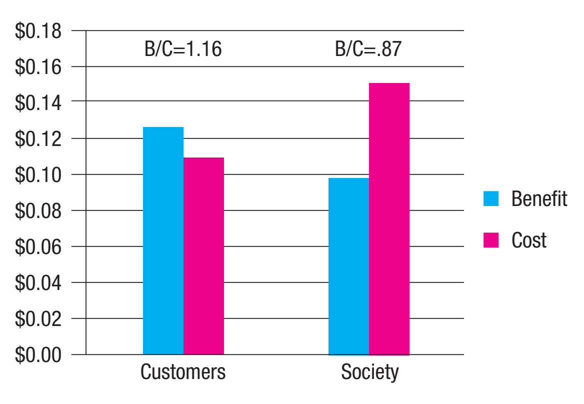
Table 4 - Costs

	(1) Project Cost $/Kwh	(2) ITC & Other $/Kwh	(3) NEM Payment $/Kwh	(4) Total Net Cost $/Kwh
Customers	$0.15	($0.04)	$0.00	$0.11
Society	$0.15	$0.00	$0.00	$0.15

Table 4 - Benefits

	(5) Loss & TOU Leveled Energy $/Kwh	(6) Leveled Capacity $/Kwh	(7) Leveled REC $/Kwh	(8) Leveled Transmission $/Kwh	(9) Leveled Distribution $/Kwh	(10) Leveled Externalities $/Kwh	(11) Leveled NEM Revenue $/Kwh	(12) Leveled Total Benefits $/Kwh	(13) B/C Ratio
Customers	$0.05	$0.01	$0.05	$0.02	$0.00	$0.00	$0.00	$0.13	1.16
Society	$0.05	$0.01	$0.00	$0.02	$0.00	$0.05	$0.00	$0.13	0.87

Graph 4



is set at $0.05/kWh versus $0.04/kWh in Table 2. These inputs lead to a reordering of the relative economics across stakeholder groups, as shown by the B/C ratios presented in column 13 and on Graph 3. The B/C ratios for non-solar customers, society, and the solar customers are, respectively, 1.71, 0.47 and 0.65. Thus, the project now appears economic for non-solar customers but not for solar customers or society. The societal economics have improved, but the B/C ratio is still less than one, indicating that the project remains uneconomic.

Other cases yielding different results can be easily developed, and this framework allows one to evaluate project economics based on one's own assumptions, expectations, and notions about which variables should be considered. In addition, it allows one to describe what circumstances would have to prevail to bring about various outcomes, like an "everyone wins" scenario where the benefit-cost ratios are greater than one for all stakeholders.

V- Utility-Scale Projects

Tables 2 and 3 depict alternative outcomes for small-scale, net-metered projects. As illustrated in Table/Graph 4, this same framework can also be used to evaluate the type of larger PV projects generally undertaken by utilities as opposed to individual customers. Two important differences between utility-scale and small-scale NEM projects are apparent. First, the larger projects display lower, unitized all-in costs. Second, although under many circumstances average utility rates will increase with utility projects, as they do with net metered projects, the magnitude will be less and the cost shifting between customers is eliminated. The overall increase will be less, other things equal, because utility sales do not decline and thus fixed costs are spread over more billing units. The tension between solar and non-solar customers is eliminated because all customers will be solar customers.

Table 4 depicts results for a utility-scale project. There are only two stakeholder groups, customers (all customers) and society. Given these particular assumptions, the project appears economic for customers but not for society, primarily because of the societal subsidies. Again, the results vary with the assumptions and it is up to users to determine the assumptions that align with their expectations.

VI – Managing Outcomes

More than just a mechanical technique for estimating outcomes, the process of altering inputs and comparing scenario results illuminates the key dynamics and the inherent trade-offs among interest groups that accompany the adoption of solar PV as an energy resource. Obviously, one would hope for a “win-win-win” case where the B/C ratios were greater than one for all stakeholders, indicating positive economic benefits for all, but that would be unlikely under current circumstances. So, in order to accommodate increasing amounts of solar PV, decision makers will have to balance the interests of the different stakeholders.

In situations like those depicted in the Tables 2 and 3, where the expected levelized cost of electricity with rooftop solar PV exceeds the projected market value of the output, subsidies and/or cost shifting will be necessary to encourage development of these systems, because without the subsidies there would be little, if any, economic incentive for customers to invest in them. Even utility-scale projects, which generally exhibit lower unitized costs, will, in most cases, appear uneconomic in the absence of subsidies, REC payments or imputed environmental benefits. As noted above, there may be good reasons for a utility, a community, or broader society to use subsidies and wealth transfers to encourage the adoption and use of any technology, including solar PV, but it is important for public authorities and other decision makers to appreciate the economic constraints and inherent trade-offs, and to explicitly consider what levels of subsidization and cost shifting seem appropriate.

To a large degree, decisions regarding societal subsidies are made at the federal or state levels, although local communities may also create incentives through tax abatement or other economic development programs. Also, in many cases, NEM programs are designed by state lawmakers and/or regulators. Certainly, utilities can influence these policies but they will likely not be the principal architects. However, utilities can directly influence cost shifting and rate impacts, and they can affect the nature and scope of solar resource development in their service territories by pursuing programs that meet overall renewable goals in the most efficient manner possible.

Conventional rate design mechanisms provide familiar tools for utilities to manage cost shifting and rate impacts. As shown in Section III, for a given scale of NEM program, the degree of cost shifting is directly related to the divergence between the NEM payments to solar customers and the actual costs avoided when the NEM production displaces utility output. In many cases, but not all, NEM payments are based on the utility’s retail volumetric charges, so a utility can minimize cost shifting by setting the volumetric charges as close as possible to its actual variable costs, while relying more on customer charges and less on usage-sensitive demand charges to recover fixed costs.

Not only does proper rate design address practical rate impact issues, but it can also help prevent ill-informed public perceptions about a utility’s attitude toward renewable resources and energy efficiency. Solar proponents often portray the utilities as calcified monopoly institutions intent on killing solar power. In certain cases, they have assailed utilities for attempting to mitigate cost shifting by imposing surcharges on NEM production to recover the fixed costs not avoided by the program, likening such proposals to the taxing of customer-installed efficiency measures. Surcharges of this sort may indeed seem inappropriate when portrayed in that way. However, they actually make good economic sense when a significant portion of a utility’s fixed costs – costs not avoided by NEM programs or energy efficiency measures -- are recovered through the utility’s volumetric charges. In such circumstances, a properly designed surcharge would be fair, and economically efficient, but it may not appear that way to a public audience. These surcharges would not be needed if the volumetric charges reflected true avoided costs, and fixed costs were recovered in customer charges and/or less usage-sensitive demand charges.

This is not to suggest that designing rates to better accommodate solar PV would be a simple, non-controversial undertaking. Utility rate structures vary across jurisdictions, companies and customer classes within companies. Rate stability is generally a key rate making goal, and rate redesign, which often creates winners and losers among customer classes, can lead to instability. But, significant penetration of solar PV is also likely to create winners and losers, and it would be best to explicitly address these effects. Intelligent rate design provides a means for utilities to balance various interests as they pursue their business and public policy goals.

Along with proper rate design, it should recognized that to the extent solar PV is being pursued to fulfill renewable portfolio standard requirements or to satisfy customer or community interests, as opposed to meeting NEM mandates, utilities may be able to reduce cost shifting and overall adverse rate impacts, by meeting their solar goals with larger utility-scale projects that cost less on a unit basis and avoid cost shifting among utility customers.

VII - Conclusion

As noted at the outset, solar PV has been growing rapidly in recent years, spurred by decreasing costs, RPS requirements, mandated NEM programs, consumer preferences and utility integrated resource plan initiatives. But, the rapid growth does not, by itself, demonstrate the economic viability of solar PV as a power resource. It is clear that the penetration of solar PV has been aided by direct subsidies, and indirect subsidization in the form of higher utility rates and cost shifting among utility customers. These incentives may be rooted in laudable public policy goals, but they, along with other factors, can complicate the economic analysis of solar PV, causing the assessments to differ for different stakeholder groups. Decision makers, both public authorities and utility managers, will have to balance different constituent interests when setting and pursuing renewable goals. The foregoing discussion provides a framework for explicitly identifying trade-offs and evaluating the economics of solar PV from alternative perspectives.

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[i] SEIA, U.S. Solar Market Insight 2012 Year in Review (http://www.seia.org/research-resources/us-solar-market-insight-2012-year-review), last visited 05/09/2014.

[ii] Actually, to the extent that NEM customers are net purchasers from the utility, they will help make up a small portion of the shortfall through higher rates as well.

[iii] In the case of NEM the solar customer would most likely be the investor and thus capture the benefit. For utility-scale projects the ITC would not be available to government owned electric utilities and in many cases it would be difficult for even for Investor owned utilities to directly capture the benefit. However, both could reap at least a portion of the benefit by either partnering with a tax investor or by procuring the output through a purchase power arrangement with a third party that is able to utilize the benefit.

[iv] See Rocky Mountain Institute, A Review od Solar PV Benefit and Cost Studies , second edition September, 2013 (www.rmi.org/elab) last visted 05/09/2014; VT Public Service Department, Evaluation of Net Metering in Vermont, January 15, 2013; EEI. A Policy Framework for Designing Distributed Generation Tariffs, November 2013; and California Solar Initiative Cost-Effectiveness Evaluation, prepared for California Public Utilities Commission, April 2011; Edison Electric Institute, Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business,January 2013..

[v] All values are leveledized over the planning horizon. Energy and capacity values should be adjusted for line losses and any pertinent seasonal/time-of-use characteristics. For range of values used in other studies see supra note iv.

[vi] The variable in the table represents the total value of all incentives, including federal and state tax incentives, grants etc. This value can vary greatly depending on the nature and timing of the project, the type of investor, region of the country and utility jurisdiction. While the federal ITC may not be directly available to all investors (including government-owned utilities or private investors with limited tax appetite), a portion of the benefits may be obtainable through arrangements with third parties. For present purposes, a proxy value equal to 25% of installed cost is used to capture all societal subsidies.

[vii] This particular layout is chosen for ease of exposition, but clearly since variables can be arranged on either side of an equation by switching signs, different configurations, are possible, and perhaps preferable for some. For example, as opposed to showing the federal ITC as a cost offset (cost item with a negative sign) one could depict it as a positive benefit cash flow.

[viii] EIA, Electric Power Monthly, February 2014. (http://www.eia.gov/electricity/monthly/update/), last visited 05/09/2014

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