From: DOLEZEL Cindy
To: MENZA Candice
Subject: Staff model for cost-shifting discussion - UM1716- Investigation #2
Date: Thursday, February 18, 2016 4:05:51 PM
Attachments: Revised Comparisons.2.8.xlsx
SolarWorkshop3.Feb5.16.doc

Candice can you send to UM1716 distribution list please?
Thanks,
Cindy

Dear UM1716 Parties,

Attached please find a detailed Staff model, which is a work in progress version and explanation of the materials presented by Staff at the last workshop in December 2015. We would like to informally receive your feedback via email (to me via email) on these materials by Wednesday, April 1, 2016.

The attached comparisons are being distributed in a spirit of collaboration. Staff wants to express our appreciation for all of the input we have received thus far from the parties. The Venn Diagram was particularly valuable for laying out the basic terms. Staff hopes that the use of a common set of terms will foster mutual understanding regarding all the models. It is easier to make distinctions if one starts from a common set of terms and assumptions. As we ask for feedback regarding the Staff model, in particular, we ask you to please bring to our attention any perceived errors of logic or fact.

If you have any questions, please don't hesitate to contact me or George Compton.

Thank you,
Cindy

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Estimating Utility Solar and Netmetering Net Cost Shifting: Six Hypothetical Numerial Examples

NOTE: The lightly shaded column represents the utilities' model outcomes; the darker shaded column the PUC Staff's.

	Pre-Solar			Post-Solar						
Customer	**a1 = Marg. Cost**	**b1 = Revenue**	**Subsidy from Customer (SPO) = b1 - a1**	**CB2 = Marg. Cost**	**B1 = Net Revenue**	**VD2 = Value of Imported Solar**	**NEM Net cost Burden (BTR) = NCI = CB2 - B1 - VD2**	**VL1 = Savings from Reduced Load = a1 - MB2**	**Staff's Net Cost Shift (NNCS) = (b1 - B1) - (VD2 + VL1) = ΔR - ΔC**	**Staff's Net Cost Shift (NNCS) = SPO + BTR**
-1	$1,100	$1,300	$200	$1,000	$900	$100	$0	$100	$200	$200
0	$1,500	$1,400	-$100	$1,200	$1,100	$50	$50	$300	-$50	-$50
1	$900	$800	-$100	$820	$500	$130	$190	$80	$90	$90
2	$1,400	$1,530	$130	$1,250	$1,235	$75	-$60	$150	$70	$70
3	$900	$800	-$100	$860	$650	$50	$160	$40	$60	$60
4	$1,400	$1,530	$130	$1,300	$1,250	$50	$0	$100	$130	$130

Terms:

a1: Annual marginal cost of the customer's load had it not installed solar.

b1: Utility revenues associated with the load whose cost is a1.

Pre-solar revenue shortfall: Marginal cost minus revenue received.

CB2: Annual marginal cost of a solar customer's load as it is directly experienced by the utility -- i.e., the behind-the-meter load is disregarded.

B1: Net NEM utility revenues, i.e., the revenues received from the load whose cost is CB2 less the revenues paid out for the solar energ imported from the customer through the grid.

VD2: Avoided cost or value received by the utility for the imported solar energy.

Post-solar NEM revenue shortfall: Marginal cost minus sum of net revenue received and value received from imported solar.

VL1: Utility avoided cost owing to the load reduction caused by the solar installation = a1 - CB2.

Net Cost Shift: The solar-caused reduction in revenues as offset by avoided costs from the load reduction and the imported solar **= (b1 - B1) - (VL1 + VD2) = ΔR - ΔC**

Equivalent: **Net Cost Shift =** Pre-Solar Subsidy (i.e., eliminated) plus the Post-Solar Net Cost Burden.
= (b1 - a1) + (CB2 - [B1 + VD2]) = SPO + BTR, from page 8.

Customer Descriptions:

-1. This is a large-load customer despite little heating or cooling loads, who also doesn't change his load profile following solar. Most of the solar production is exported to the grid.

0. This customer had large air-conditining use prior to his solar installation; solar output primarily went behind-the-meter. His heavy on-peak load caused him to be a burden to the system prio to obtaining solar.

1. This is a small-load customer who doesn't change his load profile following installing solar eqipment. Most of the solar production is exported to the grid.

2. This is a large-load customer despite little heating or cooling loads, who also doesn't change his load profile following solar. About half of the solar production is exported to the grid.

3. This customer is like customer #1 except it adds a substantial amount of summer-time load following his solar installation. Most of the solar production is retained as behind the meter consumption.

4. This customer is like customer #2 except it adds a substantial amount of summer-time load following his solar installation. Most of the solar production is retained as behind the meter consumption.

Respective Customer Observations:

-1. The utility breaks even with this customer in the post-solar setting, but because of the loss of the $200 subsidy from the pre-solar setting, the burdensome cost shift is that $200 loss.

0. The utility suffers a slight loss ($50) from this customer in the post-solar setting, but due to avoiding the $100 pre-solar burden, there is a net cost shift **benefit** from this solar/NEM customer.

1. This customer goes from being a $100 per year burden to being a $190 per year burden, for a net burden increase, or cost shift, of $90.

2. This customer goes from being a $130 per year rates <u>benefactor</u> to being a $60 per year benefactor. The <u>loss</u> of benefits results in a <u>positive</u> cost shift, or general increase in rates of $70 (i.e., $130 - $60).

3. This customer goes from being a $100 per year burden to being a $160 per year burden, for a net burden increase, or cost shift, of $60.

4. This customer goes from being a $130 per year rates <u>benefactor</u> to having rates that precisely covered costs. The <u>loss</u> of benefits results in a <u>positive</u> cost shift, or general increase in rates of $130 (i.e., $130 - $0).

On Modeling Net-Metered, Solar-Induced Cost Shifting

By George R. Compton, OPUC Staff

Preface and Reader's Guide

Background: Idaho Power (Idaho), PacifiCorp (PAC), Portland General Electric (PGE), and the Oregon PUC Staff (Staff) presented cost-benefit models in various stages of development in the UM 1716 Cost Shifting Workshop No. 2 that took place in mid-December, 2015. PAC's and PGE's models were similar by virtue of wanting to incorporate behind the meter consumption and production in their cost shifting models. Idaho's model did not appear to incorporate those elements, focusing on the cost of service coming directly from the utility. Staff argued for excluding behind the meter consumption/production and for associating solar-induced costs shifts with before- and after-installation loads and revenues of solar customers, while recognizing that solar installations can be associated with substantial increases in electricity consumption by some customers.

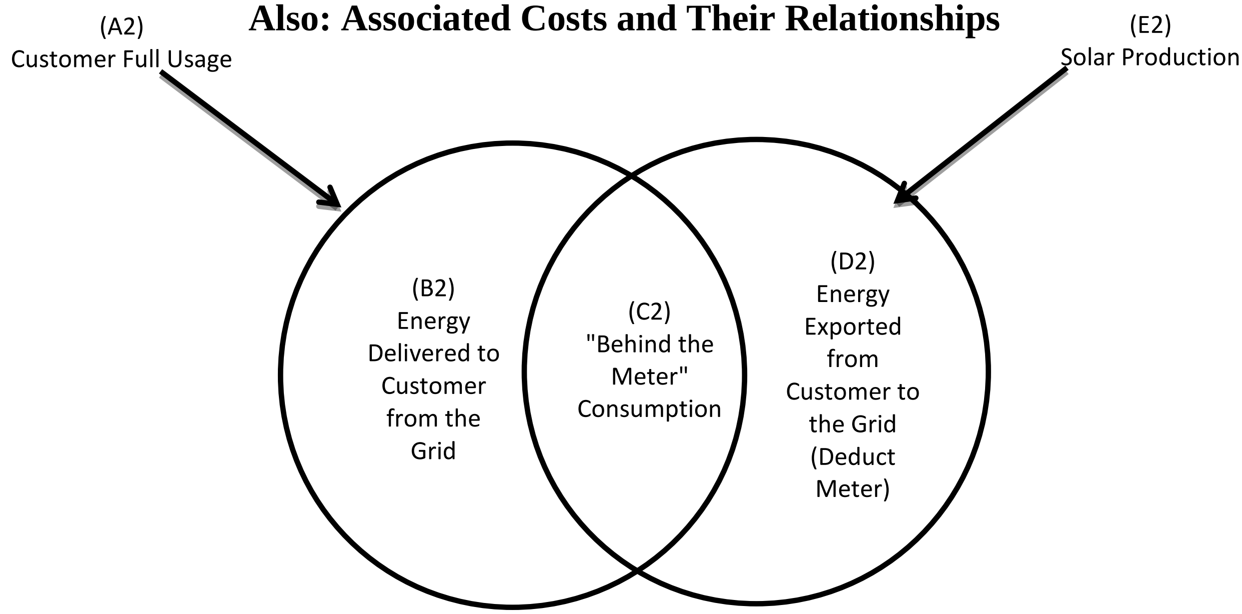
Purposes of this Presentation:

- The first purpose of this effort on behalf of Staff is to place all four of those parties' models within a framework that shares a number of terms and relationships in common. Such a framework fosters an understanding of areas of agreement and areas of disagreement among the models. Regarding the latter, the disagreement may not be a matter of conflict as much as a matter of the models having different scopes or realms as to what is attempted to be models.
- A tentative demonstration will also be submitted which reaches the conclusion that all four parties' models will yield the same results as to the degree to which the net revenues from net-metered solar customers will cover their direct costs of service (where the direct service excludes behind-the-meter production and consumption).
- A distinction will be made between that dimension of potentially incomplete cost recovery from solar customers and the type of cost-shifting that takes place given a pattern of reduced consumption in the presence of inverted-block, kWh-based electricity prices. A major component of cost shifting is the loss of net-revenue-benefits to other ratepayers when a high-use customer, with revenues in excess of costs, installs solar equipment and converts to being a low-use utility customer with costs in excess of revenues. *This element is not included in the utility models that were presented at the workshop.*

Definition of Net-Metered, Solar-Induced Cost Shifting: A general rate increase, or a rate increase centered on one or more particular customer schedules, owing to net-metered solar displacing conventional electricity consumption and production.

Presentation Contents Overview:

A Venn Diagrammatic Portrayal of Solar Consumption and Production—Including Net Metering
Also: Associated Costs and Their Relationships



Primary Source: Figure 2 of PacifiCorp's presentation at the UM 1716 Fixed Cost Workshop #2
Note: Subscripts were added to distinguish between letters used in common by PAAC's Figures 1 and 2.

Some terms and relationships:

A2: Full requirements load, including the behind-the-meter consumption.

B2: Solar customer's load directly served by the utility, i.e., excluding consumption behind the meter.

C2: Behind-the-Meter electricity consumption—includes both energy and capacity dimensions.

D2: Energy produced by the customer's solar resource and exported to the utility through the grid.

E2: Total solar production, i.e., C2 + D2.

B2 and D2 are "known," i.e., can be measured directly. In both cases, the load/delivery shape and timing are relevant.

A2 = B2 + C2 = B2 + (E2 – D2).

CB2: COS to the utility of B2.

CC2: Cost of C2 *as if it were served by the utility*.

A1 ≡ CA2 = CB2 + CC2: Cost of service (COS) for A2 in its entirety, reflecting both energy and capacity, as if the utility itself also served what went behind-the-meter.

RB2: Revenues collected by the utility for sales B2.

RD2: Revenues paid out by the utility for purchases D2.

B1 = RB2 – RD2: Utility net revenues from solar customers.

VC2 ≡ CC2: The value, or avoided cost to the utility by virtue of the behind-the-meter consumed electricity being produced by the solar customer.

VD2: The value, or avoided cost to the utility, reflecting both energy and capacity costs, of being able to substitute its *imported* solar for power from alternative sources. (That power's cost is regarded as sunk for this purpose, and does not enter into the estimation of VD2. Numerical clarification: A utility might pay 10 cents per kWh for net-metered solar energy, which in turn displaces 3 cent natural gas. The value of the solar energy is just the 3 cents. The 10 cents is ignored in this context.)

C1 ≡ VE2 = VC2 + VD2: The value to the utility of the entire solar production (E2).

Two Frameworks for Assessing a Solar Customer's Under- or Over-Recovery of Costs – Yielding Identical Results

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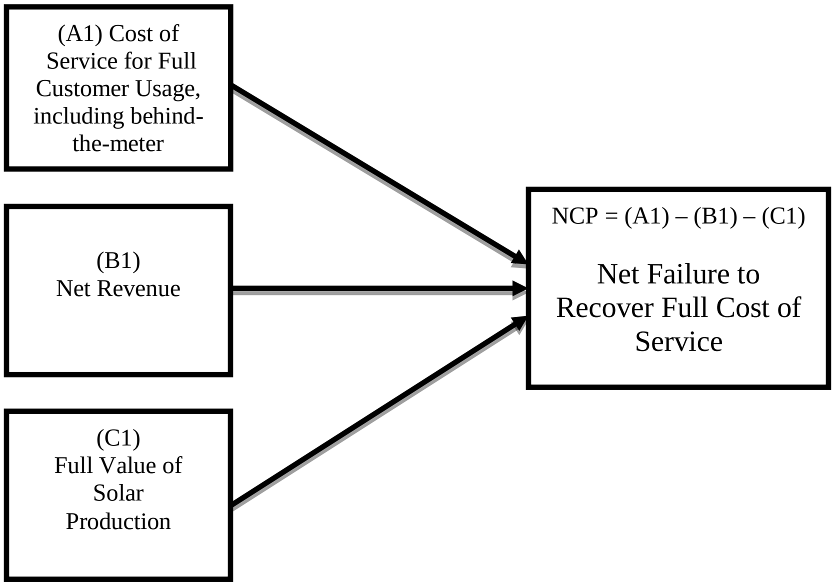
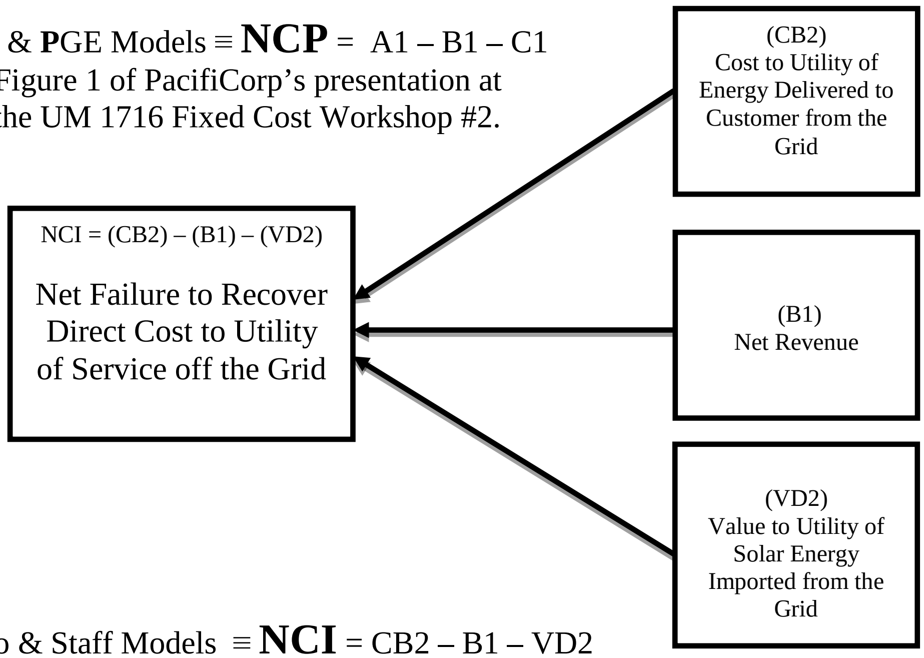


Net Cost for **P**AC & **P**GE Models ≡ **NCP** = A1 – B1 – C1
Primary Source: Figure 1 of PacifiCorp's presentation at the UM 1716 Fixed Cost Workshop #2.



Net Cost for **I**daho & Staff Models ≡ **NCI** = CB2 – B1 – VD2

<u>Testing for the equivalence of NCP and NCI</u>:

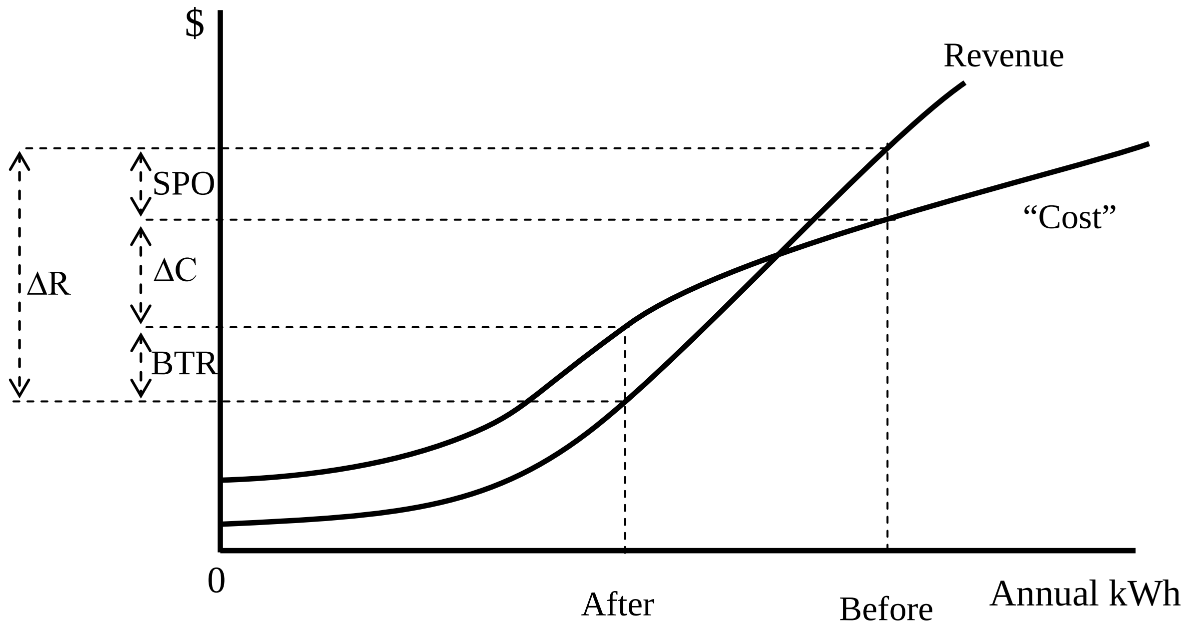
A1 – B1 – C1 ? = CB2 – B1 – VD2
(CB2 + CC2) – B1 – (VC2 + VD2) ? = CB2 – B1 – VD2, substituting components for A1 and C1
(CB2 + VC2) – B1 – (VC2 + VD2) ? = CB2 – B1 – VD2, substituting VC2 for its equivalent, CC2
CB2 – B1 + (VC2 – VC2) – VD2) ? = CB2 – B1 – VD2, rearranging terms
CB2 – B1 – VD2 = CB2 – B1 – VD2, eliminating the self-cancelled terms.

QED

General Conclusion: Under-recovery of costs due to sales to solar, net-metered customers occurs when the direct cost of serving those customers (*i.e., ignoring behind-the-meter consumption*) exceeds the sum of the net revenues received (i.e., having deducted payments for solar energy imported by the utility) *plus* the value to the utility of that imported solar energy (i.e., by virtue of its ability to displace other energy and capacity resources). Contrary to the PAC and PGE models, the full-requirements and full solar production variables are not used in the calculation of the revenue shortfall or surplus.

Page 4 A Graph Depicting Adverse Cost Shifting from a Pattern of Reduced Consumption in the Presence of Inverted, Kwh-Based Rates. (Disregarding Net Metering)

Individual Residential Customer Expected Revenues and Costs as a Function of Annual kWh's



Notes on the graph; What are depicted are hypotheticals in the sense that it shows the expected relationships between annual kWh consumption and expected revenues and costs. If, for example, a utility had 10 thousand customers, on the graph would be 20 thousand dot pairs, with one dot on the graph pairing each customer's annual kWh for a given year with the revenues collected from him, and the other dot connecting those same kWh with his assessed cost of service. The indicated curves represent the smoothed averages of the customers' dot pairs across the range of annual kWh. At a given level of energy consumption, individual customers' costs will vary due to the fact that utility-incurred costs are a function of both energy (kWh) and demand (kW), which means that there will be a range of costs incurred depending on the various customers' load shapes, e.g., how much of their demand took place during high-cost peak periods versus low-cost valley periods. Similarly, and absent flat energy rates, expected revenues are not exactly connected to energy consumption due to the fact that some customers' consumption is "peakier" than others—causing more of their energy to be charged at the higher, tail-block rate within the inverted-block pricing structure.

What is displayed in this instance is the case where a customer's long-term consumption changes from being something above the revenue-to-costs crossover point to something below.

Code:

ΔR ≡ The reduction in revenues following the reduction in consumption.

ΔC ≡ The reduction in direct utility costs following the reduction in consumption.

SPO ≡ The Subsidy Paid Out by the high-use customers, prior to whatever caused their reduction in consumption, owing to their revenues exceeding their costs. **The loss of subsidy contributes to the cost shift.**

BTR ≡ The Burden To Ratepayers, following whatever caused their reduction in consumption, owing to their revenues falling below their costs. **This is equivalent to the NCI of the previous page.**

Cost shift definition/description: The degree to which the reduction in revenues is not offset by a reduction in costs. ***Equivalently:*** **The degree to which cost-equilibrating electric rates must be elevated (in the case of this graph) to compensate for *both* the removal of a subsidy (i.e., where revenues exceeded costs) and the addition of a burden (i.e., where revenues are beneath costs).**

Relationships—Visually:

Cost Shift = ΔR – ΔC = SPO + BTR

Page 5

Relationships—In Words and Logic:

Cost Shift = ΔR – ΔC Given a reduction in sales and, therefore, in revenues, costs will be shifted to other ratepayers if the reduction in costs is insufficient to compensate for the reduction in revenues. (If cost went down the same amount as did the revenues, then there would be no need to elevate rates because existing rates would still cover costs.)

Or

Cost Shift = SPO + BTR Additive contributors to costs shifting to other ratepayers are the loss of subsidies from high-use customers combined with a new ratepayer burden owing to a failure of revenues to cover the direct utility costs incurred in serving the reduced load. Numerical example: Say that given the rate structure that, prior to installing solar, a very large customer had been "contributing" $200 a year in terms of his revenues exceeding his costs. Then assume that with solar and NEM the utility sustained a "loss" of $300 owing to net revenues being beneath net costs. The total cost shift will then be $500, i.e., the loss of the $200 benefit plus taking on a new $300 burden.

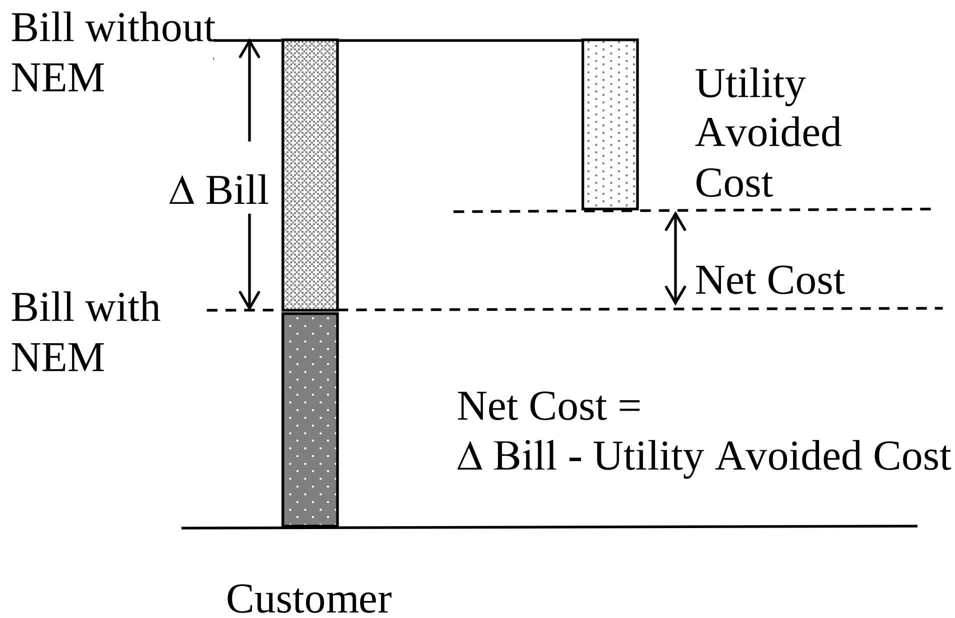
Caveat: Cost shifts don't require moving from above average consumption to below average. Visual inspection of the graph indicates cost-shifting, albeit at a lesser degree, a) when customer starts to the right of the break-even level of consumption and stays there, resulting in a lower level of consumption and subsidy; or b) when customer starts to the left of the break-even level of consumption and stays there, and causes a larger burden owing to a greater shortfall between revenues and costs. **Barring a major change in a customer's load *shape*, a reduction in kWh consumption can be expected to result in adverse cost shifting.** Customer '0' in the numerical attachment is an example of the exception: His high peak summer use caused him to be a pre-solar burden: That burden was erased with his solar installation and behind-the-meter solar consumption.

Application to Solar:

1. For obvious reasons, residential solar customers tend to have been above-average consumers of electricity prior to their installing solar. Furthermore, OPUC-regulated residential rates incorporate the indicated inverted-block structure. Therefore, independent of the net-metering aspects, there becomes the presumption of adverse cost-shifting following large-scale solar installations by residential customers owing to their reduced purchase of utility-supplied power given the new behind-the-meter solar production.
2. In order to bring out the effects of net-metering, additional elements must be brought into the simplified cost shift model and relationships depicted in the graph. "Revenues" now becomes "net revenues" in order to take into consideration what is paid out by the utility for the imported, net-metered solar power. "Cost reductions" must go beyond savings owing to reduced electricity supplied to also include resource savings from being able to substitute the imported solar for whatever the conventional incremental power supply alternative would have been.
3. In any event, since cost-shifting is a direct effect of a consumer shrinking his load (in this instance owing to his having installed solar equipment), in order to be able to estimate the degree of solar-attributed cost shifting it is necessary to include in the equation what the load would have been had there not been the solar installation. That would constitute the "Before" information on the previous page's graph. "After" depicts consumption, costs, and revenues following the solar installation.

 OPUC Proposed Solar-Induced Cost Shifting Model

E3's Primitive Net Cost-Shift Model (Exact Replication)



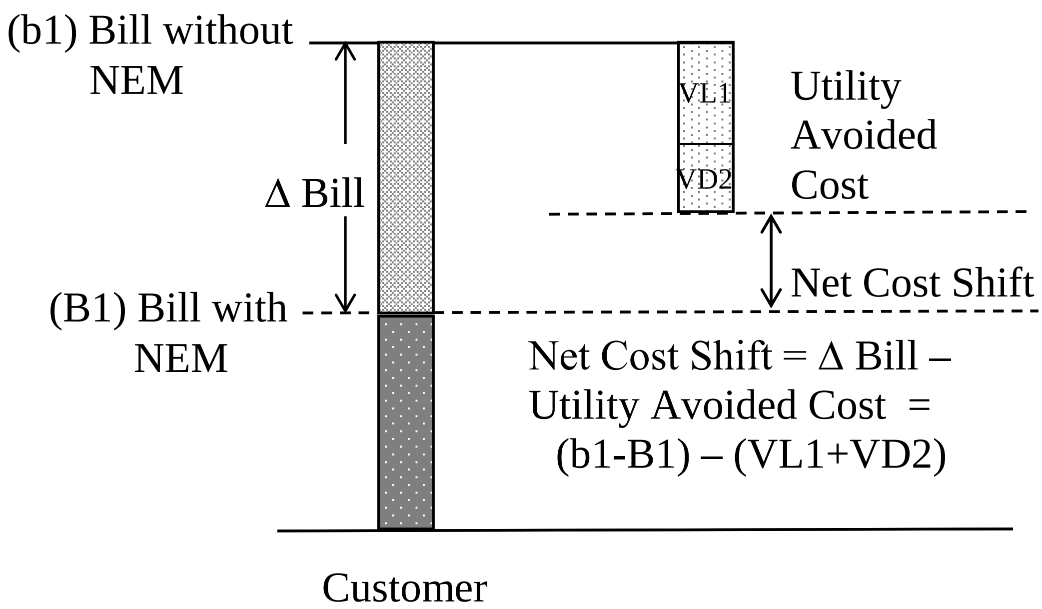
Source: 2010 Energy and Environmental Economics, Inc. study for the Calif. PUC, page 18.

Comments and Observations: The objective of the OPUC approach is to model total, or net, cost shifting as defined in the preface. The above figure—obtained from a California PUC document—is a primitive depiction of a model whose purpose is to estimate net cost shifting. **It says "Net Cost" but it should say "Net Cost *Shift*"** because that is what it measures (as properly constituted) and that is what regulators ultimately want to know. Note that a key element in the above figure is "Bill without NEM." "Bill without NEM," in conjunction with the cost of service associated with that bill will establish the degree of subsidy from the customer prior to acquiring solar. Recall that total/net cost shifting incorporates a loss-of-subsidy element. *Since that element does not appear in the utilities' models, those models cannot be expected to estimate total/net cost-shifting.* "Bill[s] without NEM," i.e., revenues absent, or prior to, solar and NEM, comprises a primary element in the OPUC Staff approach.

The utilities' (i.e., PacifiCorp [PAC], Portland General Electric [PGE], and Idaho Power [Idaho]) cost models provide essential information regarding the degree to which NEM revenues will cover the direct costs imposed by the solar customers. However, unless the pre-/non-solar revenues-to-costs relationship is also modeled, the extent of total/net cost shifting that occurs under solar and NEM cannot be known. The utilities' models exclude the aspect of cost shifting that is attributed to the loss of subsidy or increase in cost recovery burden that tends to accompany reductions in electricity consumption.

Page 7 OPUC Proposed Solar-Induced Cost Shifting Model

Staff's Minimally Refined E3 *Cost Shift* Model (NNCS)



<u>New Terms for Estimating Cost Shifting (Refer Also to Page 2):</u>

b2: Pre- or absent-solar load served by the utility.

a1: Marginal cost of b2.

b1: Utility revenues from customers absent, or prior to receiving, solar and net electricity metering (NEM).

B1 (from page 2): Utility net revenues from solar customers.

Δ Bill = b1 – B1 = ΔR as shown on page 4.

CB2 (from page 2): COS to the utility of B2.

Utility Avoided Costs = VL1 + VD2 = ΔC as shown on page 4.

VL1: Avoided, or reduced, cost to the utility, reflecting both energy and capacity costs, from a customer's having reduced its load—in this instance owing to the solar installation.

VL1 = a1 **–** CB2

VD2 (from page 2): The value, or avoided cost to the utility, reflecting both energy and capacity costs, of being able to substitute its *imported* solar for power from alternative sources.

NNCS = Net NEM Cost Shift (Staff) = (b1 **–** B1) – (VL1 + VD2), i.e., the loss of revenues (b1 – B1) from the conversion to solar that is not offset by the sum of the reduction in direct utility service costs (VL1, i.e., disregarding behind-the-meter production) plus the utility's cost that is avoided owing to being able to substitute the imported solar power for its alternatives (VD2).

Symbolically: **NNCS =** (b1 - B1) – (VL1 + VD2) ≡ **ΔR – ΔC** as shown on page 4.

Wrapping Up

I. A demonstration of the algebraic equivalence between the staff's straightforward cost shift model outcome (NNCS) and the sum of the lost pre-solar customer subsidy/burden plus the solar/NEM cost of service recovery shortfall

The purpose here is to show how, when applied to net-metered solar, the two net cost-shift expressions, **ΔR – ΔC** and **SPO + BTR** produce the same numerical results.

Note: Refer to the terms and relationships in previous pages.

ΔR – ΔC = (b1 – B1) – (VL1 + VD2) ≡ NNCS

The lost pre-solar customer subsidy/burden (**SPO**) = Pre-Solar Bill/Revenues minus Cost-of-Service = b1 – a1

Solar/NEM cost of service recovery shortfall (**BTR**) ≡ NCI = CB2 – B1 – VD2, from page3.

Adding those two expressions: **SPO + BTR** = (b1 – a1) + (CB2 – B1 – VD2)

Rearranging terms: = (b1 – B1) – ([a1 – CB2] + VD2)
= (b1 – B1) – (VL1 + VD2), since [a1 – MB2] = VL1
= NNCS
= **ΔR - ΔC**

QED

II. The attached spreadsheet contains four numerical examples where the net cost shift (NNCS) is calculated along with its constituent components, SPO and BTR.

III. A note on data requirements. Staff's net cost shift model requires the following information for its implementation: The first three items are also required for the utilities' models; the fourth is readily available (prior year's same-month revenues appear in the monthly bills). Only the fifth item may pose a challenge, albeit clearly not insurmountable.

1. Annual net revenues from solar customers.
2. Cost of serving solar customers as seen at the utility's meter.
3. The value, or avoided cost to the utility, reflecting both energy and capacity costs, of being able to substitute its *imported* solar for power from alternative sources. This is the "resource value of solar" as narrowly defined from the utilities' and their *general* customers' viewpoints.
4. Annual net revenues from solar customers for the year prior to their acquiring solar, or what the revenues would have been had the (new) customer not acquired solar.
5. Utility cost of service for solar customers for the year prior to their acquiring solar. This should be reasonably doable for PGE customers by the use of their recorded hourly meter data. With an adequate sample size the information should also be transferrable to PAC customers with similar demographics.

IV. **Several meanings to the "resource value of solar":**

1. Narrowly construed: The direct resource value to the utility (i.e., and its customers in general) is the value it can make of the imported solar as a substitute for conventional capacity and energy resources. This is the VD2 element in the Staff model. It is offset by whatever amount is paid by the utility for the imported solar.
2. More broadly construed utility value: There is also the indirect benefit to the utility associated with the reduction in load owing to behind-the-meter solar consumption. Because the addition of solar can also lead to an increase in overall load, the logically superior means of measuring that benefit is by comparing before-solar and post-solar loads, costs, and revenues. That measurement approach is also more straightforward empirically as opposed to attempts to impute a solar installation's total electrical output based upon engineering specifications without elaborate adjustments based upon specific installation characteristics.
3. Broadly construed societal values—impossibly quantified—include environmental benefits.