Why Treating Social Cost of Carbon as a Fixed Cost Neutralizes Its Impact

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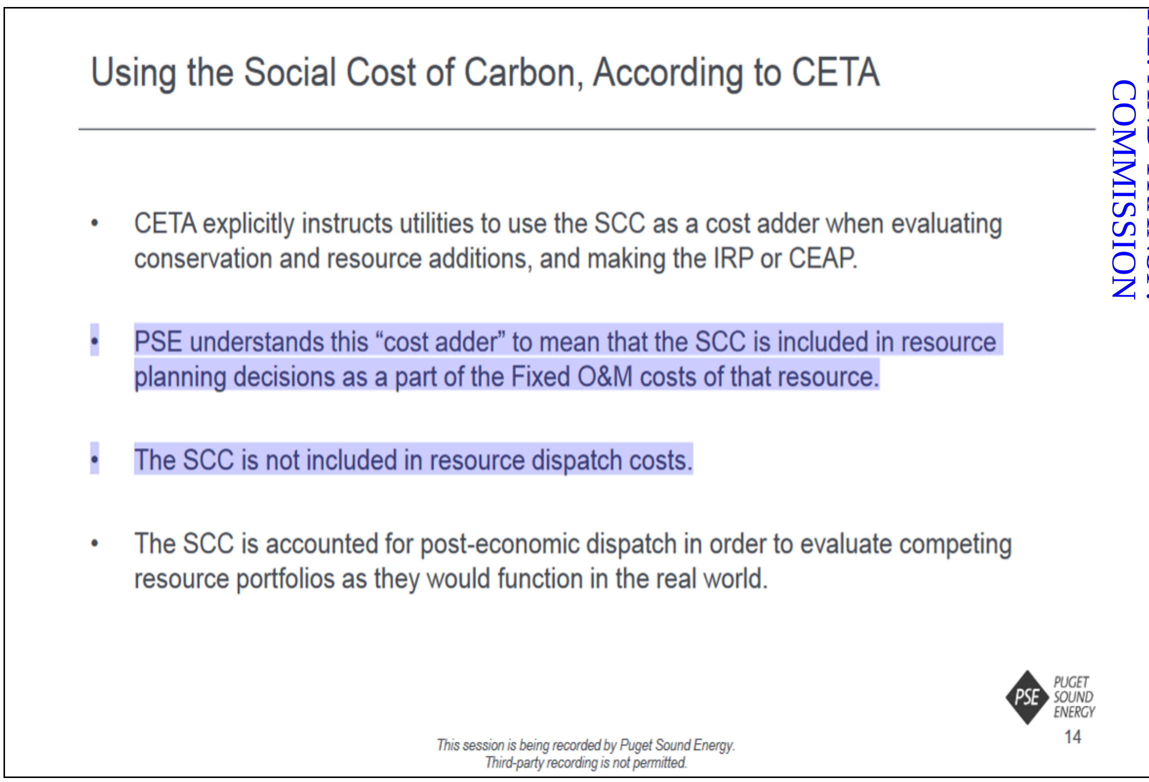
There appear to be serious methodological errors in the process that Puget Sound Energy (PSE) proposes to use in incorporating the social cost of carbon (SCC) in its 2021 Integrated Resource Plan (IRP) analyses.

As part of PSE's July 21, 2020 IRP Webinar *Social Cost of Carbon* (Webinar #5), PSE presented slide 14 (below). I draw the reader's attention to the two highlighted sentences, which state that 1) the social cost of carbon (SCC) will be treated as a fixed cost and that 2) SCC will be excluded from resource dispatch modeling. As someone with more than a nodding acquaintance with optimization, I find both of these statements puzzling and highly irregular.



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Firstly, the social cost of carbon—the cost that PSE's carbon emissions imposes on all of us but that PSE does not pay for—varies directly with the quantity of greenhouse gas emitted. It makes no sense to treat it as a fixed cost; it clearly is a variable cost. Moreover, economic optimization procedures, which lie at the core of PSE's planning process, depend critically on how costs respond to incremental changes. Treating a variable cost as though it is a fixed cost will neutralize (or disable) the impact of that cost in the optimization.

The second highlighted sentence is troubling as well, because including a major cost component like the social cost of carbon in some steps of the analyses but not others will inevitably lead to discordant results. In late 2019, PSE presented cost data to stakeholders showing that gas costs that are burdened with SCC were more than three times as high as the gas commodity cost alone.[i] Cost differences that large will inevitably have major impacts on optimal portfolio selections and should not be excluded without a compelling rationale.

Including SCC in IRP analyses is mandated under the Clean Energy Transformation Act (CETA).[ii] To the extent that resource dispatch modeling is part of the planning process, it must include SCC. I understand that "real-world" dispatch decisions are outside of the scope of this particular mandate in CETA. But PSE should not compromise the planning and resource acquisition process in which they are compelled to use the SCC, using the argument that they are not compelled to use SCC in making real-world dispatch decisions.

PSE has not offered a coherent rationale for the unusual modeling decisions they propose to use. The closest thing I've found to a rationale appears on slide 20 from Webinar #5. I believe the slide employs specious reasoning. I explain why in an endnote.[iii]

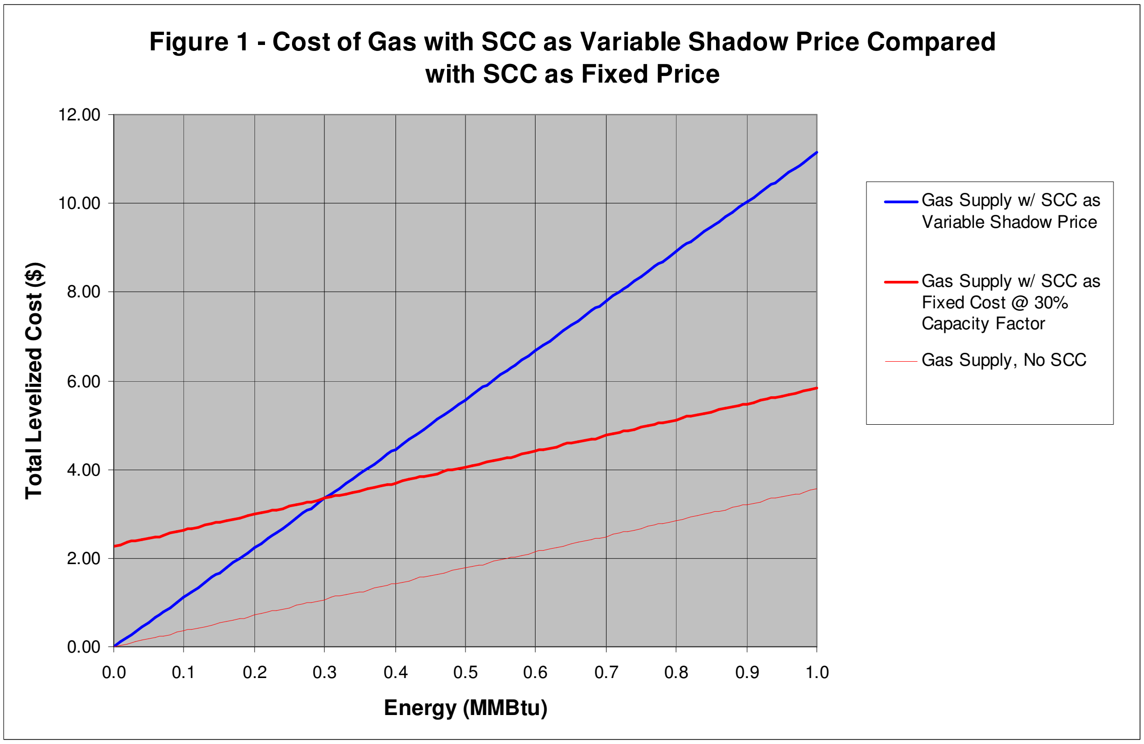
In the section below I address only my concern about treating SCC as a fixed cost. The distortions and inconsistencies created by excluding SCC from dispatch modeling seems self-evident. Doing so is also clearly at odds with Section 14 (3) (a) of CETA.

Consequences of Treating SCC as a Fixed Cost

I present below a series of graphs that explain why treating SCC as a fixed cost will neutralize its impact in determining least-cost portfolios. The graphs are based mostly on assumptions drawn from PSE's own presentations.

Assumption	Source	
Ann. capacity factor for generic gas plant = 30%	Slide 20, 2021 IRP Webinar #5	
Commodity price for gas = \$3.56/MMBtu	Slide 15, TAG Mtg. #8 – 9/19/19	
Social cost of carbon = \$6.30/MMBtu	"	"
Upstream Social cost of carbon = \$1.28/MMBtu	"	"
Total SCC-burdened cost for gas = \$11.14/MMBtu	"	"

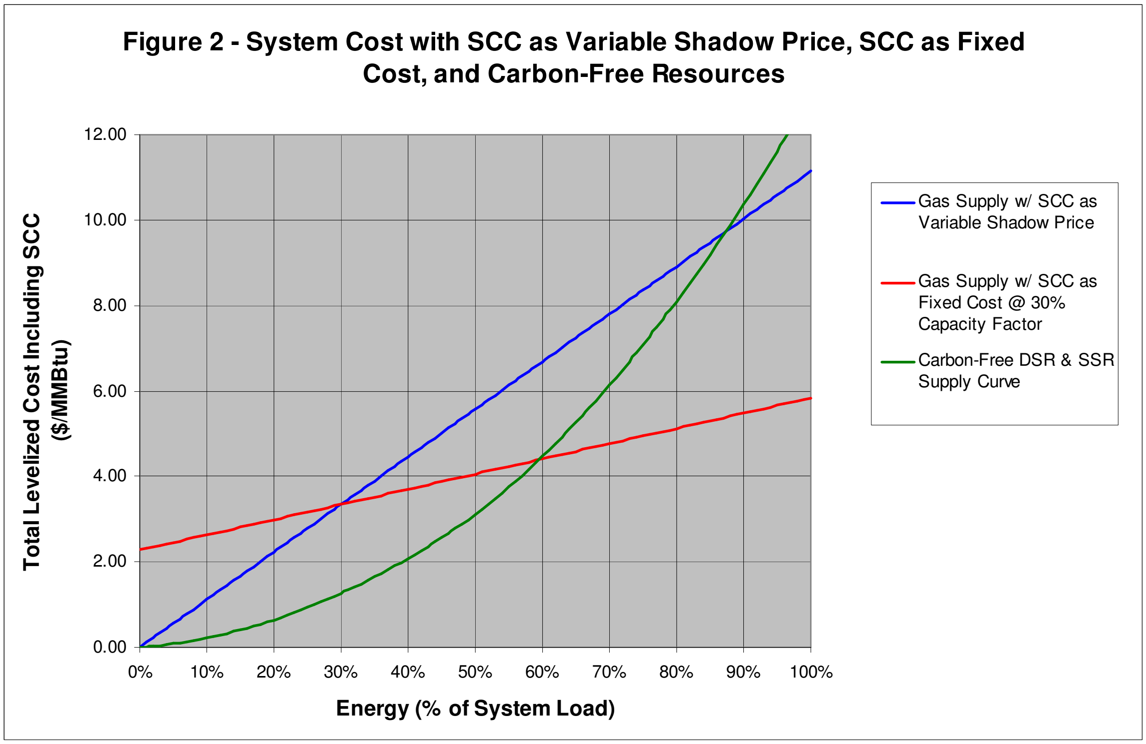
The graphs below illustrate the basic process for selecting optimal collections of resources (or portfolios) using a simple example. In the example, portfolios consist of a generic gas plant resource and some collection of carbon-free demand- and supply-side resources. The purpose of the optimization is to find portfolios that meet 100% of system load at the lowest reasonable cost.



In the graph above [Figure 1], the thin red line at the bottom represents the levelized cost of a fossil gas plants when only the commodity price of the gas is included. The slope of the line reflects its variable cost (or price), $3.56/MMBtu, which is based on PSE's 2019 value. The solid blue line represents the cost of that same gas plant when its cost is fully burdened using the SCC shadow price. The slope of the blue line reflect its variable cost (or price) of $11.14/MMBtu.

PSE's proposed analysis method, referred to on slide 20 (copied in endnote iii), employs an economic dispatch analysis to determine how much the plant will run when exposed to the price of gas fully-burdened with SCC, which resulted in a 30% capacity factor. The social cost of the carbon emissions based on that level of operation is then added as a fixed cost. The result is shown as the thick red line. The blue and red lines intersect at the 30% capacity factor determined by the dispatch model, indicating that their total costs are the same at that point. Notice, however, that the slope of the thick red line remains the same as without SCC, reflecting the fact that SCC is treated only as a fixed cost. The variable cost of the gas plant resource is based solely on its commodity price of $3.56/MMBtu.

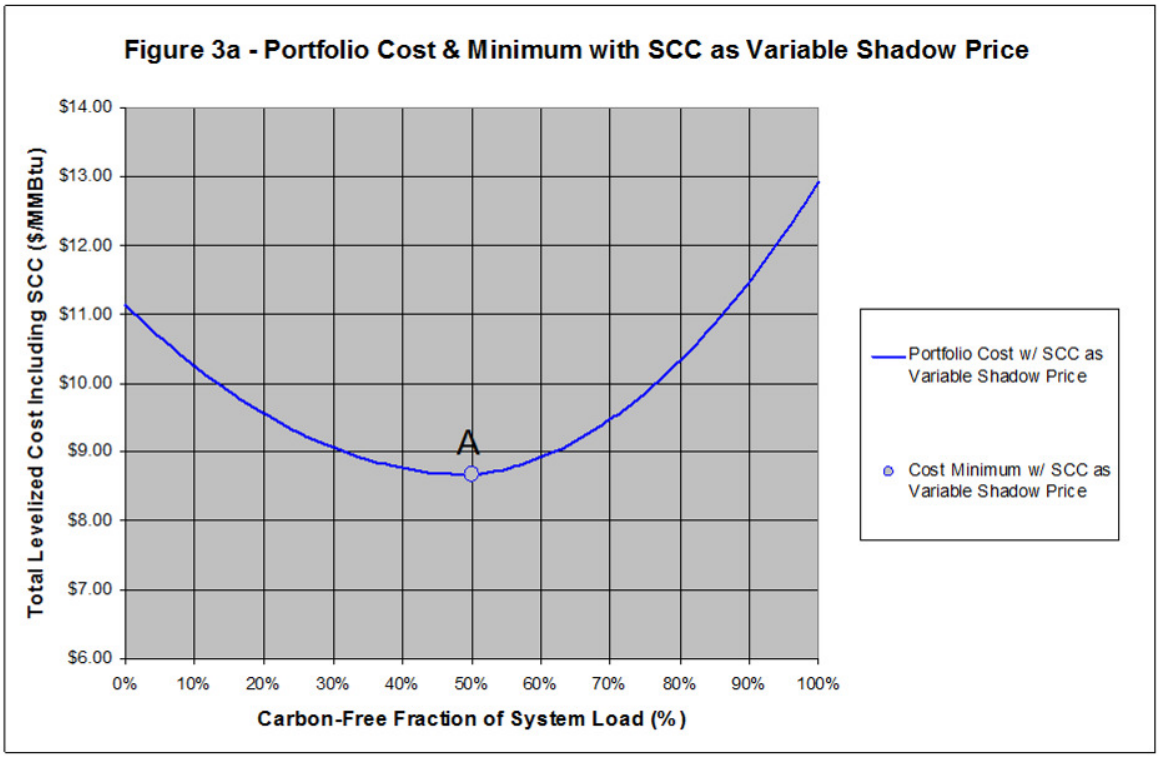
In the graph below [Figure 2], I have add a green line representing a market basket of carbon-free measures that could be deployed to meet system load. The green line is an example of a "supply curve." In this case, it represents a variety of both demand-side and supply-side carbon-free measures along with their attendant levelized costs.



While the green line is hypothetical, any supply curve will exhibit this same concave upward form provided a variety of measures are included and those measures are sorted from the most economically productive to the least.

From these lines, we can determine the mix of gas and carbon-free resources that will lead to the least-cost portfolios under the two competing analysis methods—SCC as fixed cost (red) and SCC as variable cost (blue). Those familiar with such graphs may recognize that the least-cost mix of resources will occur where the slopes of the lines are the same. The least-cost combination of carbon-free resources (green line) and gas supply where SCC is treated as a fixed cost (red line) will occur where their slopes match and carbon-free resources meet about 12% of system load. Where SCC is treated as a variable cost component for gas supply (blue line), the slope of the green line matches the slope of blue line where carbon-free resources meet about 50% of system load.

These cost minimums can be seen more clearly in the graphs below [Figures 3a, 3b, and 3c] where the same underlying data are presented as total portfolio costs (the sum of line pairs from the previous graph). The X-axis has been modified to represent the percent of system load met with carbon-free resources (which involved reversing the gas cost (blue line) scale left to right). Point A represents the least-cost portfolio when SCC is treated as a variable shadow price. As can now be seen easily, the cost minimum occurs at a carbon-free fraction of 50% of system load.



In Figure 3b below, the red line represents the total levelized cost when SCC is treated as a fixed cost assuming a capacity factor of 30%, as in Figure 2. The lowest point on the cost curve occurs at Point B. This identifies the least-cost portfolio using PSE's proposed method. The carbon-free fraction at point B is 12% of system load. The dashed blue line, representing the least-cost portfolio when SCC is treated as a shadow price, is included for comparison.

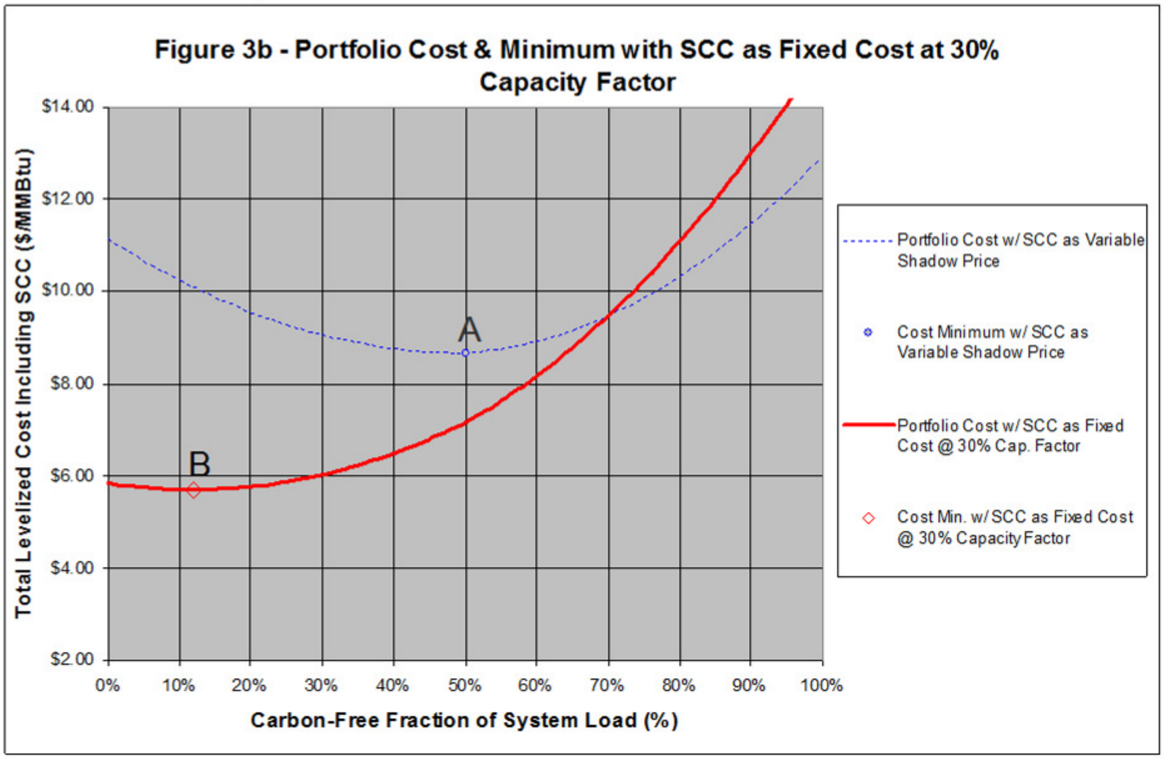
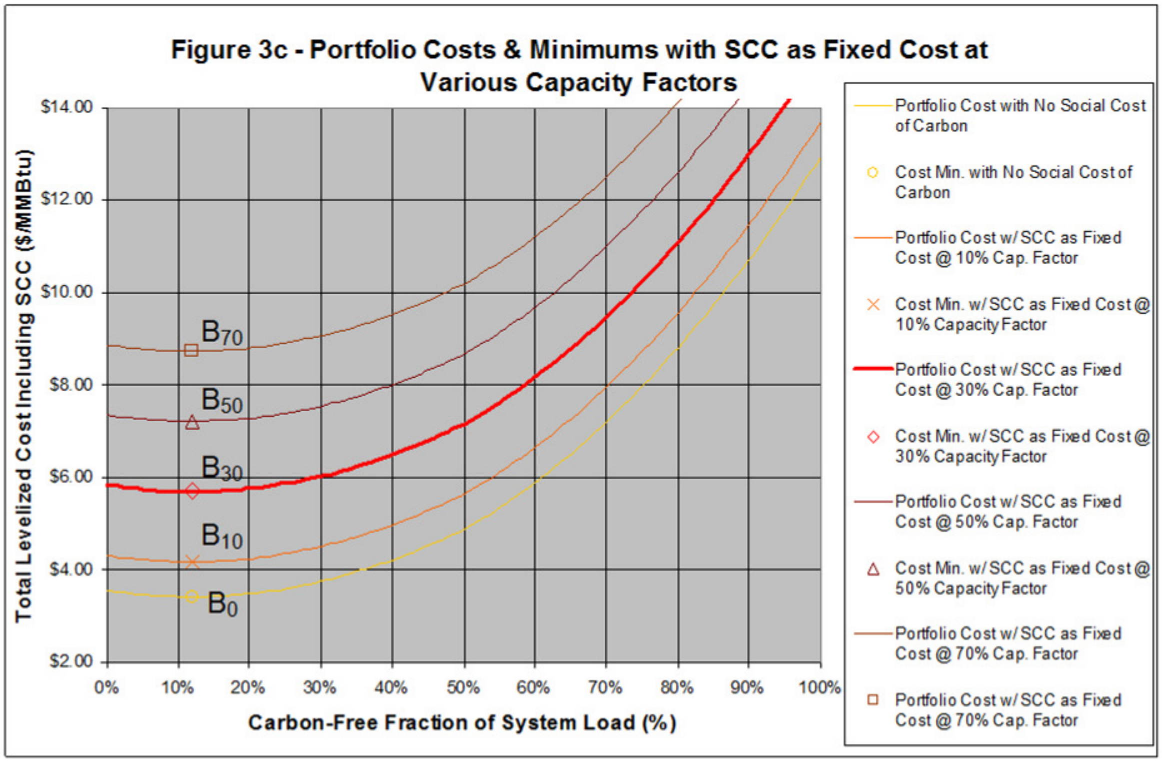


Figure 3b illustrates that treating SCC as a fixed cost leads to a very different outcome than if it is treated as a variable cost. When SCC is treated as a fixed cost, it impacts the apparent total cost of the portfolio, but it has no effect in determining the makeup of the optimal portfolio.

Figure 3c illustrates what happens when we alter capacity-factor assumptions using PSE's fixed-cost approach for implementing SCC. The series of lines represent total levelized cost where SCC is treated as a fixed cost over a range of capacity-factors. In sequence from top to bottom (brown to gold) the lines represent capacity factors of 70%, 50%, 30%, 10%, and 0%. Using zero percent capacity factor produces the same effect as not including the social cost of carbon at all.

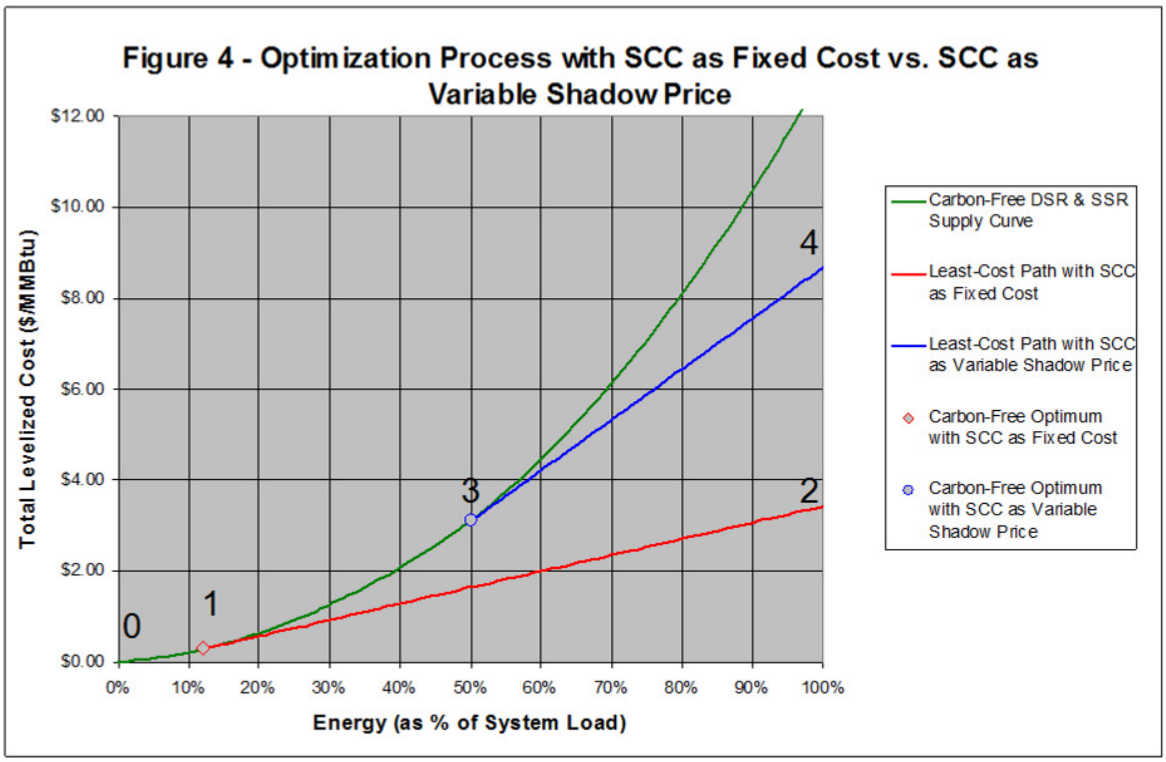


The noteworthy aspect of this family of curves is that, although total costs vary with assumed capacity factor, the cost minimums all occur at the same point on the X-axis, where the fraction of system load met using carbon-free resources is 12%.

This result is not a consequence of the graphical method I have chosen for illustration, but rather is grounded in economic fundamentals. When assessing the economic benefit of an additional increment of a carbon-free measure, if SCC is treated as a fixed cost, it is like adding its SCC benefit to both sides of the equation, nullifying its effect. PSE's proposed analysis method would neutralize (or disable) the impact of SCC in the IRP analysis process. Using PSE's proposed method, you could set the SCC price to $150/tonneCO2e (more than double the current price) and the least-cost portfolio would be unaffected.

Interestingly, PSE admits to the fact that their method for implementing SCC may result in it having no impact on slide 24 from their July 21, 2020 webinar, where they conclude: "With the CETA renewable requirement, the application and the value of social cost of carbon has little to no effect on portfolio resource additions." I don't know anyone who has experience working in the energy space who would contend that you could more than triple the cost of an energy source without affecting how, where, and even if that energy source will be used.

I have included Figure 4 below to provide an explanation of the competing methods for implementing SCC in a simple narrative form. Think of the optimization process as a journey whose purpose is to gather a portfolio of resources to fully meet system load at the lowest reasonable cost. The journey starts at point 0 at the left of the graph, with no resources yet acquired. As you move to the right, you are acquiring resources, and as you move upward you are incurring costs. You seek the lowest (or easiest) feasible path to acquire the needed resources.



Initially, the least expensive path is found by travelling along the green line representing available carbon-free resources. These might include programs that replace incandescent lighting with LEDs or purchase agreements for power from small hydroelectric projects. As the least expensive resources have been acquired, successive acquisitions become increasingly expensive, and the slope of the supply curve steepens. At point 1, you have reached the point at which it would be more expensive to cover additional load with carbon-free resources than to use the gas-plant resource represented by the red line, which reflect on only the commodity price of gas. Therefore, you follow the red line to point 2 at the right, filling the remainder of the portfolio with gas plant(s).

Note that this process of selecting the least-cost portfolio does not depend on the absolute cost of the portfolio, only on selecting the available measure having the lowest variable cost at each opportunity. You could add a large fixed cost to this scenario (as PSE proposes to do to implement SCC). That would change the numbers along the Y-axis scale, but would not effect the slope of the red line, hence the resulting least-cost portfolio would be unchanged.

Now imagine a second journey in Figure 4 under a scenario in which the slope of the gas-plant resource line is much steeper—the blue line. The line now includes the previously unpriced costs of carbon emissions. Under this scenario, you begin acquiring carbon-free resources as before following the green line. But instead of stopping at point 1, you continue along the green line acquiring more carbon-free resources than before. These resources might include additional energy efficiency programs, wind farms, distributed solar, and batteries. Beyond point 3, the lowest-cost path available is provided by the gas plant, so you proceed along the blue line to the right to point 4 covering the remainder of system load using gas plants.

In this hypothetical example, when SCC is used correctly as a variable cost, it leads to a least-cost portfolio containing over four times the quantity of carbon-free resources (50% vs. 12%) while reducing carbon emission by more than 40% (50% vs. 88%), when compared with PSE's proposed fixed-cost method.

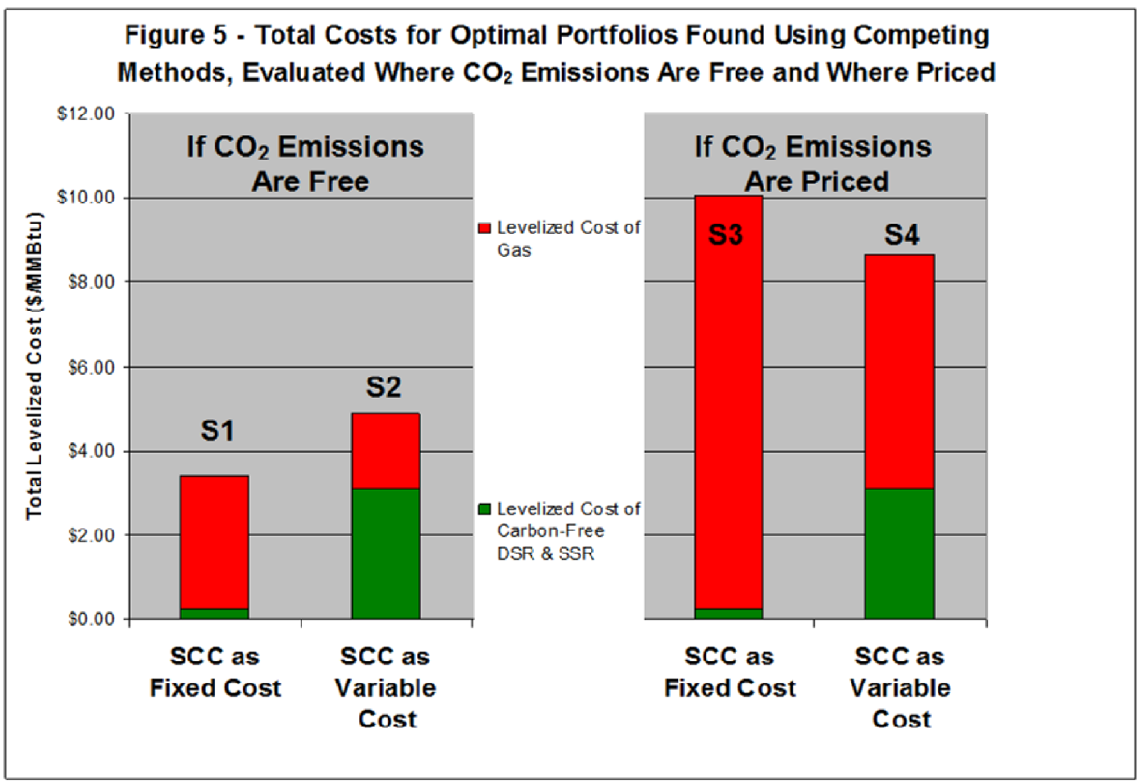


Figure 5 compares the total costs associated with the least-cost portfolios from my hypothetical example. Adjacent vertical bars represent results when the two competing methods of implementing SCC are used. The two bars on the left show the results of the two methods in a world in which carbon emissions are assumed to impose no cost on society. I have labeled these

S1 and S2 for Scenario 1 and Scenario 2. One can understand these as the result you would get if you used the two methods and evaluated them in a world in which you did not care about climate impacts. Scenario 3 (S3) and Scenario 4 (S4) shows the results you get using the same two methods when you evaluate their results in a world in which you do value those climate impacts and have implemented effective policy (i.e., CETA) to mitigate their costs. CETA compels us to operate in the world on the right.

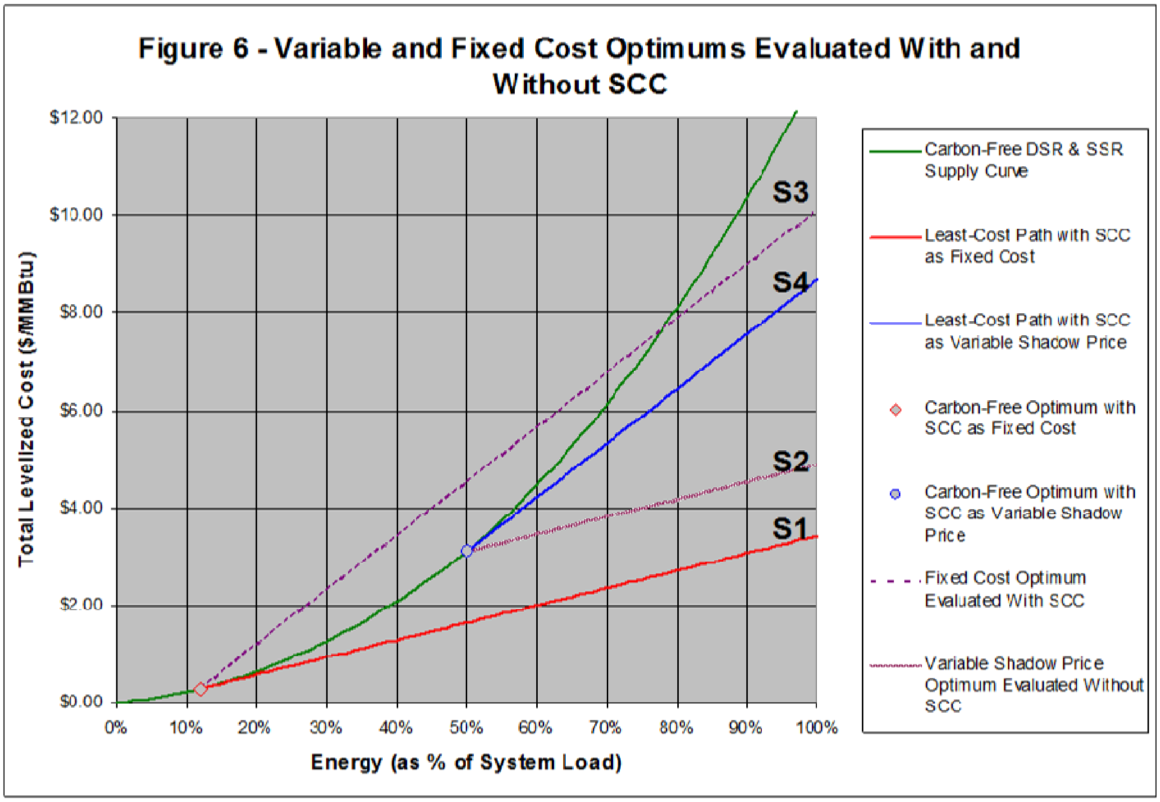


Figure 6 shows the same four scenarios as Figure 5 using the journey narrative presented in Figure 4. I will explain the additional lines using Scenario 3. You follow the green line from the graphs origin until you have covered 12% of system load. At that point, because you have treated SCC as a fixed cost, you conclude that no additional carbon-free resources are cheaper than gas resources, as reflected by the red line. You fill the remainder of the portfolio with the gas plant resource. But because you are operating in a scenario in which carbon emissions are actually valued at the social cost of carbon, you end up at point S3, with a cost for the portfolio of $10.09/MMBtu. This would be a suboptimal outcome. The green path to 50% carbon-free resources followed by the blue path to point S4, has a significantly lower total portfolio cost of $8.67/MMBtu.

I believe CETA compels PSE to do its planning and acquisition analyses in a world that acknowledges the very real costs of carbon emissions. In that world, use of a fixed-cost SCC methodology would lead to portfolios that significantly under-utilize carbon-free resources and impose far higher costs on society than a method that correctly implements SCC as a variable cost.

Conclusion

The conceptual justification for PSE's proposed method for implementing SCC is not so much weak or flawed as it is nonexistent. PSE has supported the case for using their fixed-cost SCC methodology, using specious reasoning and illogical inferences (see endnote iii). In addition, one can readily demonstrate, as I have done, that using the methodology will lead to SCC having no effect on the least-cost portfolios, hence no effect on the planning process. It is not plausible to believe that the Washington Legislature mandated use of SCC but intended it to be implemented in a way that ensures it has no impact.

PSE should simply abandon all further use of this bogus methodology. The UTC should make it clear through rulemaking and through its other determinations that treating SCC as a fixed cost would not be compliant with legal mandates under CETA and other regulations, such as RCW 19.280.020.

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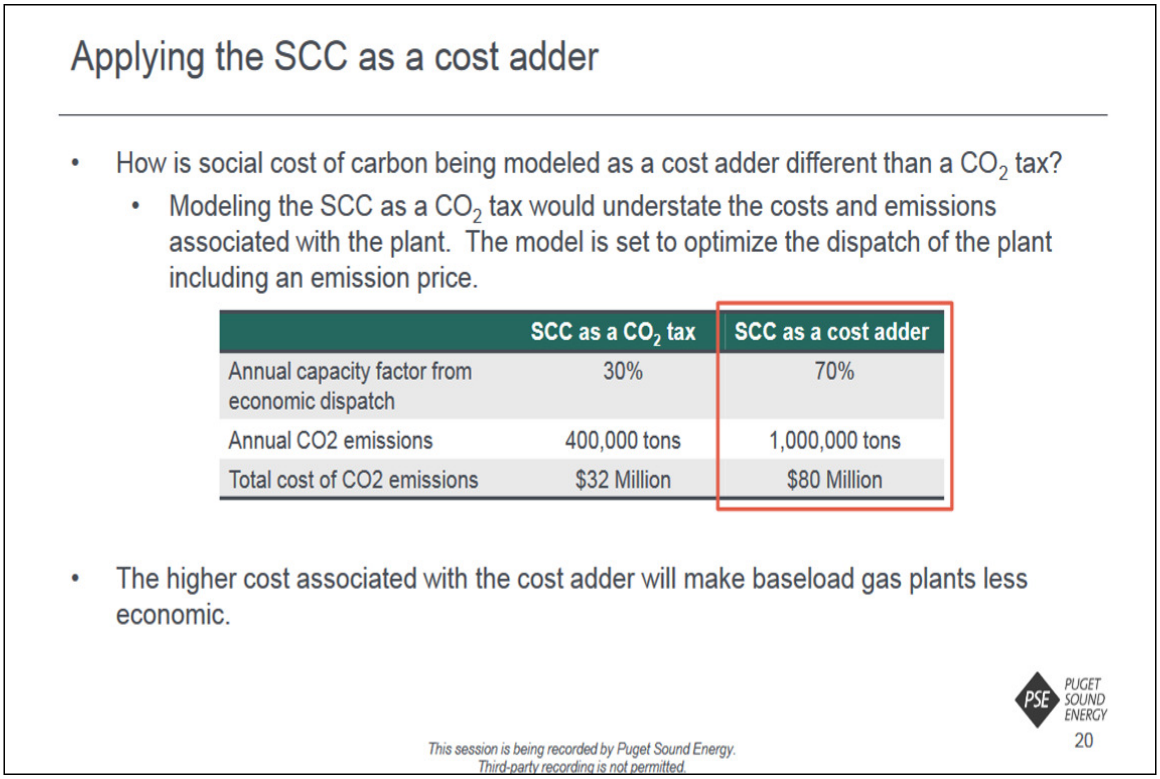
[i] The following figures were presented to the PSE's 2019 IRP Technical Advisory Group at the September 19, 2019 TAG #8 meeting:

Price of fossil methane =	$3.56 / MMBtu	
Social Cost of Carbon =	$6.30	"
SCC upstream adder =	$1.28	"
TOTAL =	$11.14	"

[ii] Section 14 (3) (a) of CETA reads, "An electric utility shall consider the social cost of greenhouse gas emissions, as determined by the commission for investor-owned utilities pursuant to section15 of this act and the department for consumer-owned utilities, when developing integrated resource plans and clean energy action plans. An electric utility must incorporate the social cost of greenhouse gas emissions as a cost adder when:

(i) Evaluating and selecting conservation policies, programs, and targets;
(ii) Developing integrated resource plans and clean energy action plans; and
(iii) Evaluating and selecting intermediate term and long-term resource options."

[iii] Two bulleted sentences from slide 20 from Webinar #5 (below) contain faulty inferences and specious reasoning.



I show corrections to PSE's two erroneous statements on slide 20 with strikeouts and insertions below:

- Modeling the SCC as a CO_2 tax would understate the costs and emissions associated with the plant.

- Modeling the SCC as a ~~CO2 tax~~variable cost would ~~understate~~lower the costs and emissions associated with the plant.

Modeling SCC as a variable cost will cause the least-cost portfolio, on which the IRP is based, to have lower emissions and hence lower costs. This is not "understating costs and emissions." It is a correct assessment of the performance attributes of the least-cost portfolio—the very evidence that the planning and resource acquisition process is compelled to use to select cleaner, lower-cost resources.

- The higher cost associated with the cost adder will make baseload gas plants less economic.

- The higher cost associated with the ~~cost adder will make baseload~~ portfolio that results from treating SCC as a fixed cost reflects the fact that gas plants are less economic when SCC is included.

The higher costs associated with the gas plant dispatching 70% of the time is not due to the fixed-cost SCC method PSE proposes to use, but rather to the fact that 70% dispatch of the plant is uneconomic. The statement confuses the method for evaluating the option with the option itself. The optimizations are run to determine the least-cost portfolio. The bulleted statement makes it sound as though the total cost of CO2 emissions drives the portfolio selections. That is misleading.

A logical inference from slide 20 would be that if you dispatch a gas plant using a price that is fully laden with SCC you will see far less operation, lower emissions, and lower unpriced emission costs (i.e., SCC) than if you dispatch based on the commodity price alone, which is, in effect, what happens when you treat SCC as a fixed cost.

There may be an issue that arises as a result of mandating use of SCC in planning and resource acquisitions while not mandated its use in real-world operations. It may be worth examining whether this disparity results in suboptimal outcomes with practical significance, or whether the issue is just theoretical. But my understanding of CETA suggest that issue lies outside of the scope of CETA rulemaking.