

Rebuttal Testimony  
Anne E. Smith, Ph.D.

Before the Office of Administrative Hearings  
600 North Robert Street  
St. Paul, MN 55101

For the Minnesota Public Utilities Commission  
121 Seventh Place East, Suite 350  
St. Paul, MN 55101

In the Matter of the Further Investigation into Environmental and Socioeconomic Costs  
Under Minnesota Statute § 216B.2422, Subdivision 3

MPUC Docket No. E-999/CI-14-643  
OAH Docket No. 80-2500-31888

Exhibit \_\_\_\_\_ (AES-R)

**Rebuttal Testimony of Anne Smith**  
**On Behalf of Great River Energy**  
**Minnesota Power, Otter Tail Power Company,**  
**And the Minnesota Large Industrial Group**

Carbon Dioxide

August 12, 2015

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6

1 **I. INTRODUCTION**

2 Q. PLEASE STATE YOUR NAME.

3 A. Dr. Anne Smith.

4

5 Q. ARE YOU THE SAME DR. SMITH WHO PREVIOUSLY SUBMITTED  
6 TESTIMONY IN THIS PROCEEDING ON BEHALF OF GREAT RIVER  
7 ENERGY, MINNESOTA POWER, OTTER TAIL POWER COMPANY, AND THE  
8 MINNESOTA LARGE INDUSTRIAL GROUP?

9 A. Yes.

10

11 **II. RESPONSE TO MR. MARTIN**

12 Q. HAVE YOU REVIEWED THE PRE-FILED DIRECT TESTIMONY OF NICHOLAS  
13 F. MARTIN OF XCEL ENERGY?

14 A. Yes, I have.

15

16 Q. HAVE YOU EVALUATED THE STATISTICAL METHOD USED BY MR. MARTIN  
17 TO RE-ANALYZE THE OUTPUT OF THE INTERAGENCY WORKING  
18 GROUP'S MODELING?

19 A. Yes, I have. Mr. Martin describes the range of environmental cost values  
20 resulting from the model runs of the Integrated Assessment Models ("IAMs")  
21 performed by the IWG when it was determining its Social Cost of Carbon  
22 ("SCC"). The IWG averaged the outputs for each of the three discount rate  
23 assumptions that it chose. Mr. Martin, however, suggests that instead of

1 averaging the results, that the environmental cost value instead should be based  
2 upon choosing a narrower range from this broad set of output values. His  
3 approach equally weights the outputs from IAM model runs using each of the  
4 three discount rates used by the IWG.

5  
6 Q. WHAT IS YOUR OPINION OF THAT METHODOLOGY?

7 A. Mr. Martin's analysis generally provides information about the very wide range of  
8 environmental cost values that lie beneath the three individual average SCC  
9 values that the IWG provides for each of the three discount rate assumptions that  
10 the IWG chose. However, there is no foundation in statistical theory or decision  
11 theory, nor any objective principle, to support the way a narrower range from that  
12 very wide range is then chosen to recommend for use in Minnesota. Lacking  
13 such an objective principle, the same data could be used to identify narrower and  
14 lower SCC ranges that have the same probability of being accurate as the range  
15 recommended in the testimony; and the same data could be used to identify  
16 wider and higher SCC ranges that have the same probability of being accurate.  
17 For that reason, the suggested approach is inherently subjective. More  
18 problematically, Mr. Martin's approach unquestioningly adopts every one of the  
19 IWG's subjective framing decisions despite the criticism of those assumptions on  
20 pages 3:1-4:3, 4:22-7:4, and 11:5-14:9 of his pre-filed direct testimony, and then  
21 injects one more very strong -- but unstated -- subjective assumption of his own,  
22 which is that the discount rates of 2.5%, 3%, and 5% should be given equal  
23 probability of being the "correct" value. The IWG at least recognized that SCC

1 estimates based on different discount rates should be reported separately,  
2 leaving SCC users the ability to decide for themselves which of the three  
3 discount rates to emphasize for their decision-making purposes. Furthermore,  
4 even if all of the other subjective assumptions that Mr. Martin applied were to be  
5 repeated, but the discount rate of 2.5% were to be given zero weight so as to  
6 eliminate the discount rate which does not have an empirical basis, his approach  
7 would produce a lower recommended range for SCC values.

8  
9 Q. IN YOUR OPINION, DOES THE METHODOLOGY PRESENTED BY MR.  
10 MARTIN REASONABLY SATISFY THE CRITERIA FOR DETERMINING  
11 ENVIRONMENTAL COST VALUES FOR CO<sub>2</sub> PRESENTED ON LINES 12 TO  
12 20 OF PAGE 2 OF HIS TESTIMONY?

13 A. No, it does not satisfy the majority of the eight criteria listed in Mr. Martin's  
14 testimony at page 2:12-20 for determining environmental cost values for CO<sub>2</sub>. I  
15 will address each one in turn.

16  
17 The first criterion listed is that one should "use a damage cost approach to  
18 valuing environmental costs." I agree his approach is founded, in a very broad  
19 sense, on a damage cost approach. However, as I have explained in my direct  
20 testimony, the integrated assessment models that are being used to calculate  
21 SCC estimates contain highly aggregated damage functions that are not fully  
22 consistent with the standard notion of the damage cost approach, and it is this  
23 aggregated approach that lacks evidentiary basis. I also note on page 33 of my

1 June 1, 2015, pre-filed direct testimony that the difficulty with establishing a  
2 sound evidentiary basis when limited to these types of models suggests that a  
3 damage cost approach may not be the best approach for Minnesota to set a CO<sub>2</sub>  
4 environmental cost value. Thus, I would suggest that this criterion, while being  
5 met in principle by Mr. Martin's approach, may not be a criterion that the  
6 Commission should retain.

7  
8 The second criterion advanced by Mr. Martin is that the approach to determine  
9 environmental cost values for CO<sub>2</sub> should "reasonably address the inherent  
10 uncertainty in estimating climate change damages over almost 300 years." This  
11 is not met by Mr. Martin's approach. As I have explained in my direct testimony,  
12 the IWG's framing approach does not reasonably address the inherent  
13 uncertainties of estimating societal values over 300 years and relies on fixed  
14 assumptions about societal values that are highly speculative. Because Mr.  
15 Martin's approach uses only the IWG's estimates, it inherently also fails this  
16 criterion.

17  
18 Mr. Martin's third criterion is that the approach to determine environmental cost  
19 values for CO<sub>2</sub> "reflect the absence of consensus on discount rate choice." This  
20 criterion is not met by Mr. Martin's approach. As I have explained above, Mr.  
21 Martin actually makes a strong assumption on the discount rates, which is to not  
22 only adopt the exact range of values that the IWG considered in its analyses, but  
23 then to assign equal weight to each of the three values. The IWG at least

1 provided potential users of their SCC estimates information about how the SCC  
2 value differs depending on what discount rate the user may wish to choose, or  
3 emphasize (albeit limited to the range between 2.5% and 5%). Mr. Martin's  
4 approach has removed that flexibility from potential users of his recommended  
5 range, and has replaced it with his own personal judgment on this matter, without  
6 any objective basis for that choice.

7  
8 The fourth criterion is that the approach to determine environmental cost values  
9 for CO<sub>2</sub> should "use statistically sound methods." This criterion also is not met by  
10 Mr. Martin's approach. As I have already stated, there is no foundation in  
11 statistical theory or decision theory to support the way a narrower range was  
12 chosen from that very wide range of IWG estimates to be the range  
13 recommended for use in the policy/decision context that Minnesota faces. The  
14 method that the IWG used was to report the mean (or "average") over the range.  
15 The IWG's approach is at least founded in standard statistical theory. Statistical  
16 and decision theories also indicate that using only a mean value may not always  
17 be appropriate, depending on the decision context and on the nature of the  
18 underlying probability distribution. Mr. Martin's testimony starts from this latter  
19 concern; however, Mr. Martin does not offer an alternative approach that has any  
20 particular theoretical properties that could be used to claim that it is "sound," or  
21 even "*more* sound" than using a range of the mean values over a range of  
22 alternative (subjective) discount rate assumptions, as presented in the IWG  
23 report. The lack of any sound statistical underpinning to the suggested method is

1 evidenced by the fact that the same data could be used to identify narrower and  
2 lower SCC ranges that have the same probability as the suggested range; and  
3 they could be used to identify wider and higher SCC ranges that have the same  
4 probability as Mr. Martin's range.

5  
6 The fifth criterion is that the selected range for the environmental cost values for  
7 CO<sub>2</sub> should "reflect an appropriate level of risk tolerance." This criterion is not  
8 met either. First, the term "risk tolerance" is not being used in the manner that it  
9 is used in decision theory. Setting questions of terminology aside, the second  
10 problem is the assumption that the set of assumptions used by the IWG fully  
11 reflect the true range of uncertainty on how to assess an SCC, so that by simply  
12 plotting out the full distribution of IWG-specific estimates, one can claim to have  
13 plotted out the probability distribution on the actual SCC value. As the analysis in  
14 the expert report accompanying my direct testimony demonstrates, reasonable  
15 alternative assumptions to those of the IWG produce very different mean  
16 estimates, and hence very different underlying distributions of estimates than that  
17 of the IWG. Thus, there is no objective principle with which one can estimate the  
18 probability that the "true" value of the SCC will lie within any particular range that  
19 may be selected from the distribution of estimates that the IWG calculated. The  
20 reality here is that all SCC estimates are highly subjective, as they depend  
21 almost entirely on the framing assumptions. Different framing assumptions may  
22 be appropriate in different decision/policy contexts. There is no role for the  
23 classical statistical concept of probabilistic confidence in the "true" value of an



1 estimate that, like the SCC, is inherently determined by subjective framing  
2 choices. The correct way to manage subjective uncertainty in decision-making is  
3 to study the framing assumption options, choose appropriate ones for the  
4 decision context, and develop a distribution of estimates consistent with those  
5 choices. That is the approach I took in my direct testimony to recommend a  
6 range of environmental cost values consistent with Minnesota law.

7  
8 Mr. Martin's sixth criterion is that the approach selected to determine the  
9 environmental cost values for CO<sub>2</sub> "minimize subjective judgments." This  
10 criterion is not met in the slightest aspect. The first step in Mr. Martin's analysis,  
11 to use only SCC values estimated with IWG framing assumptions, imposes all of  
12 the subjective judgments of the IWG that I have described in my direct testimony.  
13 The second step, which did not have to be taken, was to impose the very strong  
14 subjective assumption that not only should the discount rate range considered by  
15 the IWG be adopted, but also that there is a 33% probability that the discount  
16 rate of 2.5% is "correct", a 33% probability for the 3% rate, and a 33% probability  
17 for the 5% rate. Even the IWG found that assigning probabilities to choices of  
18 discount rates was excessively subjective, and avoided doing so. In reality, this  
19 sixth criterion is completely infeasible to impose.

20  
21 The seventh criterion is that the approach to determine the environmental cost  
22 values for CO<sub>2</sub> "yield a practicable range." I do not believe this criterion is being  
23 met. In my opinion, this interpretation of the term "practicable" is not consistent

1 with the way I have seen it used in the prior record for environmental cost values.  
2 Mr. Martin seems to define “practicable” as a range of values that will lead to  
3 integrated resource planning analyses that do not leave the decision entirely  
4 dependent on which end of the range is assumed. But Mr. Martin’s review of the  
5 IWG data shows that this cannot be achieved without choosing a narrower part of  
6 the entire range – otherwise values from less than \$0 per ton to over \$900 per  
7 ton would be the result. Faced with this fact, an *ad hoc* approach was used to  
8 come up with a range that suits a particular concept of “narrow enough” and it is  
9 claimed that it is wide enough to meet an unspecified degree of “risk tolerance.”  
10 Whether this criterion is met is in the eye of the beholder. Other parties might  
11 have a different sense of how narrow is “practicable,” and how much of the full  
12 range *of the IWG’s estimates* they are prepared to ignore in order to get a  
13 sufficiently narrow range (which those advocating for the approach suggested in  
14 Mr. Martin’s testimony would inappropriately call their “risk tolerance”).  
15 Evaluation of Mr. Martin’s definition of “practicable” and how his recommendation  
16 has been developed with that goal in mind reveals that his approach lacks  
17 guiding principles for how to incorporate the objectives and values of the  
18 Commission in implementing the Minnesota law. The approach presented in Mr.  
19 Martin’s testimony is a formula for reflecting a certain set of objectives and  
20 values. In the hands of another analyst with different objectives and values,  
21 totally different ranges would be recommended.

22

1 Mr. Martin's eighth, and final, criterion is that the approach to determine  
2 environmental cost values for CO<sub>2</sub> should "be transparent, replicable, and  
3 updatable." I disagree that the approach in question could be described as  
4 "transparent" because of its many unacknowledged embedded subjective  
5 assumptions. It is certainly replicable and updatable, but so too are estimates  
6 based on alternative sets of framing assumptions such as I have recommended.  
7

8 Q. IN YOUR OPINION, DOES THE METHODOLOGY PRESENTED BY MR.  
9 MARTIN TO DETERMINE ENVIRONMENTAL COST VALUES FOR CO<sub>2</sub>  
10 ADDRESS ANY OF THE DEFICIENCIES WITH THE IWG'S SOCIAL COST OF  
11 CARBON YOU IDENTIFIED IN YOUR DIRECT TESTIMONY AND THOSE  
12 IDENTIFIED BY MR. MARTIN HIMSELF IN HIS REPORT?

13 A. No, it does not. As my direct testimony and expert report explain, there are  
14 alternative framing assumptions that the IWG did not even analyze, but which I  
15 conclude are more consistent with the criteria in the record for this proceeding.  
16 Thus, the major flaw in Mr. Martin's approach is that he has not explored the role  
17 or appropriateness of any of those many subjective and speculative assumptions  
18 in the IWG's SCC calculation. Because he has simply adopted the IWG's  
19 assumptions despite his own criticisms, and then added an assumption that even  
20 the IWG recognized was too subjective to hide in a single average SCC value  
21 estimate, it should be no surprise that Mr. Martin's recommended range is very  
22 similar to the range of average SCC estimates that the IWG recommended.  
23

1 My analysis used the same models that the IWG used but with various  
2 combinations of framing assumptions that are more consistent with Minnesota's  
3 criteria. Those alternative framing assumptions produce much lower average  
4 SCC estimates than the IWG's when I follow the IWG's method of using a  
5 statistical mean to summarize each set of 150,000 SCC estimates. Similarly, if I  
6 were to combine and graph all of the hundreds of thousands of SCC estimates  
7 generated in my own analyses -- as Mr. Martin did using the IWG's data -- one  
8 would see that the alternative framing assumptions that I applied produce a  
9 probability distribution that is concentrated at much lower SCC values, and does  
10 not extend to the same high values as the probability distribution in Mr. Martin's  
11 testimony.

12  
13 Q. IN YOUR OPINION, IS THE PROPOSED RANGE OF ENVIRONMENTAL COST  
14 VALUES PRESENTED BY MR. MARTIN BETTER SUPPORTED BY THE  
15 EVIDENCE THAN THE RANGE OF VALUES YOU RECOMMENDED IN YOUR  
16 DIRECT TESTIMONY?

17 A. No. As I have explained above, the proposed range of environmental cost  
18 values presented in the Martin testimony is based entirely on the IWG's framing  
19 assumptions, with the added assumptions of a 33% probability to a discount rate  
20 of 2.5% per year, a 33% probability to a discount rate of 3% per year, and a 33%  
21 probability to a discount rate of 5% per year. In my direct testimony, I have  
22 provided reasons why many of those assumptions, which are also inherent in Mr.  
23 Martin's analysis, lack evidentiary basis and lead to excessive speculative

1 content in the resulting SCC estimates. Mr. Martin also expresses concerns with  
2 the SCC's underlying assumptions, at pages 5:15-6:1 of his direct testimony. His  
3 decision to nonetheless apply his own subjective judgments as part of a proposal  
4 to take a subset of the IWG-specific estimates to arrive at a proposed range of  
5 environmental cost values for carbon dioxide is inexplicable. In my direct  
6 testimony, I have also recommended ranges of alternative framing assumptions  
7 that are more consistent with the criteria that I understand Minnesota to have  
8 applied in past proceedings on environmental cost values and which produce  
9 SCC estimates that rely less on assumptions lacking in evidentiary basis. Thus, I  
10 conclude the proposed range that Mr. Martin has presented is not better  
11 supported by the evidence than the range of values that I recommended in my  
12 direct testimony.

13

14 **III. CLIMATE SENSITIVITY VALUE AND OPTIMAL TEMPERATURE CHANGE**

15 Q. HAVE YOU REVIEWED THE PRE-FILED DIRECT TESTIMONY OF  
16 PROFESSOR ROY SPENCER, PROFESSOR WILLIAM HAPPER, AND  
17 PROFESSOR RICHARD LINDZEN?

18 A. Yes.

19

20 Q. ARE YOU OFFERING AN OPINION REGARDING THE EQUILIBRIUM  
21 CLIMATE SENSITIVITY VALUES RECOMMENDED BY PROFESSORS  
22 SPENCER, HAPPER, AND LINDZEN?

23 A. No. I am not taking a position regarding the equilibrium climate sensitivity value.

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Q. HAVE YOU PERFORMED ANY ANALYSIS USING EQUILIBRIUM CLIMATE SENSITIVITY VALUES RECOMMENDED BY PROFESSORS SPENCER, HAPPER, OR LINDZEN?

A. Yes, together with my colleagues at NERA, I performed a sensitivity analysis using the DICE model in order to obtain insight on the impact of a lower equilibrium climate sensitivity value on the social cost of carbon. We used the same version of the DICE model as was used by the IWG and in the work presented in my prior testimony and report (i.e., "DICE 2010"). For this additional sensitivity analysis, we first fixed the value of the equilibrium climate sensitivity in the DICE model at a fixed value of 3 rather than using the probability distribution used in the IWG's modeling. I used 3 because it is the 50<sup>th</sup> percentile value of the IWG's probability distribution. By starting with this step, I could isolate the effect of removing the probabilistic aspect of the IWG's equilibrium climate sensitivity analysis without altering its assumption about its mid-point value. We then estimated the SCC again after setting the equilibrium climate sensitivity to a fixed value of 1.5, which is more consistent with values recommended in the pre-filed testimonies of the above-named witnesses.

Q. DID YOU MAKE ANY CHANGES TO THE DICE MODEL OTHER THAN FIXING THE EQUILIBRIUM CLIMATE SENSITIVITY VALUE?

A. No. Other than fixing the equilibrium climate sensitivity value at 3 and 1.5, respectively, the DICE model was run using the same inputs and assumptions as

1 those used by the IWG. I did this sensitivity analysis for the IWG socioeconomic  
2 scenario labelled "IMAGE." Because all SCC results are so sensitive to the  
3 choice of discount rate, I did the sensitivity analysis using both 3% and 5%  
4 discount rates.

5  
6 Q. WHAT WERE THE RESULTS OF THIS ADDITIONAL SENSITIVITY  
7 ANALYSIS?

8 A. The results are set forth in the table below. For each row, I identify the specific  
9 changes I made from the IWG's own analysis using the DICE 2010 model and  
10 the IWG's socioeconomic scenario labelled "IMAGE." These are SCC values for  
11 emissions in the year 2020, and are stated in 2007\$, which is the dollar-year  
12 used in the IWG's reports. (To convert to 2014\$, multiply the values below by  
13 1.11.) As can be seen from the table, an equilibrium climate sensitivity value of  
14 1.5 produces SCC estimates that are 60 percent to 65 percent lower than the  
15 IWG's estimates, depending on the discount rate. As can also be seen from the  
16 table, only a small portion of this reduction is due to having used a fixed rather  
17 than probabilistic assumption on the parameter's value.

18  
19

1 Table 1. Sensitivity of 2020 SCC Estimates Using DICE 2010 and the IMAGE  
 2 Socioeconomic Scenario (\$/tonne CO<sub>2</sub>, 2007\$)

	3% discount rate	5% discount rate
No changes from IWG assumptions (i.e., replicating IWG's result for IMAGE scenario)	\$48	\$15
Using fixed value of equilibrium climate sensitivity = 3 (i.e., median value of IWG's probability distribution)	\$43	\$14
Using fixed value of equilibrium climate sensitivity = 1.5	\$17	\$6

3  
 4 Q. WHY DID YOU USE THE "IMAGE" SOCIOECONOMIC SCENARIO FOR THIS  
 5 SENSITIVITY ANALYSIS?

6 A. The IWG averaged five different socioeconomic scenarios together to produce its  
 7 SCC estimates. For simplicity, I decided to run just one of those scenarios to  
 8 explore the sensitivity of SCC results to the equilibrium climate sensitivity  
 9 parameter. I chose the IMAGE scenario because it produces the highest SCC  
 10 value of all five of the IWG's scenarios. One can reasonably expect a similarly  
 11 large percentage reduction in the SCC estimates using other socioeconomic  
 12 scenarios when changing the equilibrium climate sensitivity assumption to 1.5.  
 13 However, their resulting dollar per ton values will be lower than the \$6 to \$17 per  
 14 ton that is derived using just the IMAGE scenario because they start at lower  
 15 values when using the IWG's assumed probability distribution on the climate  
 16 sensitivity parameter. (The SCC values produced by DICE using the other four



1 socioeconomic scenarios range from \$28 to \$40 per ton for a 3% discount rate,  
2 compared to \$48 per ton in the IMAGE case. The SCC values produced by  
3 DICE using the other four socioeconomic scenarios range from \$10 to \$13 per  
4 ton for a 5% discount rate, compared to \$15 per ton in the IMAGE case.)

5  
6 Q. ARE YOU RECOMMENDING THAT THE COMMISSION ADOPT THE VALUES  
7 ABOVE OR USE A SPECIFIC EQUILIBRIUM CLIMATE SENSITIVITY VALUE?

8 A. No, I am not making any recommendation regarding the equilibrium climate  
9 sensitivity value.

10  
11 Q. HAVE YOU REVIEWED THE PRE-FILED DIRECT TESTIMONY OF  
12 PROFESSOR ROBERT MENDELSON?

13 A. Yes. Professor Mendelsohn ran another version of the DICE model (called  
14 "DICE2013") using DICE's own internal discount rates (starting at 5% today, and  
15 falling to 2.7% in 2200), the model's optimized forecast of emissions and GDP,  
16 an equilibrium climate sensitivity of 3, and thresholds in the damage function of  
17 1.5 degrees centigrade and 2.0 degrees centigrade (1.5°C and 2°C) . (A damage  
18 function with a threshold is one that predicts zero damage in any year in which  
19 the projected temperature change relative to the 1990 level is less than the  
20 assumed threshold value. Professor Mendelsohn adapted the DICE2013  
21 model's damage function to have such a threshold parameter, describing it in  
22 pages 8:24- 9:25 of his pre-filed direct testimony as the "optimal" amount of  
23 temperature change relative to what happened to occur in 1900.) Based on this

1 analysis, Professor Mendelsohn obtained an estimate of the social cost of carbon  
2 of between \$4 and \$6 per ton of CO<sub>2</sub> emitted in the year 2015, where \$4 per ton  
3 is associated with the 2.0°C threshold assumption and \$6 per ton is associated  
4 with the 1.5°C threshold assumption. Accordingly, Professor Mendelsohn  
5 adopted an estimate for the SCC in 2015 of between \$4 and \$6 per ton.  
6 Professor Mendelsohn also ran the DICE model with these two threshold levels  
7 combined with a climate sensitivity of 1.5 instead of 3, which yielded a result  
8 between \$0.30 and \$0.80 per ton.

9  
10 Q. CAN YOU COMPARE THE RESULTS OF YOUR SENSITIVITY ANALYSIS ON  
11 THE EQUILIBRIUM CLIMATE SENSITIVITY TO THE RESULTS REPORTED  
12 BY PROFESSOR MENDELSONH?

13 A. Professor Mendelsohn's sensitivity analysis for the effect of a lower equilibrium  
14 climate sensitivity, which is provided in Table 2 of Exhibit 2 of his testimony,  
15 starts from his own SCC estimates, not from the IWG's estimates. His own SCC  
16 estimates are \$4 to \$6 per ton for emissions in 2015. His analysis also shows  
17 that changing the equilibrium climate sensitivity from 3 down to 1.5 produces a  
18 very large percentage reduction in the SCC estimate. For example, against his  
19 model's SCC estimate of \$4 to \$6 per ton when using the equilibrium climate  
20 sensitivity of 3, the value falls to \$0.30 to \$0.80 per ton, respectively, when  
21 instead using an equilibrium climate sensitivity of 1.5. My own DICE runs, which  
22 use the IWG's version of DICE, demonstrate that the high sensitivity of SCC  
23 estimates to an equilibrium climate sensitivity of 1.5 also can be expected in the

1 IWG's SCC estimates and is thus not attributable to the various other differences  
2 between Professor Mendelsohn's modeling and that of the IWG.

3  
4 Q. WHAT DIFFERENCES IN PROFESSOR MENDELSON'S MODELING  
5 EXPLAIN WHY HIS SCC VALUES USING AN EQUILIBRIUM CLIMATE  
6 SENSITIVITY ANALYSIS OF 3 ARE \$4 TO \$6 PER TON WHILE THOSE IN  
7 YOUR TABLE ABOVE ARE \$14 TO \$43 PER TON?

8 A. There are several, which I describe below, but the most significant one is his  
9 assumption that the optimal temperature is 1.5°C to 2°C higher than pre-  
10 industrial (i.e., year 1900) levels. First, Professor Mendelsohn's modeling uses a  
11 discount rate that is endogenous to DICE, rather than the constant rates that the  
12 IWG assumed. It is apparent from Table 1 of his Exhibit 2 (and other information  
13 he provides) that a roughly equivalent constant discount rate is between 4% and  
14 5%. Thus, his estimates of \$4 to \$6 per ton should be compared to values closer  
15 to (and somewhat above) the \$14 per ton estimate from my table above.  
16 Second, he is reporting SCC estimates for emissions in the year 2015, while I  
17 have used 2020 SCC estimates for comparability to results available in the IWG  
18 reports. That would reduce the values in my table somewhat more. Third, he is  
19 using a different version of DICE (DICE2013), and that model's optimized  
20 socioeconomic projections, whereas I am using the IMAGE socioeconomic  
21 scenario of the IWG. This also would probably cause the values in my table to  
22 be higher than his (for reasons explained by Professor Mendelsohn in Section  
23 II.C of Exhibit 2 to his pre-filed direct testimony). However, the most significant

1 difference in his analysis is almost certainly the application of a threshold in the  
2 damage function in the range of 1.5°C to 2°C above 1900 temperature levels.  
3 For example, when I use a discount rate of 4.5%, an equilibrium climate  
4 sensitivity value of 3, and report the SCC value for 2015 emissions, the IMAGE  
5 scenario and DICE 2010 produces an SCC value of \$15 per ton. However, when  
6 I also apply a 2°C threshold to DICE 2010's damage function in the same  
7 manner that Professor Mendelsohn did for DICE2013, my estimate of the 2015  
8 SCC value falls to \$5 per ton. This estimate is comparable to Professor  
9 Mendelsohn's estimate of \$4 per ton, and is remarkably similar given that I have  
10 used the IWG's version of DICE (DICE 2010) rather than DICE2013, an  
11 approximation of the time-varying endogenous discount rate that Professor  
12 Mendelsohn's analysis uses, and the IWG's highest-cost socioeconomic scenario  
13 (IMAGE) rather than the optimized mitigation scenario of DICE2013.

14  
15 Q. IN WHAT DOLLAR-YEAR ARE PROFESSOR MENDELSON'S SCC  
16 ESTIMATES STATED?

17 A. I am not sure. When he summarizes the IWG's SCC values (at page 9 of Exhibit  
18 2 of his pre-filed direct testimony) he states they are "all measured in 2007 USD."  
19 This might lead one to expect that his own SCC estimates are also in 2007  
20 dollars (as my own SCC estimates). However, he never specifically states the  
21 dollar-year for his own estimates. If his SCC values are stated in earlier-year  
22 dollars, such as 2005\$, they would be higher when stated in the 2007\$ I have  
23 used. This would bring my estimate even closer to his. The reverse would be

1 true if his estimates are in later-year dollars than 2007\$. However, the effect of  
2 adjusting to exactly comparable dollar-years, if it should be necessary, would be  
3 too small to eliminate the similarity of our respective SCC estimates.

4  
5 Q. ARE YOU RECOMMENDING THAT THE COMMISSION ADOPT THE VALUES  
6 ABOVE OR USE A SPECIFIC TEMPERATURE-CHANGE THRESHOLD?

7 A. No, I am not making any recommendation regarding the value of the optimal  
8 temperature change.

9  
10 Q. WHAT DO YOU CONCLUDE FROM THIS ADDITIONAL SENSITIVITY  
11 ANALYSIS?

12 A. I conclude that the lower SCC estimates reported in Professor Mendelsohn's  
13 analysis would also be supported by the IWG's models, if his alternative  
14 assumptions about equilibrium climate sensitivity and optimal temperature levels  
15 were to be adopted. I further conclude that a change in the equilibrium climate  
16 sensitivity assumption to a range of 1.5 would -- *on its own* -- reduce the IWG's  
17 SCC estimate by roughly as much as applying an assumption that the optimal  
18 temperature increase is in the range of 1.5°C to 2°C above 1900 levels. This  
19 second conclusion cannot be derived from Professor Mendelsohn's pre-filed  
20 direct testimony and associated exhibits, but can be derived from the additional  
21 information provided by my analyses described above.

22

**IV. CONCLUSION**

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2 Q. DOES THIS CONCLUDE YOUR REBUTTAL TESTIMONY?

3 A. Yes, it does.