

BEFORE THE MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS

600 North Robert Street
St. Paul, Minnesota 55101

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION

121 Seventh Place East Suite 350
St. Paul, Minnesota 55101-2147

In the Matter of the Further Investigation into
Environmental and Socioeconomic Costs
Under Minn. Stat. § 216B.2422, Subd. 3

MPUC DOCKET NO. E-999/CI-14-643

OAH Docket No. 80-2500-31888

**MINNESOTA LARGE INDUSTRIAL GROUP'S
PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW
REGARDING PHASE I (CO₂ TRACK)**

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FINDINGS OF FACT

1. On February 10, 2014, the Minnesota Public Utilities Commission (“Commission” or “MPUC”) issued an Order in Docket No. E-999/CI-00-1636 reopening its investigation into environmental costs of different methods of generating electricity under Minn. Stat. § 216B.2422, subd. 3.
2. The Commission determined that the investigation would be best resolved in the context of a contested case proceeding conducted by the Office of Administrative Hearings (“OAH”), and sought input on the scope of the investigation, whether to retain an expert, and the possible role of an expert, from a stakeholder group led by Minnesota Department of Commerce, Division of Energy Resources (“DOC-DER”) and the Minnesota Pollution Control Agency (“MPCA,” and with DOC-DER the “Agencies”).¹
3. On June 10, 2014, the Agencies filed a report noting a lack of agreement among participants to previous stakeholder meetings or in subsequent comments. The report included the agencies’ recommendations concerning the scope and process of the investigation, and the retention of an expert.² The contentious issue was that the Commission should adopt the federal social cost of carbon without further proceedings.³
4. On June 16, 2014, the Commission requested comments on the report and recommendations.
5. From June 25, 2014, through August 20, 2014, the Commission received comments from

¹ Notice and Order for Hearing at 1 and 4, MPUC Dockets E-999/CI-000-1636 and E-999/CI-14-643 (October 15, 2014).

² *Id.* at 3-4.

³ *Id.* at 4.

the following entities:⁴

- Fresh Energy, Sierra Club, Izaak Walton League of America – Midwest Office, Will Steger Foundation, Center for Energy and the Environment, and the Minnesota Center for Environmental Advocacy (“the Clean Energy Organizations” or “CEO”);
- Great River Energy, Minnesota Power, and Otter Tail Power Company (filing jointly);
- The Lignite Energy Council
- Peabody Energy Corporation (“Peabody”);
- The Minnesota Chamber of Commerce (“the Chamber”);
- The Minnesota Large Industrial Group
- The State of North Dakota
- Xcel Energy (“Xcel”)

6. On October 15, 2014, the Commission issued its Notice and Order for Hearing in which it set forth the scope of the investigation, as follows:⁵

The Commission will investigate the appropriate cost values for PM_{2.5}, SO₂, NO_x, and CO₂. The Commission will not further investigate at this time the environmental costs of other greenhouse gasses such as methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). Because CO₂ represents 99% of greenhouse gas emissions, an accurate environmental cost value for CO₂ will account for almost all greenhouse gas costs. This will result in a more manageable proceeding and allow the parties to focus their resources.

It would be premature at this stage to adopt the federal SCC values for CO₂ as the Agencies recommend. The Commission still believes that a contested case proceeding is necessary to fully consider the Agencies’ proposed CO₂ cost values. The Commission will therefore not act at this time on the Agencies’

⁴ *Id.* at 1-2.

⁵ Notice and Order for Hearing, *id.*, at 4-5.

proposal to adopt the federal SCC values immediately. But, in light of the record so far, the Commission will ask the Administrative Law Judge to determine whether the Federal Social Cost of Carbon is reasonable and the best available measure to determine the environmental cost of CO₂ and, if not, what measure is better supported by the evidence.

The Commission will require parties in the contested case proceeding to evaluate the costs using a damage cost approach, as opposed to (for example), market-based or cost-of-control values. When last faced with the question of the preferred approach to estimate environmental cost values, the Commission stated that, as between estimates based on damage or based on cost-of-control, the damage-cost approach is superior because it appropriately focuses on actual damages from uncontrolled emissions.

Nothing in this proceeding justifies reaching a different conclusion now. Where a damage cost can be reasonably estimated, it represents a superior method of valuing an emission's environmental cost. The Commission is persuaded that a damage-cost approach can be used for the emissions under investigation, and will therefore require it.

7. The Commission also authorized DOC-DER, on a discretionary basis, to work with the Office of Management and Budget to retain a consultant under Minn. Stat. § 216B.62, subd. 8 and, if a consultant was retained, the Commission required that the consultant use reduced-form modeling to estimate damage costs.
8. The Commission also referred the matter to OAH for a contested case proceeding, which assigned the undersigned Administrative Law Judges (“ALJs”) LauraSue Schlatter and Jeffery Oxley.⁶
9. Also in its October 15, 2014, Notice and Order for Hearing, the Commission identified the issues for parties to “thoroughly address,” as follows:⁷
 - Whether the Federal Social Cost of Carbon is reasonable and the best

⁶ Notice and Order for Hearing, *id.* at 5 and 8.

⁷ Notice and Order for Hearing, *id.* at 5 and 8.

available measure to determine the environmental cost of CO₂ under Minn. Stat. § 216B.2422 and, if not, what measure is better supported by the evidence.

- The appropriate values for PM_{2.5}, SO₂, and NO_x under Minn. Stat. § 216B.2422, subd. 3.

10. The Commission referred the above two issues to the OAH for separate contested case proceedings.

11. On December 9, 2014, following a prehearing conference on November 14, 2014, ALJ Schlatter issued the First Prehearing Order that:

1. Identified the following entities as parties: Clean Energy Organizations; DOC-DER; Peabody; Otter Tail Power; Great River Energy; Minnesota Power; Lignite Energy Council; the Chamber; the Minnesota Large Industrial Group; and Northern States Power d/b/a/ Xcel Energy;
2. Established process to develop a public notice plan;
3. Allowed parties to submit memoranda on the question of the burden of proof as it applies to the Federal Social Cost of Carbon, alternative means of measuring the cost of CO₂, SO₂, NO_x, and PM_{2.5}; and
4. Adopted the following schedule:

Document or Event	Due Date
Public Notice Plan	January 30, 2015
Memoranda Regarding Burdens of Proof	February 4, 2015
Comments on Public Notice Plan	February 17, 2015
Responsive Memoranda Regarding Burdens of Proof	February 18, 2015
Second Prehearing Conference	March 3, 2015
Intervention Deadline	April 1, 2015
Public Notice Implementation	May 1, 2015

Document or Event	Due Date CO₂	Due Date SO₂, NO₂, and PM_{2.5}
Direct Testimony	June 1, 2015	TBD (<i>August 1, 2015</i>)
Public Hearing(s), if any (not bifurcated)	TBD (<i>August 2015</i>)	TBD (<i>August 2015</i>)
Rebuttal Testimony	TBD (<i>September 1, 2015</i>)	TBD (<i>October 15, 2015</i>)
Surrebuttal Testimony	TBD (<i>October 1, 2015</i>)	TBD (<i>November 15, 2015</i>)
Deadline for Public Testimony	TBD (<i>October 1, 2015</i>)	TBD (<i>October 1, 2015</i>)
Status Conference	TBD (<i>October 5, 2015</i>)	TBD (<i>January 4, 2016</i>)
Evidentiary Hearing	TBD (<i>October 12-16, 2015</i>)	TBD (<i>approx. January 6-15, 2016</i>)
Issues Matrix	TBD (<i>November 12, 2015</i>)	TBD (<i>February 1, 2016</i>)
Initial Briefs	TBD (<i>November 24, 2015</i>)	TBD (<i>February 16, 2016</i>)
Reply Briefs, Proposed Findings of Fact and Comments, if any, on Issues Matrix	TBD (<i>December 15, 2015</i>)	TBD (<i>March 1, 2016</i>)
ALJ Report (May or may not be bifurcated)	TBD (<i>April 15, 2016, if bifurcated; or May 16, 2016 if not bifurcated</i>)	TBD (<i>May 16, 2016</i>)

12. On March 5, 2015, ALJ Schlatter issued a Protective Order.
13. On March 11, 2015, ALJ Schlatter filed a Recommendation for Public Hearings and Public Notice Plan that summarized for the Commission her consultation with the parties and Commission staff, consistent with the Commission's Notice and Order for Hearing, that stated her recommendation that the public should be offered the opportunity to provide input in writing as well as through public hearings, and that stated her request that the Commission agree to implement and bear the cost of the public notice plan and the public hearings in this matter.

14. On March 20, 2015, ALJ Schlatter granted MPCA's petition to intervene as a party.
15. On March 27, 2015, based on parties' legal memoranda and comments, ALJ Schlatter issued an Order Regarding Burdens of Proof that provides, as follows:
 - a. A party or parties proposing that the Commission adopt a new environmental cost value for CO₂, including the Federal Social Cost of Carbon, bears the burden of showing, by a preponderance of the evidence, that the value being proposed is reasonable and the best available measure of the environmental cost of CO₂.
 - b. A party or parties proposing that the Commission adopt a new environmental cost value for one or more of the criteria pollutants – SO₂, NO_x, and/or PM_{2.5} – bears the burden of showing, by a preponderance of the evidence, that the cost value being proposed is reasonable, practicable, and the best available measure of the criteria pollutant's cost.
 - c. A party or parties proposing that the Commission retain any environmental cost value as currently assigned by the Commission bears the burden of showing, by a preponderance of the evidence, that the current value is reasonable and the best available measure to determine the applicable environmental cost.
 - d. An environmental cost value currently being applied by the Commission is presumed to be practicable, as required by Minn. Stat. § 216B.2422, subd. 3. A party challenging an existing cost value on the grounds that it is not practicable bears the burden of demonstrating impracticability by a preponderance of the evidence.
 - e. A party or parties, opposing a proposed environmental cost value must demonstrate, at a minimum, that the evidence offered in support of the proposed values is insufficient to amount to a preponderance of the evidence. This requirement does not apply to a party challenging an existing cost value based on its alleged impracticability, as described in paragraph 4, above.
 - f. Any proponent of an environmental cost value, including existing environmental cost values, shall file direct testimony in support of its proposal according to the schedule set forth in the Second Prehearing Order in this matter.
 - g. A party advocating for retention of an existing cost value may not refer by reference to evidence or testimony from the Commission's CI-93-583 docket or related dockets, but must

introduce any evidence on which it intends to rely in this docket, whether the evidence is drawn from an older docket or is new evidence.

- h. A party may propose an environmental cost value not proposed in direct testimony in the party's rebuttal testimony only if the new cost value is offered in response to a cost value proposed in direct testimony.
 - i. The order in which the parties will conduct direct and cross-examination at the evidentiary hearings will be determined at later dates after rebuttal testimony has been filed, but at least two weeks before either evidentiary hearing.
 - j. The Administrative Law Judge incorporates the following portions of the Commission's Notice and Order for Hearing into this Order:
 - 1) the parties will use a damage cost approach; and [Footnote omitted]
 - 2) any DOC consultant must use reduced-form modeling. [Footnote omitted].
16. On April 16, 2015, ALJ Schlatter issued her Third Prehearing Order that encouraged parties to jointly file pre-filed testimony, briefs or other pleadings, and to share responsibilities for cross-examination of witnesses to the extent appropriate and consistent with their positions and interests in the docket, and ordered parties to be prepared to discuss their plans for sharing cross-examination at the prehearing status conferences on September 17 and December 18, 2015. Absent a specific demonstration of relevance, ALJ Schlatter determined that testimony as to the efficacy of renewable energy or renewable energy policy is presumed to be irrelevant to the proceedings and will be excluded.
17. On April 16, 2015, ALJ Schlatter granted the petitions to intervene as parties of Doctors for a Healthy Environment ("DHE"), the Clean Energy Business Coalition ("CEBC"), and Interstate Power and Light ("IPL").

18. On May 27, 2015, following its April 23, 2015, meeting, the Commission issued its Order Requiring Public Hearing, as recommended by ALJ Schlatter.
19. May 29, 2015, the Commission provided ALJ Schlatter with its proposed date, time, and place for a public hearing, as well as its proposed Notice Plan.
20. On June 1, 2015, parties filed Direct Testimony regarding CO₂.
21. On June 2, 2015, the Commission issued its Notice of Public Hearing and Comment Period.
22. On August 4, 2015, ALJ Schlatter issued her Fourth Prehearing Order that identified the evidentiary hearing date for the CO₂ matter as September 24-30, 2015, and scheduled a prehearing conference to take place on August 14, 2015, for the primary purpose of discussing parties' plans for cross-examination, waiver of witness appearances, and requests for dates or times certain regarding witness trial appearances.
23. On August 14, 2015, the ALJs held a prehearing conference.
24. On August 5, 2015, parties filed Direct Testimony regarding the criteria pollutants PM_{2.5}, SO₂, and NO_x.
25. On August 12, 2015, parties filed Rebuttal Testimony regarding CO₂.
26. On August 28, 2015, ALJ Schlatter issued her Fifth Prehearing Order setting forth the following changes to the CO₂ schedule:

Document or Event	New Date	[Original Date]
Final CO ₂ Prehearing Conference	September 21, 2015 [time omitted]	[September 17, 2015]
Objections to any prefiled direct or rebuttal testimony or witness	September 3, 2015	[September 11, 2015]
Objections to any surrebuttal	Unchanged	September 17, 2015

testimony or witness		
Response to surrebuttal objections	September 18, 2015	

27. On September 3, 2015, in the CO2 matter, DOC-DER and MPCA filed a Notice of Motion and Motion to Strike direct and rebuttal testimony of witnesses Drs. Happer, Lindzen, Bezdek, and Tol.
28. On September 3, 2015, in the CO2 matter, Peabody filed a Motion to Exclude the Rebuttal Testimony of Shawn Rumery and Christopher Kunkle, and a Motion to Exclude the Direct and Rebuttal Testimony of Dr. Hanemann and Dr. Polasky in their entirety, and the statistical opinions of Mr. Martin.
29. On September 3, 2015, in the CO2 matter, the Minnesota Large Industrial Group filed a Motion to Strike testimony of Dr. Hanemann, Dr. Polasky, and certain testimony of Mr. Martin.
30. On September 10, 2015, parties filed Surrebuttal Testimony regarding CO2.
31. On September 11, 2015, certain parties filed responses to motions to strike or exclude testimony.
32. On September 15, 2015, Peabody filed a Motion to Exclude the Surrebuttal testimony of Dr. Peter Reich in its entirety, and certain testimony of Drs. John Abraham, Andrew Dessler, and Kevin Gumey.
33. On September 15, 2015, the Minnesota Large Industrial Group filed a Motion to Strike the Surrebuttal Testimony of Dr. Peter Reich.
34. On September 15, 2015, as to certain motions regarding direct and rebuttal testimony, ALJ Schlatter issued an Order on Motions By Peabody Energy Corporation, the

Minnesota Department of Commerce, and the Pollution Control Agency to Exclude and Strike Testimony which:

- Denied the Agencies' motions to strike direct and rebuttal testimony, with a limited exception;
- Granted the Agencies' motion to strike certain rebuttal testimony of Dr. Happer; and
- Denied Peabody's motion to exclude the testimony of Mr. Rumery and Mr. Kunkle;

35. On September 15, 2015, as to certain other motions regarding direct and rebuttal testimony, ALJ Schlatter issued an Order On Motions By Minnesota Large Industrial Group and Peabody Energy Corporation to Exclude and Strike Testimony which:

- Denied motions of the Minnesota Large Industrial Group and Peabody to exclude the testimony of Drs. Hanemann and Polasky; and
- Denied motions of the Minnesota Large Industrial Group and Peabody to exclude certain parts of Mr. Martin's testimony.

36. On September 18, 2015, the Agencies filed their Response to Peabody Motion to Exclude Expert Witness Surrebuttal Testimony.

37. On September 18, 2015, the Clean Energy Organizations filed their Response to the Minnesota Large Industrial Group's Motion to Strike Surrebuttal Testimony of Dr. Peter Reich, and Peabody Energy's Motion to Exclude Dr. Peter Reich and Certain Testimony of Drs. Abraham and Dessler.

38. On September 21, 2015, as to motions regarding Surrebuttal testimony, ALJ Schlatter issued an Order On Motions by Minnesota Large Industrial Group and Peabody Energy Corporation to Exclude and Strike Testimony which:

- Denied both parties' motions to exclude the testimony of Dr. Reich with limited exception;
- Denied Peabody's motion to exclude certain testimony of

Dr. Abraham; and

- Denied Peabody's motion to exclude certain testimony of Dr. Dressler.

39. On September 21, 2015, the Agencies filed a Motion to Amend Protective Order in order to accommodate discovery by the Agencies and to identify the MPCA as one of the government agencies that will possess protected data in this matter.
40. On September 23, 2015, granting the Agencies' motion to amend, ALJ Schlatter issued an Amended Protective Order.
41. From September 24 to September 30, 2015, the evidentiary hearing in the CO₂ matter took place in the Commission's large hearing room.
42. On October 14, 2015, regarding the CO₂ matter and the criteria pollutants PM_{2.5}, SO₂, and NO_x, ALJ Schlatter issued her Sixth Prehearing Order that set forth the following schedule:

Document or Event	Due Date CO₂	Due Date SO₂, NO₂, and PM_{2.5}
Rebuttal Testimony		October 30, 2015
Status Conference		November 2, 2015, 9:30 a.m.
Objections to any prefiled direct or rebuttal testimony or witness		November 6, 2015
CO ₂ Issues Matrix	November 12, 2015	
Responses to objections to direct or rebuttal testimony or witness		November 18, 2015
CO ₂ Initial Briefs	November 24, 2015	
Surrebuttal Testimony		December 4, 2015
CO ₂ Reply Briefs, Proposed Findings, Comments on	December 15, 2015	

Document or Event	Due Date CO₂	Due Date SO₂, NO₂, and PM_{2.5}
Issues Matrix		
Status Conference – in person		December 18, 2015, 9:30 a.m.
Objections to any prefiled surrebuttal testimony or witness		December 18, 2015
Evidentiary Hearings (may be adjusted if status conferences indicate less time is needed)		January 6-8, and 11-15, 2016, 9 a.m.
Issues Matrix		February 16, 2016
Initial Briefs		March 1, 2016
Reply Briefs, Proposed Findings, Comments on Issues Matrix		April 15, 2016
ALJ Report	April 15, 2016	June 15, 2016

43. On November 12, 2015, the parties filed a joint Issues Matrix.
44. On November 24, 2015, parties filed Initial Briefs in the CO₂ matter.
45. On December 15, 2015, parties filed Reply Briefs in the CO₂ matter.
46. The Minnesota Large Industrial Group (“MLIG”) intervened in this proceeding moved by great concern about the impact on electricity rates of the requested adoption of the federal government’s Interagency Working Group’s federal social cost of carbon (“FSCC” or generically “SCC”) for use in Minnesota resource planning and other resource-selection proceedings under Minn. Stat. § 216B.2422.
47. This proceeding is somewhat unique in that the large industrials also represent the economic interests of much smaller commercial ratepayers and regular households.
48. While the Department of Commerce is a party to the proceeding, the Attorney General’s

Office as consumer advocate is not.

49. The MLIG has expressed concern that by advocating for the adoption of only a 3% discount rate rather than the entire FSCC range recommended by the federal government's Interagency Working Group on the Social Costs of Carbon ("IWG"),⁸ the Department is asking the Commission to adopt only the high end of the FSCC range, which high end exceeds the low end of the range by a factor 3.5 (compare Ex. [307](#) (Table 4A) lines 1 (FSCC value of \$42.14 at 3% discount rate) and 4 (FSCC value of \$12.03 at 5% discount rate)).
50. The MLIG has further expressed that it is troubled by what appears to be a disconnect between the Department's position in this docket and the ultimate rate impact that position could have if adopted by the Commission.

POSITIONS OF THE PARTIES

Doctors for a Healthy Environment

51. Doctors for a Healthy Environment relied on William N. Rom, M.D., M.P.H. to support adoption of the FSCC as the environmental cost value for CO₂ in Minnesota.
52. Dr. Rom testified that exposure to PM_{2.5} and ozone increases mortality and that warmer temperatures increase these mortality effects,⁹ but acknowledged that the U.S. Environmental Protection Agency has standards for regulating ozone and PM_{2.5}, that those standards are "designed to protect human health," and that ozone and PM_{2.5} levels have generally declined in the United States.¹⁰

⁸ See [June 10, 2014, comments of the Minnesota Department of Commerce, Division of Energy](#) at 10.

⁹ Ex. [500](#) (Rom Rebuttal) at 12, 17-18; Tr. Vol. 4 at 160:9-162:15 (Rom).

¹⁰ Tr. Vol. 4 at 166:21-167:18 (Rom).

53. Minnesota is in “attainment” for PM_{2.5} and ozone.
54. Dr. Rom further testified that there will be harm from increased temperatures, but that there “would be a positive effect on less cold-related morbidity.”¹¹
55. Dr. Rom further blamed forest fires for harm to human health, and testified that the toxicity of particles from forest fires is much greater than the particle toxicity from industry, power plants, and traffic.¹²
56. Dr. Rom acknowledged, however, that he has no training to allow him to provide an expert opinion regarding the causal connection between CO₂ levels and forest fires, that “[i]t’s usually humans that cause forest fires, or lightning,” and that “establishing the relative causation between heat and wildfire pollution is difficult.”¹³
57. Dr. Rom further acknowledged that he has no training to comment on any relationship between water use for irrigation in the United States on the one hand and wildfires on the other hand.¹⁴
58. The ALJs find that no showing has been made by Doctors for a Healthy Environment of a causal connection between CO₂ levels and forest fires.
59. Dr. Rom further testified that “heat has outweighed coal in mortality,”¹⁵ that some health impacts are not included in the FSCC estimates, and that he believed “the \$37 figure per ton of CO₂ should be a lower limit.”¹⁶

¹¹ Tr. Vol. 4 at 163:1-17; 166:15-18 (Rom).

¹² *Id.* at 162:16-25.

¹³ Tr. Vol. 4 at 168:24-170:15 (Rom); Ex. [500](#) (Rom Rebuttal) at 19.

¹⁴ Tr. Vol. 4 (Rom) at 170:16-20.

¹⁵ *Id.* at 163:1-17.

¹⁶ *Id.* at 164:24-25; Ex. [500](#) (Rom Rebuttal) at 8-9.

60. On the other hand, Dr. Rom acknowledged that breathing CO₂ does not cause asthma, that the integrated assessment models (“IAMs”) relied upon by the IWG (FUND, PAGE, and DICE) include numerous health-impact considerations, that he has no firsthand knowledge working with the IAMs, that he does not have any expertise on DICE, PAGE, or FUND, that he has no training as an economist or environmental economist, that he has no training in modeling, and that he has no training in meteorology or other sciences specifically related to the cause and effect between CO₂, temperature, and positive and negative feedbacks.¹⁷
61. Most importantly, Dr. Rom does not “propose any specific value” in this proceeding, has not assigned any values to damages that he claims may not be included in the IAMs, and has not provided “any specific way of determining what the right [CO₂ externality] value should be in this proceeding.”¹⁸
62. Accordingly, the ALJs find that while Dr. Rom may be an eminent physician, his testimony shows that he was neither qualified to opine about the reliability, practicability, or appropriateness of the FSCC for application in the Minnesota regulatory context, such that Doctors for a Healthy Environment has failed to introduce admissible foundational evidence to support adoption of the FSCC as developed by the IWG.
63. The ALJs accordingly find that Doctors for a Healthy Environment failed to meet their burden of proof to show that the “value being proposed [by means of the FSCC value] is reasonable and the best available measure of the environmental cost of CO₂,” as required

¹⁷ Tr. Vol. 4 at 165:1-166:3; Ex. [500](#) at 9.

¹⁸ Tr. Vol. 4 at 165:1-7; 165:25-166:4.

by the March 27, 2015, [Burdens of Proof Order](#),¹⁹ Minn. Rules Part 1400.7300, subp. 5, and *In re Quantification of Env'tl. Costs Pursuant to Laws of Minn. 1993, Chapter 356, Section 3*, 578 N.W.2d 794, 801 (Minn. Ct. App. 1998).

Clean Energy Business Coalition

64. The Clean Energy Business Coalition relied on the testimony of Shawn Rumery and Chris Kunkle to support adoption of the FSCC as the environmental cost value for CO₂ in Minnesota.
65. Mr. Rumery is the Director of Research at the Solar Energy Industries Association in Washington, D.C.²⁰
66. Mr. Rumery testified in pre-filed testimony that proper valuation of the costs associated with the environmental pollution generated by the electricity industry will create a more level playing field, sending the right signals to the market to promote non-CO₂ emitting energy technologies and thus ramping up industries that can create jobs, strengthen the economy, and help support a cleaner and healthier environment.²¹
67. Mr. Kunkle is a Regional Policy Manager for Wind on the Wires.²²
68. Mr. Kunkle's pre-filed testimony was virtually identical to Mr. Rumery's, and again posited that proper valuation of the costs associated with the environmental pollution generated by the electricity industry will create a more level playing field, sending the right signals to the market to promote non-CO₂ emitting energy technologies and thus ramping up industries that can create jobs, strengthen the economy, and help support a

¹⁹ [Order Regarding Burdens of Proof dated March 27, 2015](#) at 2 and 6.

²⁰ Ex. [700](#) (Rumery Rebuttal) at 1.

²¹ Ex. [700](#) (Rumery Rebuttal) at 2.

²² Ex. [701](#) (Kunkle Rebuttal) at 1.

cleaner and healthier environment.²³

69. Stipulations were entered into the record with respect to both Mr. Kunkle and Mr. Rumery's testimony to the effect that neither has formal training in modeling or the climate science underlying the IWG, PAGE, FUND, and DICE modeling.²⁴
70. Neither Mr. Kunkle nor Mr. Rumery further sought to express an expert opinion about the fundamentals of the IWG's process in establishing a federal social cost of carbon.
(*Id.*)
71. Thus, neither expressed an expert opinion about (equilibrium) climate sensitivity, (*id.*), the appropriate discount rate to be used in this proceeding, (*id.*), the appropriate temporal scope or horizon for Minnesota's environmental cost of carbon values, whether it be the year 2100, 2140, or 2300,²⁵ nor about the appropriate geographic scope to be included in Minnesota's environmental cost of carbon values, whether it be Minnesota, the United States or a fraction thereof, or global or a fraction thereof.²⁶
72. Neither Mr. Kunkle nor Mr. Rumery expressed an expert opinion about the reliability of the models underlying the IWG's modeling, to wit, PAGE, FUND, and DICE.²⁷
73. While Mr. Kunkle and Mr. Rumery endorsed the concept of proper valuation of externalities associated with the electricity-generation industry, the importance of establishing the correct value is not in dispute; the question is what that value is or should be.

²³ *Id.* at 2; Tr. Vol. 5 at 15:21-31:16 (Kunkle).

²⁴ Exs. [437](#) and [438](#).

²⁵ *Id.*

²⁶ *Id.*

²⁷ *Id.*

74. But neither Mr. Kunkle nor Mr. Rumery could offer and neither sought to offer any opinion about the validity of the federal social cost of carbon values.²⁸
75. Instead, Mr. Kunkle broadly endorsed any higher environmental cost value for CO₂, seeking testifying that “if the Commission adopts a more accurate value on cost externalities, the transition to a cleaner, flexible energy system will be accelerated, thus helping to shield Minnesota taxpayers from the price spikes associated with fossil fuels.”²⁹
76. The ALJs find that Mr. Rumery’s and Mr. Kunkle’s testimony amounted to nothing more than an endorsement of the efficacy of renewable energy and renewable-energy policy, which type of testimony was held irrelevant to the issues in the case.³⁰
77. Importantly, both Mr. Rumery and Mr. Kunkle stipulated, through counsel, that they could not and did not seek to offer any opinion about the best monetary amount to account for the costs or benefits of carbon emissions.³¹
78. The ALJs find that in the absence of any proffered testimony about the validity or reliability of the FSCC and in the absence of any testimony about the best monetary amount to account for the costs or benefits of carbon emissions, the Clean Energy Business Coalition failed to meet its burden of proof to show that the “value being proposed [by means of the FSCC value] is reasonable and the best available measure of the environmental cost of CO₂,” as required by the March 27, 2015, [Burdens of Proof](#)

²⁸ Exs. [437](#) and [438](#).

²⁹ Tr. Vol. 5 at 17:25-18:5 (Kunkle).

³⁰ [Third Prehearing Order dated April 16, 2015](#) at 2, ¶ 3.

³¹ Exs. [437](#) and [438](#).

[Order](#),³² Minn. Rules Part 1400.7300, subp. 5, and *In re Quantification of Env'tl. Costs Pursuant to Laws of Minn. 1993, Chapter 356, Section 3*, 578 N.W.2d 794, 801 (Minn. Ct. App. 1998).

Clean Energy Organizations and the Agencies

79. The CEOs and the Agencies have introduced evidence in support of their proposition that the FSCC is reasonable and the best available measure to determine the environmental cost of CO₂, offering the testimony of Dr. Stephen Polasky, Dr. John Abraham, Dr. Andrew Dessler, and Dr. Peter Reich (CEOs), and Dr. W. Michael Hanemann and Dr. Kevin Gurney (Agencies).
80. None of these witnesses operated the models, however.³³
81. The FSCC summary schedules provide (rounded)³⁴ FSCC values of \$12 at a 5% discount rate, \$43 at a 3% discount rate, \$65 at a 2.5% discount rate, and \$125 at a 3% discount rate, 95th percentile, each for 2020 emissions per metric ton (in 2007 dollars).³⁵

The MLIG and the Utility Group

82. The MLIG and a group of utilities consisting of Great River Energy, Minnesota Power, and Otter Tail Power Company (the “Utility Group”) disagree with adoption of the FSCC, and have offered alternative environmental cost values for CO₂.
83. The MLIG and the Utility Group shared a common witness, Dr. Anne E. Smith, and are

³² [Order Regarding Burdens of Proof dated March 27, 2015](#) at 2 and 6.

³³ *See, e.g.*, Tr. Vol. 1 at 64 (Polasky); Tr. Vol. 2B at 62 (Hanemann); Ex. [422](#).

³⁴ The exact amounts provided by the models are set forth in Table 4 of Exhibit 2 to Dr. Smith’s direct testimony (Ex. [302](#) at 43) and Table 4A (Ex. [307](#)), and reflect values at a 3% discount rate of \$42.14 in 2007 dollars and \$46.88 in 2014 dollars, both per metric ton, and values at a 5% discount rate of \$12.03 in 2007 dollars and \$13.39 in 2014 dollars.

³⁵ *See* Ex. [100](#) at Schedule 3 at p. 18 (App. A1).

most closely aligned in their alternative values, which are between Xcel Energy's proposal (*infra*) and Peabody's proposal (*infra*).

84. Dr. Smith who testified about a number of errors in and issues with the methods used by the IWG.
85. Required to provide opinions based on a damage-cost approach basis,³⁶ Dr. Smith is the only witness in this proceeding who invested the time and energy to re-run the models multiple times, first under the original assumptions used by the IWG to verify that she was running them correctly, and then under four corrective key framing assumptions, to wit, time horizon (the years 2100 or 2140, rather than the year 2300); discount rates (3%, 5%, and 7%, rather than 2.5%, 3%, and 5%); marginal ton considered (first or average ton emitted, rather than last ton); and geographic scope (U.S. rather than global).³⁷
86. Dr. Smith's proposed range for emissions in the year 2020 is \$1.62 to \$5.14 (in 2014 dollars per net metric ton).³⁸
87. The MLIG further retained Dr. Ted Gayer, who testified regarding the geographic scope and advocated the use of a Minnesota, rather than a global, scope of damage calculation in the absence of express reciprocity, or at most a much smaller share of the damages scope, such as U.S. damages, if one were to consider demonstrative feelings of altruism even in the absence of reciprocity.
88. Dr. Gayer testified that the IWG "did provide some estimates of the national domestic

³⁶ See [Notice and Order for Hearing dated Oct. 15, 2014](#) at 4.

³⁷ Ex. [300](#) (Smith Direct) at 29:13-22.

³⁸ The low value is based on modeling damages from the first ton emitted, 5 percent discount rate, U.S. damages, and a modeling horizon to year 2100. The high value is based on the average of first ton and last ton emitted, 3 percent discount rate, U.S. damages, and a modeling horizon to year 2140. (Tr. Vol. 2A at 60:17-63:3(Smith).)

benefits, but there was no effort to estimate the state-specific benefits of reducing CO₂.”³⁹ “For one set of national estimates, the IWG relied on one integrated assessment model (the FUND model) that permitted a U.S.-only analysis. This model suggests that the national SCC is about 7 to 10 percent of the global benefit. This would imply that using a global SCC measure where a national measure is appropriate results in an over-estimate of benefits of approximately 10- to 14-fold.”⁴⁰ “Making this adjustment of the global SCC to domestic benefits (using the IWG’s 2013 update) yields a SCC of \$0.77-\$1.10, \$2.24-\$3.20, \$3.57-\$5.10, and \$6.23-\$8.90 (2010 damage values in 2007 dollars).”⁴¹

89. Dr. Gayer showed that applying the IWG’s GDP-scaling approach results in extremely small damage estimates, considering that the estimate of the benefit to Minnesota is less than 0.4 percent of the estimated global benefit.⁴²
90. Even applying the GDP-scaling to the highest IWG FSCC estimate suggests a Minnesota-specific environmental cost value (“ECV”) of only about \$0.37 per metric ton of CO₂ (2010 damage value in 2007 dollars).⁴³

³⁹ Ex. [400](#) (Gayer Direct) at App. 2 at 15.

⁴⁰ *Id.*

⁴¹ Ex. [400](#) (Gayer Direct) at App. 2 15-16 (respectively for damages calculated at a 5% discount rate, 3% discount rate, 2.5% discount rate, and 3% discount rate, 95th percentile). Dr. Gayer also testified that another IWG approach, which considered that the national social cost of carbon is about 23 percent of the global benefit, would yield FSCC values of \$2.53, \$7.36, \$11.73, and \$20.47 (2010 damage values in 2007 dollars, again for damages calculated respectively at a 5% discount rate, 3% discount rate, 2.5% discount rate, and 3% discount rate, 95th percentile). (*Id.* at 16.)

⁴² Ex. [400](#) (Gayer Direct) at App. 2 at 16-17. Dr. Polasky agreed that Minnesota’s share of worldwide CO₂ production is only approximately 0.486%. (Tr. Vol. 1 at 183-191 (Polasky); Exs. [432](#) and [413](#).)

⁴³ Ex. [400](#) at App. 2 at 16-17.

Xcel Energy

91. Xcel Energy also disagrees with adoption of the FSCC, and has offered alternative environmental cost values for CO₂.
92. Xcel Energy's proposal is arrived at using the IWG's data, which data is then substantially slimmed down to approximately 38% of the data points considered by the IWG, after which various statistical methods are applied.
93. Xcel suggests an environmental cost value ("ECV") of CO₂ range of 12.13 to \$41.40 per net short ton for emission year 2020 (in 2014 dollars).⁴⁴
94. This is equivalent respectively to \$13.37 to \$45.65 per net *metric* ton for emission year 2020 (in 2014 dollars),⁴⁵ which are respectively within 0.15% and 2.6% of the IWG's 5% and 3% FSCC discount values.⁴⁶

Peabody Energy

95. Peabody similarly disagrees with adoption of the FSCC, and has introduced a large amount of evidence showing that the scientific assumptions supporting the FSCC are invalid.
96. Peabody's experts arrived at a number of different estimates. Dr. Mendelsohn suggested that social cost of carbon values should range from \$4 to \$6 per metric ton at an equilibrium climate sensitivity ("ECS") of approximately 3°C, \$0.30 to \$0.80 per metric

⁴⁴ Tr. Vol. 4 at 15:16-23 (leakage) (Martin); *id.* at 121:11-19 (ECV) (Martin); Ex. [601, Martin Rebuttal](#) at 5:5-17 (ECV); *id.* at 51:5-53:25 (leakage-ECV to be applied to net tons).

⁴⁵ Tr. Vol. 4 at 122:2-12 (Martin).

⁴⁶ *Id.* at 121:1-125:18.

ton at an ECS of 1.5°C, and \$1.10 to \$2.00 per metric ton at an ECS of 2°C.⁴⁷

97. Dr. Tol testified that under the IWG’s parameters the FUND model as originally developed by him and as run by him estimated a social cost of carbon of \$8 per ton in 2011 and \$6.60 per ton in 2014, but arrived at negative social cost of carbon values (*i.e.*, carbon as a benefit) if the ECS is lower than 3°C.⁴⁸
98. Dr. Tol testified he did not know what the IWG changed to his model to arrive at the FSCC values calculated by the IWG using the FUND model.⁴⁹
99. Dr. Bezdek stated that the Minnesota CO₂ values established in 1997 should be kept as they are, or reduced to about \$0.20 to \$2.00 per ton or lower.⁵⁰

THE FSCC

100. As Mr. Martin has credibly testified, the FSCC was designed as a component of cost-benefit analysis of future Federal regulations, as part of the regulatory impact analysis required by the Office of Management and Budget under Executive Order 12866.⁵¹
101. Dr. Smith noted that the IWG itself has noted the express purpose in estimating the FSCC is “to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO₂) emissions into cost-benefit analyses of regulatory actions that have small, or ‘marginal,’

⁴⁷ See, *e.g.*, Ex. [214](#) (Mendelsohn Direct) at 2.

⁴⁸ See Ex. [238](#) (Tol Rebuttal report) at 4, 6-9.

⁴⁹ Ex. [238](#) (Tol Rebuttal report) at 6.

⁵⁰ Ex. [228](#) (Bezdek Direct) at 1-9, 26-28, 36; Ex. [232](#) (Bezdek Rebuttal) at Ex. 2 at 19, 22-23, 29, 38-39, 46-49, 87-88; Ex. [235](#) (Bezdek Surrebuttal) at 20-57, 66-71, 101-114.

⁵¹ Ex. [600, pt. 1](#) (Martin Direct) at 12:1-5.

impacts on cumulative global emissions.”⁵²

102. The IWG intended the FSCC for use in federal regulation primarily affecting private consumption, rather than in the context of the expenditure of private capital.⁵³
103. The outcome of this proceeding will be used in Minnesota resource planning, which affects the expenditure of private capital.
104. The intended purpose of the FSCC is only to help identify, among the vast array of possible regulations to reduce greenhouse gas (“GHG”) emissions, those regulations that have positive net benefits.
105. The FSCC was not designed to develop the content of the regulation or influence the choice of options to comply.⁵⁴
106. In contrast, if used in integrated resource planning and other Commission decisions in the Minnesota context, “the imprecise SCC would not [be called upon to] help determine *whether* to regulate, but rather *how* to make individual resource allocation decisions.”⁵⁵
107. These decisions – such as whether to operate or retire a power plant, what type of generation capacity to invest in, how to set solar tariffs, how to evaluate Conservation Improvement Program (CIP) benefits – are sometimes binary, difficult to reverse, and often have large and long-term implications for electricity rates, environmental impacts,

⁵² Ex. [302](#) (Smith Direct report) at 32 (*citing* February 2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 at 1 (copy attached as Schedule 2 to Ex. [100](#) (Polasky Direct))).

⁵³ Ex. [101](#), [Ex. 1](#) (July 2015 *Response to Comments, Social Cost of Carbon for Regulatory Impact Analysis Under Executive order 12866* (Interagency Working Group on Social Cost of Carbon)) at 21-22.

⁵⁴ Ex. [600](#), [pt. 1](#) (Martin Direct) at 12:22-13:11; Ex. [601](#), [Martin Rebuttal](#) at 19-22; Ex. [602](#) (Martin Surrebuttal) at 7-9, 19-22.

⁵⁵ Ex. [600](#), [pt. 1](#) (Martin Direct) at 13:13-20. *See also id.* at 13:22-14:9; Ex. [601](#), [Martin Rebuttal](#) at 19:23-20:22:4; Ex. [302](#) (Smith Direct, Ex. 2) at 32, Para. 1.

and reliability.”⁵⁶

108. The Agencies, through Dr. Hanemann, have argued for adoption of the FSCC notwithstanding this distinction, and commented that “[t]he IWG’s SCC estimates have also been used in analysis and discussions outside of the United States. For example, Canada used a social cost of carbon based on the IWG’s SCC in their regulatory impact analysis for the 2013 Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations” and “on April 22, 2014, Montgomery County, Maryland, revised its County Code 18A on environmental sustainability to require the SCC to be incorporated into return on investment for efficiency and sustainability decisions.”⁵⁷
109. The ALJs agree with Xcel Energy and the MLIG that these two references are misleading, and that no showing has been made that another government has used the IWG’s FSCC for the purpose for which it is being proposed in this contested proceeding.
110. Specifically, as Mr. Martin has testified, to the extent the Canadian government “copied” the IWG’s FSCC, “[t]his is an example of using the SCC precisely as intended – for cost-benefit analysis of federal regulations.”⁵⁸
111. Accordingly, the ALJs agree with Mr. Martin and the MLIG that the Canadian reference

⁵⁶ Ex. [600, pt. 1](#) (Martin Direct) at 13:13-20. *See also id.* at 13:22-14:9; Ex. [601, Martin Rebuttal](#) at 19:23-20:22:4; Ex. [302](#) (Smith Direct, Ex. 2) at 32, Para. 1.

⁵⁷ Ex. [800, pt. 1](#) (Hanemann Direct) at 62:13-21.

⁵⁸ Ex. [601, Martin Rebuttal](#) at 20:12-21. It should further be noted that the automobile industries in the United States and Canada are integrated and that the alignment of the Canadian Regulations with the U.S. EPA standards was deemed important, so that the same U.S. EPA-estimated vehicle technology choices and adoption rates were used in the Canadian analysis. “This leads to the same proportional costs per vehicle, adjusted for exchange rates, as those that were used in the U.S. EPA analysis.” *See* <http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html> (cited in Ex. [800, pt. 1](#) (Hanemann Direct) at 62, n.41) at section 7.5.1.

does not provide any rationale for using the IWG’s FSCC for Minnesota Public Utility Commission decisions.⁵⁹

112. Similarly, as to the Montgomery County, Maryland, Code, Mr. Martin testified that this regulation, like the federal FSCC, “also is more akin to deciding whether or not to regulate, than to making resource planning decisions.”⁶⁰

113. Even if these two government entities did adopt the FSCC for purposes similar to those at issue in Minnesota, no showing has been made that either government entity held a contested hearing or even that public comments were filed and considered. On the contrary, the Canadian announcement as cited by Dr. Hanemann suggests that no Board of Review was established.⁶¹

114. The ALJs conclude that no deference should be accorded to a decision taken by foreign governments in matters in which interested parties have not been heard.

115. This proceeding, and the able advocacy displayed, shows again the importance of adversary proceedings.

116. The Agencies, through Dr. Hanemann, have also suggested that the Commission should consider using the FSCC for integrated resource planning because four utilities have already done so.⁶²

117. As Mr. Martin has noted, Dr. Hanemann has provided no details about how the FSCC

⁵⁹ Ex. [601, Martin Rebuttal](#) at 20:12-21.

⁶⁰ *Id.* at 20:1-21.

⁶¹ See <http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html> (cited in Ex. [800, pt. 1](#) (Hanemann Direct) at 62, n.41) at first paragraph.

⁶² Ex. [800, pt. 1](#) (Hanemann Direct) at 63.

was used,⁶³ and that Dr. Hanemann’s discussion instead abruptly shifted to the use of an “internal price of carbon for planning purposes,” for which he cites a Carbon Disclosure Project (CDP) publication finding that 29 companies, including Xcel Energy, use such a price.⁶⁴

118. The ALJs agree with Mr. Martin and Xcel that Dr. Hanemann here confuses a regulatory cost proxy with a CO₂ damage cost value.
119. The CDP report refers to Xcel Energy’s use of a \$20 per ton carbon price as a way to account for the potential cost of future CO₂ regulations.
120. However, as the Department of Commerce and Clean Energy Organizations have noted, the regulatory cost range does not estimate damages and therefore cannot serve as the basis for a CO₂ externality value.⁶⁵
121. The Commission’s regulatory cost range is derived from estimates of the cost of achieving compliance with future CO₂ regulations, and makes no attempt to estimate

⁶³ Ex. [601, Martin Rebuttal](#) at 20:23-21:12.

⁶⁴ Ex. [800, pt. 1](#) (Hanemann Direct) at 63.

⁶⁵ See for example the CEOs’ “Memorandum in Support of Clean Energy Organizations’ Motion to Update Externality Values for Use in Resource Decisions,” *In the Matter of the Quantification of Environmental Costs* in Docket Nos. E999/CI-93-583. October 9, 2013, page 14, noting that “Pursuant to §216H.06, the Commission is required to apply projected likely carbon regulatory costs in resource acquisition proceedings. Regulatory costs are not the same as externalities and to compare them would be an apples-to-oranges comparison...” See also *Comments of the Minnesota Department of Commerce, Division of Energy Resources and the Minnesota Pollution Control Agency* in Docket No. E999/CI-00-1636. June 10, 2014, page 15 and 17, recommending the Commission require that any CO₂ externality values be damage values, not compliance costs, willingness-to-pay/accept, or other value types. The “internal price of carbon” cited by Dr. Hanemann from the CDP report is a proxy for regulatory compliance costs, not damage values.

climate damages from CO₂ emissions.”⁶⁶

122. The ALJs accordingly conclude that neither the Canadian example, nor the Montgomery County example or the “utility integrated resource plan” example set forth on page 63 of Dr. Hanemann’s pre-filed direct testimony can support the application of the FSCC in the current context.

Challenges to the FSCC

123. The FSCC has been challenged on the basis that it relies on outdated information, that the damage functions are not unduly speculative above 3°C, that the IWG improperly harmonized the models on which the IWG based its FSCC calculations, that the IWG used improperly low discount rate, that the time horizon used by the IWG renders the FSCC wholly unreliable and speculative, that the IWG improperly used an incorrect “last emitted” marginal ton, that the IWG used a global geographic scope that is not appropriate for Minnesota resource planning in the absence of reciprocity, and that the use of the IWG’s 95th percentile FSCC value over-weights uncertain risks relative to more certain risks.

Uncertainty

124. Even the proponents of the FSCC concede that there is an incredible amount of uncertainty involved with the federal model, admitting that “[t]here’s inherent uncertainty in predicting future damages,”⁶⁷ and that there is “a lot of uncertainty.”⁶⁸
125. Dr. Polasky testified that what the economy and personal preferences of society will look

⁶⁶ Ex. [601, Martin Rebuttal](#) at 20:23-21:12.

⁶⁷ Tr. Vol. 1 at 114:16-17 (Polasky).

⁶⁸ Tr. Vol. 5 at 63:19-20 (Reich).

like in the year 2300 has “got great uncertainty about it.”⁶⁹ In fact, Dr. Polasky has admitted that the models cannot be tested; “this is an experiment ... so [the models are] [in] the category of projections.”⁷⁰

126. Opponents to the FSCC have shown that the IWG’s FSCC values are based on unreliable damage functions for temperature increases above 3°C.
127. The IWG modified Stanford University Energy Modeling Forum (“EMF”) 22 scenarios to extend the EMF assumptions by 200 years, from the year 2100 to the year 2300.⁷¹
128. The Agencies concede that “the IWG made some assumptions to extend the projections [from the EMF-22 exercise horizon of the year 2100] through 2300.”⁷²
129. The ALJs agree with the MLIG that the Agencies’ concession is a rather significant understatement, inasmuch as not only GDP, but also population and greenhouse gas emissions trajectories were all extended by 200 years.⁷³
130. A recent study by the Electric Power Research Institute (EPRI, 2014) evaluates the reasonableness of these IWG projections in detail and concludes “As a group, the extensions lack a coherent, viable, and intuitive storyline (or set of storylines) that drive all of the extensions from 2100 to 2300.”⁷⁴

⁶⁹ Tr. Vol. 1 at 172:13-17 (Polasky).

⁷⁰ Tr. Vol. 1 at 81:6-12; 81:13-82:1; 82:24-83:6 (Polasky). *See also* Tr. Vol. 4 at 81:5-8 (Martin) (“regardless of the time horizon, there are serious challenges in estimating climate damages”) (referring to statements in EPRI Technical Assessment).

⁷¹ Ex. [302](#) (Smith Direct report) at 66.

⁷² [Agencies Initial Brief](#) at 41.

⁷³ [Agencies Initial Brief](#) at 41 n.35.

⁷⁴ Ex. [302](#) (Smith Direct report) at 68 (citations omitted).

131. EPRI arrives at these conclusions for the following reasons:

The forecasts are not self-consistent. The IWG extrapolates land-use CO₂ emissions, non-CO₂ radiative forcing, population, GDP, and fossil and industrial CO₂ emissions. But these extrapolations are done in isolation without considering the effect of one forecast on all other forecasts. Therefore, the set of extensions lack internal consistency.⁷⁵

The forecasts are inconsistent regarding physical facts. EPRI finds all the IWG's extensions except the 5th Scenario result in an amount of CO₂ emissions that greatly exceed the CO₂ emissions that could come about from the combustion of all current estimates of global fossil fuel reserves. Current estimates of total CO₂ embodied in reserves of fossil fuel fall between 3,700 and 7,100 Gt CO₂. All IWG scenarios except the 5th Scenario forecasts total cumulative emissions in excess of 8,100 Gt CO₂ in 2200 and above 10,900 Gt CO₂ by 2300. The MERGE scenario's cumulative 2300 emissions exceed the emissions from reserves by 4.5 to 8.5 times. None of these relationships invalidate the IWG scenarios because new technologies could be developed or resources found that would greatly increase the level of reserves, but this would likely mean a significant increase in fossil fuel prices. However, none of the IWG extensions consider the feedback that the high demand for fossil fuels could have on the prices of fossil fuels. EPRI notes this relationship between current reserves and the amount of fossil energy that the IWG's extensions imply will be needed "further illustrates the need to consider socioeconomic structure and its uncertainty in the development of socioeconomic and emissions assumptions."

There is a lack of diversity among the forecasts. The possible ways in which the world will evolve over the next three hundred years is much greater than five. But in some ways, the five scenarios represent only two regulatory outcomes. The four EMF scenarios represent a [business-as-usual] situation where no action is taken to reduce GHG emissions, and the 5th scenario represents

⁷⁵ Population growth rate declines linearly, reaching zero in the year 2200. GDP/per capita growth rate declines linearly, reaching zero in the year 2300. The decline in the fossil and industrial carbon intensity (CO₂/GDP) growth rate over 2090-2100 is maintained from 2100 through 2300. Net land use CO₂ emissions decline linearly, reaching zero in the year 2200; and non-CO₂ radiative forcing remains constant after 2100. (Ex. [302](#) (Smith Direct report) at 68 (citations omitted).)

a scenario in which the world strives to be on a 550 ppm CO₂ concentration.

Furthermore, the formulas to project the post 2100 forecasts for population, GDP per capita, carbon intensity, net land use CO₂ emissions, and non-CO₂ radiative forcing are the same for all scenarios. Therefore, the IWG fails to consider a broad range of ways in which the market could evolve as required in the OMB's guidelines for regulatory analysis.⁷⁶

132. Dr. Smith testified that this horizon is “really extraordinary,” that it is based on the IWG’s own extrapolations from EMF 22 scenarios that end in the year 2100,⁷⁷ and that the IWG has failed to account for future adaptive decisions.⁷⁸ Specifically, Dr. Smith testified that:

A horizon of 2300 means the IWG is using the IAMs to make projections almost three hundred years into the future. Such far-future economic projections are inherently highly speculative, to the point where they are nearly worthless. Today, we have almost no idea what the global economy will look like in 2300, let alone what impacts specific changes in temperature will have on that economy -- just as those alive in 1715 would have found it nearly impossible to make accurate predictions regarding our economy and societal values today. Moreover, the IWG’s 2300 model horizon assumes, unrealistically, that future generations will passively endure temperature changes as high as 10°C above pre-industrial levels, without taking any steps whatsoever to address the causes of such temperature changes.⁷⁹

133. Dr. Smith pointed out that the IAMs’ damage functions are based on a limited number of studies of the economic impact of warming of 3°C or less,⁸⁰ but that the IAMs, however,

⁷⁶ Ex. [302](#) (Smith Direct report) at 68-69 (citations omitted).

⁷⁷ Dr. Smith was the supervisor of modeling teams involved in EMF 22. Ex. [300](#) at 920-10:10.

⁷⁸ Tr. Vol. 2A at 56:10-15 (Smith); Ex. [300](#) at 22:7-20 (Smith).

⁷⁹ Ex. [300](#) (Smith Direct) at 22:7-20; *see also* Ex. [601](#), [Martin Rebuttal](#) at 24:12-25:8.

⁸⁰ Ex. [300](#) at 18:17-19:2. Dr. Polasky agrees with Dr. Smith and with the IWG that “there is currently a limited amount of research linking climate impacts to economic damages.”

(continued)

are used to predict the damage to the economy of much greater changes in temperature.⁸¹

134. Dr. Smith testified that lacking any foundational data for the greater range, the modelers have had to extrapolate the shape of a damages curve above 3°C without being able to validate the shape with empirical data,⁸² and that despite the absence of an empirical foundation, the higher damage levels at higher projected temperatures in the modeled damages curve elevate the IWG's SCC estimates.⁸³

135. Quoting Professor Pindyck, Dr. Smith stated that

[IAMs] can say nothing meaningful about the kinds of damages we should expect for temperature increases of 5°C or more.Thus we are left in the dark; IAMs cannot tell us anything useful about catastrophic outcomes, and thus cannot provide meaningful estimates of the SCC.⁸⁴

136. In addition, according to Dr. Smith, the FSCC estimates are speculative because of the lack of specificity of the dose-response relationships that are implicit in the IAMs' extrapolations.⁸⁵

137. The current estimates of CO₂ environmental cost values for Minnesota were based on estimates of loss in GDP due to projected temperature changes through the year 2100, with an assumption that temperature will have increased 4°C above pre-industrial levels

(continued)

(Tr. Vol. 1 at 83:7-85:3 (Polasky); Ex. [100](#) at Schedule 2 (Feb. 2010 IWG Technical Support Document) at 5.)

⁸¹ *Id.*

⁸² *Id.*

⁸³ Ex. [300](#) (Smith Direct) at 18:17-19:2.

⁸⁴ Ex. [304](#) (Smith Surrebuttal) at 10:22-11:6 (citations omitted).

⁸⁵ Ex. [300](#) (Smith Direct) at 19:21-20:1.

by that time.⁸⁶

138. The principal witness in the original proceeding (Mr. Ciborowski) “relied upon projections that either ended by or before 2100, or addressed only temperature changes of 2.5°C or 3°C, which were being projected to occur well before 2100.”⁸⁷
139. Dr. Smith pointed out that “[t]hese researchers’ decisions to limit their analytic horizons (observed in both Mr. Ciborowski’s references and also in the EMF 22 scenarios) are not because they fail to understand that damages from GHG emissions in the near term will last beyond 2100. Rather, modelers know that the uncertainty in any projections they can make expands as those projections go further in time, until at some point the projections are not useful or meaningful. When the projections depend strongly on assumptions about technologies and/or consumer preferences, analysts feel that horizons much beyond 80 to 100 years is where uncertainty reaches that overly speculative point.”⁸⁸
140. Dr. Smith testified in her pre-filed testimony that “Cline (1992) is the one source that Mr. Ciborowski relied on that considers the role of potential damages in the far future (2250), at much higher temperatures (10°C), and even he presented his calculations as a “conceptual” exercise. He concluded:

[P]erhaps the single most important need for research on greenhouse policy is to identify the prospective damages over the very-long-term, on the order of 250-300 years. The scientific community simply has not made these estimates... The furthest out the scientific community has yet been prepared to venture is to the year 2100.

141. In making this statement, Cline makes it clear that projections of damages beyond about

⁸⁶ Ex. [302](#) (Smith Direct report) at 69.

⁸⁷ *Id.*

⁸⁸ Ex. [302](#) at 69.

2100 are simply thought experiments that cannot be treated as credibly as the estimates for the period up through 2100.”⁸⁹

142. Dr. Smith has unambiguously expressed that the IWG’s values beyond the year 2100 are “driven more by the speculative portions of the IAMs’ damages functions than by the portions that have at least some evidentiary basis.”⁹⁰

143. Both the CEOs’ witnesses and the Agencies’ witnesses agree that the damages are inherently uncertain, and become more and more uncertain as the time horizon is extended.⁹¹

144. Dr. Polasky testified that there really isn’t empirical data to support the estimation of damages above a 3°C degree increase in temperature from temperatures at pre-industrial times, and that we haven’t even reached 2°C above pre-industrial (year 1900) levels.⁹²

145. Furthermore, Dr. Polasky testified that

Q. Okay. Now, is it realistic to predict what is going to happen 300 years into the future?

A. As with all of these things, there’s uncertainty. So the further you go out, yes, it’s very uncertain. 300 years? It’s uncertain 100 years.

Q. Is it actually realistic to think that somebody back in 1715 could predict what the temperature would be today and what the effect of the temperature would be on our current GDP?

A. Certainly not with the science they had in 1715. But realistically, you know, the point is, yeah, the further out you go

⁸⁹ *Id.* at 69-70 (citations omitted).

⁹⁰ Ex. [300](#) at 23:2-5.

⁹¹ *See, e.g.*, Tr. Vol. 1 at 114:16-17 (Polasky: “inherent uncertainty in predicting future damages”); Tr. Vol. 1 at 11:20-12:1; 81:6-12; 81:13-82:1; 82:24-83:6; 172:13-17 (Polasky); Tr. Vol. 5 at 63:19-20 (Reich).

⁹² Tr. Vol. 1 at 124:7-13; 211:21-25 (Polasky).

the more difficult it is. The greater the range of uncertainty, that is correct.⁹³

146. Asked what, then, is the period of time over which present damage functions can be considered to be supported by evidence, Dr. Smith testified that

One answer would be to look to the lifespan of technologies available or foreseeable today, and that can be reasonably anticipated to be installed when the extant but aging technologies are replaced. Even the longest-lived technologies, such as electricity generating plants, rarely remain economical to operate more than about 80 years; accounting for the period over which presently foreseeable technologies might be adopted could expand the reasonable horizon perhaps another 40 years.⁹⁴

147. Dr. Smith therefore credibly concluded that “[t]his indicates that a modeling horizon for SCC estimates that do not contain undue speculative content regarding monetized damages would be about 2100 and no more than 2140. The reasonable horizon would be considerably less for projecting societal values in sectors that are served by less long-lived forms of capital.”⁹⁵

148. Dr. Smith further credibly explained that

Stated another way, the amount of speculation about societal risks and preferences using a 2100 horizon for SCC estimation would be similar to attempting to project societal values associated with today’s medical procedures, devices, drugs and immunizations, our communication methods such as the internet and smartphones, our range of food sources, our uses of electricity and gasoline, our methods of electricity generation, and our household appliances as an extension of the mix of services consumed and technologies available in 1935.⁹⁶

⁹³ Tr. Vol. 1 at 89:22-90:11 (Polasky).

⁹⁴ Ex. [302](#) (Smith Direct report) at 75.

⁹⁵ Ex. [302](#) (Smith Direct report) at 75.

⁹⁶ *Id.*

A 2140 horizon would be like attempting to estimate societal values for such services and capabilities from the vantage point of 1895's demands and capabilities. The former would perhaps anticipate the relative importance of various types of services within a degree of recognition, but overstate each sector's vulnerabilities. The latter would probably be far off base.⁹⁷

149. The ALJs agree with the MLIG that the record shows, by more than a preponderance of the evidence, that the IWG's FSCC values lack any empirical basis for temperature increases above 3°C, and are based on unreliable damage functions beyond a horizon of the year 2100 or (at most) 2140. In turn, this means that the FSCC proponents' suggestion and recommendation that the ALJs and the Commission accept the IWG's FSCC, without adjustments, as Minnesota's ECV of CO₂ must be rejected.

The Equilibrium Climate Sensitivity

150. Peabody Energy in particular has challenged the scientific basis for the FSCC.
151. The IWG has founded its calculation of the FSCC on the Intergovernmental Panel on Climate Change's ("IPCC") November 2007 Fourth Assessment Report ("AR4").⁹⁸
152. Of great importance to this case is the Equilibrium Climate Sensitivity ("ECS").
153. The ECS is the amount of temperature increase caused by a doubling of CO₂.⁹⁹
154. It is undisputed that the IWG did not use the climate sensitivity numbers provided by the IAMs, and instead relied on its own estimates on climate sensitivity.¹⁰⁰
155. In doing so, the IWG did not rely on one fixed sensitivity, but applied a Roe & Baker

⁹⁷ Ex. [302](#) (Smith Direct report) at 75.

⁹⁸ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 12. *See also* Ex. 405 (IPCC Fifth Assessment Report) [part 1](#) at 16 & n.16 and [part 36](#) at 1110-1111.

⁹⁹ Tr. Vol. 2A at 16:5-7 (Lindzen); Ex. 405 (IPCC's 2013 Fifth Assessment Report) [part 36](#) at 1110.

¹⁰⁰ Tr. Vol. 1 at 97:18-21 (Polasky).

distribution¹⁰¹ within a range of climate sensitivities contained in AR4.¹⁰²

156. The MLIG, the Utility Group, and Peabody have shown by a preponderance of the evidence that the IWG’s FSCC is out of date with respect to the value of the equilibrium climate sensitivity.
157. The importance of the ECS cannot be understated in this context; with the discount rate, the ECS is a “very important driver” in the damages calculations made by the PAGE, DICE, and FUND models.¹⁰³
158. The IWG has acknowledged that since it issued the FSCC,
- the IPCC issued a Fifth Assessment Report that updated its discussion of the likely range of climate sensitivity compared to AR4. The new assessment reduced the low end of the assessed likely range (high confidence) from 2°C to 1.5°C, but retained the

¹⁰¹ Ex. [100](#) at Schedule 2 at 13-14 (IWG “selected Roe and Baker distribution”).

¹⁰² See Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 12.

¹⁰³ Tr. Vol. 1 at 166:12-167:4 (Polasky). Dr. Smith has shown that a 1.5°C change in the ECS would lower the IWG’s estimates by 57% to 60%. See Ex. [303](#) (Smith Rebuttal) at 13:2-15:3 & Table 1:

Table 1. Sensitivity of 2020 SCC Estimates Using DICE 2010 and the IMAGE Socioeconomic Scenario (\$/tonne CO₂, 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

Comparison is against the IMAGE scenario with the fixed ESC of 3. Comparison against the initial IWG assumptions, with the ECS Roe and Baker distribution would yield 60% and 65% reductions. See Ex. [303](#) (Smith Rebuttal) at 13:2-15:3. Dr. Smith has credibly testified that “only a small portion of this reduction is due to having used a fixed rather than probabilistic assumption on the parameter’s value.” *Id.* at 14:8-17.

high end of the range at 4.5°C. Unlike in AR4, the new assessment refrained from indicating a central estimate of ECS. This assessment is based on a comprehensive review of the scientific literature and reflects improved understanding, the extended temperature record for the atmosphere and oceans, and new estimates of radiative forcing.¹⁰⁴

159. According to the IPCC’s 2013 Fifth Assessment Report (“AR5”), the new studies underlying the lowering of the low end of the ECS range “suggest a best fit to the observed surface and ocean warming for ECS values in the lower part of the *likely* range.”¹⁰⁵
160. To put this statement in context, Dr. Dessler, testifying for the CEOs, testified that “the ocean takes up heat. That’s where most of the heat trapped by greenhouse gases goes.”¹⁰⁶
161. According to CEO witness Dr. Polasky, the AR4 ECS is outdated, and the “measure of central tendency” first and last found in AR4 has been abandoned.¹⁰⁷
162. The importance of the IPCC’s AR5 has been urged forcefully by the Agencies:
- “[Dr. Gurney] discussed the importance of the IPCC 5th Assessment Report”¹⁰⁸
 - Dr. Gurney “compared the protocols followed by several Peabody witnesses with the much more appropriate protocols followed by the authors of the IPCC 5th Assessment Report”¹⁰⁹
 - “the synthesis supplied by the IPCC is the best comprehensive review of global

¹⁰⁴ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 12. *See also* Ex. 405 (IPCC Fifth Assessment Report) [part 1](#) at 16 & n.16 and [part 36](#) at 1110-1111.

¹⁰⁵ Ex. 405 [part 36](#) at 1111, first full paragraph (*italics in original*).

¹⁰⁶ Tr. Vol. 3B at 8:24-9:1 (Dessler).

¹⁰⁷ Tr. Vol. 1 at 165:10-15 (Polasky).

¹⁰⁸ [Agencies Initial Brief](#) at 8.

¹⁰⁹ *Id.*

temperature records”¹¹⁰

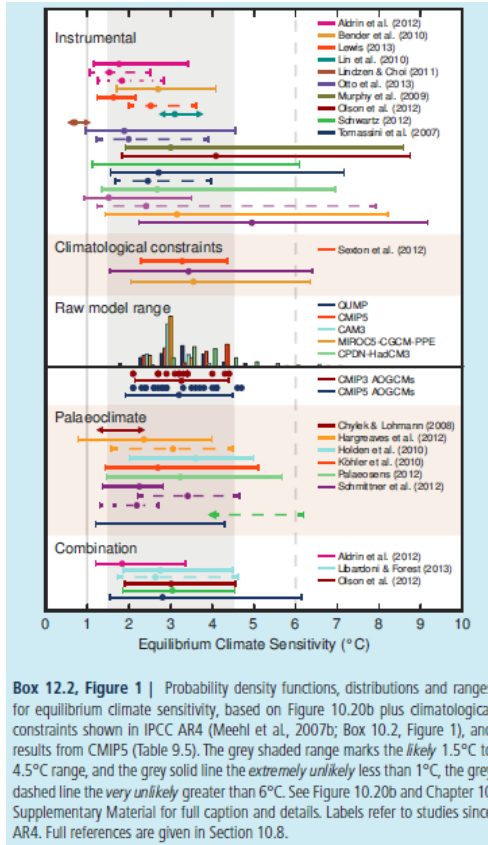
- “The most authoritative contemporary source is the IPCC’s 5th Assessment Report...”¹¹¹
- “Dr. Gurney reiterated that the IPCC 5th Assessment Report, which is the most comprehensive assessment of research on the issue of CO₂ fertilization and the role of CO₂ fertilization within climate change ...”¹¹²
- “The most reliable evidence on this topic is the IPCC 5th Assessment Report...”¹¹³
- “The IPCC 5th Assessment Report includes a thorough and comprehensive review of this important metric [the ECS] of the climate system; different aspects are discussed in at least three different chapters. ... The reported range of ECS values are based on multiple lines of evidence, including paleoclimate, model simulations, and instrumental measurements, as is demonstrated in the following figure from the IPCC’s 5th Assessment Report:

¹¹⁰ *Id.* at 24.

¹¹¹ [Agencies Initial Brief](#) at 50.

¹¹² *Id.* at 55

¹¹³ *Id.* at 56.



(Agency Initial Brief at 91, *citing* Ex. [405 \(AR5\), pt. 36](#) at 1110.)

163. The AR4’s higher-range ECS and the “central estimate” of 3°C were both expressly abandoned in AR5, based on “a comprehensive review of the scientific literature” and because of an “improved understanding, the extended temperature record for the atmosphere and oceans, and new estimates of radiative forcing.”¹¹⁴
164. The Agencies recognize in this respect that “it would be unreasonable to base a scientific assessment of climate change on an old IPCC Assessment Report rather than the current Assessment Report.”¹¹⁵
165. The ALJs find that the IWG is, in fact, based “on an old IPCC Assessment Report rather

¹¹⁴ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 12. *See also* Ex. 405 (IPCC Fifth Assessment Report) [part 1](#) at 16 & n.16 and [part 36](#) at 1110-1111.

¹¹⁵ [Agencies Initial Brief](#) at 34.

than the current Assessment Report.”¹¹⁶

166. The Agencies try to explain how a return to the *status quo ante* increases, rather than decreases to the SCC, citing Freeman *et al.*¹¹⁷
167. Under the circumstances, the ALJs agree with the MLIG that this theory must be rejected.
168. In Mark C. Freeman et al., *Climate Sensitivity Uncertainty: When is Good News Bad?*, Harvard Kennedy School, Faculty Research Working Paper Series (2015),¹¹⁸ Freeman focuses only on the change from a 2°C-4.5°C range to a 1.5°C-4.5°C range, calls the lowering of the bottom “good news,” but then explains that the willingness to pay would increase (“bad news”) because the estimate of its standard deviation would have increased.¹¹⁹
169. The ALJs agree with the MLIG that Freeman *et al.* overlook that the IPCC also announced that the new studies underlying the lowering of the low end of the ECS range “suggest a best fit to the observed surface and ocean warming for ECS values in the lower part of the *likely* range.”¹²⁰
170. Accordingly, the ALJs conclude that contrary to Freeman’s assumption that the “decrease in mean is due to a widening of the uncertainty range,”¹²¹ the uncertainty range has actually decreased, while, simultaneously, the low end of the range has been lowered.

¹¹⁶ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 12. *See also* Ex. 405 (IPCC Fifth Assessment Report) [part 1](#) at 16 & n.16 and [part 36](#) at 1110-1111.

¹¹⁷ *See* [Agencies Initial Brief](#) at 88-90.

¹¹⁸ The article is not peer-reviewed. *See* article cover disclaimer.

¹¹⁹ Mark C. Freeman et al., *Climate Sensitivity Uncertainty: When is Good News Bad?*, Harvard Kennedy School, Faculty Research Working Paper Series (2015) at 1.

¹²⁰ Ex. 405 [part 36](#) at 1111, first full paragraph (*italics in original*).

¹²¹ Freeman (2015) at 2.

171. As addressed in the [MLIG's initial brief](#)¹²² and in [Peabody's initial brief](#), the IWG further has not only ignored AR5, it never applied its Roe & Baker analysis to the full range.

Peabody has correctly observed that,

The IWG centered its Roe & Baker distribution on AR4's "best estimate" of 3°C. (Ex. [100](#), Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 13.) As in AR4, two-thirds of the probabilities used by the IWG fell between 2 and 4.5°C. (*Id.*) However, the IWG included far fewer probabilities below 1.5°C than it should have based on AR4. (*Id.*) Instead of 10 percent of probabilities falling at 1.5°C and below, only 1.3 percent did. (*Id.*) In fact, the 10th percentile was nearly at 2°C (10th percentile = 1.91). (*Id.*)¹²³

172. Under AR5, 5% of the values should have fallen at 1.0°C and below. The IWG placed the 5th percentile of the ECS at 1.72°C, however.¹²⁴ AR5 furthermore reduced the likelihood that the ECS was above 4.5°C. While in AR4 the IPCC still held that "[v]alues substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values,"¹²⁵ AR5 now provides that "Equilibrium climate sensitivity is ... very unlikely greater than 6°C."¹²⁶ But the IWG's FSCC is based on a distribution in which 10% of the values are 5.86°C or more and 5% of the values are 7.14°C or more:¹²⁷

¹²² See, e.g., [MLIG Initial Brief](#) at 4, 31-36.

¹²³ [Peabody Initial Brief](#) at 77.

¹²⁴ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 13.

¹²⁵ Ex. [268](#) at 38.

¹²⁶ Ex. 405 (IPCC Fifth Assessment Report) [part 1](#) at 16.

¹²⁷ Ex. [101](#) at Schedule 1 (July 2015 IWG Response to Comments) at 13.

Table 1: Summary Statistics for Four Calibrated Climate Sensitivity Distributions

	Roe & Baker	Log-normal	Gamma	Weibull
Pr(ECS < 1.5°C)	0.013	0.050	0.070	0.102
Pr(2°C < ECS < 4.5°C)	0.667	0.667	0.667	0.667
5 th percentile	1.72	1.49	1.37	1.13
10 th percentile	1.91	1.74	1.65	1.48
Mode	2.34	2.52	2.65	2.90
Median (50 th percentile)	3.00	3.00	3.00	3.00
Mean	3.50	3.28	3.19	3.07
90 th percentile	5.86	5.14	4.93	4.69
95 th percentile	7.14	5.97	5.59	5.17

173. In light of the change in ECS between AR4 and AR5, the abandonment of the central estimate, the IPCC’s statement in AR5 that new studies underlying the lowering of the low end of the ECS range “suggest a best fit to the observed surface and ocean warming for ECS values in the lower part of the *likely* range,”¹²⁸ and the above-reflected sensitivity of the values to the ECS, the ALJs find that the opponents to the FSCC have shown by more than a preponderance of the evidence that the IWG’s FSCC values are based on an improper ECS, and that the FSCC proponents’ suggestion and recommendation that the ALJs and the Commission accept the IWG’s FSCC, without adjustments, as Minnesota’s ECV of CO₂ must be rejected.

The discount rate

174. The ECS problem is exacerbated by the IWG’s use of 2.5%, 3%, and 5% discount rates that are inappropriate in the Minnesota context of Minn. Stat. § 216B.2422, subd. 3.

175. With the ECS, the discount rate is one of the most important drivers behind the FSCC.¹²⁹

¹²⁸ Ex. 405 [part 36](#) at 1111, first full paragraph (*italics in original*).

¹²⁹ Tr. Vol. 4 at 82:8-10 (Martin) (“the discount rate observes [*sic*] more influence on the results than any other factor”); Ex. [302](#) (Smith Direct report) at 80 (“A very important framing question in the case of regulations that have benefits and/or costs that endure for
(continued)

176. The IWG has acknowledged that

The choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law. Although it is well understood that the discount rate has a large influence on the current value of future damages, there is no consensus about what rates to use in this [climate change] context.”¹³⁰

177. As Dr. Smith has credibly and cogently testified, many of the values recommended in the literature and in this proceeding are driven more by moral philosophy than informed by empirical analysis.¹³¹

178. OMB Circular A-4 (Exhibit [417](#)) provides that when a regulation will affect private sector capital spending, such as is the case here, discount rates of 3% and 7% must be shown, because 7% approximates the opportunity cost of displaced private sector investment.

179. Recommendations for the right discount rate can be categorized as either (1) descriptive of observed human behavior, consistent with market evidence that reveals human preferences, or (2) prescriptive or normative in nature, reflecting subjective moral judgments without evidentiary basis.¹³²

180. Dr. Smith testified that the use of a 2.5% rate is unsupported by empirical evidence, does not meet the criteria that Minnesota used in the prior proceeding, and noted that an

(continued)

a long period of time, as is the case with climate policy, is the choice of discount rate.”). See also Ex. [302](#) at 90, Table 14, demonstrating “the large effect that the discount rate has on the SCC values.” See further Ex. [100](#) at Schedule 2 (July 2010 IWG Technical Support Document) at 17. Dr. Polasky has remarked, “what one assumes about the discount rate matters hugely.”¹²⁹

¹³⁰ Ex. [100](#) at Schedule 2 (July 2010 IWG Technical Support Document) at 17.

¹³¹ Ex. [302](#) (Smith Direct report) at 80.

¹³² Ex. [302](#) (Smith Direct report) at 80.

element of the IWG's decision to adopt this rate as one of three rates was to insert a subjective view and ethical considerations among some policy analysts that people living today should not discount the consumption of future generations in the manner which they discount their own within-generation consumption choices.¹³³

181. Dr. Smith testified that the “prescriptive approach for setting lower-than-observed discount rates when conducting a [benefit cost analysis] for a policy that affects multiple generations often starts with an appeal to the ethical notion that it is inappropriate for present generations to give less weight to the consumption that entirely different generations will enjoy than we give to our own current generation’s consumption.”¹³⁴
182. “The statement that the consumption (‘welfare’) of future generations should be given fair consideration when society makes decisions today that may have very long-term consequences is easy to accept. However, the prescription that the way to accomplish this is to use a discount rate that is lower than, and inconsistent with, empirical evidence of current societies’ consumption rate of interest is not the only approach that economists/philosophers have suggested for ethically accounting for future generations.”¹³⁵
183. Dr. Smith pointed out that intergenerational welfare and growth models, as well as theories of intragenerational welfare, have been analyzed to assess economic criteria for intergenerational comparisons.
184. Any number of possible intergenerational distributions can be derived from the models,

¹³³ Ex. [302](#) (Smith Direct report) at 80-82; 87-89.

¹³⁴ *Id.* at 87.

¹³⁵ Ex. [302](#) (Smith Direct report) at 87-88.

but Prof. Mishan of the London School of Economics wrote that “no economic criterion can produce acceptable answers to the distribution problem – whether at a point of time or over time – since the problem is basically an ethical one.”¹³⁶

185. Recognizing the ethical issue is one of personal opinion, Prof. Mishan suggests he believes most people would agree on one premise with respect to intergenerational ethics:

For whatever be our view of the fundamental factors explaining differences in existing incomes, we are likely to agree that an equal per capita real consumption for all generations is an eminently fair arrangement ... In sum, the ethical appeal of equality of per capita consumption over generational time is independent of a belief in the justice of an equal division of the product in any existing society, and is far more compelling.¹³⁷

186. This eloquent observation caused Dr. Smith to testify that “economic analysis offers no way to sort among prescriptive formulas. It is thus false to view the common prescription of adjusting the discount rate to lower levels than is descriptive of existing society’s consumption rate of time preference as the only ethical way to handle the question of fairness to future generations. In fact, studies have shown that the approach of addressing this concern through lowered discount rates creates analytic problems. Two such problems were noted by Farrow and Viscusi: time inconsistency and infinite benefits. Nordhaus (2007) further demonstrates that an overly low discount rate in an IAM model such as his DICE model results in nonsensical implications for savings rates.”¹³⁸
187. Dr. Smith has further noted that while “prescriptive discounting adjustments are to be avoided, the quote from Mishan suggests alternative ways to give consideration to the

¹³⁶ Ex. [302](#) (Smith Direct report) at 87 (citing Ezra J. Mishan, *Economic Criteria for Intergenerational Comparisons*, *Journal of Economics* 37(3-4):281-306 (1977) at 304).

¹³⁷ Mishan (1997) at 300-301.

¹³⁸ Ex. [302](#) (Smith Direct report) at 88 (citations omitted).

welfare of future generations. If he is correct that most would agree that we should manage existing societal decisions so that future generations will have at least our level of real consumption, then we can look to the IAMs’ projected consumption to determine how well different emissions regulations meet that objective.”¹³⁹

188. Table 12 in [Dr. Smith’s report, Exhibit 302](#) (p.89) presents the real per capita consumption in each of the five IAM baseline scenarios in the current time (2020), and then in 2100, 2200, 2300. “These consumption paths are the endogenous ones that DICE calculates, given the climate impacts associated with each scenario’s respective projection of emissions.”¹⁴⁰ “In other words, the damage function in the model decreases the raw IWG projections of GDP in light of the emissions projected and their projected impact on temperature.”¹⁴¹

Table 12. Real Undiscounted Consumption per Capita Over Time IAM Scenarios (Baseline Emissions)

	IMAGE	MERGE	MESSAGE	MiniCAM	5th scenario
<i>Real global consumption per capita</i>					
2020	\$ 9,194	\$ 7,427	\$ 8,595	\$ 7,613	\$ 8,171
2100	\$ 37,133	\$ 22,892	\$ 26,912	\$ 36,671	\$ 31,106
2200	\$ 125,365	\$ 43,798	\$ 53,759	\$ 134,827	\$ 90,555
2300	\$ 169,660	\$ 49,239	\$ 63,872	\$ 187,494	\$ 122,001
<i>Consumption relative to 2020 consumption</i>					
2100 relative to 2020	4	3	3	5	4
2200 relative to 2020	14	6	6	18	11
2300 relative to 2020	18	7	7	25	15

Source: NERA runs of DICE model using median equilibrium climate sensitivity (ECS=3)

189. Dr. Smith has testified that Table 12 shows that “even after absorbing the impacts of temperature change, all of the IAM scenarios are predicting that future generations will

¹³⁹ Ex. [302](#) (Smith Direct report) at 88.

¹⁴⁰ *Id.*

¹⁴¹ Ex. [302](#) (Smith Direct report) at 88 n.132. These calculations used the median value of the ECS (*i.e.*, 3°C). (*Id.*)

be far wealthier and have far higher consumption than is the case in the present. In fact, by 2100, they project that real consumption will be 3 to 5 times higher than we have today. By 2300, when the largest amount of climate impact (with unreduced business-as-usual emissions) will have occurred,¹⁴² consumption will be between 7 and 25 times higher than we have today. Thus, the IAM scenarios that the IWG has used to compute the SCC of a ton of emission today are also implying that any cost we incur today will reduce our consumption in the present while adding to the vastly higher welfare of future generations.”¹⁴³

190. The ALJs agree that given this significant increase in future generations’ consumption despite temperature change and the effects thereof and given the very significant factor by which the proponents of the FSCC seek to have resource-planning inputs increase to account for highly speculative damages over a very long time horizon, it is appropriate that to recommend to the Commission that it continue to act conservatively.¹⁴⁴
191. The ALJs agree with ALJ Klein’s express recognition in 1996 that “the possibility of utilities paying more for resources than their environmental benefits justify is just as bad

¹⁴² As stated above, for four of the five IWG scenarios, the baseline emissions projection reflects a business-as-usual world. (Ex. [302](#) (Smith Direct report) at 53.) The “5th scenario” has a baseline that reflects global emissions being reduced to achieve atmospheric concentration stabilization at 550 ppm, but this scenario receives only 20% weight in the calculation of the IWG’s SCC values, as it is only one of five scenarios that are averaged together. (*Id.*)

¹⁴³ Ex. [302](#) (Smith Direct report) at 88.

¹⁴⁴ Ex. [305](#) (March 22, 1996, Findings of Fact, Conclusions, Recommendation and Memorandum (ALJ Allan W. Klein), Docket 93-583) at Finding 36 (“The adopted values should be conservative.”)

as paying less than their benefits justify.”¹⁴⁵

192. The data in this proceeding shows that adoption of a reasonable and appropriate discount rate will not lead to the current generation taking advantage of such future generations, although, by definition, the current generation will be paying for the impacts of the values adopted as a result of this proceeding.¹⁴⁶
193. As recognized *supra*, the IWG itself has noted the express purpose in estimating the FSCC is “to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO₂) emissions into cost-benefit analyses of regulatory actions that have small, or ‘marginal,’ impacts on cumulative global emissions,”¹⁴⁷ and the IWG intended the FSCC for use in federal regulation primarily affecting private consumption, rather than in the context of the expenditure of private capital.¹⁴⁸
194. The ALJs agree with opponents to the FSCC that the record shows that while it may be appropriate to use lower private consumption rates of interest for the discount rate in an IWG model geared towards private consumption, that discount rate is not appropriate here.

¹⁴⁵ Ex. [305](#) (March 22, 1996, Findings of Fact, Conclusions, Recommendation and Memorandum (ALJ Allan W. Klein), Docket 93-583) at 17 and at Finding 36 (“The adopted values should be conservative.”).

¹⁴⁶ The MLIG has expressed great concern for the impact on ratepayers in general, including household consumers of electricity, (Tr. Vol. 1 at 41:5-13), while Xcel, through Mr. Martin, has stated that “adoption of high CO₂ environmental cost values could result in increased energy costs, which could disproportionately affect lower-income rate payers, minorities, and the elderly.” (Ex. [601, Martin Rebuttal](#) at 35:18-22.)

¹⁴⁷ Ex. [302](#) (Smith Direct report) at 32 (*citing* February 2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 at 1 (copy attached as Schedule 2 to Ex. [100](#) (Polasky Direct))).

¹⁴⁸ Ex. [101, Ex. 1](#) (July 2015 *Response to Comments, Social Cost of Carbon for Regulatory Impact Analysis Under Executive order 12866* (Interagency Working Group on Social Cost of Carbon)) at 21-22.

195. In Minnesota, approximately two-thirds of Minnesota's electricity consumption is by large industry and small, medium, and large companies. Only about one-third of Minnesota's electric consumption is by households.¹⁴⁹
196. The outcome of this proceeding will be used in Minnesota resource planning, which affects the expenditure of private capital.
197. Initial investment decisions and resource choices are made exclusively by the utilities, which make (Commission-approved) capital investment choices.
198. The Commission has as recently as May 8, 2015, approved Xcel's capital structure and the rate of return at a weighted pre-tax cost of 7.35% for 2014 and 7.38% for 2015 in Xcel Energy's Minnesota Electric Rate case, using a 9.72% cost of equity.¹⁵⁰
199. This is important because these figures are used as a discount rate in integrated resource planning. For example, in Xcel Energy's most recent integrated resource plan dated January 2015, Xcel Energy assumed a before-tax weighted discount rate of 7.58% (after-tax discount rate of 6.62%) to determine the present value of revenue requirements:¹⁵¹

¹⁴⁹ Tr. Vol. 4 at 89:4-14 (Martin).

¹⁵⁰ See [May 8, 2015, Findings of Fact, Conclusions, and Order in Docket No. E-002/GR-13-868](#) at 61-62.

¹⁵¹ Martin testimony, Tr. Vol. 4 at 94:1-95:17; Ex. [436](#) at 6.

C. Modeling Assumptions – Detail

1. Capital Structure and Discount Rate

The rates shown in Table 1 were calculated by taking a weighted average of Minnesota (85 percent) and Wisconsin (15 percent) information from the January 2014 Corporate Assumptions Memo. The after tax weighted average cost of capital of 6.62 percent is used to calculate the capital revenue requirements of generic resources. It is also used as the discount rate to determine the present value of revenue requirements.

Table 1: Capital Structure

	Capital Structure	Allowed Return	Before tax Elec. WACC	After tax Elec. WACC
L-T Debt	45.24%	5.12%	2.33%	1.37%
Common Equity	52.56%	9.89%	5.24%	5.24%
S-T Debt	2.20%	0.64%	0.01%	0.01%
Total			7.58%	6.62%

200. It would be entirely inconsistent for the State to approve a CO₂ environmental cost value that assumes a low discount rate for an extended investment horizon (150-200 years), which value would be used in resource planning where a higher discount rate is assumed over a shorter time horizon (15-30 years).
201. It is undisputed that retaining a 3% discount rate is appropriate.
202. The ALJs agree with Dr. Smith that a 2.5% discount rate is unsupported by empirical evidence, that interest rates below 3% were previously rejected by the Commission, and that the adoption of purely subjective views, as the IWG did, is not appropriate nor necessary, as set forth above.¹⁵²
203. The ALJs find that the use of a 7% discount rate is appropriate in Minnesota resource planning, which affects the expenditure of private capital.
204. The ALJs accordingly find that either the use of both 3% and 7% discount rates, as part of a range of the ECV of CO₂ is reasonable or, in the alternative, that it is reasonable to

¹⁵² See Ex. [302](#) (Smith Direct report) at 80-82; 87-89.

use a weighted 5.66% discount rate, arrived at by taking the lower (risk-free) 3% discount rate and merging it on a weighted basis (1/3) based on approximate state-wide relative energy consumption¹⁵³ with a 7% corporate discount rate (2/3).¹⁵⁴

Geographic scope of damages calculation

205. The Commission currently uses a global geographic scope for the calculation of the ECV of CO₂.¹⁵⁵
206. The MLIG and the Utilities Group have introduced cogent evidence to support their position that a global scope is inappropriate.
207. It is undisputed that no reciprocal action will follow from Minnesota's unilateral action in setting a global scope for the calculation of the ECV of CO₂.¹⁵⁶

¹⁵³ See [MLIG Initial Brief](#) at 77-78 (citing Tr. Vol. 4 at 89:4-14 (Martin)).

¹⁵⁴ $3\% + 7\% + 7\% = 17\% / 3 = 5.66\%$

¹⁵⁵ In 1997, the Commission considered:

Parties further objected that it would be “impracticable” for Minnesota to adopt CO₂ values because CO₂ (and any associated global warming) could not be addressed with any appreciable impact by Minnesota alone. It is true that CO₂ emissions in Minnesota (approximately 33 million tons per year) constitutes approximately 0.1 percent of global CO₂ emissions (approximately 60 billion tons per year). The objectors’ argument, however, does not really challenge the practicability (feasibility) of setting CO₂ values, but instead questions the wisdom of doing so in view of what they view as the inconsequential impact of such an effort. Their argument that nothing should be done because nothing “significant” (in the eyes of the objectors) can be done is a political argument not appropriately before the Commission. The legislature has made the appropriate political decision that the Commission should value CO₂ to the extent that this is feasible and, after rejecting some proposed ranges for CO₂ the Commission has done so.

([Order Establishing Environmental Cost Values](#) (January 3, 1997) at 26.)

¹⁵⁶ See, e.g., Tr. Vol. 4 at 100:21-23 (Martin) (other states and countries are likely to make CO₂ decisions on their own basis rather than in response to Minnesota's actions); Ex. [601, Martin Rebuttal](#) at 39 (Commission unable to negotiate explicit reciprocity); *id.* at 39-40 (Minnesota's adoption of a global SCC value – if it shifts resource planning decisions to reduce or even eliminate Minnesota's CO₂ is likely to lead to emissions

(continued)

208. It is undisputed that CO₂ travels globally. In fact, it takes about one month for CO₂ to circulate around the Northern Hemisphere, such that if the CO₂ above Minnesota were to suddenly vanish, other CO₂ from the rest of the world would take its place in about a one-month period.¹⁵⁷
209. Accordingly, and as the IWG has noted, addressing global GHG emissions in a meaningful way requires all major emitting nations to reduce their emissions significantly, not just the U.S. emitters.¹⁵⁸
210. Dr. Smith has credibly testified that this fact “leads to exactly the *opposite* conclusion about inclusion of global benefits in the SCC value from what the IWG concluded.”¹⁵⁹ The reason is that IAMs “compute a high \$/ton value for a ton of U.S. emission not because the U.S.’s emissions are *causing* such high damages, but rather the SCC estimate is driven upwards by the effect of all of the other nations’ uncontrolled CO₂ emissions.”¹⁶⁰ Otherwise stated, if no other nation emitted GHGs, then the SCC estimate

(continued)

leakage in an interconnected electricity system which would further diminish any effect. Meanwhile, because Minnesota has already made significant investments to reduce GHGs, a high SCC could lead to relatively high-cost further actions compared to mitigation options available elsewhere. This means the benefit (reduction in climate damages experienced by Minnesotans) would be small to negligible, while Minnesota utility customers could bear greater direct costs than they would under a resource plan that used a U.S. or Minnesota SCC value); Tr. Vol. 1 at 179:2-7 (Polasky) (does not “really know” whether concept of taxing or regulating to provide a benefit to persons outside the taxing or regulating jurisdiction is highly unusual); Tr. Vol. 3A at 99:2-24; 100:20-23 (Dessler) (no knowledge; China will not act in response to Minnesota’s actions).

¹⁵⁷ Tr. Vol. 4 at 151:20-152:3 (Gurney).

¹⁵⁸ Ex. [302](#) (Smith Direct report) at 95-96.

¹⁵⁹ Ex. [302](#) (Smith Direct report) at 96 (citations omitted; emphasis in original).

¹⁶⁰ Ex. [302](#) (Smith Direct report) at 95-96 (emphasis in original).

would be entirely due to U.S. emissions; however, that SCC estimate would be lower than what the IWG has computed.”¹⁶¹

211. After due consideration, the ALJs agree that in the absence of other nations’ CO₂ emissions, it would be entirely appropriate to employ a global geographic damages scope, but that given those other nations’ emissions and in the absence of reciprocity, it is inappropriate for Minnesota to do so, both under the analysis offered by Dr. Smith and Dr. Gayer, and after considering remarks by Prof. Pindyck.¹⁶²
212. Prof. Pindyck’s article has been cited for the proposition that he does not believe that the flaws in the IAMs should cause the political process to sit back and do nothing. As cited in the [Agencies Initial Brief](#) at 62:

My criticism of IAMs should not be taken to imply that, because we know so little, nothing should be done about climate change right now, and instead we should wait until we learn more. Quite the contrary. One can think of GHG abatement policy as a form of insurance: society would be paying for a guarantee that a low-probability catastrophe will not occur (or is less likely). As I have argued elsewhere, even though we don’t have a good estimate of the SCC, it would make sense to take the Interagency Working Group’s \$21 (or updated \$33) number as a rough and politically acceptable starting point and *impose a carbon tax (or equivalent policy) of that amount*. This would help to establish that there is a social cost of carbon, and that social cost must be internalized in the prices that consumers and firms pay. (Yes, most economists already understand this, but politicians and the public are a different matter.) Later, as we learn more about the true size of the SCC, the carbon tax could be increased or decreased accordingly.¹⁶³

213. The ALJs are mindful that the action suggested by Prof. Pindyck is a political action,

¹⁶¹ *Id.* at 96 (citations omitted).

¹⁶² *Id.*

¹⁶³ Robert S. Pindyck, “Climate Change Policy: What Do Models Tell Us?” (2013a) *Journal of Economic Literature* 51(3), 860-872 at 870 (emphasis added).

within the purview of the Minnesota Legislature or the U.S. Congress, rather than the Commission.¹⁶⁴

214. The ALJs agree with the MLIG that the benefits of the tax envisioned by Prof. Pindyck are not global, but limited to the taxing jurisdiction, which in this case would be Minnesota. If Minnesota levies a tax on CO₂ emissions, the revenue is collected in Minnesota. It is not reasonable to assume that the Minnesota Legislature would turn around and distribute those funds in surrounding states, in the absence of reciprocity.
215. Imposing the higher SCC estimate made by the IWG on U.S. entities pushes U.S. entities to make an unfairly large amount of emissions reductions, but without global benefit given the small portion of Minnesota's contribution to global emissions.¹⁶⁵ Alternatively, if other countries imposed a SCC value on their own emissions equivalent to the SCC value the U.S. imposes, then their emissions would be lowered too, which would lower the global SCC.
216. This analysis does not suggest that Minnesota should not compute an ECV for CO₂, but the value should be computed with a local geographic scope at this time.

The 95th percentile FSCC value

217. The IWG has published four sets of values, calculated at discount rates of 2.5%, 3%, 5%, and the 95th percentile values at a 3% discount rate.¹⁶⁶

¹⁶⁴ See, e.g., [Agencies Initial Brief](#) at 107 (referencing development of a “stringent abatement policy” which is well beyond the scope of the Commission’s statutory role and the ALJs’ task in this proceeding).

¹⁶⁵ Ex. [302](#) (Smith Direct report) at 96. The Commission recognized Minnesota’s small contribution in 1997. [Order Establishing Environmental Cost Values](#) (January 3, 1997) at 26 (at the time approximately 0.1 percent of global CO₂ emissions).

¹⁶⁶ See Ex. [100](#) at Schedule 3 at Table A1 (p.18).

218. Various authors, including Dr. Polasky, advocate for the use of the 95th percentile FSCC value as an “insurance policy.” Dr. Polasky testified that the FSCC and home insurance, both involve uncertainty about what damages might occur in the future. If we could be certain there would be no damages to our house over the next year, the value of home insurance would be zero. But the value of insurance is greater than zero because there is some, perhaps small, probability that a damage-causing event will happen (e.g., severe storm, fire). Suppose that there is a 5 percent chance of such an event occurring. That means there is a 95 percent chance that no such event will occur. In other words, 95 times out of 100, the possible future cost of damage to our home is \$0.00. Five times out of 100, however, the cost of those damages could be quite large. If we calculate the median of expected damages over the coming year, it is zero.¹⁶⁷
219. Dr. Gayer disagreed, and explained in his surrebuttal testimony that the use of the IWG’s 95th percentile FSCC value over-weights uncertain risks relative to more certain risks, and confuses “uncertainty” with “risk.”¹⁶⁸
220. Dr. Gayer explains that the mistake made is classical, and is known as the Ellsberg Paradox.¹⁶⁹
221. Dr. Gayer testified that risk is the probability of an event occurring; uncertainty is the degree of imprecision in the estimate of risk.¹⁷⁰ He explained that if one considers two new automobiles. One poses a well-known defect risk of 2 in 1,000 over the lifetime of the vehicle. The other is newer to the market, and there is a 50-50 chance that the defect

¹⁶⁷ Ex. [101](#) (Polasky Rebuttal) at 38.

¹⁶⁸ Ex. [401](#) (Gayer Surrebuttal) at 14.

¹⁶⁹ The Ellsberg Paradox is a paradox in decision theory in which people’s choices violate the postulates of subjective expected utility in that they demonstrate a preference for taking on risk in which they know the specific odds rather than an alternative risk in which the odds are completely ambiguous. It is generally taken to be evidence for ambiguity aversion. (Ex. [401](#) (Gayer Surrebuttal) at 15 n.3.)

¹⁷⁰ Ex. [401](#) (Gayer Surrebuttal) at 14:18-19.

risk is either 1 in 1,000 or 3 in 1,000. Both of these automobiles have the same average risk (2 in 1,000), but the latter has greater uncertainty about the risk.¹⁷¹ In this example the vehicles should be equally insured against defect risk, since they both have the same average risk (2 in 1,000).¹⁷² However, the Ellsberg Paradox has demonstrated that people mistakenly exhibit a form of ambiguity aversion that makes the precisely known risk of the first automobile less fearsome than the uncertain risk of the second automobile.¹⁷³

222. Dr. Gayer showed that ambiguity aversion is a form of irrational behavior and should not be confused with risk aversion in which people are averse to the risk of incurring a large loss. Dr. Gayer explained that people might quite rationally choose to purchase a homeowners insurance policy for \$1,000 even though the expected losses are only \$800, but losses could be significant. Dr. Gayer accordingly testified that a very low probability of a catastrophic loss would make such insurance attractive to a risk-averse person and could be quite rational. What would not be rational is to be swayed by the uncertainty regarding the risk probability.¹⁷⁴

223. Dr. Gayer opined that the use of the 95th percentile value of a risk estimate (as Dr. Polasky is suggesting) is similarly a mistake.¹⁷⁵ Doing so over-weights uncertain risks relative to more certain risks and distorts our policies and regulations in harmful ways.

224. Dr. Gayer illustrated his opinion credibly by another hypothetical example, where there is enough money to clean up one hazardous waste site and one must decide between two

¹⁷¹ Ex. [401](#) (Gayer Surrebuttal) at 14:19-15:1.

¹⁷² *Id.* at 15.

¹⁷³ *Id.*

¹⁷⁴ Ex. [401](#) (Gayer Surrebuttal) at 16.

¹⁷⁵ Ex. [401](#) (Gayer Surrebuttal) at 15.

sites. Site A contains a chemical contaminate that is well studied by researchers and presents a cancer risk of 1.25 in a million, known with certainty. Site B presents a relatively less researched contaminant that has an estimated cancer risk of 1 in a million, but there's a 50 percent chance of no risk and a 50 percent chance of a risk of 2 in a million. Site A presents a higher average risk (25 percent higher than the risk at Site B), so the resources should be devoted to cleaning it up before Site B, since doing so will prevent more cancer cases. Dr. Gayer showed that if one puts undue weight on uncertainty, the resources will be devoted to cleaning up the more uncertain Site B, which decision, on average, would result in *more* expected cancer cases because of the higher average risk of cancer by not cleaning up Site A.¹⁷⁶

225. Dr. Hanemann uses an example similar to Dr. Polasky's example to support the use of the 95th percentile: "We wouldn't get on a plane if there was a 5% chance of the plane crashing, but we're treating the climate with that same level of risk in a very offhand, complacent way."¹⁷⁷
226. Dr. Gayer explained that although we should not ignore climate risks, Dr. Hanemann, like Dr. Polasky and the IWG, confuses risk with uncertainty. Dr. Gayer testified that "[t]he correct analogy is to suppose that Plane 1 has a 5 percent chance of crashing and we know with certainty that the risk is 5 percent (*i.e.*, it will definitely crash 5 in 100 times). Suppose Plane 2 has an average risk of crashing of 4 percent, but there's a 50 percent chance that its risk of crashing is really 0 percent and a 50 percent chance that its risk of crashing is really 8 percent. Plane 2 has a lower average risk, so the rational

¹⁷⁶ Ex. [401](#) (Gayer Surrebuttal) at 16:10-17:2.

¹⁷⁷ Ex. [801](#) (Hanemann Rebuttal) at 71.

choice is to choose to fly on Plane 2 rather than Plane 1. Of course, the Ellsberg Paradox suggests that numerous people (including apparently Dr. Polasky and Dr. Haneman[n]) would choose to fly on Plane 1, not understanding the higher risk they are taking. By including the 95th percentile of the SCC distribution (and not including the 5th percentile), Dr. Hanemann is in effect putting more weight on regulating uncertain, lower average, risk over more certain, higher average, risk. A classic Ellsberg-Paradox analytical mistake.”¹⁷⁸

227. The ALJs find that Dr. Gayer’s explanation is correct, and that adoption of the 95th percentile damages calculation does not, in fact, have an empirical basis, and should not be adopted for Minnesota resource planning proceedings.

The marginal ton

228. The IWG’s FSCC values are calculated assuming that the emitted ton of CO₂ being valued would be the last ton to be added to the global CO₂ emissions inventory. According to Dr. Smith, this overstates the marginal damage.
229. Dr. Smith testified that it is inappropriate to assume that a particular ton of CO₂ emitted in the near future would be the last ton to be decided on as part of a 300-year “business as usual” baseline of otherwise unconstrained future emissions,¹⁷⁹ since many of the tons

¹⁷⁸ Ex. [401](#) (Gayer Surrebuttal) at 17:14-18:5.

¹⁷⁹ For four of the five IWG scenarios, the baseline emissions projection reflects a business-as-usual world. Thus, each 2020 ton is valued against a future baseline projection in which no other reductions are ever made. However, if there is to be any actual climate benefit in reducing CO₂ emissions in Minnesota, those actions *have* to be part of a comprehensive policy. (Ex. [302](#) (Smith Direct report) at 53 (emphasis in original).) The “5th scenario” has a baseline that reflects global emissions being reduced to achieve atmospheric concentration stabilization at 550 ppm, but this scenario receives only 20% weight in the calculation of the IWG’s SCC values, as it is only one of five scenarios that are averaged together. (*Id.*)

emitted that contribute to the FSCC will not be emitted until much later than the Minnesota tons in question and by others than Minnesota, while the carbon emitted in Minnesota is no more or less harmful than carbon emitted elsewhere and is also no more or less harmful than any of the tons assumed to be emitted in the future.¹⁸⁰

230. Dr. Smith testified that, for example, the FSCC value for 2020 depends on the concentration of greenhouse gasses projected to already exist by 2020, all emissions produced in 2020, and all emissions produced from 2020 into the far future.¹⁸¹

231. Dr. Smith further testified that in the case of greenhouse gases, the marginal damage estimate varies with the baseline projection of greenhouse gas emissions and is higher if it is calculated against a baseline reflecting a world in which no greenhouse gas control policies are in place, compared to a world that includes global greenhouse gas control policies.¹⁸²

232. Dr. Smith thus concluded that a more appropriate marginal value should be calculated using a projection of CO₂ and other greenhouse gas emissions consistent with the global target that is considered appropriate to address climate change concerns, which the IWG did not do.¹⁸³

233. Dr. Mendelsohn agrees with this critique, noting that the IWG calculated the SCC “assuming zero abatement not only today but forever. Not only in the United States but

¹⁸⁰ Ex. [300](#) at 20:7-21:1.

¹⁸¹ Ex. [300](#) at 20:18-21.

¹⁸² Ex. [300](#) at 21:16-21.

¹⁸³ Ex. [300](#) at 21:21-22:5.

everywhere.”¹⁸⁴ In Dr. Mendelsohn’s words, “[t]he IWG made a conceptual error by measuring the wrong SCC.”

234. Mr. Martin also agrees with Dr. Smith and testified that the IWG’s calculation of damages by using the “last ton” as the marginal use creates excessive damages, and that an “average ton” should be used instead of the “last ton.”¹⁸⁵

235. The CEOs and Xcel Energy have expressed concern about the methodology used to value the “first ton,”¹⁸⁶ but neither defends the IWG’s “last ton” approach, which has never been used in Minnesota.

236. It is not entirely clear how the “average ton” is currently calculated in Minnesota.

237. The CEOs, and Dr. Polasky, claim that “[Dr. Smith] disagrees with the future emission projections used by the IWG and she therefore changes them.”¹⁸⁷

238. The MLIG has responded that “this criticism is false, as Dr. Smith used the exact same emissions trajectories (the quantity of emissions emitted) as the IWG. As Dr. Smith testified, ‘Nobody is making [any projection of global emissions stopping in 2020]. It’s an analytic device to understand what the lower bound marginal cost per ton is.’”¹⁸⁸

239. Dr. Smith explained that:

Tr. Vol. 2A,
124:21 I was trying to say that the dollar per tons, in
124:22 theory, if we didn’t have this historical overburden
124:23 of past emissions that are still in the atmosphere,

¹⁸⁴ Ex. [214](#) (Mendelsohn Direct) at 15:21-16:2; Exhibit [216](#) (Mendelsohn Direct report) at 9, 10.

¹⁸⁵ Tr. Vol. 4 at 46:3-47:14.

¹⁸⁶ [CEOs Initial Brief](#) at 29-31; [Xcel Initial Brief](#) at 28-29.

¹⁸⁷ [CEOs Initial Brief](#) at 30 (*citing* Ex. [101](#) (Polasky Rebuttal) at 10).

¹⁸⁸ MLIG Reply Brief at 34 (*citing* Tr. Vol. 2A at 89:14-25).

124:24 would go down to \$0 per ton. I would know the lower
124:25 bound. But that isn't the case, so I wanted to know
125:1 how low can the dollar per ton conceivably go in
125:2 this model if there were no further emissions.

125:3 What's the starting point of that
125:4 marginal cost curve, given what we can't change,
125:5 which is history. So the lower bound, that's my
125:6 first ton estimate. It just means this is the
125:7 dollar per ton if we were to emit another ton today
125:8 and not assign damages to that ton that we're
125:9 emitting today to any future tons that haven't yet
125:10 even been emitted, that Minnesota won't be emitting.
125:11 That it will be some other global parties that are,
125:12 emitting.

125:13 So if you just want to know how low can
125:14 that dollar -- how sensitive is the dollar per ton,
125:15 the marginal dollar per ton estimate, out of these
125:16 models, it gives us an estimate of that. A very
125:17 specific estimate, there's no ambiguity about it.
125:18 That's an analytical device.

125:19 These models are very, very complex
125:20 models. You put in all sorts of emissions and other
125:21 assumptions and they churn through complicated
125:22 scientific equations, and then they churn through
125:23 damage functions that vary. And nobody knows what's
125:24 going inside them, and they pop out a number dollar
125:25 per ton. And then you churn through with different
126:1 assumptions and it pops out a number dollar per ton.

126:2 The question is, what's the underlying --
126:3 there's an implicit underlying dollar per ton
126:4 marginal cost curve that goes from the lowest lower
126:5 bound up to the values that the IWG has projected by
126:6 assuming with 80 percent probability that there will
126:7 be no other changes in emissions and we'll just
126:8 carry more and more future emissions into the damage
126:9 calculation.

126:10 So any modeler who's working with a
126:11 complicated model like this, this is the technique
126:12 you use to back out what the implicit marginal cost
126:13 per ton is in a complicated bottom-up model, and
126:14 that's what I did.

126:15 I could have done lots of things in
126:16 between, but all I wanted to know is how sensitive
126:17 is it? How much different might the number get if
126:18 we used a different forecast that involved some form
126:19 of global reduction, and I didn't try to do every

126:20 kind of projection of global reduction possible
126:21 starting from the business as usual down to zero. I
126:22 just did the two and said the right answer is
126:23 somewhere in the middle.

240. No other party has sought to determine what the damages value would be if Minnesota emissions would be stopped, while the rest of the world would continue on a business-as-usual approach.
241. The ALJs agree that that calculation is important to determine the damage caused by the Minnesota pulse, which is what is being measured in this proceeding.
242. Dr. Smith’s work allows the Commission to determine how to actually calculate the “average marginal ton” that as a concept has been used since 1997 as the Commission sets the ECV of CO₂.

ALTERNATIVES TO THE FSCC

243. The ALJs find in light of the above findings, that it is necessary to review alternatives to the FSCC.
244. Xcel Energy has proposed an alternative to the IWG’s FSCC that is based on a limited range, consisting of only approximately 38% of the data points considered by the IWG, without any modifications to the underlying data.
245. The Company acknowledged, through Mr. Martin, that “the Federal SCC was not designed for integrated resource planning or other Commission decisions, and is inherently and irreducibly uncertain.”¹⁸⁹
246. Xcel Energy’s approach unquestioningly adopts every one of the IWG’s subjective framing decisions, despite its own criticism of those assumptions on pages 3:1-4:3, 4:22-

¹⁸⁹ Ex. [600, pt. 1](#) (Martin Direct) at 50:20-23.

7:4, and 11:5-14:9 of Mr. Martin’s pre-filed direct testimony,¹⁹⁰ and then injects one more very strong -- but unstated -- subjective assumption, which is that the discount rates of 2.5%, 3%, and 5% should be given equal probability of being the “correct” value.¹⁹¹

247. Dr. Smith testified, “[t]he IWG at least recognized that SCC estimates based on different discount rates should be reported separately, leaving SCC users the ability to decide for themselves which of the three discount rates to emphasize for their decision-making purposes.”¹⁹²

248. Any adjustment in any of the interest rates, or any adjustment in the weight to be accorded any of those rates, requires complete rejection of Xcel Energy’s numbers, because the Xcel Energy data does not break out the discount rates.¹⁹³

249. As set forth above, the ALJs cannot recommend the 2.5%, 3%, 5%, and 95th percentile at 3% IWG values.

250. The ALJs further agree that Xcel Energy’s proposal omits the most likely damages numbers. Figure 9 on page 65 of Mr. Martin’s Direct¹⁹⁴ testimony shows a histogram of the 450,000 IWG values considered by Xcel for inclusion.¹⁹⁵ Figure 9 further shows that the most frequent damage number in the entire set of 450,000 values was approximately \$5 or \$6, as depicted by the histogram’s peak, which “was a little bit below our lower

¹⁹⁰ Ex. [600, pt. 1](#).

¹⁹¹ Ex. [303](#) (Smith Rebuttal) at 3:17-23.

¹⁹² *Id.* at 3:23-4:3.

¹⁹³ *See, e.g.*, Ex. [303](#) (Smith Rebuttal) at 4:3-7; Ex. [600, pt. 1](#) (Martin Direct) at 67:13-17 (new modeling required for change in discount rates).

¹⁹⁴ Ex. [600, pt. 1](#).

¹⁹⁵ Tr. Vol. 4 at 240:12-22.

bound and a little bit above zero.”¹⁹⁶

251. Xcel’s recommendations are thus based on data that it knows exclude the most likely damages amount, which amount was below the lower bound of data considered by Xcel:

Q. So the \$5 to \$6, which was a kind of a guesstimate that you gave to Mr. Brown, [as] the tip of the histogram, that’s the kind of data that was excluded from Xcel’s study, right?

A. That’s right....¹⁹⁷

252. Because Xcel’s alternative proposal does not fix the issues with the ECS, the damages-calculation horizon, or the discount rate, excludes 62% of the total data, and because the most likely damages lacks an appropriate foundation, Xcel Energy’s alternative to the FSCC must be rejected.

253. The MLIG and the Utilities Group have offered a valid alternative, namely to run the three IAMs relied upon by the IWG, but modifying the damages horizon to the year 2100 (low end) or 2140 (high end); modifying the discount rate to 7% (low end) and 3% (high end) or a fixed 5.66%; using the first (low end) or average (high end) marginal metric ton, and applying a local geographic scope, which can be increased to U.S. damages if the Commission were to provide 100% altruistic weight to all other U.S. states.

254. Applying the above adjustments yields a range for emissions in the year 2020 of \$0.37 to \$5.14 (in 2014 dollars per net metric ton).

255. The low value is based on modeling damages from the first ton emitted, 7 percent discount rate, Minnesota damages, and a modeling horizon to the year 2100, applying the

¹⁹⁶ Tr. Vol. 4 at 241:10-21; *id.* at 243:4-22.

¹⁹⁷ *Id.* at 243:23-244:6.

IWG's GDP-scaling to the highest FSCC estimate.¹⁹⁸ The high value is based on the average of first ton and last ton emitted, 3 percent discount rate, U.S. damages, and a modeling horizon to year 2140.¹⁹⁹ Application of U.S. damages to the low end would increase the low end to \$0.90 per net metric ton of CO₂. See Ex. [307](#) (Table 4A, copy attached) at lines 32 and 42.

LEAKAGE

256. The purpose of this proceeding is to determine an ECV of CO₂, so that relevant societal costs may be properly internalized by the CO₂-emitting entity.
257. Where emissions move outside the regulated jurisdiction as a result of regulation, it is improper to impose those costs on the remaining Minnesota emitters.
258. Dr. Smith has credibly testified in this regard that the issue of “leakage” may cause significant and unexpected side effects, including, but not limited to, electricity generation shifting to differently-regulated states causing a smaller net CO₂ reduction than anticipated, or even a net total offset (100% leakage) or a net increase in CO₂ emissions.²⁰⁰
259. While leakage is not an issue in this proceeding, in that the amount per metric ton of the ECV of CO₂ is not affected by leakage, the IWG has recognized and instructed that “[t]he SCC estimates are multiplied by estimates of the net GHG emissions changes to calculate the value of benefits associated with a policy action in a given year. It is in the

¹⁹⁸ See Tr. Vol. 2A at 60:17-63:3; Ex. [307](#).

¹⁹⁹ *Id.*

²⁰⁰ Tr. Vol. 2A at 102:9-103:13; 103:24-104:1 (Smith); Ex. [401](#) (Gayer Surrebuttal) at 9:7-10:3.

estimation of net GHG emissions ... that any leakage should be accounted for.”²⁰¹

260. The application of the ECV of CO₂ to net tons allows for the internalization of actual costs, rather than phantom costs, and is the correct way to express the ECV of CO₂.

CONCLUSIONS OF LAW

1. A party or parties proposing that the Commission adopt a new environmental cost value for CO₂, including the Federal Social Cost of Carbon (“FSCC”), bears the burden of showing, by a preponderance of the evidence, that the value being proposed is reasonable and the best available measure of the environmental cost of CO₂.²⁰² Conversely, a party opposing a particular proposal need *only* demonstrate that the proponent of proposed value cannot meet the preponderance requirement, because the proponent’s evidence is flawed, or the proposal is impracticable.²⁰³ If the weight of the evidence is evenly balanced, for and against, the *opponent* has met its burden because the proponent will not have achieved the required preponderance of the evidence.²⁰⁴
2. Doctors for a Healthy Environment failed to meet their burden of proof to show that the “value being proposed [by means of the FSCC value] is reasonable and the best available measure of the environmental cost of CO₂,” as required. Minn. Rules Part 1400.7300, subp. 5, and *In re Quantification of Env’tl. Costs Pursuant to Laws of Minn. 1993, Chapter 356, Section 3*, 578 N.W.2d 794, 801 (Minn. Ct. App. 1998).
3. In the absence of any proffered testimony about the validity or reliability of the FSCC

²⁰¹ Ex. [101](#) at 33.

²⁰² [Order Regarding Burdens of Proof dated March 27, 2015](#) at 2, ¶ 1.

²⁰³ *Id.* at 6 (emphasis added).

²⁰⁴ [Burden of Proof Order](#) at 6 (emphasis added).

and in the absence of any testimony about the best monetary amount to account for the costs or benefits of carbon emissions, the Clean Energy Business Coalition failed to meet its burden of proof to show that the “value being proposed [by means of the FSCC value] is reasonable and the best available measure of the environmental cost of CO₂,” as required. Minn. Rules Part 1400.7300, subp. 5, and *In re Quantification of Env'tl. Costs Pursuant to Laws of Minn. 1993, Chapter 356, Section 3*, 578 N.W.2d at 801.

4. The record shows, by more than a preponderance of the evidence, that the IWG’s FSCC values lack any empirical basis for temperature increases above 3°C, and are based on unreliable damage functions beyond a horizon of the year 2100 or (at most) 2140. In turn, this means that the FSCC proponents’ suggestion and recommendation that the ALJs and the Commission accept the IWG’s FSCC, without adjustments, as Minnesota’ ECV of CO₂ must be rejected.
5. In light of the change in ECS between AR4 and AR5, the abandonment of the central estimate, the IPCC’s statement in AR5 that new studies underlying the lowering of the low end of the ECS range “suggest a best fit to the observed surface and ocean warming for ECS values in the lower part of the *likely* range,”²⁰⁵ and the sensitivity of the values to the ECS, the opponents to the FSCC have shown by more than a preponderance of the evidence that the IWG’s FSCC values are based on an improper ECS, and that the FSCC proponents’ suggestion and recommendation that the ALJs and the Commission accept the IWG’s FSCC, without adjustments, as Minnesota’ ECV of CO₂ must be rejected.
6. It is reasonable to use a weighted 5.66% discount rate, arrived at by taking the lower (risk-free) 3% discount rate and merging it on a weighted basis (1/3) based on approximate

²⁰⁵ Ex. 405 [part 36](#) at 1111, first full paragraph (*italics in original*).

state-wide relative energy consumption²⁰⁶ with a 7% corporate discount rate ($\frac{2}{3}$). Alternatively, it is reasonable to use both the 3% and 7% discount rates, as part of a range of the ECV of CO₂.

7. The Commission should discontinue use of the global scope of damages calculations.
8. The ECV for CO₂ should be computed with a local geographic scope at this time.
9. If the Commission were to provide 100% altruistic weight to all other U.S. states, a U.S. geographic scope should be used for the damages calculation.
10. The concept of the use of a 95th percentile (at 3% discount rate) damages calculation should not be adopted for Minnesota resource planning proceedings.
11. The ECV of CO₂ should be calculated using a first and average marginal ton.
12. Damages should be expressed in net tons, to account for leakage.
13. The MLIG and the Utilities Group have offered a valid alternative to the FSCC, namely to run the three IAMs relied upon by the IWG, but modifying the damages horizon to the year 2100 (low end) or 2140 (high end); modifying the discount rate to 7% (low end) and 3% (high end) or a fixed 5.66%; using the first (low end) or average (high end) marginal ton, and applying a local geographic scope, which can be increased to U.S. damages if the Commission were to provide 100% altruistic weight to all other U.S. states.
14. Applying the above adjustments yields a range for emissions in the year 2020 of \$0.37 to \$5.14 (in 2014 dollars per net metric ton).
15. The low value is based on modeling damages from the first ton emitted, either the 5.66% or the 7 percent discount rate, Minnesota damages, and a modeling horizon to the year

²⁰⁶ See [MLIG Initial Brief](#) at 77-78 (citing Tr. Vol. 4 at 89:4-14 (Martin)).

2100, applying the IWG's GDP-scaling to the highest FSCC estimate.²⁰⁷ The high value is based on the average of first ton and last ton emitted, 3 percent discount rate, U.S. damages, and a modeling horizon to year 2140.²⁰⁸ Application of U.S. damages to the low end would increase the low end to \$0.90 per net metric ton of CO₂. *See* Ex. [307](#) (Table 4A, copy attached) at lines 32 and 42.

²⁰⁷ *See* Tr. Vol. 2A at 60:17-63:3; Ex. [307](#).

²⁰⁸ *Id.*

TABLE 4A

Summary of SCC Estimates for Alternative Values, Including Average Ton.¹

	# changes from base inputs	Discount Rate	Time Horizon	Geographic Scope	Which Tonne	2020 SCC Value (2007\$/net tonne)	2020 SCC Value (2014\$/net tonne)
1.	0	3%	2300	Global	Last	\$42.14	\$46.88
2.	1	3%	2140	Global	Last	\$32.53	\$36.19
3.	1	3%	2100	Global	Last	\$22.14	\$24.63
4.	1	5%	2300	Global	Last	\$12.03	\$13.39
5.	2	5%	2140	Global	Last	\$10.70	\$11.90
6.	2	5%	2100	Global	Last	\$9.03	\$10.05
7.	1	7%	2300	Global	Last	\$4.84	\$5.38
8.	2	7%	2100	Global	Last	\$4.26	\$4.74
9.	1	3%	2300	U.S.	Last	\$6.88	\$7.65
10.	2	3%	2140	U.S.	Last	\$5.36	\$5.96
11.	2	3%	2100	U.S.	Last	\$3.97	\$4.42
12.	2	5%	2300	U.S.	Last	\$2.28	\$2.54
13.	3	5%	2140	U.S.	Last	\$1.99	\$2.22
14.	3	5%	2100	U.S.	Last	\$1.77	\$1.97
15.	2	7%	2300	U.S.	Last	\$1.03	\$1.15
16.	3	7%	2100	U.S.	Last	\$0.92	\$1.03
17.	1	3%	2300	Global	First	\$27.59	\$30.70
18.	2	3%	2140	Global	First	\$21.55	\$23.98
19.	2	3%	2100	Global	First	\$15.55	\$17.30
20.	2	5%	2300	Global	First	\$8.43	\$9.38
21.	3	5%	2140	Global	First	\$7.65	\$8.51
22.	3	5%	2100	Global	First	\$6.70	\$7.45
23.	2	7%	2300	Global	First	\$3.65	\$4.06
24.	3	7%	2100	Global	First	\$3.33	\$3.70
25.	2	3%	2300	U.S.	First	\$4.83	\$5.37
26.	3	3%	2140	U.S.	First	\$3.88	\$4.32
27.	3	3%	2100	U.S.	First	\$3.05	\$3.40
28.	3	5%	2300	U.S.	First	\$1.76	\$1.96
29.	4	5%	2140	U.S.	First	\$1.59	\$1.77
30.	4	5%	2100	U.S.	First	\$1.46	\$1.62
31.	3	7%	2300	U.S.	First	\$0.87	\$0.96
32.	4	7%	2100	U.S.	First	\$0.81	\$0.90

¹ The Average Ton figures in Table 4A are derived by taking the average of the first and last ton figures for a given discount rate, geographic scope, and time horizon set forth in Table 4 in the Expert Report of Anne Smith. For example, the average ton for a 3% discount rate, 2300 time horizon, and global scope in Line 33 is derived by taking the averages of the first (line 17) and last ton (line 1) for the same discount rate, time horizon, and global scope.

(Cont'd)

	# changes from base inputs	Discount Rate	Time Horizon	Geographic Scope	Which Tonne	2020 SCC Value (2007\$ /net tonne)	2020 SCC Value (2014\$ /net tonne)
33.	1	3%	2300	Global	Average	\$34.87	\$38.79
34.	2	3%	2140	Global	Average	\$27.04	\$30.09
35.	2	3%	2100	Global	Average	\$18.85	\$20.97
36.	2	5%	2300	Global	Average	\$10.23	\$11.39
37.	3	5%	2140	Global	Average	\$9.18	\$10.21
38.	3	5%	2100	Global	Average	\$7.87	\$8.75
39.	2	7%	2300	Global	Average	\$4.25	\$4.72
40.	3	7%	2100	Global	Average	\$3.80	\$4.22
41.	2	3%	2300	U.S.	Average	\$5.86	\$6.51
42.	3	3%	2140	U.S.	Average	\$4.62	\$5.14
43.	3	3%	2100	U.S.	Average	\$3.51	\$3.91
44.	3	5%	2300	U.S.	Average	\$2.02	\$2.25
45.	4	5%	2140	U.S.	Average	\$1.79	\$1.99
46.	4	5%	2100	U.S.	Average	\$1.62	\$1.80
47.	3	7%	2300	U.S.	Average	\$0.95	\$1.06
48.	4	7%	2100	U.S.	Average	\$0.87	\$0.97