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414 Nicollet Mall
Minneapolis, MN 55401

December 15, 2015

—Via Electronic Filing—

The Honorable LauraSue Schlatter,
The Honorable John Oxley
Office of Administrative Hearings
P.O. Box 64620
St. Paul, MN 55164-0620

RE: REPLY BRIEF AND FINDINGS OF FACT REGARDING CO₂
INVESTIGATION INTO ENVIRONMENTAL AND SOCIOECONOMIC COSTS
MPUC DOCKET NO. E999/CI-14-643
OAH DOCKET NO. 80-2500-31888

Dear Judges Schlatter and Oxley:

Northern States Power Company, doing business as Xcel Energy, submits this Reply Brief and Findings of Fact in the above-referenced docket.

This response has been filed in eDockets and thereby served on the parties to this proceeding. Consistent with the First Prehearing Order, we are also providing a printed version via U.S. mail to your office. As a courtesy we will also email to you only Word versions of these documents.

Please contact me at james.r.denniston@xcelenergy.com or (612) 215-4656 if you have any questions regarding this filing.

Sincerely,

/s/

JAMES R. DENNISTON
ASSISTANT GENERAL COUNSEL

Enclosures
c: Service Lists

CERTIFICATE OF SERVICE

I, Jim Erickson, hereby certify that I have this day served copies of the foregoing document on the attached list of persons.

xx by depositing a true and correct copy thereof, properly enveloped with postage paid in the United States mail at Minneapolis, Minnesota; or

xx by electronic filing.

MPUC Docket No: E-999/CI-14-643

Dated this 15th day of December 2015.

/s/

Jim Erickson

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
David	Aafedt	daafedt@winthrop.com	Winthrop & Weinstine, P.A.	Suite 3500, 225 South Sixth Street Minneapolis, MN 554024629	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Michael	Ahern	ahern.michael@dorsey.com	Dorsey & Whitney, LLP	50 S 6th St Ste 1500 Minneapolis, MN 554021498	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Marc	Al	marc.al@stoel.com	Stoel Rives LLP	33 South Sixth St Ste 4200 Minneapolis, MN 55402	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Hugh	Brown	brown.hugh@dorsey.com	Dorsey & Whitney LLP	Suite 1500 50 South Sixth Street Minneapolis, Minnesota 55402	Electronic Service	No	OFF_SL_14-643_Official CC Service List
B. Andrew	Brown	brown.andrew@dorsey.com	Dorsey & Whitney LLP	Suite 1500 50 South Sixth Street Minneapolis, MN 554021498	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Carl	Cronin	carl.cronin@xcelenergy.com	Xcel Energy	414 Nicollet Mall Minneapolis, Minnesota 55401	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Leigh	Currie	lcurrie@mncenter.org	Minnesota Center for Environmental Advocacy	26 E. Exchange St., Suite 206 St. Paul, Minnesota 55101	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Patricia	DeBleekere	tricia.debleeckere@state.mn.us	Public Utilities Commission	Suite 350 121 Seventh Place East St. Paul, MN 55101	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
James	Denniston	james.r.denniston@xcelenergy.com	Xcel Energy Services, Inc.	414 Nicollet Mall, Fifth Floor Minneapolis, MN 55401	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Jessica	Dexter	jdexter@elpc.org	Environmental Law & Policy Center	394 Lake Avenue, Ste. 309 Duluth, MN 55802	Electronic Service	No	OFF_SL_14-643_Official CC Service List

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Brian	Draxten	bhdraxten@otpc.com	Otter Tail Power Company	P.O. Box 496 215 South Cascade Street Fergus Falls, MN 565380498	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Tristan	Duncan	tduncan@shb.com	Shook Hardy & Bacon, L.L.P.	2555 Grand Blvd. Kansas City, MO 64108	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Bret	Eknes	bret.eknes@state.mn.us	Public Utilities Commission	Suite 350 121 7th Place East St. Paul, MN 551012147	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Jim	Erickson	jim.g.erickson@xcelenergy.com	Xcel Energy	414 Nicollet mall 7th Flr Minneapolis, MN 55401	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Benjamin	Gerber	bgerber@mncchamber.com	Minnesota Chamber of Commerce	400 Robert Street North Suite 1500 St. Paul, Minnesota 55101	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Bruce	Gerhardson	bgerhardson@otpc.com	Otter Tail Power Company	PO Box 496 215 S Cascade St Fergus Falls, MN 565380496	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Emerald	Gratz	emerald.gratz@state.mn.us	Office of Administrative Hearings	PO Box 64620 Saint Paul, Minnesota 55164-0620	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Thomas J.	Grever	tgrever@shb.com	Shook, Hardy & Bacon L.L.P.	2555 Grand Blvd. Kansas City, MO 64108	Electronic Service	No	OFF_SL_14-643_Official CC Service List
J Drake	Hamilton	hamilton@fresh-energy.org	Fresh Energy	408 St Peter St Saint Paul, MN 55101	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Linda	Jensen	linda.s.jensen@ag.state.mn.us	Office of the Attorney General-DOC	1800 BRM Tower 445 Minnesota Street St. Paul, MN 551012134	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Kevin D.	Johnson	kdjohnson@stoel.com	Stoel Rives LLP	Suite 4200 33 South Sixth Street Minneapolis, MN 55402	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Sarah	Johnson Phillips	sjphillips@stoel.com	Stoel Rives LLP	33 South Sixth Street Suite 4200 Minneapolis, MN 55402	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Hudson	Kingston	hkingston@mncenter.org	MN Center for Environmental Advocacy	26 East Exchange Street, Suite 206 St. Paul, Minnesota 55101	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Brad	Klein	bklein@elpc.org	Environmental Law & Policy Center	35 E. Wacker Drive, Suite 1600 Suite 1600 Chicago, IL 60601	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Kevin	Lee	kevin@kevinleelaw.com		400 S. 4th St. Suite 401-111 Minneapolis, MN 55415	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Jonathan	Massey	jmassey@masseygail.com	Massey & Gail LLP	1325 G Street NW Washington, DC 20005	Electronic Service	No	OFF_SL_14-643_Official CC Service List
David	Moeller	dmoeller@allete.com	Minnesota Power	30 W Superior St Duluth, MN 558022093	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Andrew	Moratzka	apmoratzka@stoel.com	Stoel Rives LLP	33 South Sixth Street Suite 4200 Minneapolis, MN 55402	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Jeff	Oxley	jeff.oxley@state.mn.us	Office of Administrative Hearings	600 North Robert Street St. Paul, MN 55101	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Michelle	Rebholz	michelle.rebholz@state.mn.us	Public Utilities Commission	Suite 350121 Seventh Place East St. Paul, MN 55101	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Kevin	Reuther	kreuther@mncenter.org	MN Center for Environmental Advocacy	26 E Exchange St, Ste 206 St. Paul, MN 551011667	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Laureen	Ross McCalib	lrossmccalib@greenergy.com	Great River Energy	12300 Elm Creek Boulevard Maple Grove, MN 55369-4718	Electronic Service	No	OFF_SL_14-643_Official CC Service List
LauraSue	Schlatter	LauraSue.Schlatter@state.mn.us	Office of Administrative Hearings	PO Box 64620 St. Paul, MN 55164-0620	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Janet	Shaddix Elling	jshaddix@janetshaddix.com	Shaddix And Associates	Ste 122 9100 W Bloomington Frwy Bloomington, MN 55431	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Sean	Stalpes	sean.stalpes@state.mn.us	Public Utilities Commission	121 E. 7th Place, Suite 350 Saint Paul, MN 55101-2147	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List
Donna	Stephenson	dstephenson@greenergy.com	Great River Energy	12300 Elm Creek Boulevard Maple Grove, MN 55369	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Eric	Swanson	eswanson@winthrop.com	Winthrop Weinstine	225 S 6th St Ste 3500 Capella Tower Minneapolis, MN 554024629	Electronic Service	No	OFF_SL_14-643_Official CC Service List
SaGonna	Thompson	Regulatory.records@xcelenergy.com	Xcel Energy	414 Nicollet Mall FL 7 Minneapolis, MN 554011993	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Erin	Vaughn	evaughn@shb.com	Shook, Hardy & Bacon L.L.P.	2555 Grand Blvd. Kansas City, MO 64108	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Colin	Wicker	wicker.colin@dorsey.com	Dorsey & Whitney LLP	50 6th Street South Suite 1500 Minneapolis, MN 55402	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Alexis	Williams	williams@fresh-energy.org	Fresh Energy	408 St. Peter St Suite 220 St. Paul, MN 55102	Electronic Service	No	OFF_SL_14-643_Official CC Service List
Daniel P	Wolf	dan.wolf@state.mn.us	Public Utilities Commission	121 7th Place East Suite 350 St. Paul, MN 551012147	Electronic Service	Yes	OFF_SL_14-643_Official CC Service List

**STATE OF MINNESOTA
BEFORE THE OFFICE OF ADMINISTRATIVE HEARINGS
FOR THE
MINNESOTA PUBLIC UTILITIES COMMISSION**

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

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

XCEL ENERGY REPLY BRIEF REGARDING CO₂

December 15, 2015

James R. Denniston
Assistant General Counsel
NORTHERN STATES POWER COMPANY,
a Minnesota corporation
414 Nicollet Mall, 5th Floor
Minneapolis, MN 55401
Telephone: (612) 215-4656

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MPUC Docket No. E-999/CI-14-643

**XCEL ENERGY REPLY BRIEF
REGARDING CO₂**

I. INTRODUCTION

Northern States Power Company, doing business as Xcel Energy, respectfully provides this Reply Brief in support of its proposed methodology to update the environmental cost of CO₂ used for integrated resource planning and other Commission decisions under Minn. Stat. § 216B.2422, subd. 3(a). This brief responds to the Initial Briefs filed by the Department of Commerce and Minnesota Pollution Control Agency (Agencies); Clean Energy Organizations (CEO); Great River Energy, Minnesota Power, and Otter Tail Power Company (GRE/MP/OTP); Minnesota Large Industrial Group (MLIG); and Peabody Energy Corporation (Peabody).

II. AGENCIES AND CEO¹

Xcel Energy recognizes that the Agencies and CEO do not take identical positions on the environmental cost of CO₂. We address them jointly in this section only because both propose Commission adoption of the Federal Social Cost of

¹ Joined by Clean Energy Business Coalition (Clean Energy Business Coalition Initial Brief at 1). Xcel Energy's responses to CEO in this Reply Brief should be read as applying equally to the Clean Energy Business Coalition.

Carbon (SCC) Technical Support Document executive summary values; and because they make some similar critiques of Xcel Energy's proposal, such that addressing these together reduces repetition.

A. Areas of Agreement

The pre-filed testimony, evidentiary hearings and Initial Briefs made clear that there are broad areas of agreement between the Agencies, CEO and Xcel Energy. All three Parties agree that the Integrated Assessment Models (IAMs), their underlying climate science, and the Federal Interagency Working Group's (IWG) methodology, while far from perfect, represent a reasonable and best available starting point to develop the Commission's CO₂ environmental cost range. While Xcel Energy believes the Commission's regulatory cost range under Minn. Stat. §216H.06 might have represented a reasonable and less uncertain proxy, the Commission's requirement of a damage cost approach appears to rule this option out.

Where Xcel Energy disagrees with the Agencies and CEO is on how the IWG chose to summarize its results by presenting, in the executive summary of each Technical Support Document (TSD), four point estimates – three simple averages, and a 95th percentile without any corresponding 5th percentile. This is just one of many possible ways to summarize the data. It may or may not have been appropriate for the SCC's intended purpose of Federal regulatory impact analysis; that question is not at issue here. However Xcel Energy believes, because of the fundamental differences between Federal regulatory impact analysis and the proposed application to integrated resource planning and other Commission decisions, that adopting any one, or all four, of these falsely precise point estimates would be inappropriate. We have proposed a different way of summarizing the data into a *range* (as mandated by the statute) that we believe addresses the problem of

false precision and best balances the many different criteria the ALJs and Commission should consider in updating the CO₂ environmental cost values.

More specifically, Xcel Energy has no objection to several components of the IWG methodology highlighted by the Agencies and CEO: the choice of DICE, FUND and PAGE as the three IAMs to use to estimate damages; the standardization of input parameters to facilitate a model inter-comparison exercise; the conversion of DICE into a simulation model; the use of standardized population, economic growth and emissions inputs from the Stanford Energy Modeling Forum-22 (EMF-22) exercise; the choice to treat equilibrium climate sensitivity (ECS) as an uncertain parameter by making random draws from a probability distribution; the use of a Monte Carlo approach in which each model is run 10,000 times per emission year, discount rate and EMF-22 scenario; the standardization of discount rates across IAMs; and the choice of 2.5, 3 and 5 percent discount rates².

Finally, the Agencies, CEO and Xcel Energy all appear to acknowledge that some of the modeling choices made by the IWG are not based on objective scientific questions to which there is a single correct answer, but rather policy judgments. The Agencies and CEO support the IWG's policy judgments on matters such as the geographic scope of damage assessment, modeling horizon, discount rate, and estimating marginal damages from the first, last or average ton. They recommend that the Commission adopt the IWG's judgments without considering others. Xcel Energy takes a more nuanced stance, acknowledging that the IWG's policy judgments are subjective and that the Commission could retain them or decide differently. Our proposed range effectively retains the IWG's judgments, since it is built from the IAM outputs as run by the IWG. However we

² Agencies' Initial Brief at 24-31, CEO Initial Brief at 10-20.

have indicated how our range could be adjusted if the Commission decides different policy judgments are appropriate when transplanting the SCC from its intended purpose to the significantly different purpose of state-level Commission decisions.

B. Differences in Purpose Do Matter in this Proceeding

The Agencies maintain that using the Federal SCC executive summary values for integrated resource planning and other Commission decisions is appropriate, despite the SCC's intended use only for Federal regulatory impact analysis. The IWG noted recently that it has not recommended use of the SCC “outside the regulatory context, such as in NEPA analysis, *state level decision making*, and ‘pricing’ carbon in the marketplace.”³ The Agencies argue that the SCC is intended for cost-benefit analysis, and that integrated resource planning is a form of cost-effectiveness or cost-benefit analysis in which all alternatives have the same benefit and the analyst is attempting to identify the least-cost means of achieving a given target or goal.⁴ The Agencies also list other examples of the SCC's use, including some Federal regulatory impact analyses, other Federal applications, the Commission's use of the SCC in its Value of Solar docket, and use of the SCC in other utility integrated resource plans.⁵

We respectfully disagree. First, in integrated resource planning all modeled alternatives do not have the same benefit. Integrated resource planning models consider many alternative resource plans to try to identify a “preferred plan” to propose for Commission approval. Each plan involves a different mix of existing resources, possible resource additions and resource retirements at different dates,

³ Ex. 101 (Polasky Rebuttal) Schedule 1: Interagency Working Group on Social Cost of Carbon, United States Government. July 2015. *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. Page 41; emphasis added.

⁴ Agencies' Initial Brief at 37-38.

⁵ Agencies' Initial Brief at 38-39.

and therefore has different costs and benefits. Even limiting consideration to the benefit at issue in this proceeding – damages avoided by reducing emissions – the alternate plans differ significantly in their emissions profile and therefore have different benefits in terms of reducing emissions and avoiding climate change damages. Nor is the CO₂ environmental cost range used to determine the least-cost means of achieving a given emissions target – again, the modeled plans each have different emission profiles – but rather to compare the Present Value of Societal Cost (PVSC) of the plans and provide a ranking of those plans as one element in the Commission’s selection of a preferred plan. The Commission seeks to minimize PVSC, which includes both direct costs to utility customers and externality costs, balanced with other decision criteria such as affordability, reliability, resource and diversity.⁶

Second, even if both Federal regulatory impact analysis and integrated resource planning involve elements of cost-benefit analysis, the Agencies’ brief does not address the crux of the argument made in Mr. Martin’s pre-filed testimony and at the evidentiary hearings.⁷ When used for Federal regulatory impact analysis, the SCC only serves to estimate whether the benefits of a regulation exceed its costs, indicating whether the federal agency should proceed with that regulation. In Mr. Martin’s Clean Power Plan example, EPA used the SCC as required, to determine that in EPA’s view the net benefits of the proposed regulation exceed costs – which they did, in EPA’s view, regardless whether the SCC value chosen was \$12 or \$120 per ton of CO₂ emissions. The SCC was then set aside and had no further effect. It did not determine EPA’s approach to, or the stringency of, the regulation (which was based on EPA’s statutory authority), the selection of resource choices to reduce emissions (which is left to states in designing flexible

⁶ Hearing Transcript Vol. 3B at 156-158 (Martin).

⁷ E.g., Ex. 600 (Martin Direct) at 6, 12-14; Ex. 601 (Martin Rebuttal) at 21-22; Ex. 602 (Martin Surrebuttal) at 7-9.

implementation plans), or function as a “price on carbon” (which would emerge from market dynamics, if states choose to create CO₂ emission markets).⁸

If transplanted to integrated resource planning, the SCC could have a much different and more direct effect. It would affect resource choices – not just whether to regulate, but which generation resources to build and which to retire – with impacts that are more concrete, potentially costly for utility customers, and potentially difficult to reverse. This does not mean the IWG’s modeling cannot be used, but it does highlight the importance of avoiding false precision. Whereas whether the SCC value chosen was \$12 or \$120 made no difference in EPA’s regulatory impact analysis of the Clean Power Plan, these values would point to dramatically different resource planning alternatives. Xcel Energy has argued that this is reason to exercise caution. The IWG’s modeling can be used as a reasonable and best available starting point, but rather than adopting the falsely precise point estimates presented in the TSD executive summaries, the Commission should consider the significant differences in purpose and impact and adopt a CO₂ environmental cost range specific to the proposed application, based on balanced consideration of the eight criteria Xcel Energy proposed.⁹

Third, we do not see the relevance to this docket of the Agencies’ examples of other uses of the SCC¹⁰. The Agencies mention other Federal rulemakings – the EPA’s light- and heavy-duty vehicle GHG rules, the Mercury and Air Toxics standard – where the SCC was only used for its intended purpose of regulatory impact analysis. They mention use by the Federal government in grant applications and airport planning, and by Montgomery County, Maryland for a county code;

⁸ Ex. 602 (Martin Surrebuttal) at 7-8.

⁹ Xcel Energy’s Initial Brief at 13-14.

¹⁰ Agencies’ Initial Brief at 38-39.

these are not obviously relevant to integrated resource planning or other Commission decisions.

The Agencies note that the Commission included the SCC as one component of the Value of Solar (VOS) methodology it approved in April, 2014. However, in that docket the Commission's decision options were limited to simple approval or disapproval of the VOS methodology overall, without the opportunity to disapprove specific components. In accepting use of the SCC for the avoided environmental cost component, the Commission apparently intended to ensure that its decision in the VOS docket would have no bearing on its future decision whether adopting the SCC in the externalities docket is appropriate:

The Commission is currently re-evaluating its environmental externality costs. The Commission only decides here the narrow question of whether the values recommended by the Department reasonably fulfill the statutory mandate for a Value of Solar methodology. Approval of the Department's methodology and the values it contains does not prejudge the outcome of that investigation, or any other pending or future Commission proceeding.¹¹

Finally, the Agencies note Dr. Hanemann's assertion that other utilities are using the SCC for integrated resource planning or incorporating it "in their recent planning documents"¹². Dr. Hanemann appeared to confuse the SCC with the use of an internal price of carbon (i.e., a regulatory cost proxy) for planning purposes, citing a Carbon Disclosure Project publication that points to Xcel Energy's use of the Commission's CO₂ regulatory cost range under Minn. Stat. §216H.06¹³.

C. Xcel Energy Has Not Suggested the SCC is "Too High"

¹¹ *In the Matter of Establishing a Distributed Solar Value Methodology under Minn. Stat. § 216B.164, subd. 10 (e) and (f)*. Docket No. E-999/M-14-65. ORDER APPROVING DISTRIBUTED SOLAR VALUE METHODOLOGY. April 1, 2014. Page 12-13.

¹² Agencies' Initial Brief at 39.

¹³ Ex. 601 (Martin Rebuttal) at 20-21.

The Agencies and CEO highlight reasons why the IWG’s methodology may underestimate damages because it omits some categories of physical, ecological and economic impacts, and incompletely characterizes potential “tipping points” or catastrophic damages¹⁴. Xcel Energy has not disagreed. The Agencies and CEO generally dismiss factors that could cause the IWG’s methodology to overestimate damages, such as incomplete modeling of adaptation and no endogenous modeling of technological change or future societal response to experienced damages. While acknowledging adaptation and technological change will occur, the Agencies suggest this is uncertain and “while the uncertainty regarding adaptation and technological change offsets to some degree the uncertainty regarding catastrophic damages from climate change, Dr. Hanemann strongly doubted that it fully counterbalances the latter uncertainty”¹⁵. The Agencies and CEO also acknowledge governmental efforts to promote CO₂ mitigation, but point to the political opposition to these efforts and suggest countries are unlikely to reach agreement¹⁶. The Agencies suggest Xcel Energy “believes the IWG’s estimate of the SCC may be too high because it has not adequately accounted for future actions to reduce CO₂ emissions or otherwise mitigate the climate change impacts of atmospheric carbon”¹⁷.

Mr. Martin at no point in this proceeding claimed that the SCC is “too high,” or claimed knowledge of which omitted factors – those that cause the methodology to underestimate damages, or those that cause it to overestimate – are more significant. Rather, he pointed to omissions such as adaptation and endogenous technological change that, if better captured, would tend to bring the SCC values down, and omissions such as excluded damages and catastrophic

¹⁴ Agencies’ Initial Brief at 66-69, CEO Initial Brief 21.

¹⁵ Agencies’ Initial Brief at 133-34.

¹⁶ Agencies’ Initial Brief at 44, 72, 134.

¹⁷ Agencies’ Initial Brief at 134-35.

damages that, if better captured, would tend to push the SCC values up. Because it is unknown how these balance out, Mr. Martin argued against adopting both the low-probability estimates at the low end of the SCC results, and the low-probability estimates at the high end of the SCC results. He argued against adopting the 95th percentile estimate only, since this puts the emphasis entirely on the low-probability, high-damage estimates. He proposed an initial range from the 25th percentile at 5 percent discount rate to the 75th percentile at 2.5 percent discount rate – effectively dropping the lowest and highest estimates, but retaining about 75 percent of the SCC estimates for a given emission year. He argued for a final range that is risk-averse in the sense of excluding more low than high damage estimates. In this sense Mr. Martin agrees with Dr. Hanemann that a degree of risk aversion is appropriate¹⁸, though he disagrees it would be appropriate to adopt just a high estimate (e.g., the 95th percentile alone) – effectively a one-sided risk aversion that ignores the omissions that could cause the IWG methodology to overestimate.

Speaking to the issue of selecting a CO₂ environmental cost range under uncertainty, the ALJ in the original externalities proceeding stated that “the possibility of utilities paying more for resources than their environmental benefits justify is just as bad as paying less than their benefits justify.”¹⁹ This suggests a two-sided risk aversion; the ALJ appeared to believe that in integrated resource planning it is equally undesirable to overestimate and to underestimate damages from CO₂. We believe this logic still holds.²⁰ Considering that there are modeling uncertainties that may cause the IAMs to both underestimate damages in some respects and overestimate damages in other respects, we do not believe it is

¹⁸ Agencies’ Initial Brief at 69.

¹⁹ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3*. Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION AND MEMORANDUM. March 22, 1996. Page 17.

²⁰ Though we differ with the ALJ’s wording “utilities paying more”; it is not utilities, but utility customers, who largely bear the cost of resource choices under cost-of-service regulation.

appropriate to place emphasis only on the incomplete modeling of high-end damages – e.g., by adopting the 95th percentile SCC value but not the 5th – and suggest that because adaptation, technological change, and governmental cooperation are uncertain, they should be ignored. Nor has Xcel Energy suggested that we are so confident in adaptation, technological change and governmental cooperation as to conclude the SCC damage estimates are “too high” and recommend adoption of the 5th percentile value. A potential solution would be to adopt the 5th and 95th percentile values, but we argued that this is inappropriate because both of these are by definition very low-probability estimates, and because adopting both would not meet the statutory criterion of practicability, since they would simply point to diametrically opposite resource plans²¹. Instead, Xcel Energy’s proposed method of dealing with the significant uncertainty on *both* ends of the spectrum is to derive a range that focuses on the higher-probability damage estimates and appropriately balances risk tolerance and practicability.

D. The “Mean vs. Median” Debate is Misleading

The Agencies argue that it was appropriate for the IWG to calculate the mean (i.e., average) across each distribution of 150,000 SCC estimates for a given discount rate and emission year, because the high-damage, low-probability estimates in the long right tail of the SCC probability distributions are not “outliers” but rather values within the distribution. They contend that Mr. Martin attempted to deemphasize these values by using the median rather than the mean.²² Similarly, the CEO assert that Xcel Energy proposed CO₂ environmental cost values based on the median of SCC results rather than the mean, and that our range

²¹ Ex. 602 (Martin Surrebuttal) at 13-16.

²² Agencies’ Initial Brief at 107-09.

somehow “prioritize(s) the median value over the mean” or “calculates a range of estimates around the central value, or median”²³.

Xcel Energy has not proposed – in fact, we explicitly opposed – Commission adoption of the median.²⁴ We opposed adoption of any point estimate, including the mean, median or 50th percentile, or any other single percentile, because of the problems of false precision discussed throughout our testimony. Instead, we derived a *range*, not a point estimate, based on two endpoints or “bookends” that we believe represent an appropriate balancing of the eight standard of review criteria we proposed, and in particular a balancing of uncertainty, risk tolerance, and practicability. Neither of the bookends of our range is the median of its respective discount rate distribution, and our testimony nowhere suggests that our bookends were selected in relation to the median. They were selected as the most appropriate percentiles after reviewing the full range of percentiles from 1st to 99th.²⁵

A range rather than point estimates – besides being mandated by the statute and consistent with Commission precedent since the 1990s – is in our view necessary considering the irreducible uncertainty of estimating climate damages. We proposed that the appropriate way to design this range is to consider that there are both low-probability, low-damage estimates and low-probability, high-damage estimates – we did not suggest only the high damage estimates should be treated as “outliers” and discarded. We proposed to focus on the higher probability damages, initially retaining all but 25 percent of the 450,000 damage estimates for a given emission year. We also proposed that both ends of this range be given equal weight in the modeling sensitivities used in integrated resource planning.

²³ CEO Initial Brief at 25-26.

²⁴ Ex. 602 (Martin Surrebuttal) at 9, 11.

²⁵ Ex. 600 (Martin Direct) at 56, Ex. 602 (Martin Surrebuttal) at 12.

Thus while we do not advocate adoption of the median, Xcel Energy does maintain that adopting one (or three) falsely precise point estimates based on the mean would be inappropriate for integrated resource planning and other Commission decisions. Adopting just the mean value at 3 percent discount rate²⁶ would be inappropriate because it is a falsely precise point estimate; because it is based on averaging; and because even the IWG has not claimed there is consensus that 3 percent is the “correct” discount rate.²⁷ Adopting all three mean values at 2.5, 3 and 5 percent discount rates²⁸ would still be inappropriate because these do not in fact constitute a range, but rather three point estimates at different discount rates, and because they are based on averaging.

E. Xcel Energy Proposes a Different Approach to Risk Aversion

The Agencies and CEO also dispute Xcel Energy’s rationale against adoption of the 95th percentile SCC value published in the TSD executive summaries, maintaining that it is important to focus on low-probability, high-damage risks. They use metaphors of home insurance considering unlikely but catastrophic risks²⁹, and of getting on a plane that has a 5 percent chance of crashing³⁰. Mr. Martin responded to these metaphors, explaining why though initially appealing, they are not actually similar to the question of selecting an appropriate CO₂ environmental cost range³¹.

As noted earlier, adopting the 95th percentile value without the corresponding 5th percentile would be inappropriate because it would place all the emphasis on the low-probability but potentially catastrophic outcomes, ignoring

²⁶ Agencies’ Initial Brief at 122, footnote 84.

²⁷ When using the SCC for Federal regulatory impact analysis, the IWG urges agencies not to use a single discount rate value but to consider all the estimates. See November 2013 TSD, page 12.

²⁸ Agencies’ Initial Brief at 122.

²⁹ CEO Initial Brief at 26.

³⁰ Agencies’ Initial Brief at 109-10.

³¹ Ex. 602 (Martin Surrebuttal) at 16-18.

that there are also factors (such as adaptation and technological change) that are not captured in the IAMs and may cause them to overestimate. The Commission could adopt the 95th percentile to reflect low-probability, high-damage outcomes, *and* the 5th percentile to reflect low-probability, low-damage outcomes, but doing so would violate the criterion of practicability since these values would point to diametrically opposite resource plans and thus provide no useful information for Commission decision-making.³²

The CEO assert that Mr. Martin’s proposed range “excludes half of the IWG’s assessed outcomes, or distributions, at each discount rate... This exclusion means that there is a 50 percent chance that damages from climate change will fall outside Xcel’s proposed range”.³³ This is incorrect. It would be correct if we had established our initial range from the 25th percentile to the 75th percentile of a single discount rate. However, we established our initial range from the 25th percentile of the 5 percent discount rate distribution to the 75th percentile of the 2.5 percent discount rate distribution. This method retained significantly more than half of all values for the combined discount rate distribution of 450,000 values per emission year. Mr. Martin specified what percentage of those 450,000 estimates it retained³⁴:

- For emission year 2010: 74.82 percent
- For emission year 2020: 75.14 percent
- For emission year 2030: 74.58 percent
- For emission year 2040: 74.00 percent
- For emission year 2050: 73.46 percent

The CEO also claim that it is only true that Xcel Energy’s range has a 75 percent likelihood of encompassing damages from climate change “if the 3 percent discount rate distribution is far likelier than either the 2.5 percent or 5 percent

³² Ex. 602 (Martin Surrebuttal) at 13, 15-16; Xcel Energy’s Initial Brief at 19-20.

³³ CEO Initial Brief at 28.

³⁴ Ex. 600 (Martin Direct) at 63.

discount rate distributions, because combining data from all three distributions centralizes the 3 percent discount rate”.³⁵ This is likewise incorrect. Our method does nothing to “centralize” or treat as likelier the SCC values calculated at 3 percent discount rate; we merely aggregate the 150,000 SCC estimates for each discount rate into a combined discount rate distribution of 450,000 SCC estimates for an emission year. The values calculated at 3 percent discount rate are $1/3$ of this combined discount rate distribution; they are in no way given greater weight than the 2.5 percent or 5 percent discount rate values.

Thus, Xcel Energy’s initial range from the 25th percentile value at 5 percent discount rate to the 75th percentile value at 2.5 percent discount rate retains approximately 75 percent of the IWG’s estimates, meaning it represents tolerance for an approximately 25 percent chance that the actual value of climate change damages (according to the IAMs) has been excluded. When we equally weight the values for each discount rate at each end of this range – which Mr. Martin acknowledged is not explicitly a risk aversion measure, but rather a way to remain agnostic on the crucial ethical question of discount rate choice – what results is a range that eliminates more low-damage estimates (36 percent) than high-damage estimates (26 percent), and as such errs on the side of risk aversion from a climate change damages perspective.³⁶

In summary, Xcel Energy does not believe the appropriate approach to risk aversion in this proceeding is to adopt falsely precise mean estimates, nor to adopt a 95th percentile value that places all the emphasis on low-probability, high-damage estimates and ignores the fact that there are also uncertainties and omissions that could cause the IWG methodology to overestimate. Instead, we believe it is appropriate to select bookends that focus on the higher-probability damages but

³⁵ CEO Initial Brief at 28.

³⁶ Ex. 602 (Martin Surrebuttal) at 13, 35.

still retain a large majority (75 percent) of the estimates, and then accept a final range that excludes more low than high damage estimates. This approach to risk tolerance does not come at the price of losing practicability.

F. CEO Repeat Critiques of Xcel Energy's Statistical Methods

The CEO assert that the endpoints of Xcel Energy's proposed range are "arbitrary and subjective" and that Mr. Martin "chose the endpoints based on whether a desired result was achieved, rather than attempting to describe the IWG data"³⁷ The latter allegation is unsubstantiated in the record. While some Parties criticized Xcel Energy's statistical choices, nowhere in pre-filed testimony or the evidentiary hearings did any Party suggest Xcel Energy pre-selected its desired range and designed a method to achieve it. Our rationale and methods are described in Mr. Martin's pre-filed testimony.³⁸ Mr. Martin's Surrebuttal at 11-12 specifically addresses the allegation that our statistical choices were arbitrary, unprincipled or subjective. Rather than pre-selecting percentiles, Xcel Energy began with all percentiles of the distribution of 150,000 SCC values for each emission year and discount rate, from the 1st to the 99th. This represented a range from \$-9/ton (indicating a net benefit of \$9/ton from emitting CO₂) to damages of over \$600/ton.³⁹ We examined all these percentiles, but ultimately chose the 25th percentile value at 5 percent discount rate and 75th percentile value at 2.5 percent discount rate as the bookends of our initial range.⁴⁰ We chose these percentiles because they, in our view, reflected the most appropriate balancing of uncertainty, risk tolerance and practicability. We noted that other percentiles (1st and 99th, 5th and 95th, etc.) could have been chosen, and would have reflected lower risk

³⁷ CEO Initial Brief at 26-27.

³⁸ Ex. 600 (Martin Direct) at 54-65, Ex. 601 (Martin Rebuttal) at 6-8, Ex. 602 (Martin Surrebuttal) at 4, 12-14, and 25.

³⁹ Ex. 600 (Martin Direct) at 56.

⁴⁰ Ex. 600 (Martin Direct) at 58, updated in Ex. 601 (Martin Rebuttal) at 7.

tolerance; but because of the wide range in the IAM model outputs, these would merely have pointed to diametrically opposed resource plans – one pointing to a plan that retires renewable resources and adds fossil generation, the other to a plan that retires fossil generation and adds renewable generation.⁴¹ We did not believe this sort of CO₂ environmental cost range would be useful for Commission decision-making.

G. CEO Prefer a Different Treatment of Discount Rates

The CEO criticize Xcel Energy’s equal weighting of discount rates, calling this averaging.⁴² Mr. Martin discussed why there is an important qualitative difference between *averaging* discount rates – suggesting there is a “correct” discount rate, equal to the average of the three – and *equally weighting* the SCC values at three different discount rates – suggesting that, because discount rate choice is an inherently ethical decision about which no consensus exists according to the IWG, it is appropriate not to give greater weight to the SCC estimates calculated at one discount rate than another.⁴³

In addition, presenting our range separately by discount rate would have resulted in recommending six CO₂ environmental cost values, rather than two, for each emission year. Mr. Martin acknowledged we could have done so, but suggested this would not have met the practicability criterion. Requiring utilities to model six different CO₂ environmental cost values per year would have presented many conflicting signals for integrated resource planning. Some of the values would be coincidentally virtually identical, despite representing different policy judgments about how to weight the welfare of future generations – for example \$13.10, the 25th percentile value at 3 percent discount rate, and \$13.17, the 75th percentile value

⁴¹ Ex. 602 (Martin Surrebuttal) at 13, 15-16, 22, 33.

⁴² CEO Initial Brief at 27-28.

⁴³ Ex. 602 (Martin Surrebuttal) at 37.

at 5 percent discount rate. Others would be so far apart – e.g., \$2.48, the 25th percentile value at 5 percent discount rate, and \$67.08, the 75th percentile value at 2.5 percent discount rate – as to point in opposite directions for integrated resource planning. Also, adopting six CO₂ environmental cost values for each emission year would also be inconsistent with Commission precedent since the 1990s of adopting just two values, low and high.⁴⁴

H. Updating the CO₂ Environmental Cost Range is Not a Purely Academic Exercise

The CEO appear to believe that the Commission’s choice of CO₂ environmental cost values should be treated as an entirely hypothetical or academic exercise, merely “describing the IWG data”⁴⁵ without any consideration of practicability in how the values will be used. We disagree. First, the statute *requires* consideration of practicability.⁴⁶ The CO₂ environmental cost range established in this proceeding must be practicable in the context where it is applied, which by the statute is defined as “evaluating and selecting resource options in all proceedings before the Commission.”⁴⁷ It is not practicable to set externality values that do not provide useful information when used for their intended purpose. We recognize that there is a distinction between the establishment of externality values (the scope of this proceeding) and the application of such values in resource planning decisions. Practicability is a requirement that applies to the establishment of externality values, and we strongly believe that it encompasses setting values that will be usable and useful for their intended purpose.

⁴⁴ Ex. 602 (Martin Surrebuttal) at 21-22.

⁴⁵ CEO Initial Brief at 27.

⁴⁶ Minn. Stat. § 216B.2422, subd. 3(a) requires the Commission, “to the extent **practicable**, quantify and establish **a range** of environmental costs associated with each method of electricity generation” [emphasis added].

⁴⁷ Minn. Stat. § 216B.2422, subd. 3(a).

Xcel Energy has argued two specific outcomes would be impracticable. First, it would be impracticable if the Commission adopts two diametrically opposed values (such as \$-9 and \$600 per short ton, the 1st and 99th percentile values; or \$13.34 and \$136.70 per short ton, the lowest and highest Federal SCC executive summary values for 2020), because the two ends of the Commission’s range would point to diametrically opposed PVSC rankings, and the Commission would have no reasonable alternative but to discard both sets of plans. Second, it would be impracticable if the Commission adopts an unreasonably large number of different, similar and dissimilar values (such as six values representing the low and high at each discount rate), because such a large number of resource planning sensitivities would provide too many conflicting signals, many of them pointing to similar plans despite representing different policy judgments.

I. CEO Misstate the Burden of Proof

The CEO maintain that “other parties in this proceeding have offered alternative values to the Federal SCC. But none has met its burden to show by a preponderance of the evidence that its proposed value is preferable to the Federal SCC. The Federal SCC is, therefore, the best available measure”.⁴⁸ In other words, the CEO assert that if other Parties have not shown by a preponderance of the evidence that their proposed values are preferable to the SCC, the SCC is by default the best available measure.

This view is not consistent with the ALJ’s March 27, 2015 Order, which states that “[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

⁴⁸ CEO Initial Brief at 25.

CO₂.”⁴⁹ The Order contains no suggestion of a presumptive adoption of the SCC if Parties proposing an alternative are viewed not to meet the preponderance of the evidence standard. Rather, it puts equal burden on Parties proposing adoption of the Federal SCC to show by a preponderance of the evidence that the SCC is reasonable and the best available measure.

J. Agencies Propose Adoption of November 2013 Values

We are unclear why the Agencies now propose adoption of the executive summary values from the November 2013 TSD, since this has been superseded by a July 2015 update. This appears to go against the recommendation of Dr. Hanemann, who advised that the Commission follow any updates made by the IWG.⁵⁰ The IWG updated the SCC values in a July 2015 TSD, making two very minor corrections resulting in values generally \$1-3 per metric ton lower than the November 2013 TSD.⁵¹

K. Regulatory vs. Externality Costs

The Agencies’ discussion of “polluter pays” or “Pigouvian” taxes as remedies used by governments to internalize externalities and correct market failures⁵² appears to blur the distinction between externalities and regulatory costs, and between pollution taxes and market-based “cap and trade” approaches. This is a distinction that the Commission has been intent to keep clear in this docket, insisting that the updated externality values proposed by parties to this proceeding

⁴⁹ Order Regarding Burdens of Proof, Pub. Util. Comm’n Docket No. E-999/CI-14-643/Office of Admin. Hearings Docket No. at 2 (Mar. 27, 2015).

⁵⁰ Ex. 800 (Hanemann Direct) at 61.

⁵¹ Ex. 601 (Martin Rebuttal) at 3.

⁵² Agencies’ Initial Brief at 11-12.

be damage cost estimates rather than regulatory costs.⁵³ Several of the Agencies' examples – the emission trading scheme for sulfur dioxide under Title IV of the Clean Air Act, Southern California's RECLAIM cap-and-trade market for NO_x emissions, and the European Union's CO₂ Emission Trading Scheme – are not examples of pollution taxes, but rather market-based trading schemes. In these systems, the government sets a cap on total emissions and allows trading, and the price that emerges for SO₂, NO_x, or CO₂ allowances reflects supply and demand for allowances and the economics of making on-system emission reductions vs. purchasing allowances. The pollution price in these systems is in no way based on a governmental estimate of damages. In contrast, with a Pigouvian pollution tax – including the SCC, if this were to become the basis for a carbon tax – the government decides the level of the tax to impose based on its calculation of damages caused by the pollutant and the price necessary to internalize those damages. The price does not emerge from market dynamics and the actual cost of reducing pollution, as in the market-based examples cited, but rather from the government's calculation of damages (based on a combination of science and policy judgments). The latter is what is being proposed in this proceeding: to calculate an appropriate "tax" based on estimated damages and impose that tax in integrated resource planning to affect resource selection. Market-based pollution pricing systems do not provide support for using the SCC; these are more in the nature of regulatory cost proxies that the Commission has elected not to use in this proceeding.

L. Whether and How to Address Emission Leakage

⁵³ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216B.2422, Subd. 3.* Docket Nos. E999/CI-00-1636 and E999/CI-14-643. NOTICE AND ORDER FOR HEARING. October 15, 2014.

Finally, the Agencies propose that the Commission should not consider emission leakage either when updating or when applying the CO₂ environmental cost range. They argue that the Commission only has jurisdiction over utilities in Minnesota and the “level of GHG emissions in other states is not the responsibility of the Commission”.⁵⁴ We agree that the Commission has jurisdiction only in Minnesota, but would draw the opposite conclusion. Since the Commission in this proceeding wishes to adopt a CO₂ environmental cost range that as accurately as possible estimates the benefits (avoided damages) from emission reductions due to actions in Minnesota over which it has jurisdiction, ignoring leakage that may result from these decisions in other states would tend to overestimate benefits. Nonetheless, we agree the Commission should not address leakage in this proceeding. This proceeding attempts to estimate damages per ton of CO₂ emitted or avoided, not estimate the number of net tons emitted or avoided, which can only be done in the context of a Commission proceeding on a specific resource decision.

III. GRE/MP/OTP and MLIG

A. Areas of Agreement

Xcel Energy agrees with the other Minnesota utilities and MLIG that the proponents of adoption of the Federal SCC executive summary values have not shown, by a preponderance of the evidence, that these values represent a reasonable and best available measure for the Commission’s environmental cost of CO₂.⁵⁵ We agree that the statutory direction to quantify and establish environmental cost values “to the extent practicable” must be considered in

⁵⁴ Agencies’ Initial Brief at 130.

⁵⁵ GRE/MP/OTP Initial Brief at 1, MLIG Initial Brief at 67.

updating the values⁵⁶, dictating that practicability in the proposed application be considered rather than treating this proceeding as a purely academic exercise to describe the IWG data or explore climate change damages. We agree that the Federal SCC was not designed for use in state-level decision making or integrated resource planning.⁵⁷

B. GRE/MP/OTP's Review Criteria Are Not More Appropriate than Xcel Energy's

Xcel Energy has proposed throughout this proceeding eight “standard of review” criteria to help the ALJs and the Commission evaluate Parties’ proposals recommending various methodologies and CO₂ values.⁵⁸ Dr. Smith argued that Xcel Energy’s proposal did not meet its own criteria, stated that Xcel Energy’s criteria are fundamentally different from those previously relied on by the Commission, and proposed four criteria of her own: solid evidentiary basis, no excessive speculation, conservative assumptions, and reflecting the needs and impacts of Minnesota residents. Dr. Smith also argued that her first three criteria are based on the original 1990s externalities proceeding.⁵⁹

Two of Xcel Energy’s criteria are explicitly established in the statute or by Commission order: the requirement for a practicable range, and the requirement of a damage cost approach. The remainder were proposed to help the ALJs to evaluate the various proposals before them. They take into account the nature of this proceeding (e.g., inherent uncertainty, tolerance for risk, and subjectivity in assumptions). We do not agree that solid evidentiary basis or no excessive speculation were used as review criteria in the original externalities proceeding, as

⁵⁶ GRE/MP/OTP Initial Brief at 5.

⁵⁷ GRE/MP/OTP Initial Brief at 11-14, MLIG Initial Brief at 23, 28-31.

⁵⁸ Ex. 600 (Martin Direct) at 2, Ex. 601 (Martin Rebuttal) at 13, Ex 603 (Martin opening statement) at Hearing Transcript Vol. 3B at 101-105.

⁵⁹ Ex. 300 (Smith Direct) at 16; Ex. 304 (Smith Surrebuttal) at 2-7; GRE/MP/OTP Initial Brief at 5-8.

claimed by Dr. Smith.⁶⁰ Conservative values were recommended by the ALJ because at that time (1996) “quantification of environmental costs [was] still in its infancy.”⁶¹

C. Dr. Smith’s Alternate Framing Assumptions Are Not Less Subjective than the IWG’s

The GRE/MP/OTP brief is nearly silent on Xcel Energy’s proposal, but does recommend that the Commission not adopt Xcel Energy’s proposed range because “Mr. Martin did not make any changes to IWG’s framing assumptions”.⁶² MLIG similarly asserts that “Mr. Martin’s approach unquestioningly adopts every one of the IWG’s subjective framing decisions”.⁶³

Mr. Martin did not unquestioningly adopt the IWG’s policy judgments. He devoted considerable attention to Dr. Smith’s proposed alternate framing assumptions, agreeing with her that these represent subjective policy judgments rather than matters of objective scientific fact. He discussed the arguments both for and against the IWG’s policy judgments, explained why Xcel Energy chose not to alter them, but also explained how Xcel Energy’s range could be adjusted if the Commission makes different policy judgments from the IWG.⁶⁴ We briefly review below Mr. Martin’s responses to Dr. Smith. Ultimately, the alternate framing assumptions she proposes are merely different policy judgments, no more or less subjective than those of the IWG.

⁶⁰ The Commission in fact mentioned “sufficiently reliable basis,” as was recognized in GRE/MP/OTP Initial Brief at 6. See, *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3*. Docket No. E-999/CI-93-583. ORDER ESTABLISHING ENVIRONMENTAL COST VALUES. January 3, 1997 at 26.

⁶¹ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3*. Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION AND MEMORANDUM. March 22, 1996 at 17.

⁶² GRE/MP/OTP Initial Brief at 25, footnote 95.

⁶³ MLIG Initial Brief at 65.

⁶⁴ Ex. 601 (Martin Rebuttal) at 37-53.

First, the geographic scope of damage assessment is a policy judgment on which there is no “correct” answer. There are reasonable rationales for focusing on global damages, based in the economic theory of a global collective action problem and the desire to encourage reciprocity. There are reasonable rationales for focusing on U.S. or Minnesota damages, based in arguments of economic standing and an assumed lack of reciprocity.⁶⁵ Limiting the scope to U.S. damages would be inconsistent with the earlier externalities proceeding.⁶⁶

Second, modeling horizon is a policy judgment on which there is no “correct” answer. Mr. Martin acknowledged that shortening the modeling horizon to 2100 or 2140 reduces the number of years for which speculation is required regarding population, economic growth, emissions, technological change, temperature change, and the response of future societies to temperature change.⁶⁷ However, it neglects – effectively sets at zero, despite Dr. Smith’s claims that they can be considered qualitatively⁶⁸ – any damages after 2100 or 2140.⁶⁹ A modeling horizon of 2100 would, however, be consistent with the earlier externalities proceeding.⁷⁰

Third, whether to treat marginal damages as the first, last or average ton is a policy judgment on which there is no “correct” answer. Mr. Martin agreed that the IWG’s last-ton methodology may overstate the damages from Minnesota emissions and the benefits (i.e., avoided damages) from reducing emissions in Minnesota, because of the IAM’s convex damage functions and because of the way the methodology assumes all past, current, and future emissions in the reference case

⁶⁵ Ex. 601 (Martin Rebuttal) at 39, Ex. 602 (Martin Surrebuttal) at 29.

⁶⁶ Ex. 602 (Martin Surrebuttal) at 31.

⁶⁷ Ex. 601 (Martin Rebuttal) at 44-45.

⁶⁸ Hearing Transcript Vol. 2A at 76-80.

⁶⁹ Ex. 602 (Martin Surrebuttal) at 30.

⁷⁰ Ex. 602 (Martin Surrebuttal) at 31.

and then assigns all incremental damages to the “pulse” case.⁷¹ However, Dr. Smith’s way of arriving at first-ton damages – which is necessary not only for her first-ton estimate of \$1.62/net metric ton, but also for averaging against the last-ton method in order to arrive at her average-ton estimate of \$5.14/net metric ton – is to set global emissions to zero in 2020. This is not a realistic assumption.⁷² Mr. Martin noted that, lacking a realistic way of calculating first-ton damages, he did not see an obvious way to derive an average-ton estimate from the data available.⁷³ He noted that calculating first-ton damages would be inconsistent with the earlier externalities proceeding, though average-ton damages are consistent with the earlier proceeding.⁷⁴

Fourth, discount rate is a policy judgment on which there is no “correct” answer, and no way to avoid the inherently ethical dimensions of this intergenerational decision. MLIG asserts that “the IWG used an incorrect discount rate”⁷⁵, but even Dr. Smith did not claim there is a “correct” discount rate. MLIG asserts that lower discount rates are “driven more by moral philosophy than informed by empirical analysis” and that the use of a 2.5 percent rate is “unsupported by empirical evidence”⁷⁶. In fact, what Dr. Smith has demonstrated is merely that we have more evidence of the preferences of current generations than we do of the preferences of future generations. She presented evidence, based on data on the preferences of current generations, favoring the 3 and 5 percent discount rates. She did not present any evidentiary basis for discarding the 2.5 percent discount rate as less likely to represent the preferences of future

⁷¹ Ex. 601 (Martin Rebuttal) at 46.

⁷² Ex. 602 (Martin Surrebuttal) at 30-31.

⁷³ Hearing Transcript Vol 4 at 46-49.

⁷⁴ Ex. 602 (Martin Surrebuttal) at 31.

⁷⁵ MLIG Initial Brief at 46.

⁷⁶ MLIG Initial Brief at 47.

generations.⁷⁷ Lacking such evidence, discarding the 2.5 percent rate is just as much taking an ethical (or “moral philosophy”) position as using it – an unstated policy position that we should only consider the preferences of those generations about whom we have empirical evidence. Mr. Martin acknowledged, however, that discount rates of 3 and 5 percent would be consistent with the earlier externalities proceeding.⁷⁸

D. Xcel Energy’s Range Can be Adjusted for Different Policy Judgments on Discount Rate

MLIG asserts that “any adjustment in any of the [discount] rates,⁷⁹ 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”.⁸⁰ This is incorrect; Mr. Martin explained how Xcel Energy’s range could be adjusted if the Commission makes a different policy judgment on discount rate.⁸¹ If the Commission decided to drop one of the IWG’s three discount rates, Xcel Energy’s proposal would be simple to modify by dropping those 150,000 values from the combined discount rate distribution of 450,000 values before calculating our percentiles. Our method would then automatically assign equal weight to the remaining values. Conversely, if the IWG in the future decided to add a discount rate (e.g., 7 percent, 1.5 percent, etc.) and the Commission decided to follow suit, the new set of 150,000 values calculated at this discount rate would be added to the combined discount rate distribution before calculating our percentiles. Our method would then automatically assign equal weight to the prior and the new values.

⁷⁷ Ex. 601 (Martin Rebuttal) at 41-43, Ex. 602 (Martin Surrebuttal) at 29-30.

⁷⁸ Ex. 602 (Martin Surrebuttal) at 31.

⁷⁹ MLIG’s brief in this sentence reads “any adjustment of the interest rates,” but the context is a discussion of discount rates and we assume this is a typo.

⁸⁰ MLIG Initial Brief at 65.

⁸¹ Ex. 601 (Martin Rebuttal) at 43.

E. Mr. Martin has Responded to Critiques of Xcel Energy’s Statistical Methods

GRE/MP/OTP allege that Xcel Energy’s proposal is “not consistent with any recognized and accepted statistical method”.⁸² MLIG asserts, citing Dr. Smith, that “there is no foundation in statistical theory or decision theory, nor any objective principle, to support the way a narrower range from that very wide range is then chosen by Xcel and recommended for use in Minnesota. Lacking such an objective principle, the same data could be used to identify narrower and lower SCC ranges that have the same probability of being accurate as the range recommended in Mr. Martin’s testimony; and the same data could be used to identify wider and higher SCC ranges that have the same probability of being accurate”.⁸³

Merely repeating statistical critiques that Mr. Martin has already rebutted in detail⁸⁴, without presenting any new evidence, is unpersuasive. In short, the statistical methods employed by Xcel Energy’s consultants, the Brattle Group, are far from unusual. They simply involve finding the percentiles (1st through 99th) of each distribution of 150,000 SCC estimates for a given discount rate and emission year, and of combined discount rate distributions of 450,000 SCC estimates for a given emission year. Taking percentiles of a dataset is a recognized and accepted, even rudimentary statistical method; the fact that the SCC dataset is large does not make taking percentiles somehow less defensible. Mr. Martin also explained how Xcel Energy selected, as the bookends of our range, the percentiles that we believe represent an appropriate balancing of uncertainty, risk tolerance and practicability.⁸⁵ Choosing which percentiles to use is a matter of policy judgment no different from

⁸² GRE/MP/OTP Initial Brief at 25, footnote 95.

⁸³ MLIG Initial Brief at 64-65, citing Smith Rebuttal at 3.

⁸⁴ Ex. 602 (Martin Surrebuttal) at 9-20 and 24-28.

⁸⁵ Ex. 602 (Martin Surrebuttal) at 11-14.

the policy judgments embedded within the proposal of Dr. Smith and every other Party.

Regarding MLIG's assertion above, Mr. Martin has explained that narrower and lower SCC ranges, and higher and wider SCC ranges, would *not* have the same probability of being "accurate," i.e., of containing the actual value of future climate damages as predicted by the IAMs.⁸⁶ Xcel Energy's initial range has a 75 percent probability of containing the actual value of future climate damages as predicted by the IAMs. Narrower ranges would have a smaller probability of containing this value. Wider ranges would have a higher probability of containing the value – though, depending how wide they are, could result in an impracticable range that assigns the lowest PVSC to two opposite resource plans.

No Party proposed a method that involves less policy judgment or uses more robust statistical methods than Xcel Energy's. In fact, Dr. Smith's proposal retains all the statistical flaws of the IWG methodology – modifying the framing assumptions but then, like the IWG, recommending *point estimates* that represent the average (under her framing assumptions) of the SCC results across IAMs and EMF-22 scenarios. These are not in fact ranges and as such, are subject to false precision and are not compliant with the statute.

F. MLIG Prefers a Different Approach to Risk Aversion

MLIG asserts that "Xcel Energy's proposal omits the most likely damages numbers," referencing the histogram on page 65 of Mr. Martin's Direct Testimony.⁸⁷ MLIG is correct that this figure suggests the most frequently occurring damage estimate in the distribution of 450,000 SCC estimates for 2020 was slightly to the left of Xcel Energy's lower bookend. The histogram peaks at a

⁸⁶ Ex. 602 (Martin Surrebuttal) at 14.

⁸⁷ MLIG Initial Brief at 66.

value slightly lower than the \$12.33 per ton lower bound in Mr. Martin’s Direct Testimony (revised to \$12.13 per ton in his Rebuttal Testimony per the IWG’s July 2015 TSD). This indicates that the most frequent value in IAM model runs, occurring in slightly over 2.5 percent of the runs, was a slightly lower dollar value than our lower bound. Our lower bound, based on the intersection of the curve and the red dotted line, appears to occur in about 2.3 percent of the model runs. The lower bound of our initial range, \$2.48 per ton (i.e., the 25th percentile at 5 percent discount rate) is well below the histogram peak, but our lower bound moves up to \$12.13 per ton when we equally weight discount rates.⁸⁸

MLIG appears to prefer to err on the side of avoiding the risk that the CO₂ environmental cost range is too high. This is a legitimate concern, and it is important to consider this risk, but also to balance it with aversion to the risk of underestimating climate damages. Mr. Martin noted that Xcel Energy’s final range excludes more low-damage estimates than high-damage estimates.⁸⁹ Risk aversion is not the intended effect of equally weighting discount rates – the intended effect is to acknowledge there is no objectively correct discount rate – but we believe that a degree of risk aversion is appropriate. That is, we are willing to set our lower bound slightly higher than some values that are (very slightly) more probable.

G. Rejecting Xcel Energy’s Alternative Would Indeed Meaningfully Change the Ranges Presented to the Commission

MLIG asserts that “rejection of Xcel’s ‘alternative’ does not meaningfully change the numbers presented to the Commission in this proceeding” because our lower and upper bounds are similar to the Federal SCC executive summary average

⁸⁸ See Ex. 600 (Martin Direct) at 64-65.

⁸⁹ Ex. 600 (Martin Direct) at 64, Ex. 602 (Martin Surrebuttal) at 13, 35.

values at 3 and 5 percent discount rates.⁹⁰ We disagree that our proposal does not meaningfully change the numbers presented to the Commission. To demonstrate this, we respectfully refer the ALJs back to Figure 2 of Mr. Martin’s rebuttal, which compares all Parties’ proposed values on the common basis of nominal dollars per short ton.⁹¹

For emission year 2020, Xcel Energy is proposing a range from \$12.13 to \$41.40 in 2014 dollars per short ton, equivalent to \$13.39 to \$45.69 in nominal dollars per short ton. Parties advocating adoption of the Federal SCC executive summary values propose values of \$12, \$42, \$62 and \$123 in 2007 dollars per metric ton⁹², equivalent to \$13.34, \$46.68, \$68.90 and \$136.70 in nominal dollars per short ton. We agree that Xcel Energy’s lower bookend of \$13.39 is coincidentally very similar to the lowest Federal SCC executive summary value of \$13.34, albeit calculated in an entirely different way. However our higher bookend of \$45.69 is significantly different from the higher Federal SCC executive summary values of either \$68.90 or \$136.70. Our higher bookend is similar to one of the Federal SCC mid-range values – the 3 percent discount rate average value of \$46.68 – but proponents of adopting the Federal SCC have not indicated they are willing to drop the 2.5 percent discount rate average value of \$68.90 or the 3 percent discount rate 95th percentile value of \$136.70. Xcel Energy’s recommended range also significantly differs from the values proposed by GRE/MP/OTP, MLIG, and Peabody, as shown in the same figure.⁹³

Therefore rejecting Xcel Energy’s proposed range would very meaningfully change the numbers presented to the Commission in this proceeding. It would also eliminate the *only* proposal that represents a true range – i.e., a statistically derived

⁹⁰ MLIG Initial Brief at 66.

⁹¹ Ex. 601 (Martin Rebuttal) at 12.

⁹² Per the July 2015 TSD, Appendix A at page 17. Ex. 601 (Martin Rebuttal), Schedule 1.

⁹³ Ex. 601 (Martin Rebuttal) at 12.

range, rather than a series of point estimates using different assumptions – derived from a balanced consideration of uncertainty, risk tolerance and practicability. We do not believe the ALJs should eliminate the most robust proposal from Commission consideration.

H. MLIG Suggests that Xcel Energy’s Range is Not Updatable

MLIG asserts that Xcel Energy’s proposal is dependent on IWG modeling “and thus for the most part not independently updatable”.⁹⁴ We are not clear why MLIG believes our range is not updatable. Xcel Energy has not only claimed, but in fact has demonstrated, that our range is updatable. When the IWG updated its SCC estimates in July 2015, Xcel Energy updated its range in a matter of days by obtaining the new model outputs and running the same statistical procedures as we had on the November 2013 TSD data.⁹⁵ We acknowledge that the proposal of MLIG’s original witness Dr. Gayer would also be easy to update, since it merely involves applying adjustment factors to the new IWG data. In contrast the proposal of Dr. Smith – whose proposal MLIG now appears to advocate in lieu of Dr. Gayer’s⁹⁶ – would not be so easy to update. It would be updatable, but doing so would require the Commission hiring a consultant of Dr. Smith’s caliber to obtain the IAMs, revise their code to Dr. Smith’s recommended alternate framing assumptions, and re-run the models.

I. MLIG Shifts its Recommended Range Significantly, Very Late in the Proceeding

MLIG in its Initial Brief significantly shifts its recommendation from the recommendation made by its own witness. Dr. Gayer suggested using the Federal

⁹⁴ MLIG Initial Brief at 67.

⁹⁵ Ex. 601 (Martin Rebuttal) at 5-8.

⁹⁶ MLIG Initial Brief at 67.

SCC executive summary values, i.e., retaining all the IWG’s framing assumptions except global damages, and applying adjustment factors to convert the Federal SCC executive summary values into U.S. and Minnesota damage estimates. Dr. Gayer proposed adoption of eight ranges for U.S. damages (\$0.77-\$2.53, \$2.24-\$7.36, \$3.57-\$11.73, and \$6.23-\$20.47), plus a ninth value of \$0.37 for Minnesota damages (all in 2007 dollars per metric ton for 2010 emissions).⁹⁷ MLIG now discards all of these recommendations except the \$0.37 one, recommending in their Initial Brief a range from \$0.37 to \$5.14 per net metric ton (in 2014 dollars).⁹⁸ We question whether MLIG shifting its recommendation so significantly this late in the proceeding is procedurally appropriate or gives other Parties adequate opportunity to respond to the new proposal.

IV. PEABODY

A. Areas of Agreement

Xcel Energy agrees with Peabody that the proponents of adopting the Federal SCC executive summary values have not shown by a preponderance of the evidence that these values are reasonable and the best available.⁹⁹ We also agree that Peabody’s proposal – or at least one of their multiple proposals, that of Dr. Mendelsohn – constitutes a damage cost approach¹⁰⁰ and is practicable.¹⁰¹

B. Xcel Energy’s Proposed Range is not “Very Close to the FSCC”

Peabody asserts that “the ultimate values [Mr. Martin] recommended were very close to the FSCC”.¹⁰² It is true that the lower bookend of Xcel Energy’s range

⁹⁷ Ex. 400 (Gayer Direct) at 10.

⁹⁸ MLIG Initial Brief at 87.

⁹⁹ Peabody Initial Brief at 111.

¹⁰⁰ Peabody Initial Brief at 107; Ex. 601 (Martin Rebuttal) at 36.

¹⁰¹ Ex. 601 (Martin Rebuttal) at 36.

¹⁰² Peabody Initial Brief at 105.

is coincidentally close to the lowest Federal SCC executive summary value (\$13.34 vs. \$13.39 for 2020, on the common metric of nominal dollars per short ton), though it is derived in a different and in our view more statistically robust way. The upper bookend of Xcel Energy's range is meaningfully different from the two higher Federal SCC executive summary values (\$45.69, vs. \$68.90 and \$136.70, again in nominal dollars per short ton).¹⁰³

C. Practicability and a Range Are Required by Statute

Peabody asserts that none of Xcel Energy's proposed standard of review criteria is specified in the statute.¹⁰⁴ This is incorrect. Our criterion that the CO₂ environmental cost values represent a practicable range is directly derived from the statute.¹⁰⁵ Our criterion of a damage cost approach was required by the Commission. The remainder are criteria that Xcel Energy proposes because they are helpful for the ALJs to evaluate the various recommendations before them.

D. Uncertainty Does Not Justify Inaction

Peabody proposes that the uncertainty in estimating climate change damages is too great to justify a value greater than zero, or a departure from the Commission's current values.¹⁰⁶ We disagree. The uncertainty is significant, but the Commission routinely makes policy decisions under uncertainty. Xcel Energy has proposed that the uncertainty is not a reason for setting the values at zero, or for not updating the values. It is a reason to exercise caution and not adopt the Federal SCC executive summary values uncritically, but instead develop a defensible range that reflects a balanced consideration of our eight criteria.

¹⁰³ Ex. 601 (Martin Rebuttal) at 12.

¹⁰⁴ Peabody Initial Brief at 107.

¹⁰⁵ Minn. Stat. § 216B.2422, subd. 3(a) requires the Commission, "to the extent **practicable**, quantify and establish a **range** of environmental costs associated with each method of electricity generation" [emphasis added].

¹⁰⁶ Peabody Initial Brief at 107.

E. Peabody Rehashes Statistical Critiques to which Mr. Martin has Responded

Peabody repeats a variety of critiques raised by Dr. Wecker that were solidly refuted in Mr. Martin's testimony.¹⁰⁷ With apologies for the repetition, we briefly restate those responses here:

- Peabody notes that Mr. Martin is not a statistician and describes Dr. Wecker's statistical expertise.¹⁰⁸ Mr. Martin did not claim to be a statistician. Instead, Xcel Energy retained Brattle to apply statistical methods that are well-accepted and in fact fairly rudimentary. Brattle's statisticians have similar qualifications to Dr. Wecker. Brattle's Dr. Phil Hanser holds a Phil.M. in Economics and Mathematical Statistics from Columbia University, has been a member of the American Statistical Association since 1974, served for six years on the American Statistical Association's Advisory Committee to the Energy Information Administration (EIA), has extensive experience applying statistical methods in utility decision making, and has published extensively in applied statistics and mathematics.¹⁰⁹
- Peabody repeats Dr. Wecker's objection that Mr. Martin's testimony did not sufficiently cite the statistical literature.¹¹⁰ Mr. Martin felt it unnecessary to cite statistical literature in support of statistical methods as simple and well-accepted as taking the percentiles of a dataset.¹¹¹

¹⁰⁷ Ex. 602 (Martin Surrebuttal) at 9-20 and 24-28.

¹⁰⁸ Peabody Initial Brief at 108.

¹⁰⁹ Ex. 602 (Martin Surrebuttal) at 24; Ex. 600 (Martin Direct), Schedule 9 at 25-49.

¹¹⁰ Peabody Initial Brief at 108.

¹¹¹ Ex. 602 (Martin Surrebuttal) at 25.

- Peabody repeats Dr. Wecker’s allegation that Mr. Martin used “novel *ad hoc* procedures of his own invention”.¹¹² Calculating the percentiles of a dataset is not novel, *ad hoc*, or a method invented by Mr. Martin or Brattle. It is common and well-accepted. Mr. Martin explained in detail the statistical methods Brattle used: how the dataset of 2.25 million SCC estimates for 2010, 2020, 2030, 2040 and 2050 was aggregated and how the percentiles were taken.¹¹³ Mr. Martin also provided a clear and explicit rationale why Xcel Energy chose the 25th percentile at 5 percent discount rate and 75th percentile at 2.5 discount rate as the bookends of our range – a decision that was not arbitrary or unprincipled, as Dr. Wecker alleges, but rather a conscious and explicit balancing of uncertainty, risk tolerance and practicability.¹¹⁴
- Dr. Wecker objected to the bootstrapping technique used in Mr. Martin’s methodology. Bootstrapping estimates the variability of a statistic of a population when limited information is available, as is the case with the results of the IWG’s modeling. Because of the large number of data points (150,000 for each discount rate and emission year), the results of the bootstrapping were very close to the estimates that would have been reached by directly ordering the 150,000 values from the smallest to the largest without bootstrapping. However, bootstrapping added a reasonable measure of precaution, given the uncertainty about the underlying IWG modeling results.¹¹⁵

¹¹² Peabody Initial Brief at 108.

¹¹³ Ex. 600 (Martin Direct) at 54-65; Ex. 602 (Martin Surrebuttal) at 25-26.

¹¹⁴ Ex. 602 (Martin Surrebuttal) at 11-22.

¹¹⁵ Ex. 602 (Martin Surrebuttal) at 26-27.

- Peabody asserts that “for 13 of the 15 distinct sets of IWG cost estimates calculated using the FUND IAM, the 5th percentile falls below zero, implying that the corresponding SCC estimate is not ‘statistically significantly’ greater than zero”.¹¹⁶ This appears to be correct, referencing the July 2015 TSD.¹¹⁷ It is not clear what objection Peabody is raising here. Mr. Martin did not suggest the FUND model’s predictions of negative damages are incorrect, nor exclude these negative damages from the SCC dataset before taking his percentiles. The negative results are part of the 450,000 values per emission year on which he took percentiles. It is true that selecting the 25th percentile at 5 percent discount rate as our lower bound excludes these values, but it does so based on a balancing of risk tolerance and practicability. Our higher bound similarly excludes all values above the 75th percentile at 2.5 percent discount rate.
- Peabody asserts that Mr. Martin “failed to provide any principled basis for the proposed CO₂ environmental cost values” and his “proposed range is the product of entirely arbitrary subjective judgment”.¹¹⁸ Again, Mr. Martin explicitly addressed these accusations in testimony. He explained why the methods are not arbitrary and unprincipled, and in what respects they include subjective policy judgment, as do the proposals of Peabody’s witnesses and those of every other Party.¹¹⁹

Merely repeating Dr. Wecker’s criticisms, without addressing Mr. Martin’s response to those criticisms or providing any further evidence, is unpersuasive.

¹¹⁶ Peabody Initial Brief at 108.

¹¹⁷ Ex. 601 (Martin Rebuttal), Schedule 1. See the 5th percentile values for FUND in Appendix Table A2 at pages 18-19.

¹¹⁸ Peabody Initial Brief at 108.

¹¹⁹ Ex. 602 (Martin Surrebuttal) at 11-12.

F. Peabody Mischaracterizes Xcel Energy's Concept of Risk Tolerance

Peabody asserts that Mr. Martin's proposed range does not meet his own criterion of an appropriate level of risk tolerance, because setting the Commission's CO₂ environmental cost value too high could influence the decision to invest in new generating capacity that is not actually in the public interest; result in high costs to Minnesota utility customers, including low-income and energy-intensive trade-exposed industrial customers; and increase the potential for leakage.¹²⁰ We agree these are important concerns. Keeping electricity affordable, safe, reliable, and increasingly clean are Xcel Energy's paramount objectives in integrated resource planning.

However, we did not propose a one-sided view of risk tolerance that only avoids adopting values that are too high. We defined risk tolerance as tolerance for the risk that the Commission's adopted range fails to include the actual value of future climate change damages, in *either* direction – i.e., that this value lies below the lower bookend of the Commission's CO₂ environmental cost range, or above its upper bookend.¹²¹ While we agree that setting the values “too high” – i.e., overestimating damages from Minnesota emissions and the benefits (avoided damages) from emission reductions – should be avoided, we also believe setting the values “too low” – i.e., underestimating damages from Minnesota emissions and the benefits to society of reducing these emissions – should also be avoided. Setting the values too low could influence the decision not to invest in new generating capacity that is in fact in the public interest. We believe our range represents the appropriate balance of both types of risk aversion.

¹²⁰ Peabody Initial Brief at 109.

¹²¹ Ex. 600 (Martin Direct) at 56-57; Ex. 602 (Martin Surrebuttal) at 12-14.

G. Peabody Misconstrues the Plain Meaning of Xcel Energy's Criterion to Minimize Subjective Judgments

Peabody asserts that Mr. Martin's proposed range does not meet his own criterion of minimizing subjective judgments because "a social cost of carbon based on the best available science (as Peabody's approach reflects) is the best way of minimizing subjective judgments".¹²²

Mr. Martin was explicit throughout his testimony, and in his opening statement at the evidentiary hearings, that the types of policy judgments he discusses do not concern the climate science, but rather the non-scientific questions to which there is no objectively "correct" answer: the geographic scope of damage assessment, modeling horizon, discount rate, and so on.¹²³ Mr. Martin did not suggest the science is subjective. Xcel Energy does not believe Peabody has shown that their approach reflects the best available science, but in fact Xcel Energy has not taken positions on the climate science questions debated by Peabody in this proceeding. We have explicitly refrained from taking positions on these issues.¹²⁴ We did not propose that the criterion of minimizing subjective judgments means identifying whose science is best. It refers to the non-scientific policy judgments that all Parties' proposals contain.

H. Peabody Asserts that its Range is Practicable

Peabody protests that its proposed ranges meet Xcel Energy's criterion of practicability.¹²⁵ We agree, and acknowledged as much: "[Dr. Mendelsohn] does use a damage cost approach (the DICE model) and proposes a practicable range of \$4

¹²² Peabody Initial Brief at 110.

¹²³ Ex. 602 (Martin Surrebuttal) at 37-51; Hearing Transcript Vol. 3B at 106.

¹²⁴ Ex. 601 (Martin Rebuttal) at 35.

¹²⁵ Peabody Initial Brief at 110.

to \$6 per ton”.¹²⁶ Peabody’s overall testimony is confusing because its various experts recommend so many different CO₂ environmental cost ranges, but taking the example of Dr. Mendelsohn’s proposed range of \$4 to \$6 per ton at 3°C equilibrium climate sensitivity, we acknowledged this range is practicable in the sense that it would be straightforward to apply, and the two ends of the range would not point to opposite resource plans. It was other proposed standard of review criteria on which we believe Peabody’s various ranges fail.¹²⁷

Whether Peabody’s recommendations in their Initial Brief continue to meet the criterion of practicability is less clear. In the brief, they recommend a zero value¹²⁸; a negative value between -\$17.97 and -\$4.05 per ton¹²⁹; retaining the Commission’s current CO₂ externality range, which is \$0.44 to \$4.53 per ton,¹³⁰ which they suggest is supported by Dr. Mendelsohn’s ranges of \$0.30 to \$0.80 per ton at 1.5°C equilibrium climate sensitivity and \$1.10 to \$2.00 per ton at 2°C equilibrium climate sensitivity¹³¹; and finally that they would also accept a Commission decision to adopt the values proposed by Dr. Mendelsohn of \$4.00 to \$6.00 per ton.¹³² We are confused what values Peabody ultimately recommends.

I. Peabody Asserts that Xcel Energy’s Range is Not Practicable

Peabody asserts that Mr. Martin’s range does not meet Xcel Energy’s own criterion of practicability because it is too broad.¹³³ We disagree. Peabody has put forward no witness with any claimed or demonstrated experience in utility integrated resource planning, whereas Mr. Martin does have such experience. We

¹²⁶ Ex. 601 (Martin Rebuttal) at 36.

¹²⁷ Ex. 601 (Martin Rebuttal) at 36.

¹²⁸ Peabody Initial Brief at 113.

¹²⁹ Peabody Initial Brief at 114.

¹³⁰ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. §216B.2422, Subd. 3.* PUC Docket Number/s: E-999/CI-93-583 and E-999/CI-00-1636. May 27, 2015.

¹³¹ Peabody Initial Brief at 115.

¹³² Peabody Initial Brief at 115.

¹³³ Peabody Initial Brief at 110.

believe the range proposed by Mr. Martin is practicable for integrated resource planning for the reasons stated throughout Mr. Martin's testimony.

J. Peabody Questions the Transparency of the IWG Process

Peabody asserts that Mr. Martin's proposal is not transparent, replicable and updatable because the IWG process was not transparent.¹³⁴ Mr. Martin did not claim the IWG process was transparent, only that Xcel Energy's methods for using the IWG data to arrive at its proposed range are transparent. He documented those methods in greater detail and with more transparency than any other Party.¹³⁵ As for replicability and updateability, Xcel Energy not only claimed, but actually demonstrated during this proceeding, this advantage of our methods. When the IWG updated its SCC estimates in July 2015, Xcel Energy accordingly updated its range in a matter of days by obtaining the new July 2015 model outputs and running the same statistical procedures as we had on the November 2013 TSD data.¹³⁶

V. SUMMARY

This Reply Brief summarizes why Xcel Energy believes proponents of adopting the Federal SCC executive summary values have not demonstrated, by a preponderance of the evidence, that these represent a reasonable and best available measure for the environmental cost of CO₂. Nor have Parties advocating alternatives – in the case of GRE/MP/OTP and MLIG, the SCC estimates under alternate framing assumptions; in the case of Peabody, various conflicting recommendations to set the CO₂ environmental cost values at negative numbers, at

¹³⁴ Peabody Initial Brief at 111.

¹³⁵ Ex. 602 (Martin Surrebuttal) at 22-24.

¹³⁶ Ex. 601 (Martin Rebuttal) at 5-8.

zero, leave them where they are, or very slightly increase them – demonstrated that these estimates are better supported by the evidence.

Xcel Energy proposed a method that uses the IWG data as its starting point but derives a range based on a balanced consideration of eight criteria. We have demonstrated this range is based on defensible policy judgments, robust statistical methods, and appropriately balances risk tolerance with practicability. We have demonstrated that practicability in the integrated resource planning context must be considered when setting the CO₂ environmental cost ranges; this is not merely a hypothetical or academic exercise. We urge the ALJs and Commission to adopt, as its updated CO₂ environmental cost, the ranges proposed in Schedules 2 and 3 of Mr. Martin’s Rebuttal Testimony.

Respectfully submitted by:

/s/ James R. Denniston

James R. Denniston
Assistant General Counsel
Northern States Power Company
414 Nicollet Mall, 5th Floor
Minneapolis, MN 55401
Telephone: (612) 215-4656

**STATE OF MINNESOTA
BEFORE THE OFFICE OF ADMINISTRATIVE HEARINGS
FOR THE
MINNESOTA PUBLIC UTILITIES COMMISSION**

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

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

**XCEL ENERGY PROPOSED FINDINGS OF FACT,
CONCLUSIONS OF LAW, AND RECOMMENDATION
ON CO₂ ISSUES
December 15, 2015**

James R. Denniston
Assistant General Counsel
NORTHERN STATES POWER COMPANY,
a Minnesota corporation
414 Nicollet Mall, 5th Floor
Minneapolis, MN 55401
Telephone: (612) 215-4656

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**STATE OF MINNESOTA
BEFORE THE OFFICE OF ADMINISTRATIVE HEARINGS
FOR THE
MINNESOTA PUBLIC UTILITIES COMMISSION**

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

OAH Docket No. 80-2500-31888
MPUC Docket No. E-999/CI-14643

**XCEL ENERGY'S PROPOSED
FINDINGS OF FACT, CONCLUSIONS OF
LAW, AND RECOMMENDATION
ON CO₂ ISSUES**

This matter came before Administrative Law Judges (ALJs) LauraSue Schlatter and J. Jeffrey Oxley for evidentiary hearing on September 24-25, 2015 and 28-29, 2015 in St. Paul, Minnesota. A public hearing was held in St. Paul, Minnesota on August 26, 2015. The following appearances were made:

Leigh Currie and Kevin Reuther, Attorneys at Law, Minnesota Center for Environmental Advocacy (26 East Exchange Street, Suite 206, St. Paul, Minnesota 55101), appeared on behalf of Minnesota Center for Environmental Advocacy, The Izaak Walton League of America – Midwest Office, Fresh Energy and Sierra Club (Clean Energy Organizations, CEOs).

Tristan L. Duncan and Jonathan Massey, Attorneys at Law, Shook, Hardy & Bacon, LLP (2555 Grand Boulevard, Kansas City, Missouri 64108), appeared on behalf of Peabody Energy Corporation (Peabody).

B. Andrew Brown and Hugh Brown, Attorneys at Law, Dorsey & Whitney, LLP (50 South Sixth Street, Suite 1500, Minneapolis, Minnesota 55402), appeared on behalf of Great River Energy, Minnesota Power, and Otter Tail Power Company (GRE/MP/OTP).

James R. Denniston, Assistant General Counsel (414 Nicollet Mall, 5th Floor, Minneapolis, Minnesota 55401), appeared on behalf of Northern States Power Company, d/b/a Xcel Energy (Xcel Energy).

Marc A. Al and Andrew P. Moratzka, Attorneys at Law, Stoel Rives, LLP (33 South Sixth Street, Suite 4200, Minneapolis, Minnesota 55402), appeared on behalf of Minnesota Large Industrial Group (MLIG).

Kevin P. Lee, Attorney at Law, Law Office of Kevin P. Lee (400 South Fourth Street, Suite 401-111), Minneapolis, Minnesota 55415) appeared on behalf of Doctors for a Healthy Environment (DHE).

Jessica Dexter, Attorney at Law, Environmental Law & Policy Center (394 Lake Avenue, Suite 306, Duluth, Minnesota), appeared on behalf of the Clean Energy Business Coalition (CEBC).

Linda S. Jensen, Assistant Attorney General (445 Minnesota Street, Suite 1800, St. Paul, Minnesota 55101), appeared on behalf of the Minnesota Department of Commerce, Division of Energy Resources and the Minnesota Pollution Control Agency (the Agencies).

Tricia Debleeckere and Sean Staples participated as representatives of the staff of the Minnesota Public Utilities Commission.

STATEMENT OF THE ISSUE

The Commission referred the issue of the appropriate values for CO₂ under Minn. Stat. §216B.2422 subd. 3 to the Office of Administrative Hearing (OAH) for a contested case proceeding. According to the Commission's Order, the purpose of the proceeding is 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."¹

ALJ Schlatter later in her Third Prehearing Order excluded "testimony regarding the efficacy of renewable energy or renewable energy policy" as presumably irrelevant, unless "its relevance is specifically demonstrated."²

Based on the Findings of Fact that follow below, the ALJs make the following:

¹ *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216.B.2422, Subd. 3.* Docket No. E-999/CI-14-643. NOTICE AND ORDER FOR HEARING, October 15, 2014. Order Point 2. Hereafter, documents in this Docket will be referred by name and date only.

² THIRD PREHEARING ORDER, April 16, 2015. Order Point 3.

RECOMMENDATIONS

The Minnesota Public Utilities Commission (the Commission) should:

1. Determine that the four Federal Social Cost of Carbon (SCC) executive summary values do not represent a reasonable and best available measure to estimate the environmental cost of CO₂.
2. Determine that the Federal SCC methodology and raw modeling outputs are, however, a reasonable and best available starting point to develop a range of CO₂ values.
3. Determine that Xcel Energy's methodology to develop a range of CO₂ values is the best available measure and reasonably balances uncertainty, risk tolerance, and practicability.
4. For the environmental cost of CO₂, adopt Xcel Energy's proposed range from \$12.13 to \$41.40 (2020 emission year, 2014 dollars per short ton), and the corresponding values for other emission years as indicated in Schedules 2 and 3 of Xcel Energy witness Nicholas Martin's Rebuttal Testimony.³

FINDINGS OF FACT

I. Procedural History

1. In 1997, the Commission established environmental costs of different methods of generating electricity under Minn. Stat. § 216B.2422 Subd. 3.⁴ In December 2000, the Commission initiated an investigation into whether the environmental cost values should be updated or expanded.⁵ Starting in 2001, the Commission authorized increasing the environmental cost values each year to account for inflation.⁶ The current range for CO₂, as updated in May 2015, is from \$0.44 to \$4.53 (in 2014 dollars per ton).⁷

³ Ex. 601 (Martin Rebuttal), Schedules 2 and 3.

⁴ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. ORDER ESTABLISHING ENVIRONMENTAL COST VALUES, January 3, 1997. ORDER AFFIRMING IN PART AND MODIFYING IN PART ORDER ESTABLISHING ENVIRONMENTAL COST VALUES, July 2, 1997.

⁵ *In the Matter of the Petition of Northern States Power Company for Review of its 1999 All Source Request for Proposals.* Docket No. E-002/M-99-888. ORDER REJECTING REQUEST FOR FURTHER INVESTIGATION, APPROVING FINAL BID SELECTIONS, AND OPENING DOCKET REGARDING EXTERNALITY VALUES, February 7, 2001.

⁶ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216.B.2422, Subd. 3.* Docket No. E-999/CI-00-1636. ORDER UPDATING EXTERNALITY VALUES AND AUTHORIZING COMMENT

2. On October 9, 2013, the Clean Energy Organizations filed a motion to reopen the investigation into environmental and socioeconomic costs under Minn. Stat. § 216B.2422 subd. 3 and requested that the Commission update the values for carbon dioxide (CO₂), sulfur dioxide (SO₂), and nitrogen oxides (NO_x) and establish a cost value for particulate matter less than 2.5 microns in diameter (PM_{2.5}).

3. On February 10, 2014, the Commission issued an Order in Docket No. E-999/CI-00-1636, reopening its investigation into environmental costs of generating electricity under Minn. Stat. § 216B.2422 subd. 3.⁸ The scope of the investigation was limited to four pollutants: CO₂, PM_{2.5}, SO₂, and NO_x. Before referring the matter to OAH, the Commission sought input on the scope of the investigation and possible retention of an expert from a stakeholder group convened by the Minnesota Department of Commerce (the Department) and the Minnesota Pollution Control Agency (MPCA).

4. On June 10, 2014, as a result of the stakeholder process, the Agencies filed a report stating that “there was little consensus arising out of the stakeholder meeting or in subsequent written comments.”⁹ Nevertheless, the Agencies made specific recommendations to the Commission regarding the development of environmental values for CO₂, PM_{2.5}, SO₂, and NO_x.

5. On October 15, 2014, the Commission issued an Order referring the further investigation of environmental cost values for CO₂, PM_{2.5}, SO₂, and NO_x to the OAH for contested case proceedings.¹⁰

6. On November 25, 2015, a first prehearing conference was held before ALJ Schlatter.

PERIODS ON CO₂, PM_{2.5}, AND APPLICATION OF EXTERNALITY VALUES TO POWER PURCHASES, May 3, 2001.

⁷ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216.B.2422, Subd. 3.* Docket No. E-999/CI-00-1636. NOTICE OF UPDATED ENVIRONMENTAL EXTERNALITY VALUES, May 27, 2015.

⁸ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216.B.2422, Subd. 3.* Docket No. E-999/CI-00-1636. ORDER REOPENING INVESTIGATION AND CONVENING STAKEHOLDER GROUP TO PROVIDE RECOMMENDATIONS FOR CONTESTED CASE PROCEEDING, February 10, 2014.

⁹ *In the Matter of the Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216.B.2422, Subd. 3.* Docket No. E-999/CI-00-1636. Comments of the Minnesota Department of Commerce and the Minnesota Pollution Control Agency. June 10, 2014 at 3.

¹⁰ NOTICE AND ORDER FOR HEARING, October 15, 2014.

7. On December 9, 2014, ALJ Schlatter issued her First Prehearing Order, which bifurcated the proceedings into two separate tracks (CO₂ and Criteria Pollutants) and established an initial schedule for both tracks.¹¹ The following were named as Parties:

- Clean Energy Organizations,
- The Department of Commerce,
- Peabody Energy Corporation,
- Otter Tail Power,
- Minnesota Power,
- Lignite Energy Council,
- Xcel Energy,
- Large Industrial Group,
- Great River Energy, and
- Minnesota Chamber of Commerce.

8. On March 3, 2015 a second prehearing conference was held before ALJ Schlatter.

9. On March 5, 2015, ALJ Schlatter issued a Protective Order to facilitate discovery and protect trade secret information and other not public data.¹²

10. On March 11, 2015, ALJ Schlatter issued a Recommendation for Public Hearings and Public Notice Plan.¹³

11. On March 19, 2015, ALJ Schlatter issued an Order Granting Intervention to MPCA.¹⁴

12. On March 19, 2015, ALJ Schlatter issued her Second Prehearing Order, which established the final schedule for the bifurcated proceedings.¹⁵

13. Parties filed Memoranda of Law on February 4, 2015 and Responsive Memoranda of Law on February 18, 2015 regarding burden of proof issues. ALJ Schlatter issued an Order Regarding Burdens of Proof on March 27, 2015.¹⁶

¹¹ FIRST PREHEARING ORDER, December 9, 2014.

¹² PROTECTIVE ORDER, March 5, 2015.

¹³ RECOMMENDATION FOR PUBLIC HEARINGS PLAN AND PUBLIC NOTICE PLAN, March 11, 2015.

¹⁴ ORDER GRANTING INTERVENTION TO MINNESOTA POLLUTION CONTROL AGENCY, March 19, 2015.

¹⁵ SECOND PREHEARING ORDER, March 19, 2015.

¹⁶ ORDER REGARDING BURDENS OF PROOF, March 27, 2015.

14. On April 16, 2015, ALJ Schlatter issued her Third Prehearing Order, which encouraged jointly filed testimony and briefs, and limited testimony regarding the efficacy of renewable energy.¹⁷ ALJ Schlatter also issued the same day an Order Granting Intervention to Doctors for a Healthy Environment, Clean Energy Business Coalition, and Interstate Power and Light Company.¹⁸

15. On May 27, 2015, the Commission issued an Order Requiring Public Hearing, which directed that one public hearing be held in the Commission's Large Hearing Room in St. Paul.¹⁹

16. On August 4, 2015, ALJ Schlatter issued her Fourth Prehearing Order, which scheduled a third prehearing conference and encouraged in-person attendance.²⁰

17. On August 14, 2015, a third prehearing conference was held before ALJ Schlatter.

18. A public hearing was held on August 26, 2015 at the Commission's Large Hearing Room in St. Paul (121 7th Place E, Suite 350, St. Paul, MN 55101), starting at 2 pm. More than 2,000 postcards, and several written comments or letters were also received.

19. On August 28, 2015, ALJ Schlatter issued her Fifth Prehearing Order regarding the CO₂ Track procedural schedule.²¹

20. On September 3, 2015, Peabody, the Agencies, and MLIG filed motions to exclude and strike Direct and Rebuttal Testimony of other Parties' witnesses.

21. On September 15, ALJ Schlatter issued two Orders regarding motions to exclude and strike Direct and Rebuttal Testimony.²²

¹⁷ THIRD PREHEARING ORDER, April 16, 2015.

¹⁸ ORDER GRANTING INTERVENTION TO DOCTORS FOR A HEALTHY ENVIRONMENT, CLEAN ENERGY BUSINESS COALITION, AND INTERSTATE POWER AND LIGHT COMPANY, April 16, 2015.

¹⁹ ORDER REQUIRING PUBLIC HEARING, May 27, 2015.

²⁰ FOURTH PREHEARING ORDER, August 4, 2015.

²¹ FIFTH PREHEARING ORDER, August 28, 2015.

²² ORDER ON MOTIONS BY MINNESOTA LARGE INDUSTRIAL GROUP AND PEABODY ENERGY CORPORATION TO EXCLUDE AND STRIKE TESTIMONY, September 15, 2015; ORDER ON MOTIONS BY PEABODY ENERGY CORPORATION, THE MINNESOTA DEPARTMENT OF COMMERCE, AND THE POLLUTION CONTROL AGENCY TO EXCLUDE AND STRIKE TESTIMONY, September 15, 2015.

22. On September 15, 2015, Peabody and MLIG filed motions to exclude and strike Surrebuttal Testimony of other Parties' witnesses.

23. On September 21, 2015, ALJ Schlatter issued an Order regarding Peabody's and MLIG's motions to exclude and strike Surrebuttal Testimony.²³

24. On September 23, 2015, ALJ Schlatter issued an Amended Protective Order.²⁴

25. On September 24-25, 2015 and September 28-29, 2015, ALJs Schlatter and Oxley held evidentiary hearings on the CO₂ track in St. Paul, Minnesota.

II. Applicable Law

A. Applicable Statute

26. This proceeding arises due to legislative directives contained in Minn. Stat. §216B.2422 subd. 3(a). This statute codifies a process for utilities' resource planning and selection. Subd. 3(a) sets the requirements for environmental costs, which are at issue in this case. Minn. Stat. §216B.2422 subd. 3(a) reads:

Subd. 3. Environmental Costs. (a) The commission shall, to the extent practicable, quantify and establish a range of environmental costs associated with each method of electricity generation. A utility shall use the values established by the commission in conjunction with other external factors, including socioeconomic costs, when evaluating and selecting resource options in all proceedings before the commission, including resource plan and certificate of need proceedings.

B. Burden of Proof

27. After providing an opportunity for the Parties to provide Memoranda and Responsive Memoranda on burden of proof issues, ALJ Schlatter issued on Order Regarding Burden of Proof on March 27, 2015.²⁵

28. In essence, ALJ Schlatter ordered that any Party proposing that the Commission adopt a new or current existing value for CO₂, including the Federal

²³ ORDER ON MOTIONS BY MINNESOTA LARGE INDUSTRIAL GROUP AND PEABODY ENERGY CORPORATION TO EXCLUDE AND STRIKE TESTIMONY, September 21, 2015.

²⁴ AMENDED PROTECTIVE ORDER, September 23, 2015.

²⁵ ORDER REGARDING BURDEN OF PROOF, March 27, 2015.

SCC, bears the burden of showing, by a preponderance of evidence, that the value is reasonable and the best available measure of the environmental cost of CO₂. In addition, if a Party proposes a CO₂ value, including any existing environmental cost value, it must file Direct Testimony in support of its proposal.

29. ALJ Schlatter also ordered that any Party that opposes a particular proposed environmental cost value must demonstrate that the particular proposal does not meet the required preponderance of the evidence standard.

C. Rule of Evidence

30. In her Order regarding MLIIG and Peabody's motion to strike testimony, ALJ Schlatter confirmed that the appropriate rule of evidence to apply in this case is the rule of the OAH.²⁶ This rule permits the admission of all evidence that has probative value, including hearsay, if it is the type of evidence on which reasonable, prudent persons are accustomed to rely in the conduct of their serious affairs (Minn. R. 1400.7300, subd. 1). The rule excludes evidence that is incompetent, irrelevant, immaterial, or unduly repetitious.

III. Parties' Proposals

31. Dr. Hanemann testified for the Agencies. He advocated adopting the Federal SCC as a reasonable and best available measure, and proposed adoption of the three values representing the average across the Integrated Assessment Models (IAMs) at 2.5, 3, and 5 percent discount rates. He proposed the 95th percentile summary value, if the SCC is viewed through the lens of risk management. Dr. Hanemann proposed a range from \$12 (5 percent discount rate average value) to \$62 (2.5 percent discount rate average value), based on the Interagency Working Group's (IWG) updated July 2015 Technical Support Document (TSD) (emission year 2020, in 2007 dollars per metric ton).²⁷ In their Initial Brief, however, the Agencies changed this position and recommended values as published in the November 2013 TSD, Appendix A, Table A1.²⁸ It is not entirely clear which values the Agencies propose, but it appears that instead of a range, they recommend adopting all four executive summary SCC values (the average across IAMs at 2.5, 3, and 5 percent discount rates and the 95th percentile value across IAMs at 3 percent discount rate; e.g., \$12, \$43, \$64, \$128 for emission year 2020, in 2007 dollars per metric ton).²⁹

²⁶ ORDER ON MOTIONS BY MINNESOTA LARGE INDUSTRIAL GROUP AND PEABODY ENERGY CORPORATION TO EXCLUDE AND STRIKE TESTIMONY, September 15, 2015.

²⁷ Ex. 802 (Hanemann Surrebuttal) at 87-88.

²⁸ Agencies' Initial Brief, Figure 7 at 36.

²⁹ Agencies' Initial Brief at 33-37.

32. Dr. Polasky testified for CEOs. He recommended adopting the Federal SCC as a reasonable and best available measure, and proposed adopting all four executive summary SCC values (the average across IAMs at 2.5, 3, and 5 percent discount rates and the 95th percentile value across IAMs at 3 percent discount rate), as published in Appendix A, Table A1 of the July 2015 TSD (e.g., \$12, \$42, \$62, and \$123 for emission year 2020, in 2007 dollars per metric ton).³⁰

33. Dr. Rom testified for DHE. He supported using the Federal SCC as a reasonable and best available measure to estimate environmental cost of CO₂.³¹

34. Mr. Kunkle and Mr. Rumery testified for CEBC. They advocated adopting the Federal SCC as a reasonable and best available measure to develop environmental values for CO₂.³²

35. Dr. Smith testified for GRE/MP/OTP/MLIG. She opposed adopting the Federal SCC methodology or values. Instead, Dr. Smith modified five key modeling assumptions made by the IWG and ran the three IAMs with the following alternative assumptions: 1) use the “first ton” or “average ton” approach instead of the IWG’s “last ton” approach to modeling marginal damages; 2) use a modeling horizon to the year 2100 or at most to the year 2140; 3) disregard the 2.5 percent discount rate and use 3 and 5 percent discount rates; 4) base values on U.S. damages; and 5) account for possible leakage.³³ For emission year 2020, Dr. Smith proposed a range from \$1.62 to \$5.14 (in 2014 dollars per net metric ton). 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 the 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 the year 2140.³⁴

36. Dr. Gayer testified for MLIG. He did not support the decision by the IWG to estimate global damages, and instead proposed converting the Federal SCC values to U.S. and Minnesota values. The IWG estimated in the February 2010 TSD that U.S. damages range from 7 percent (based on the FUND model’s regional estimate of damages in the United States) to 23 percent (based on the U.S. share of

³⁰ Ex. 101 (Polasky Rebuttal) at 2.

³¹ Ex. 500 (Rom Rebuttal) at 8-9.

³² Ex. 701 (Kunkle Rebuttal) at 2; Ex. 700 (Rumery Rebuttal) at 2.

³³ Dr. Smith did not propose that leakage be addressed in the context of this proceeding, but rather that an adjustment factor for estimated leakage be applied to the emission reductions within Minnesota in the context of specific dockets where the CO₂ environmental cost values are applied.

³⁴ Ex. 300 (Smith Direct) at 20-27, 33.

the global Gross Domestic Product [GDP] in that year) of global damages. Dr. Gayer proposed applying these adjustment factors to the four SCC executive summary values, and recommended CO₂ environmental cost ranges of \$0.77-\$2.53, \$2.24-\$7.36, \$3.57-\$11.73, and \$6.23-\$20.47 (2010 damage value in 2007 dollars). He also suggested a value of \$0.37 based on Minnesota's share of the global GDP.³⁵ In its Initial Brief, however, MLIG changed this position, dropping all but one of Dr. Gayer's nine proposed values, and recommended adopting a range from \$0.37 to \$5.14 (in 2014 dollars per net metric ton).³⁶

37. Drs. Bezdek, Happer, Lindzen, Mendelsohn, Tol, and Wecker testified for Peabody. They all opposed using the Federal SCC methodology or values and proposed various low options for the environmental cost of CO₂, ranging from negative values up to \$6 per ton. Dr. Mendelsohn used the DICE model with its internal optimization mode, emission forecasts, GDP projections, and declining discount rate, but changed some other key parameters, including the shape of the damage function and equilibrium climate sensitivity.³⁷ Dr. Mendelsohn recommended a CO₂ environmental cost range of \$4 to \$6 per metric ton in 2015 (if equilibrium climate sensitivity [ECS] is assumed to be 3°C); \$0.30 to \$0.80 per ton (if ECS is 1.5°C), and \$1.10 to \$2.00 per ton (if ECS is 2°C).³⁸ Dr. Tol attempted to replicate Dr. Mendelsohn's modifications with the FUND model by using discount rates between 3 and 7 percent and climate sensitivity values between 1°C and 3°C.³⁹ In its Initial Brief, Peabody made various recommendations, indicating it would support a negative value, a zero value, retaining the Commission's current range of \$0.44 to \$4.53 per short ton, or adopting Dr. Mendelsohn's range of \$4 to \$6 per metric ton.⁴⁰

38. Mr. Martin testified for Xcel Energy. He used the Federal SCC modeling output data and defined an initial range from the 25th percentile at 5 percent discount rate to the 75th percentile at 2.5 percent discount rate, taken of the distribution of 450,000 SCC estimates for each emission year for which the IWG provided estimates (2010, 2020, 2030, 2040, and 2050). The result was an initial range from \$2.48 (25th percentile at 5 percent discount rate) to \$67.08 (75th percentile at 2.5 percent discount rate), in 2014 dollars per short ton.⁴¹ This initial range contains approximately 75 percent of the 450,000 IAM estimates of the SCC for each emission year. Then, Mr.

³⁵ Ex. 400 (Gayer Direct) at 9-10.

³⁶ MLIG's Initial Brief at 87.

³⁷ Ex. 214 (Mendelsohn Direct) at 14-15.

³⁸ Ex. 214 (Mendelsohn Direct) at 15.

³⁹ Ex. 236 (Tol Rebuttal) at 5, 8-9.

⁴⁰ Peabody's Initial Brief at 113-115.

⁴¹ Updated based on the July 2015 TSD, 2020 emission year, 2014 dollars per short ton. See Ex. 601 (Martin Rebuttal) at 7-8.

Martin equally weighted the SCC values for each of the three discount rates at the low and high ends of the initial range. The final range Xcel Energy proposed is from \$12.13 to \$41.40 for emission year 2020, and corresponds with the 36th and 74th percentiles of the IAM's distribution of 450,000 SCC estimates for that year.⁴²

IV. Credibility of Witnesses

39. It is a common practice to rely on and use other authors' academic work and research – one could say that this is in fact the essence of research, which does not happen in isolation but requires broad knowledge of the particular field of science. Similarly, various types of scientific models are developed and made available for other researchers and experts for their use, and sharing information in the public domain is the essence of research. The ALJs thus find that a person does not need to be a climate scientist or IAM modeler to be a credible witness in this proceeding. One does not have to be the creator or modeler of an IAM in order to understand and analyze its functions. In fact, the developers of the three IAMs used by the IWG are economists, and used a significant amount of information and science that was created by others to determine modeling assumptions and parameters.⁴³

40. Neither is there a reason why the witnesses to this proceeding must have been participants in the Intergovernmental Panel on Climate Change (IPCC) or IWG in order to understand and analyze the work of these two bodies. The IPCC Assessment Reports and IWG TSDs are meant to be read and used by a variety of people with different backgrounds.

41. Mr. Martin, who testified for Xcel Energy, stood out as a knowledgeable, articulate, and credible witness. He demonstrated a solid and comprehensive understanding of the key issues in this proceeding: the SCC methodology and modeling, public policy matters, and integrated resource planning. No other witness possessed comparable carbon policy expertise combined with first-hand experience on public utility commission procedures and integrated resource planning.⁴⁴

42. The expert witnesses brought by other Parties to this proceeding did not claim practical experience with public utility commission proceedings in general or integrated resource planning in particular. They did not consider how their recommended CO₂ values would affect public policy in Minnesota or the context in which the values would be applied. For example, Dr. Polasky specifically stated during

⁴² Updated based on the July 2015 TSD, 2020 emission year, 2014 dollars per short ton. See Ex. 601 (Martin Rebuttal) at 5-8; Ex. 600 (Martin Direct) at 54-64.

⁴³ Hearing Transcript Vol. 1 at 209-210 (Polasky); Hearing Transcript Vol. 2B at 64 (Hanemann).

⁴⁴ Xcel Energy's Initial Brief at 22.

the Evidentiary Hearings that he only testified about the Federal SCC and does not know how the Commission would use the SCC values or how they would be translated into public policy.⁴⁵ However, Dr. Polasky was not unique in this regard; no witnesses other than Mr. Martin claimed expertise or spoke to how the CO₂ environmental cost values would be used in integrated resource planning and other Commission decisions.

V. Context and Nature of CO₂

43. This proceeding involves complex issues of climate change science, economics, and public policy. These issues are especially complex because of the inherent uncertainty in estimating long-term climate change damages as far as the year 2300. We cannot rely on information or facts that we know, because we simply have not experienced future centuries, future temperature changes, or future technological innovations.

44. Therefore, it is not possible to develop a methodology to estimate the externality value of CO₂ that would be solely evidence-based. Many modeling assumptions about the future – such as population, income, gross domestic product (GDP), emissions, damage functions, equilibrium climate sensitivity (ECS), technological change, adaptation, and mitigation – are estimates that cannot be based on experience or evidence. The question becomes how to manage the uncertainty and which of the proposed methodologies is the best measure to account for the uncertainty.

45. The nature of CO₂ contributes to the complexity: it is a global pollutant with long-term impacts. Emissions of CO₂ will mix in the atmosphere and have global effects regardless where they were emitted. Emissions of CO₂ in any one place will have impacts around the globe, and these impacts will persist for several hundred years.⁴⁶

46. However, this proceeding is not only a scientific and economic exercise limited to the climate change context. The results of this state-level regulatory process will affect how regulated utilities in Minnesota will select, allocate, and build resources. The approach to estimate the externality value for CO₂ must take into consideration public policy and also the context in which the CO₂ environmental values will be used. Although additional factors are considered in specific resource planning

⁴⁵ Hearing Transcript Vol. 1 at 82, 138, 178-179 (Polasky), see also Xcel Energy's Initial Brief at 25-26.

⁴⁶ Ex. 805 (Hanemann Opening Statement) at 2; Xcel Energy's Initial Brief at 1.

decisions, such as reliability, affordability, and fuel diversity, the CO₂ value will be one factor affecting these decisions.⁴⁷

47. In the resource planning context, it is equally undesirable to overestimate than underestimate damages from CO₂. The ALJs here agree with the ALJ in the original Externalities Docket: “The possibility of utilities paying more for resources than their environmental benefits justify is just as bad as paying less than their benefits justify.”⁴⁸ There simply cannot be a presumption in this proceeding that it is better to err on the side of overestimating than underestimating damages from CO₂. Instead, the objective is to quantify climate change damages as accurately as possible, considering the inherent uncertainty.

A. Adoption of a Range (Issue 31)

48. The statute implemented here, Minn. Stat. §216B.2422 subd. 3(a), requires the Commission to establish a range of environmental costs. The ALJs agree with the Commission’s Order in the original Externalities Docket that using a range appropriately acknowledges the uncertainty attending the quantification of environmental costs and that using a range permits the testing of resource plans for robustness under varying assumptions (or “sensitivities”).⁴⁹

VI. Climate Science

A. Issues Raised by Peabody Witnesses Bezdek, Happer, Lindzen, and Spencer (Issues 4, 6, 7, 8, 9, 16, 27)

49. Peabody witnesses Drs. Bezdek, Happer, Lindzen, and Spencer made several claims regarding complex issues of climate science, which are by nature uncertain. The ALJs believe that their arguments, at a high-level, can be summarized the following way:

50. First, these witnesses argue that because in their view there is no or little evidence of global warming, and at the same time, because there is evidence of the benefits of CO₂, the CO₂ externality values adopted in this proceeding could be

⁴⁷ Hearing Transcript Vol. 4 at 235 (Martin); Xcel Energy’s Initial Brief at 25.

⁴⁸ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION AND MEMORANDUM. March 22, 1996, at 17.

⁴⁹ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. ORDER ESTABLISHING ENVIRONMENTAL COST VALUES, January 3, 1997, at 14-15.

negative, zero, or left at the Commission's current values. Second, they maintain that the three IAMs used by the IWG (DICE, PAGE, and FUND) are inaccurate and overestimate warming. Third, they claim that the IWG used inappropriate assumptions for many scientific parameters. Fourth, therefore, they believe the Federal SCC is not a reasonable and the best available measure. Fifth, if any values are established in this proceeding, they recommend values that are negative, zero, minimal, or not higher than the original values updated for inflation, currently from \$0.44 to \$4.53, or in any case not higher than \$6.

51. Dr. Bezdek specifically proposed to either keep the current, updated externality value of CO₂ as established in the Original Externalities proceeding, or to reduce them to about \$0.20 to \$2.00 per ton or less based on several arguments regarding climate science. His main claim was that the benefits of CO₂ emissions, in the form of increased crop production through fertilization effects and overall economic growth, far exceed the costs of CO₂ emissions.

52. However, the ALJs find that Drs. Bezdek, Happer, Lindzen, and Spencer did not perform modeling or calculations to provide any other *measure* to estimate the CO₂ values – they merely expressed their professional opinion what they believe should be the CO₂ values. Therefore, if Drs. Bezdek, Happer, Lindzen, and Spencer proposed some CO₂ values in their testimony, the ALJs will not adopt any of those values.

53. The Minnesota legislature, in passing Minn. Stat. §216B.2422 subd. 3(a), has already made the public policy decision that Minnesota will establish an environmental value range for CO₂. The Commission further narrowed the scope of this proceeding to determine whether or not the Federal SCC is the best available measure to establish the new range.⁵⁰

54. The task here is not to decide complex questions of climate change science that have been already thoroughly vetted, researched, challenged, and discussed by an international community of environmental and climate change researchers. The ALJs will not decide on such questions as whether global warming exists, how earth temperatures should be measured, whether CO₂ benefits outweigh the damages, what is the correct value for equilibrium climate sensitivity, how damage function equations should be formulated, or whether DICE, PAGE, and FUND overestimate temperature changes and damages.

⁵⁰ NOTICE AND ORDER FOR HEARING, October 15, 2014.

55. However, the ALJs have thoroughly considered the testimony of Drs. Bezdek, Happer, Lindzen, and Spencer as evidence that the Federal SCC may not be the best available measure to establish externality values for CO₂ in Minnesota.

B. IPCC's Climate Science

56. IPCC, functioning under the auspices of the United Nations, is considered the most reliable authority and source regarding climate change science. Its Assessment Reports are developed by working groups composed of experts throughout the international scientific community and are subject to rigorous multi-level peer-review process.⁵¹ For example, IPCC selected more than 830 authors and review editors from over 80 countries to form the author teams that produced the most recent Fifth Assessment Report, published in 2013.⁵² The IPCC comprehensively synthesizes existing research and aims to provide unbiased assessment of climate change science.

VII. Federal SCC

57. The Federal SCC estimates monetary damages from CO₂ to society globally, from the year of emissions through the year 2300. The SCC was developed in 2009-10 by a U.S. governmental Interagency Working Group (IWG), which consisted of representatives from a dozen different Federal agencies.⁵³ The first SCC Technical Support Document (TSD) was published in February 2010.⁵⁴ Since then, the IWG has published three other updated TSDs in May 2013⁵⁵ (values 60-70 percent higher than in the 2010 TSD), November 2013⁵⁶ (minor updates), and July 2015⁵⁷ (minor corrections). In addition, the IWG released its Response to Public Comments in July 2015.⁵⁸

⁵¹ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION, AND MEMORANDUM, March 22, 1996; Finding No. 87; ORDER ESTABLISHING ENVIRONMENTAL COST VALUES, January 3, 1997 at 24.

⁵² Hearing Transcript, Vol. 3A at 69-70 (Abraham).

⁵³ Ex. 600 (Martin Direct) at 14.

⁵⁴ Included as Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD).

⁵⁵ Included as Ex. 600 (Martin Direct), Schedule 7 (May 2013 TSD).

⁵⁶ Included as Ex. 600 (Martin Direct), Schedule 2 (November 2013 TSD).

⁵⁷ Included as Ex. 601 (Martin Rebuttal), Schedule 1 (July 2015 TSD).

⁵⁸ Included as Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments).

58. The SCC estimates global damages from an incremental ton of CO₂ emissions by comparing damages from a reference case to a pulse case up to the year 2300; the SCC is the difference in damages between the two cases.⁵⁹

59. The IWG used three IAMs to model damages: the Dynamic Integrated Climate and Economy (DICE) model developed by Dr. William Nordhaus, the Policy Analysis of the Greenhouse Effect (PAGE) model developed by Dr. Chris Hope, and the Climate Framework for Uncertainty, Negotiation and Distribution (FUND) model developed by Dr. Richard Tol. All three IAMs were developed in the early 1990s and have been updated several times since then. The IAMs use reduced-form approaches to translate emissions into temperature response and then into net economic damages. They are all peer-reviewed and widely cited and accepted by the academic community.⁶⁰

60. The IAMs are simplified representations of the climate system and global economy, which is generally accepted as necessary in order to combine population, emissions, temperature, and damage assessments in one unified model. DICE, PAGE, and FUND are considered the only available, credible climate models that also include the final step in the process – monetizing damages from temperature change.⁶¹ The ALJs believe it was appropriate and reasonable to use these three IAMs in the Federal SCC methodology.

61. The IWG forecasted future emissions by using five different scenarios that have assumptions about population growth, GDP growth, and the CO₂ intensity of the technologies that fuel GDP growth. The IWG used four scenarios from the Stanford Energy Modeling Forum (EMF-22) as exogenous inputs to the IAMs: IMAGE, MERGE Optimistic, MESSAGE, and MiniCAM. These all are peer-reviewed and widely used and cited. In addition, the IWG created a fifth scenario, called “550 ppm average,” which assumes a global climate agreement to stabilize atmospheric CO₂ concentrations at 550 ppm by the year 2100. The IWG extended the five EMF-22 scenarios from the year 2100, the final year of the EMF-22 forecasts, to the year 2300.⁶²

A. Standardization (Issue 14)

62. In addition to using the five EMF-22 socioeconomic/emissions scenarios and extending them from the year 2100 to the year 2300, the IWG made

⁵⁹ Ex. 600 (Martin Direct) at 15.

⁶⁰ Ex. 600 (Martin Direct) at 17.

⁶¹ Xcel Energy’s Initial Brief at 12, 15.

⁶² Ex. 600 (Martin Direct) at 16, 31-35; Schedule 6 at 15.

some other changes in order to standardize the IAM inputs. It created a probability distribution for ECS based on the Roe and Baker distribution and made ECS a random variable for all three IAMs, using the Monte Carlo method to run the IAMs many times with random draws for ECS and other input parameters.⁶³ The IWG also used the same three discount rates of 2.5, 3, and 5 percent in each IAM.⁶⁴ Finally, the IWG removed the optimization feature in DICE to make its results comparable with those of PAGE and FUND, which are simulation rather than optimization models.⁶⁵

63. Dr. Mendelsohn emphasized that the IWG made so many significant changes to the original IAMs that he did not consider the IWG to be using the DICE, PAGE, and FUND models. He argued that the IWG ignored several original assumptions in each IAM, which compromised the integrity of the three IAMs to the extent that the results become questionable.⁶⁶

64. Dr. Polasky and Dr. Hanemann stated that it is a standard practice to use consistent inputs and assumptions across several models in order to make the models and their results comparable.⁶⁷

65. The ALJs recognize that the IWG made the uniform changes across the IAMs as part of its methodology in order to be able to compare and combine the results. Although this is a tradeoff between model integrity and model consistency, the ALJs believe it was reasonable for the IWG to make these standardization changes in order to provide comparable results.

B. Damage Cost Approach (Issue 2)

66. Drs. Smith, Mendelsohn, and Tol argued that the Federal SCC is not based on a damage cost approach as it is typically understood.⁶⁸

67. Mr. Martin pointed out that in the original Externalities Docket, damage cost approach was simply defined as an approach that attempts to place an economic value on the net damage to the environment caused by an energy resource, in contrast to other possible approaches (regulatory cost, willingness to pay, etc.).⁶⁹ The ALJs

⁶³ Ex. 600 (Martin Direct) at 18.

⁶⁴ Ex. 600 (Martin Direct) at 44-47.

⁶⁵ See Ex. 800 (Hanemann Direct) at 46-53.

⁶⁶ Ex. 214 (Mendelsohn Direct) at 16-17; Ex. 220 (Mendelsohn Surrebuttal) at 27.

⁶⁷ Ex. 104 (Polasky Surrebuttal) at 21-23; Ex. 800 (Hanemann Direct) at 46-53; Ex. 802 (Hanemann Surrebuttal) at 10-13.

⁶⁸ Ex. 300 (Smith Direct) 19-20; Ex. 303 (Smith Rebuttal) at 4-5; Ex. 220 (Mendelsohn Surrebuttal) at 21-25.

⁶⁹ Ex. 600 (Martin Direct) at 66; Ex. 602 (Martin Surrebuttal) at 32.

agree on this broad definition and note that the Commission's definition of damage cost approach does not appear to require disaggregated damage functions or an explicit step of estimating physical impacts on resources. Therefore, the Federal SCC is consistent with the Commission's notion of a damage cost approach.⁷⁰

C. Equilibrium Climate Sensitivity (ECS) Value (Issue 5)

68. ECS is a key input parameter for the IAMs, defined as the long-term increase in the annual global-average surface temperature resulting from a doubling of atmospheric CO₂ concentration relative to pre-industrial levels. The IWG used the statement from the IPCC Fourth Assessment Report (AR4) as the basis for its ECS probability distribution: ECS "is likely to lie in the range 2°C to 4.5°C, with a most likely value of about 3°C." ECS "is very likely larger than 1.5°C."⁷¹

69. The IWG used the Roe and Baker distribution for the ECS and calibrated it with the following assumptions: a median equal to 3°C, 66.7 percent probability that the ECS lies between 2°C and 4.5°C, and zero probability that ECS is less than 0°C or more than 10°C. The IWG then drew random values from this distribution using the Monte Carlo method (10,000 values for each emission year / discount rate combination).⁷²

70. In its Fifth Assessment Report (AR5), published in 2014, the IPCC updated its range of likely ECS values to 1.5°C to 4.5°C and no longer defined a most likely value. However, the IWG has not yet updated the ECS in its methodology to match the IPCC's Fifth Assessment Report.⁷³

71. Several Peabody witnesses argued that the ECS values used by the IWG were too high, and should have at least been updated to match the range in IPCC's AR5, 1.5°C to 4.5°C. Dr. Mendelsohn used an assumed ECS of 1.5°C in deriving his CO₂ range of \$0.30 to \$0.80 per metric ton; an assumed ECS of 2°C in deriving his CO₂ range of \$1.10 to \$2.00 per metric ton; and an assumed ECS of 3°C in deriving his CO₂ range of \$4.00 to \$6.00 per metric ton.

72. The ALJs point out that the IWG did not use the low (2°C) and high (4.5°C) point estimates of the IPCC's AR4 range as such. It created a Roe and Baker

⁷⁰ Ex. 602 (Martin Surrebuttal) at 32.

⁷¹ Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 12-13.

⁷² Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 13-14; see also Hearing Transcript Vol. 3B at 139-142 (Martin).

⁷³ Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments).

distribution and calibrated the distribution with certain assumptions. The IWG's probability distribution assumed a 66.7 percent probability that the ECS lies between 2°C and 4.5°C, but the IWG did include in this distribution ECS values lower than 2°C and higher than 4.5°C. Then, the IWG drew random values from this distribution using the Monte Carlo method, resulting in 10,000 values for each emission year / discount rate combination.⁷⁴

73. By using the Roe and Baker distribution and the Monte Carlo method, the IWG addressed the uncertainty in determining ECS values. In addition, the ALJs agree with the IWG that ECS should be based on a synthesis approach that has support from the larger scientific community and reflects the latest scientific consensus.⁷⁵

74. Considering all the uncertain parameters and policy assumptions involved in the IWG methodology, or in any other measure that attempts to estimate the environmental cost of CO₂, the ALJs find that not updating one single parameter – the low end of the ECS range – does not make the IWG methodology unreasonable. The IWG has also indicated that it will update ECS in future revisions of the SCC, based on evaluating the latest science and consulting experts, including considering using the AR5 climate sensitivity range.⁷⁶

D. Modeling Horizon (Issue 10)

75. Dr. Smith proposed shortening the modeling horizon to the year 2100 or at most to the year 2140, because it is highly speculative and uncertain to predict emissions, population growth, GDP structure, temperature changes, and damages out to the year 2300.⁷⁷

76. The Agencies, CEOs, and Xcel Energy disagreed with the way that Dr. Smith eliminated all damages from CO₂ beyond the year 2100 or 2140. This approach, despite Dr. Smith's reassurances that damages after 2100 or 2140 can be considered qualitatively by the Commission, effectively sets those damages at zero.⁷⁸

⁷⁴ Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 13-14. See also Xcel Energy's Initial Brief at 15-16.

⁷⁵ Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments) at 12.

⁷⁶ Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments) at 12. See also Xcel Energy's Initial brief at 15-16.

⁷⁷ Ex. 300 (Smith Direct) at 22-23; Ex. 302 (Smith Report) at 65-79.

⁷⁸ E.g., Ex. 602 (Martin Surrebuttal) at 30-31; Xcel Energy's Initial Brief at 28.

77. CO₂ has a long atmospheric lifetime, and its impacts will persist up to several hundred years. The IWG attempted to capture all likely costs of CO₂ emissions by covering a timeframe until the year 2300. Adopting a CO₂ externality value that has no damages in it after the year 2100 or 2140 in effect ignores those damages.⁷⁹ The ALJs believe it was reasonable for the IWG to estimate damages from CO₂ to the year 2300.

E. Marginal Ton (Issue 11)

78. The IWG ran a “reference” case (including all past and future emissions) and a “pulse” case (adding an incremental ton of CO₂), and then assigned all the difference in damages to the “pulse” case. Dr. Smith argued that this approach treats the marginal ton of CO₂ as if it were the last ton of CO₂ emissions added to the global atmosphere, and therefore effectively assumes no further mitigation globally.⁸⁰

79. In order to estimate marginal damages as if the incremental ton of CO₂ emissions was considered the “first ton,” Dr. Smith modified the IAMs in her methodology so that the baseline scenario assumes no emissions after the year for which the values are calculated. For example, her estimate of damages for emission year 2020 assumes no CO₂ emissions after the year 2020; this is the basis for her low-end value of \$1.62 per net metric ton. She also calculated an “average ton,” which represents the average of damages calculated using her first-ton method and those calculated using the IWG’s last-ton method; this is the basis for her high-end value of \$5.14 per net metric ton.⁸¹

80. The Agencies, CEOs, and Xcel Energy disagreed with the way that Dr. Smith set emissions to zero after the year 2020. Even though this approach was meant as an analytical tool, they believed it was unrealistic to assume that there are no emissions after the year 2020.

81. The ALJs believe that Dr. Smith’s modification of the IAMs to estimate the first ton and average ton value is not realistic or based on empirical evidence. Future climate change damages depend on emissions that have already occurred and emissions that will occur in the future.

82. The ALJs, while recognizing the methodological critique of the IWG’s last-ton approach, find that no Party has proposed an acceptable method of

⁷⁹ Ex. 602 (Martin Surrebuttal) at 30; Hearing Transcript Vol. 3B at 134, Vol. 4 at 54-55; Xcel Energy’s Initial Brief at 28.

⁸⁰ Ex. 300 (Smith Direct) at 20-22; Ex. 302 (Smith Report) at 50-64.

⁸¹ Ex. 300 (Smith Direct) at 20-22; Ex. 302 (Smith Report) at 50-64.

correcting this facet of the methodology. The ALJs find that the way the IWG calculated damages from an incremental ton of CO₂ remains a reasonable basis for the Commission's CO₂ environmental cost range, and incorporates a reasonable measure of risk aversion into this range.

F. Discount Rates (Issue 12)

83. The choice of a discount rate is a public policy decision, and there is no agreement in the economic literature, nor in this proceeding on the appropriate discount rate(s). As the IWG has stated, the selection of a discount rate over long periods of time “raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law.”⁸²

84. The IWG used 2.5, 3, and 5 percent constant annual rates to discount future damages to the present value of the year of emissions.⁸³

85. In the economic literature, there are suggestions for lower discount rates than the IWG used (e.g., 1.5 percent) and there are suggestions for higher discount rates than the IWG used (e.g., the 7 percent discount rate consistent with the Office of Management and Budget guidance). There are also economists who argue for a sliding discount rate, which is tied to economic growth, instead of a constant discount rate.⁸⁴

86. Dr. Smith proposed disregarding the 2.5 percent discount rate in her methodology, because it is not based on sufficient empirical evidence.⁸⁵ However, there is simply no empirical evidence of the preferences of distant future generations. That is, there is no evidence for, but also no evidence against, using a 2.5 percent discount rate. The decision on discount rates is a public policy judgment that must be made without comprehensive empirical evidence.⁸⁶ The ALJs cannot agree that discarding the 2.5 percent discount rate is less subjective or more evidence-based than retaining it.

87. Dr. Mendelsohn proposed using the DICE2013 model's variable, declining discount rate, which starts at 5 percent and declines to 3.5 percent by the

⁸² Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 17.

⁸³ Ex. 600 (Martin Direct) at 45, Schedule 6 (February 2010 TSD) at 23.

⁸⁴ E.g., Ex. 600 (Martin Direct) at 44-47; Ex. 602 (Martin Surrebuttal) at 20-21; Xcel Energy's Initial Brief at 27-28.

⁸⁵ Ex. 300 (Smith Direct) at 23-26; Ex. 302 (Smith Report) at 80-91.

⁸⁶ Ex. 601 (Martin Rebuttal) at 29; Ex. 602 (Martin Surrebuttal) at 29-30.

year 2100 and 2.7 percent by the year 2200.⁸⁷ Also Dr. Tol recommended a variable discount rate based on the Ramsey rule, but instead used in his methodology the FUND model with discount rates between 3 and 7 percent.⁸⁸

88. The Agencies, CEOs, and Xcel Energy agreed that the 2.5, 3, and 5 percent discount rates used by the IWG were appropriate.

89. The ALJs believe that the IWG's methodology to estimate the SCC by using the three different discount rates at 2.5, 3, and 5 percent was a reasonable public policy decision, and the IWG thoroughly articulated its rationale and reasons for selecting these three discount rates.⁸⁹ No Party has presented convincing reasons to make a different policy decision on discount rates.

G. Geographic Scope of Damages (Issue 13)

90. CO₂ is a global pollutant, and was treated as such in the original Externalities Docket. The ALJ in that Docket stated:

“The CO₂ emitted in any particular place on the planet is well-mixed in the atmosphere. Warming in Minnesota, for example, will be caused not just by Minnesota's CO₂ emissions, but by the global concentration of CO₂. Similarly, Minnesota's CO₂ emissions cannot be said to warm Minnesota's environment any more than they warm the rest of the planet.”⁹⁰

91. The IWG acknowledged that emissions of CO₂ in any one place will mix in the atmosphere and contribute to climate change damages globally. The IWG chose to estimate global damages in its SCC values.⁹¹

92. Several witnesses in this proceeding (Drs. Mendelsohn, Smith, and Gayer) have proposed that the CO₂ damage cost values that are applied in Minnesota resource planning decisions should only account for damages in the United States or Minnesota, rather than global damages. They pointed out that Minnesota CO₂

⁸⁷ Ex. 216 (Mendelsohn Report) at 16.

⁸⁸ Ex. 238 (Tol Report) at 4.

⁸⁹ Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 17-23; Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments) at 20-24.

⁹⁰ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION AND MEMORANDUM. March 22, 1996. Finding No. 83.

⁹¹ Ex. 600 (Martin Direct), Schedule 6 (February 2010 TSD) at 10-11.

emissions constitute only a small portion of global emissions (less than 1 percent); Minnesota will experience little benefits but bear significant costs if CO₂ values are calculated based on global damages; and Minnesota lacks authority to negotiate reciprocal international agreements to reduce global carbon emissions.⁹²

93. It is possible that the SCC could overestimate damages in Minnesota, because the SCC values are calculated based on global damages, even though any reductions in Minnesota's emissions are likely to have little effect on global damages. The likelihood of emissions leakage in an interconnected electricity system would further diminish any effect on net damages.⁹³

94. The ALJs believe it is reasonable to retain the Commission's precedent and to continue to estimate CO₂ damages globally.

95. Because the scope of CO₂ damages assessed should be global, not national or regional, the ALJs will not adopt the proposal made by Dr. Gayer (*Issue 29*), as modified in MLIG's Initial Brief (\$0.37 to \$5.14 in 2014 dollars per net metric ton), nor the proposal made by Dr. Smith, whose two proposed values (\$1.62 and \$5.14 per net metric ton) both represent U.S. damages (*Issue 28*).⁹⁴

H. Leakage (Issue 23)

96. Drs. Mendelsohn, Smith, and Gayer recommended that the range of environmental cost values adopted in this proceeding should be adjusted based on potential leakage and applied to the net reduction in emissions when used in particular resource planning decisions.⁹⁵ Dr. Hanemann disagreed, arguing that the Commission's lack of jurisdiction outside Minnesota makes it unnecessary to "modify its assessment of externality cost ranges based on what may or may not happen in other jurisdictions."⁹⁶

97. The ALJs agree with Xcel Energy that the amount of leakage will vary depending on the particular type of issue and decision in question, and therefore a leakage adjustment, if any, should be made on a case-by-case basis in the individual

⁹² Ex. 218 (Mendelsohn Rebuttal Report) at 3-4; Ex. 300 (Smith Direct) at 26-27; Ex. 400 (Gayer Direct) at 7-9, Appendix 2 (Gayer Report) at 2-15.

⁹³ Ex. 601 (Martin Rebuttal) at 39-40.

⁹⁴ Ex. 400 (Gayer Direct) at 9-10; MLIG's Initial Brief at 87; Ex. 300 (Smith Direct) at 33.

⁹⁵ Ex. 220 (Mendelsohn Surrebuttal) at 32-33; Ex. 300 (Smith Direct) at 27-29, 34-35; Ex. 401 (Gayer Surrebuttal) at 9-11.

⁹⁶ Ex. 801 (Hanemann Rebuttal) at 29-31; Agencies' Initial Brief at 130.

docket.⁹⁷ The ALJs will not make any ruling on a leakage adjustment, including whether it is appropriate as a general concept, in this proceeding.

I. Adaptation, Mitigation, and Technological Change (Issue 15)

98. The Parties agree that is impossible to predict with certainty how well and how fast future generations will adapt to increasing temperatures or reduce CO₂ emissions below the EMF-22 trajectories, and therefore the IAMs may not fully capture future adaptation, mitigation, or technological change.⁹⁸

99. The IAMs only partially predict adaptation, which includes any measures taken by future generations to adjust to or alleviate the impacts of warming. The IAMs lack endogenous modeling of technological change and innovation to reduce the CO₂ intensity of economic growth. This means that once the EMF-22 emissions trajectories are set up as exogenous, standardized inputs to the IAMs, future societies are assumed to take no further action to reduce CO₂ damages despite experiencing significant warming and severe damages.

100. Four out of the five emissions scenarios used in the IWG's methodology assume no global mitigation efforts by governments to reduce CO₂ emissions in response to increasing damages. These four EMF-22 scenarios are "business as usual" trajectories that do not assume any international climate policy. The fifth "550 ppm average" scenario used by the IWG assumes international coordination sufficient to contain CO₂ concentrations at 550 parts per million.⁹⁹

101. It is contrary to current evidence to assume that future societies will not take any action if they face growing temperatures and damages. Even today, tremendous technological innovation is taking place to reduce the CO₂ intensity of energy, and governments at the global, national, regional, state and local scale are working towards mitigation, typically by setting targets for the use of renewable energy resources and regulating greenhouse gas emissions from power plants and other sources.¹⁰⁰

102. On the other hand, it is possible that the IAMs do not capture very well the high end of SCC values, which means that they may underestimate damages. There may be higher than expected damages under future extreme conditions, which we have not experienced yet and have no evidence of. The IAMs may not fully model

⁹⁷ Ex. 601 (Martin Rebuttal) at 51-53; Ex. 602 (Martin Surebuttal) at 39-40.

⁹⁸ Xcel Energy's Initial Brief at 12.

⁹⁹ Ex. 600 (Martin Direct) at 34-35; Ex. 601 (Martin Rebuttal) at 24-25, 47-49.

¹⁰⁰ Ex. 600 (Martin Direct) at 34-35; Ex. 601 (Martin Rebuttal) at 24-25, 47-49.

“tipping point” damages or damages under more extreme climate scenarios (for example, greater temperature increases than the temperature increases for which the models have been calibrated).¹⁰¹

103. Since the IAMs are likely to incompletely capture both low end values and high end values, and since it is difficult to know how the omissions that could cause the models to overestimate damages and those that could cause them to underestimate damages balance out, the ALJs agree with Xcel Energy that it is appropriate to treat both ends of the SCC distribution equally.¹⁰²

J. SCC Executive Summary Values (Issues 20, 21)

104. The IAMs as used by the IWG predict 450,000 SCC damage estimates for any given emissions year, and those values range from negative damages (benefits) to damages of nearly \$1,000 per ton of CO₂ emissions. All four SCC values, as published in the executive summary and Appendix A, Table A1 of the TSDs, are single point estimates. Three of the values represent a simple average of 150,000 IAM predictions for a given discount rate and emission year (averages across IAMs at 2.5, 3, and 5 percent discount rates respectively). The fourth value is the 95th percentile value across the three IAMs at 3 percent discount rate.¹⁰³

105. The SCC probability distribution is strongly skewed, with a long right tail of high-damage estimates that have a low probability of occurring, as demonstrated in Figure 2 of Mr. Martin’s Direct Testimony.¹⁰⁴ The average is a poor indicator of central tendency for a non-normal, heavily skewed probability distribution such as the SCC. The less probable, but very high values pull the mean estimate up. The ALJs believe it is not appropriate to adopt any of the first three summary SCC values, because the average is greatly influenced by high outliers and because they are all falsely precise point estimates.¹⁰⁵ Even adopting three point estimates (averages at different discount rates) is not equivalent to adopting a true range.

106. The IWG included the fourth executive summary SCC value (95th percentile value at 3 percent discount rate) to “represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.”¹⁰⁶

¹⁰¹ Ex. 600 (Martin Direct) at 29.

¹⁰² Xcel Energy’s Initial Brief at 18.

¹⁰³ Ex. 600 (Marin Direct) at 19-23.

¹⁰⁴ Ex. 600 (Martin Direct) at 65.

¹⁰⁵ Ex. 600 (Martin Direct) at 25-28; Ex. 602 (Martin Surrebuttal) at 9-10.

¹⁰⁶ Ex. 600 (Martin Direct) at 29-30; Schedule 6 (February 2010 TSD) at 2.

107. The ALJs agree with Xcel Energy that there are several reasons why it is not reasonable to adopt the 95th percentile SCC value without a corresponding 5th percentile. First, nothing in the IAM modeling or results suggest that the SCC is more likely to be the 95th percentile value than the 5th percentile value. Therefore, it was statistically unsound for the IWG to present one without the other. Second, while the IAMs' incomplete modeling of catastrophic damages makes it possible that the SCC is underestimated, the IAMs' incomplete modeling of adaptation, mitigation, and technological change also makes it possible that the SCC is overestimated, which the 5th percentile value would help capture. However, both the 5th and 95th percentile values are highly improbable in statistical terms. Third, the 95th percentile value represents an unreasonably low level of risk tolerance, given that only 5 percent of the IAM model predictions exceed this value. Fourth, the 95th percentile value (\$123 for emissions year 2020) is about ten times higher than the 5 percent discount rate average value (\$12 for emissions year 2020). This difference would create too wide a range to be meaningful for resource planning purposes. Finally, the 95th percentile value is based on the 3 percent discount rate only, and therefore privileges a single discount rate. There is no indication in this proceeding that the 3 percent discount rate is objectively more "correct" than the 2.5 percent and 5 percent discount rates. In fact, most Parties have suggested retaining all three discount rates used by the IWG and treating them equally.¹⁰⁷

VIII. Alternative Proposals

A. Standard of Review Criteria

108. Mr. Martin proposed in his Direct Testimony standard of review criteria, which would give guidance how to evaluate the diverse methodologies and values recommended by the Parties throughout this proceeding. Mr. Martin recommended the following criteria, and emphasized that these criteria should be balanced against each other: a damage cost approach as ordered by the Commission; reasonably addressing the inherent uncertainty in estimating climate damages; reflecting the absence of consensus on discount rate choice; using statistically sound methods; reflecting an appropriate level of risk tolerance (which Xcel Energy defined as tolerance for the risk that the Commission's adopted range does not include the actual value of future climate change damages); minimizing subjective judgments; yielding a practicable range; and being transparent, replicable and updatable.¹⁰⁸

¹⁰⁷ Ex. 600 (Martin Direct) at 29-30; Xcel Energy's Initial Brief at 23-24.

¹⁰⁸ Ex. 600 (Martin Direct) at 2, 67-69; Ex. 601 (Martin Rebuttal) at 13.

109. Dr. Smith is the only other witness who proposed standard of review criteria in this proceeding, and she recommended the following: a solid evidentiary basis; no excessive speculation; use conservative assumptions; and reflect the needs and impacts to residents of Minnesota. Dr. Smith maintained that except for the last criteria, these were based on the original Externalities proceeding.¹⁰⁹

110. Dr. Smith and Peabody stated that Mr. Martin's proposal does not meet his own criteria, and that his criteria are not specified in the statute and are different than those previously relied on by the Commission.¹¹⁰ Xcel Energy argued that only one of Dr. Smith's review criteria was mentioned in the original Externalities proceeding: conservative assumptions. However, the ALJ at that time clearly stated that he recommended conservative values only because "the quantification of environmental costs is still in its infancy."¹¹¹

111. ALJs agree that Xcel Energy's standard of review criteria are reasonable, appropriately reflect the nature of this proceeding, and are helpful in assessing the various proposals made in this proceeding.

B. Dr. Smith's Proposal (Issue 28)

112. Dr. Smith proposed several modifications to the IWG's methodology regarding the modeling horizon, modeling of damages from a marginal ton, discount rates, geographic scope of damages, and leakage. The ALJs have discussed each of these separately as Issues 10, 11, 12, 13, and 23 above, and agreed that the IWG's assumptions were appropriate and reasonable. Therefore, the ALJs will not support Dr. Smith's methodology, alternative assumptions, or proposed CO₂ values.

C. Dr. Mendelsohn's Proposal (Issue 25)

113. Dr. Mendelsohn proposed a methodology and CO₂ values based on the DICE 2013 model only. He used DICE's internal optimization mode, emission forecasts, GDP projections, and declining discount rate, but changed some other key parameters, including the shape of the damage function and equilibrium climate sensitivity.¹¹²

¹⁰⁹ Ex. 300 (Smith Direct) at 16; Ex. 304 (Smith Surrebuttal) at 2-7.

¹¹⁰ Ex. 304 (Smith Surrebuttal) at 7; Peabody's Initial Brief at 107-111.

¹¹¹ *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3.* Docket No. E-999/CI-93-583. FINDINGS OF FACT, CONCLUSIONS, RECOMMENDATION AND MEMORANDUM. March 22, 1996, at 17.

¹¹² Ex. 214 (Mendelsohn Direct) at 14-15.

114. Dr. Mendelsohn created two modified damage functions, which assume no damage until temperatures rise to 1.5°C or 2°C above 1900 levels. He explored several ECS values ranging from 1°C to 3°C, but ultimately made his recommendation based on ECS point estimates of 1.5°C, 2°C, and 3°C. His proposed range was from \$0.30 (no damage until 2°C temperature rise and ECS of 1.5°C) to \$6.00 (no damage until 1.5°C temperature rise and ECS of 3°C), although he also maintained that the CO₂ value established in the original Externalities Docket (currently approximately \$5/ton) remains a reasonable value.¹¹³

115. Dr. Mendelsohn based his modeling of DICE on two damage functions that assume no damages until temperatures rise 1.5°C or 2°C above 1900 temperature levels. These damage functions differ from the best climate science as synthesized by the IPCC in its AR4 and AR5. The IWG used the internal damage functions of the three IAMs and did not modify or change them.

116. Dr. Mendelsohn also based his recommended CO₂ range on three ECS values (1.5°C, 2°C, and 3°C) that only represent the low end of the ECS range recommended by the IPCC in AR4 (2°C to 4.5°C) and AR5 (1.5°C to 4.5°C). He did not propose any values based on using ECS higher than 3°C or creating a probability distribution of the ECS.

117. Dr. Mendelsohn used DICE 2013 model's variable, declining discount rate, which starts at 5 percent and declines to 3.5 percent by the year 2100 and 2.7 percent by the year 2200.¹¹⁴

118. The ALJs earlier determined that the discount rates (*Issue 12*) and ECS probability distribution (*Issue 5*) used by the IWG were appropriate and reasonable. In addition to using different discount rates and ECS values, Dr. Mendelsohn modified the DICE model's damage function in a way that does not conform with the IPCC science. Therefore, the ALJs will not support Dr. Mendelsohn's methodology or proposed values.

D. Dr. Tol's Proposal (Issue 26)

119. Dr. Tol attempted to replicate Dr. Mendelsohn's modifications with the FUND model by using discount rates between 3 and 7 percent and ECS between 1°C and 3°C. However, he did not propose any CO₂ values to be adopted. The ALJs have

¹¹³ Ex. 214 (Mendelsohn Direct) at 2, 5-14; Ex. 216 (Mendelsohn Report), Table 2 at 19; Ex. 220 (Mendelsohn Surrebuttal) at 33-34.

¹¹⁴ Ex. 216 (Mendelsohn Report) at 16.

considered his testimony as evidence that the Federal SCC may not be the best available measure to establish externality values for CO₂ in Minnesota.

IX. Whether the Federal SCC is Reasonable and the Best Available Measure (Issue 1)

A. Uncertainty (Issue 22)

120. The IWG had to make policy judgments and determine scientific parameters, which are inherently uncertain when estimating climate change damages to the year 2300. The IAMs must use simplified representations of the climate system and global economy in order to estimate temperature change from emissions and monetize climate change damages within one single model. There is uncertainty regarding many scientific parameters, such as population growth, GDP growth, emissions, damage functions, and ECS. The IWG had to make several public policy decisions that are not matters of scientific fact, but subjective by nature, such as the selection of discount rates, the geographic scope of damages, modeling horizon, and the treatment of marginal emissions. It is impossible to predict with certainty how well or how fast future generations will adapt to increasing temperatures or mitigate their impacts. There may also be higher than expected damages under future extreme conditions, which we have not yet experienced.¹¹⁵

121. The IWG attempted to address the inherent uncertainty regarding climate change in several ways. For example, it used three IAMs, five different socioeconomic and emissions projections, a probability distribution for ECS, and three different discount rates. The ALJs believe that the Parties in this proceeding have not been able to demonstrate that another measure based on a damage cost approach is a more reasonable or better measure than the Federal SCC as a starting point for developing a CO₂ environmental cost range.¹¹⁶

122. However, because of the uncertainty involved in the scientific parameters and subjectivity involved in the public policy judgments of the IWG methodology, the ALJs believe it is inappropriate to use the four executive summary SCC values, which are point estimates. The ALJs agree with Xcel Energy that they imply precision that does not exist, given the uncertainty, public policy judgments, and the purpose for which the Federal SCC was originally developed.¹¹⁷

¹¹⁵ E.g., Ex. 600 (Martin Direct) at 5-6, 30-47.

¹¹⁶ See Xcel Energy's Initial Brief at 13-16.

¹¹⁷ Ex. 600 (Martin Direct) at 51-53; Ex. 602 (Martin Surrebuttal) at 3-5, 7-9; Xcel Energy's Initial Brief at 16.

B. Purpose of the Federal SCC (Issue 3)

123. The Federal SCC was initially developed to be used in regulatory impact analysis to help estimate whether the benefits of a proposed federal regulation outweigh its costs. In this application there is greater tolerance for imprecise estimates, because the key point is whether the benefits exceed the costs, but neither the benefits nor the costs need to be precisely quantified. The SCC may overestimate or underestimate the benefits of a proposed regulation, but this is not very important as long as the benefits exceed the costs at all four SCC values.¹¹⁸

124. In resource planning, the imprecise SCC would impact decisions regarding specific resource allocations and options. These decisions involve significant costs, are difficult to reverse, and often have large and long-term implications for electricity rates, environmental impacts, and reliability. Although additional factors are considered in specific resource planning decisions, such as reliability, affordability, and fuel diversity, the SCC would be one factor affecting the decisions. In its July 2015 Response to Public Comments, the IWG stated that the SCC estimates were developed for use in regulatory impact analysis and that the IWG has not recommended their use in state-level decision-making.¹¹⁹

C. Xcel Energy's Proposal (Issue 30)

125. Xcel Energy suggested that a reasonable and best available measure to establish environmental cost of CO₂ for Minnesota is to use the Federal SCC modeling data as a starting point, but not adopt the four point estimates in the Federal SCC executive summaries. The ALJs agree and recommend adopting Xcel Energy's proposal to use the IWG's modeling results and to apply well-accepted statistical methods to derive a range that appropriately balances uncertainty, risk tolerance, and practicability.¹²⁰

126. Xcel Energy's methodology treated low and high damage estimates equally and selected symmetric percentiles (25th and 75th percentiles) that reflect a reasonably low level of risk tolerance. Xcel Energy developed an initial range from the full distribution of IWG results at all three discount rates by selecting a range from the 25th percentile at 5 percent discount rate to the 75th percentile at 2.5 percent discount rate. This approach used the full distribution of IWG data and contained

¹¹⁸ Ex. 601 (Martin Rebuttal) at 20; Ex. 602 (Martin Surrebuttal) at 7-8.

¹¹⁹ Ex. 600 (Martin Direct) at 12-14; Ex. 601 (Martin Rebuttal) at 21-22; Hearing Transcript Vol. 3B at 156-158 (Martin). See also Ex. 101 (Polasky Rebuttal), Schedule 1 (July 2015 Response to Comments).

¹²⁰ Ex. 603 (Martin Opening Statement) at 1-3.

approximately 75 percent of the 450,000 SCC estimates for a given emission year.¹²¹ It produced an initial range from \$2.48 at 5 percent discount rate to \$67.08 at 2.5 percent discount rate, in 2014 dollars per short ton.¹²²

127. To further minimize subjective judgment, Xcel Energy equally weighted the SCC values for each of the three discount rates at each end of the range. Its final recommended range of \$12.13 to \$41.40 for emission year 2020 corresponded to the 36th and 74th percentiles of the IWG's modeling results, and excluded more low IAM predictions than high predictions. In total, 74 percent of all IWG modeling results were at or below the high end of Xcel Energy's proposed range.¹²³

128. The ALJs agree that since 74 percent of all IWG modeling results were at or below the high end of Xcel Energy's proposed range (\$41.40), the range reflects an appropriate level of risk tolerance. Because of the skewed distribution of SCC values, the range in fact excludes more low values with higher probability than high values with lower probability. Considering the climate change context and concerns that the IAMs do not adequately model damages from large temperature changes, the ALJs agree that it is appropriately risk averse to eliminate more values from the low end of the distribution.¹²⁴

129. The ALJs recommend that the Commission adopt a range from \$12.13 to \$41.40 (2014 dollars per short ton) as the environmental cost of CO₂, and the corresponding values for other emission years as indicated in Schedules 2 and 3 of Xcel Energy witness Nicholas Martin's Rebuttal Testimony.¹²⁵

¹²¹ Ex. 600 (Martin Direct) at 54-63.

¹²² Updated based on the July 2015 TSD, 2020 emission year, 2014 dollars per short ton. See Ex. 601 (Martin Rebuttal) at 7-8.

¹²³ Updated based on the July 2015 TSD, 2020 emission year, 2014 dollars per short ton. See Ex. 601 (Martin Rebuttal) at 5-8; Ex. 600 (Martin Direct) at 54-64.

¹²⁴ Ex. 600 (Martin Direct) at 63-64; Ex. 601 (Martin Rebuttal) at 5-8; Ex. 602 (Martin Surrebuttal) at 13-14.

¹²⁵ Ex. 601 (Martin Rebuttal), Schedules 2 and 3.