Minnesota Center for Environmental Advocacy

Using law, science, and research to protect Minnesota's environment, its natural resources, and the health of its people.

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November 24, 2015

The Honorable LauraSue Schlatter
Administrative Law Judge   **VIA ELECTRONIC FILING**
Office of Administrative Hearings
600 North Robert Street
St. Paul, MN 55101

Re: *In the Matter of the Further Investigation into Environmental and*
       Socioeconomic Costs Under Minnesota Statute 216B.2422, Subd. 3
       PUC Docket No. E-999/CI-14-643
       OAH Docket No. 80-2500-31888

Dear Judge Schlatter:

In connection to the above-referenced docket please find enclosed the Initial Post-Hearing Brief filed on behalf of Clean Energy Organizations. Also attached is an Affidavit of Service.

Please do not hesitate to contact me should you have any questions or concerns.

Sincerely,

/s/ Kevin Reuther
Kevin Reuther
Legal Director

LC/em

Enclosure

cc: Attached service list

STATE OF MINNESOTA

OFFICE OF ADMINISTRATIVE HEARINGS

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION

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

MPUC Docket No. E-999/CI-14-643, E-999/CI-00-1636

OAH Docket No. 80-2500-31888

INITIAL POST-HEARING BRIEF

OF

CLEAN ENERGY ORGANIZATIONS

NOVEMBER 24, 2015

INTRODUCTION

Minnesota Center for Environmental Advocacy, Sierra Club, and Fresh Energy (collectively, "Clean Energy Organizations" or "CEO") submit that the preponderance of the evidence shows that the Interagency Working Group's Federal Social Cost of Carbon is a reasonable measure and the best available measure of the external costs of carbon dioxide emissions. Based on all the evidence, the Administrative Law Judges ("ALJs") should recommend that the Public Utilities Commission adopt the Federal Social Cost of Carbon for use in Minnesota utility proceedings pursuant to Minnesota Statute § 216B.2422, subdivision 3.

PROCEDURAL HISTORY

In 1993, the Minnesota Legislature enacted Minnesota Statute § 216B.2422, subdivision 3, which required the Public Utilities Commission to "quantify and establish" environmental costs of electricity generation. Minn. Stat. § 216B.2422 (2014). The Commission established interim external cost values in 1994, and permanent values in 1997. Ex. 306. In 1997, the Commission established values for the air pollutants Sulfur Dioxide ("SO_2"), coarse particulate matter ("PM_{10}"), Carbon Monoxide ("CO"), Nitrogen Oxides ("NO_x"), Lead ("Pb"), and Carbon Dioxide ("CO_2"). *Id.* at 33. It adopted a range of $0.30 to $3.10 for the external cost of CO_2, the Administrative Law Judge's recommendation, which was based on lower damage figures assessed by the Pollution Control Agency's expert. *Id.* at 25-27, 33. In 2001, the Commission began to update external cost values to account for inflation, Order Updating Externality Values, Pub. Util. Comm'n Docket No. E-999/CI-00-1636 at 10 (May 3, 2001), but declined to establish an external cost for fine particulate matter ("$PM_{2.5}$") or Mercury. Order Deferring Further Action, Pub. Util. Comm'n Docket No. E-999/CI-00-1636 at 4 (Oct. 5, 2001). The Commission

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continues to use the values established in 1997 today, adjusted only for inflation. *See* Notice of

Updated Environmental Externality Values, Pub. Util. Comm'n Docket No. E-999/CI-00-1636

(May 27, 2015).

In 2013, the Izaak Walton League of America-Midwest Office, Fresh Energy, Sierra

Club, Center for Energy and Environment, Will Steger Foundation, and Minnesota Center for

Environmental Advocacy moved for the Commission to re-open the environmental externality

docket because the current values for some pollutants do not reflect the current science and

underestimate the costs of pollution. Specifically, the Clean Energy Organizations requested that

the Commission establish cost values for $PM_{2.5}$ and SO_2, and update the values for NO_x and CO_2.

Memorandum in Support of Clean Energy Orgs.' Motion, Pub. Util. Comm'n Dockets No. E-

999/CI-93-583, E-999/CI-00-1636, & E-999/CI-14-643, at 15-16 (Oct. 9, 2013). After initial

public comment, the Commission agreed to investigate the environmental and socioeconomic

costs of electricity generation for SO_2, $PM_{2.5}$, NO_x, and CO_2. Order Reopening Investigation and

Convening Stakeholder Group to Provide Recommendations for Contested Case Proceeding,

Subd. 3, Pub. Util. Comm'n Dockets No. E-999/CI-00-1636 & E-999/CI-14-643, at 5 (Feb. 10,

2014).

When it re-opened the investigation, the Commission also directed the Department of

Commerce and the Pollution Control Agency to convene a stakeholder group to help the

Commission determine the scope of that investigation. *Id.* at 6. The agencies recommended that

the Commission adopt the federal Office of Management and Budget's Social Cost of Carbon

("federal SCC") summary value at a 3% discount rate as the value for CO_2. Dep't of Commerce

& Pollution Control Agency, Comments of the Minnesota Dep't of Commerce and the Minn.

Pollution Control Agency, Pub. Util. Comm'n Docket No. E-999/CI-00-1636 (June 10, 2014).

The Commission declined to adopt the Federal SCC immediately, and referred two issues to the Office of Administrative Hearings ("OAH") for contested case hearings: what appropriate values are for SO_2, $PM_{2.5}$, and NO_x, and "[w]hether the Federal Social Cost of Carbon is reasonable and the best available measure to determine the environmental cost of CO_2 under Minn. Stat. §216B.2422 and, if not, what measure is better supported by the evidence." Notice and Order for Hearing, Pub. Util. Comm'n Dockets No. E-999/CI-00-1636 & E-999/CI-14-643/ at 8 (Oct. 15, 2014). The Honorable LaraSue Schlatter on behalf of the OAH bifurcated the hearings and testimony on CO_2 from those for the criteria pollutants SO_2, $PM_{2.5}$, and NO_x. First Prehearing Order, Office of Admin. Hearings, Docket No. 80-2500-31888, Pub. Util. Comm'n Docket No. E-999/CI-14-643 at 12 (Dec. 9, 2014).

The Clean Energy Organizations, the Minnesota Department of Commerce, and Peabody Energy Corporation had intervened with the Public Utilities Commission and were parties when the matter was submitted to the Office of Administrative Hearings. In December 2014, intervention was granted to Otter Tail Power, Minnesota Power, Lignite Energy Council, Northern States Power doing business as Xcel Energy, Minnesota Large Industrial Group, Great River Energy, and Minnesota Chamber of Commerce. *Id.* at 2, 4. In March and April, 2015, the Minnesota Pollution Control Agency, Doctors for a Healthy Environment, Clean Energy Business Coalition, and Power and Light Company were granted intervention. Order Granting Intervention to Minn. Pollution Control Agency, Office of Admin. Hearings, Docket No. 80-2500-31888, Pub. Util. Comm'n Docket No. E-999/CI-14-643 at 2 (Mar. 3, 2015); Order Granting Intervention to Doctors for a Healthy Env't, Clean Energy Bus. Coal., and Interstate Power and Light Co., Office of Admin. Hearings, Docket No. 80-2500-31888, Pub. Util. Comm'n Docket No. E-999/CI-14-643 at 3 (Apr. 16, 2015).

The parties pre-filed direct, rebuttal, and surrebuttal testimony on June 1, August 12, and September 10, 2015, respectively. A hearing was held September 24 - 29, 2015, at which time opportunity was provided for cross-examination of all witnesses.

FACTUAL BACKGROUND

Global Climate Change.

Fossil fuel combustion emits greenhouse gases, especially carbon dioxide ("CO_2"), into the atmosphere. Scientists have discovered that anthropogenic sources of CO_2 emissions are increasing the concentration of CO_2 in the atmosphere beyond levels that would occur naturally. *See e.g.* ex. 803 at 22 (a rare isotope of CO_2 that occurs naturally has not increased in concentration in proportion to increased overall CO_2 concentrations).

Greenhouse gases like CO_2 have a greenhouse-like effect on the planet: they help to trap heat in the Earth's atmosphere and warm the planet. Ex. 800 at 7. They are also well-mixed gases, meaning that once they are emitted they mix into the ambient air and spread worldwide. Ex. 802 at 13. The vast majority of climate scientists believe that anthropogenic greenhouse gas emissions have increased the greenhouse effect, resulting in increased average global temperatures. Ex. 102 sched. 3 at 3. As Dr. Abraham and others reported in 2014:

> 1) [T]here is near unanimity of consensus on the basic tenets of AGW [(anthropogenic global warming)], [and] 2) the expertise of the scientists who agree with AGW is greater than of those that dissent. This agreement intensifies with the scientists' increasing expertise in climatology.

Ex. 102 sched. 3 at 3.

Carbon dioxide affects several systems of the Earth's climate including some layers of the atmosphere, oceans, forests, glaciers, and sea ice. Ex. 800 at 6. These systems are complicated in and of themselves, and also interact with one another. *See* ex. 801 at 31-32 (discussing mechanisms of climate change). The level of warming, therefore, partly depends

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upon these system interactions, or feedback mechanisms. *Id.* The extent to which increased

levels of carbon dioxide (and other greenhouse gases) warm the planet is referred to as

equilibrium climate sensitivity ("ECS" or "climate sensitivity"). Ex. 102 at 4. As the term is used

by experts in this proceeding, it refers to the change in the temperature of the Earth that will

result from a doubling of carbon dioxide. *Id.*

Worldwide, the international panel on climate change ("IPCC") is "the leading expert

body on assessing climate change[.]" Ex. 102 sched. 3 at 4; *accord* ex. 405 Foreword at v. The

IPCC reviews, summarizes, and synthesizes scientific literature on climate change in its periodic

assessment reports. Ex. 103 at 2; ex. 405 Foreword at v. It was established by the United Nations

Environment Programme and the World Meteorologists Organization in 1988. Ex. 405 Foreword

at v.

According to the IPCC "[w]arming of the climate system is unequivocal, and since the

1950s, many of the observed changes are unprecedented over decades to millenia." *Id* at 4. It is

"virtually certain that the upper ocean has warmed" in the last 40 years, *Id.* at 8, and "the rate of

sea level rise since the mid-19th century has been larger than the mean rate during the previous

two millenia." *Id.* at 11. The IPCC reports that atmospheric concentrations of greenhouse gases

have increased to levels unseen in the last 800,000 years, noting that the increase in CO_2

concentrations is "primarily from fossil fuel emissions and secondarily from net land use change

emissions." *Id.* The Earth's oceans have absorbed approximately 30 percent of anthropogenic

CO_2, causing ocean acidification. *Id.*

The External Costs Of Greenhouse Gas Emissions -- The "Social Cost Of Carbon."

The emission of CO_2 and other greenhouse gases into the atmosphere is changing the

climate, temperature, oceans, and other Earth systems and is predicted to have adverse impacts

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on humans and the environment. Ex. 100 at 3. Adverse impacts are expected to result, for

example, from sea-level rise displacing populations living in low-lying areas, increased severity

and length of heat waves with impact impacting human health and crop production, changes in

precipitation affecting agriculture, water quality and water availability, and storm severity and

frequency, among other effects. *Id.* These impacts levy costs on society. *Id.* at 4.

The "social cost of carbon" ("SCC") estimates the cost that continued CO_2 emissions will

have due to the adverse impacts that result from those emissions. Specifically, the SCC is the

"present value of damage measured in dollar terms associated with the emission of a unit [,

generally one metric ton,] of CO_2 to the atmosphere." *Id.* The SCC value depends on several

factors, including the existing concentration of CO_2, the level of expected additional emissions,

the predicted effect on temperature, and how future costs are discounted, among others. *Id.*

Dr. Stephen Polasky, Fesler-Lampert Professor of Ecological/Environmental Economics

and Regents Professor at the University of Minnesota, is an expert in the economics of

environmental problems. *Id.* sched. 1. Dr. Polasky explained that the purpose of a social cost of

carbon is to improve decision making:

> Rational decision-making should take account of all costs and benefits and not
> just those that are currently valued via the market. Using a value for the SCC in
> utility planning is an essential component in rational economic decision-making
> for electricity generation investments … [because d]amages from climate change
> are not currently incorporated into the price paid for electricity.

Id. at 4-5. According to Dr. Polasky, costs that are borne by society at large rather than the

activity that generates the harm—as with CO_2 emissions—are a "basic form of market failure

and lead to inefficient decisions." *Id.* at 5.

The Interagency Working Group's Development Of The Federal SCC.

Executive Order 12866 directs agencies to account for the benefits and costs of regulatory action. Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Sep. 30, 1993). In 2007, a federal appeals court held one federal agency's failure to account for the benefits of carbon emission reductions arbitrary and capricious. Ctr. For Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172, 1203 (9th Cir. 2007). In 2009, the Office of Management and Budget's ("OMB's") Office of Information and Regulatory Affairs and the Office of Economic Advisers ("OEA") convened a working group that would establish a single standard quantifying costs from carbon dioxide emissions. Ex. 100 sched. 4 at 8. The working group had participants from many federal agencies and offices with pertinent expertise, including the Department of Commerce, the Department of Energy, the Environmental Protection Agency, and the OMB and OEA themselves. *Id.* at 9 tbl.2. In 2010, this Inter-Agency Working Group ("IWG" or "working group") published its results, the Federal SCC. Ex. 100 sched. 2.

The working group based the Federal SCC on prevalent research in the field. It relied upon existing academic literature in both its choices of models and modeling decisions. Ex. 100 sched. 4 at 13. The working group selected three commonly used Integrated Assessment Models ("IAMs") to assess costs. These models "combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework." Ex. 100 sched. 2 at 5. These three models, known by their acronyms DICE, PAGE, and FUND, are the same models that the IPCC also relied upon in its Fourth Assessment Report.

As models, DICE, PAGE, and FUND share a general structure. As explained by the witness for the state agencies, Dr. Michael Hanemann, they are made up of reduced form representations of economic, climate, and impact models. Ex. 800 at 30. Therefore, the models are able to combine explicit assumptions of how economic activity drives emissions, how these

emissions contribute to climate change, and how emissions impacts can be valued. *Id.* at 24.

Numeric computations assess a series of causes and effects over a given period of time. *Id.* at 25

tbl. 1, 26. Each step in the model produces an outcome in the form of a trajectory (e.g. average

annual Gross Domestic Product, average annual GHG emissions), which subsequently informs

the next step. *Id.* at 26. The final step in each model is the damage function, the output of which

identifies economic costs associated with climate change. *Id.* at 27.

Although they share a similar framework, DICE, PAGE, and FUND differ enough that

adjustments were needed to ensure outputs across these models could be compared. The IWG

identified three major parameters—sensitivity, emissions and socio-economic projections, and

discount rate—that it harmonized across the three models.

For climate sensitivity, the working group tailored a probability distribution to the

IPCC's Fourth Assessment Report range. Ex. 100 sched. 2 at 12-15; ex. 102 at 4. After

considering four different distributions, the IWG selected the distribution from Roe and Baker

because of general agreement with its theoretical underpinnings and because it most closely

reflects the judgments of the IPCC. Ex. 100 sched. 2 at 13-14. The distribution is calibrated to

have a central (median) value of 3°C with two-thirds probability that the ECS lie between 2°C

and 4.5°C and zero probability that it is less than 0°C or greater than 10°C. *Id.* at 13.

For socioeconomic and emissions projections, the IWG selected five scenarios from the

Stanford Economic Modeling Forum exercise EMF-22. *Id.* at 15-16. Four scenarios represent

futures in which CO_2 emissions continue unabated for many years, while the fifth assumes

successful efforts to limit carbon dioxide levels in the atmosphere to 550 ppm. *Id.*

The IWG also applied annual discount rates to the cost models. As Dr. Polasky

explained, economists use discount rates "to aggregate damages that occur at different times into

a single measure of the 'present value' of damages." Ex. 100 at 10. The IWG, after reviewing the literature on cost of carbon discounting, selected three discount rates: 2.5 percent, 3 percent, and 5 percent. *Id.* at 11.

Between 10,000 values for climate sensitivity and the five emission and socio-economic scenarios, the IWG produced 150,000 model runs at each discount rate, or 450,000 estimates total. Ex. 100 sched. 3 at 13. The IWG averaged the 150,000 results for each discount rate to produce three summary values for the SCC. *Id.* Finding that the models incompletely account for catastrophic damages, the IWG also reported the 95th percentile value at a 3 percent discount rate—a higher-damage scenario. Ex. 100 at 16. In 2013, the IWG updated the Federal SCC by running updated versions of all three models under the same parameters it used the first time. Ex. 100 sched. 3 at 3. The IWG has provided a schedule of values for the SCC by year, in 2007 dollars. For 2015, the Federal SCC summary values are $56 (2.5 percent discount), $36 (3 percent discount), $11 (5 percent discount), and $105 (3 percent discount, 95th percentile). Ex. 101 at 2.

STATEMENT OF THE ISSUE

The Commission has asked the parties to address and the Administrative Law Judges to make a recommendation on the following question:

> Whether the Federal Social Cost of Carbon is reasonable and the best available measure to determine the environmental cost of CO_2 under Minn. Stat. §216B.2422 and, if not, what measure is better supported by the evidence.

Notice and Order for Hearing, Pub. Util. Comm'n Docket Nos. E-999/CI-00-1636, E-999/CI-14-643/ at 8 (Oct. 15, 2014).

BURDEN OF PROOF

The ALJ's March 27, 2015 Order established that "[a] party or parties proposing that the Commission adopt a new environmental cost value for CO_2, 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 CO_2." 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). The Order further states that "[a] party or parties, opposing a proposed environmental cost value must demonstrate, at a minimum, that the evidence offered in support of the proposed values is insufficient to amount to a preponderance of the evidence." *Id.* at 3. Parties supporting "retention of an existing cost value … must introduce any evidence on which it intends to rely in this docket[.]" *Id.*

Several parties have proposed the Federal SCC, and several parties have offered alternative SCC values. Under the burden of proof adopted by the ALJs in this case, each party bears the burden to demonstrate, by a preponderance of the evidence, that its proposal is both reasonable and the preferable value.

ARGUMENT

I. THE FEDERAL SCC IS A REASONABLE MEASURE OF THE EXTERNAL COSTS OF CARBON.

The Commission has asked whether the IWG's Federal SCC is a reasonable measure of the external cost of carbon. The record evidence shows that the Federal SCC is reasonable. The IWG employed a reasonable process, used reasonable models, and made reasonable assumptions in its development of the Federal SCC. Parties critical of the IWG have failed to demonstrate otherwise.

A. The IWG Used A Reasonable Process To Establish The Federal SCC.

In 2009, OMB and the Council of Economic Advisers drew representatives from several federal agencies with pertinent expertise together to form the Interagency Working Group with

the goal of calculating externality values for greenhouse gas emissions. Ex. 100 sched. 4 at 9 tbl.2. The group worked by consensus and participants expressed satisfaction that the final product included their input. Ex. 100 sched. 4 at 13. The working group relied upon the expertise of participants to review available literature and science, discuss key inputs and assumptions, and consider public comments. *Id.* at 17; ex. 800 at 45. As the IWG expressed, "[t]he main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature." Ex. 100 sched. 2 at 3. The IWG's process culminated in its release in 2010 of a set of centralized values averaging model runs for three separate discount rates as well as a single value representing the 95th percentile of the 3 percent discount rate. *Id.*

The IWG updated its Federal SCC in May 2013 to reflect changes made by the developers of the Integrated Assessment Models that underlie calculation of the Federal SCC. Ex. 800 sched. 2. In 2014, the Government Accountability Office, in response to a request from Congress, reviewed the process employed by the IWG and issued a detailed report. Ex. 100 sched. 4. In addition, in November 2013, the Office of Management and Budget published notice of a comment period on the IWG's development of the Federal SCC. In July 2015, the IWG issued a Response to Comments that further explains the decisions it made in developing the Federal SCC and responds to various critiques and questions raised in comments received. Ex. 101 sched. 1.

Drs. Polasky and Hanemann reviewed the IWG's process and concluded that it was a reasonable approach to the task. Ex. 100 at 24; *see* ex. 800 at 64-69 (finding each of the IWG's decisions reasonable and appropriate). As Dr. Polasky expressed, the group "used a transparent

process to make it easy to understand what they did and why." Ex. 100 at 24. The IWG developed the social cost of carbon in a reasonable manner.

B.   It Was Reasonable For The IWG To Use The DICE, PAGE, And FUND Models To Calculate The Federal SCC.

The IWG's decision to use the three most-cited and accepted Integrated Assessment Models in the academic literature was reasonable and has not been seriously contested in this proceeding. Dr. Polasky stated that the IWG selected "the three most prominent and commonly cited" models to perform its analysis. Ex. 100 at 6. Dr. Hanemann testified that the "three IAMs used by the IWG are the three main such models in the literature" and described the pedigree of each. Ex. 800 at 31-33. The IPCC relies on these models in their reports. *Id.*

All of the other parties offering alternatives to the Federal SCC used one or more of these models to develop their proposals. The Minnesota Large Industrial Group, Ottertail Power, Minnesota Power and Great River Energy, for example, sponsored an alternative value from Dr. Anne Smith. Dr. Smith's proposal is based on runs of the models using different assumptions. Ex. 300 sched. 2. Likewise, Xcel Energy staff member Nick Martin developed a range of values that Xcel has submitted as its alternative to the Federal SCC. Mr. Martin's analysis is based wholly on outputs from the same three models used by the IWG. Ex. 600. Peabody Energy sponsored testimony of Dr. Mendelsohn, who proposed values based on his run of the DICE model, and Dr. Tol, who proposed an estimate based on FUND. Exs. 214, 236. The only witness who offered an alternative that was not based on one of these models is Peabody's witness Dr. Bezdek. Ex. 233 at 48 (recommending that the Commission retain the existing values, or adopt values of between $0.20 to $2.00 per ton or lower). Several witnesses responding to Dr. Bezdek showed that his opinions were far outside the mainstream, that his research lacked rigor, that he

misrepresented the research findings and conclusions of others, and that he was not a credible expert source in many of the topics on which he opined. Ex. 101 at 52-55; ex.102 at 21; ex. 105 at 21-22; ex. 107 at 11-14; ex. 801 at 6-11; ex. 803 at 2-7, 24-28; ex. 804 at 3-13, 17-19.

The preponderance of the evidence shows that the IWG's selection of the three models DICE, PAGE and FUND, to use in developing the Federal SCC was reasonable.

C. Despite Criticisms Of The Parties Opposed To Adoption Of The IWG's Federal SCC, The Preponderance Of The Evidence Shows That The IWG's SCC Is Reasonable.

The parties opposed to adoption of the Federal SCC sponsored witnesses critical of decisions made by the IWG in its use of the models and critical of the assumptions underlying some of the models. These witnesses have failed, however, to show that the assumptions and choices made by the IWG render the Federal SCC unreasonable.

1. It was reasonable for the IWG to standardize certain inputs across the three models.

As described by Dr. Hanemann, the essence of what the IWG did was to run the three models side by side and then average the results. Ex. 800 at 46. In order for that to work, the IWG had to harmonize certain parameters within the models. Those included the equilibrium climate sensitivity, socio-economic and emissions trajectories, and discount rates. Ex. 100 at 8; ex. 800 at 47. All of the remaining parameters of the models were left unchanged, including the damage function that relates temperature change to monetary damages. *Id.*

It was reasonable for the IWG to decide to harmonize the models. In fact, Dr. Hanemann testified that in his opinion "it would have been unreasonable if the IWG had *not* done this." Ex. 802 at 30. According to Dr. Hanemann, the conventional practice when doing comparisons between and among models is to standardize the external model inputs such as this. *Id.* Dr.

Polasky acknowledged that there is a downside to standardizing these parameters because some internal consistency in each model is lost. Ex. 104 at 21-22. However, Dr. Polasky noted that the IWG was fully transparent about its assumptions, and he concluded that the IWG "made a reasonable decision considering the tradeoffs." Ex. 104 at 22.

2.   The equilibrium climate sensitivity used by the IWG was reasonable.

Equilibrium climate sensitivity is an important input into the models because it establishes the relationship between emissions and temperature change—how much the temperature will increase as a result of increased CO_2 concentrations impacts the damage costs of emissions. The exact relationship between concentrations and temperature is unknown and "likely to remain unknown for the foreseeable future" because it involves complicated feedback loops, the strength of which are not currently measurable. Ex. 801 at 31-32; ex. 600 at 39 (both quoting Robert S. Pindyck, The Use and Misuse of Models for Climate Policy 1-2 (Nat'l Bureau of Econ. Research, Working Paper no. 21,097, 2015)).

To account for uncertainty in this important parameter, the IWG used a probability distribution of ECS values calibrated to the IPCC's consensus statement in the Fourth Assessment. Ex. 101 sched. 1 at 11. According to the IWG, a "valid representation of uncertainty regarding climate sensitivity should be obtained from a synthesis exercise such as that done by the IPCC that considers the full range of relevant studies." *Id.* at 12. This reasonably accounts for the uncertainty in the parameter without giving undue weight to possible but unlikely sensitivity values. It also relies upon the most authoritative source on climate change, the IPCC. The IPCC has updated sensitivity in its latest assessment, released after the IWG's most recent update of the Federal SCC, and the working group may "updat[e] the ECS distribution in future revisions to the SCC estimates" accordingly. Ex. 101 sched. 1 at 12. Dr. Polasky agreed with the IWG's

approach, noting that a distribution of values allows for consideration of many possible future effects of CO_2 emissions and that the distribution can be updated as new information is acquired (as the IWG has committed to do). Ex. 101 at 44.

Peabody witnesses Bezdek, Lindzen, Happer and Spencer criticize the ECS and, more generally, the established relationship between greenhouse gas emissions and temperature increases. They assert that the actual ECS is lower than the range used by the IWG and that temperature readings show a "hiatus" demonstrating that the model calculations over-estimate warming. Their arguments are all meritless and thoroughly refuted by other experts.

First, as explained above, it is important to remember that the IWG used a distribution of values, not a single value, for the ECS in its modeling. Therefore, the low ECS values that the Peabody witnesses promote *are included* in the IWG's federal SCC as some among many of the possible climate sensitivity values. That is the appropriate way to deal with uncertainty.

Second, the best available evidence supports the relationship between CO_2 concentration and temperature that is reflected in the model runs done by the IWG. Peabody witnesses Spencer, Lindzen, and Happer rely on estimates of sensitivity based on the 20th Century record, only one basis for estimating sensitivity. Paleo-climate records and model simulations suggest sensitivity closer to the high end of the IPCC's range. Ex. 103 at 5. Dr. Spencer created a global temperature data set based on readings from satellites, but his analysis of this data set, which concludes that the Earth is experiencing a hiatus in warming, has had a series of errors. Ex. 103 at 11-12. As Dr. Dessler explained in detail, Spencer and colleagues made errors first in correcting for changes in satellites' orbits, and later, in correcting for temperature differences between night and day, with both errors decreasing temperature changes. *Id.* at 8-9. The data also suffers from the challenges of calibrating between the instruments themselves, which orbit only a

few years and fail unexpectedly. *Id.* at 10. As the IWG explained, some legitimate research led

the IPCC to update the low end of its ECS estimate in its Fifth Assessment Report. Ex. 101

sched. 1 at 12. Because the IPCC Fifth Assessment Report came out after the IWG's last updates

to the SCC, it will consider an update to the probability distribution in the future. *Id.*

Third, the Peabody witnesses are not credible. Dr. Dessler, in responding to Dr. Spencer's

assertion about academic literature supporting a lower ECS said: "Both the original claim and the

rebuttal are deeply misleading." Ex. 106 at 4. Dr. Dessler's review of Dr. Lindzen's testimony

led to this conclusion: "This establishes a pattern of Dr. Lindzen misquoting papers." Ex. 106 at

6. With regard to Dr. Happer's support for his claims on the ECS, Dr. Dessler concluded: "While

superficially impressive, a thorough reading reveals anything but support for Dr. Happer's claim.

. . . Dr. Happer has not provided any legitimate evidence to support his claim of low

sensitivity[.]" *Id.* at 8-9. Likewise, Dr. Abraham documented scores of instances where Drs.

Spencer, Lindzen, Happer and Bezdek misinterpret or misrepresent the science on climate

change. Ex. 102 at 5-26. He concluded that the "information these witnesses rely upon is

substandard for scientific discussion." *Id.* at 27. These conclusions are shared and reinforced by

Dr. Gurney whose testimony documents the Peabody witnesses' use of selective citation and

other flawed methods of argument support their claims. Ex. 804 at 1-12.

The preponderance of the evidence demonstrates that it was reasonable for the IWG to

rely on the calibrated Roe and Baker distributions of ECS values

3. The socio-economic and emissions scenarios used by the IWG were reasonable.

The selection of future socio-economic and emissions scenarios necessarily involves

predicting the future and, therefore, a level of uncertainty. Although the models respond slightly

differently to inputs of future emissions and GDP, these factors affect results from all three. Ex. 100 sched. 2 at 27; ex. 100 at 9. As Dr. Polasky explained, "emissions determine the atmospheric concentration of CO_2, which in turn determines the rise in global mean temperature and the amount of damage from additional emissions of CO_2." Ex. 100 at 9. To account for uncertainty in predicting future economic and technological states, once again the working group relied on an authoritative source and multiple values. The IWG selected five scenarios modeled by Stanford Energy Modeling Forum exercise EMF-22 and extended predictions to 2300. Ex. 100 sched. 2 at 15. As the IWG described, "[a] key advantage of relying on these data is that GDP, population, and emission trajectories are internally consistent[.]" *Id.* at 15. The IWG selected trajectories that span a range of plausible future scenarios, in which CO_2 concentrations are stabilized at between 612 and 889 ppm in 2100. In addition, the IWG included one scenario in which worldwide action to mitigate emissions is undertaken and CO_2 concentrations are stabilized at 550 ppm. *Id.* at 15-16.

The scenarios chosen by the IWG are from a source that is "recent, peer-reviewed, published, and publicly available." *Id.* at 15. Moreover, the IWG, as with other important parameters, selected multiple values to include in its analysis. These decisions respond to uncertainty and produce reasonable results.

Parties opposed to the Federal SCC have suggested that it is not reasonable to assume that emissions will continue to increase, especially in the face of the widespread costs and destruction expected from climate change. In other words, these parties—although promoting a low SCC that would have the effect of encouraging continued increases in emissions—argue that future generations, in the face of grave economic consequences, will certainly somehow reduce

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worldwide emissions and stabilize CO_2 concentrations at a reasonable level. Drs. Polasky and Hanemann noted the irony of this position. Ex. 101 at 14; ex. 801 at 26.

These parties have provided no evidence to support their preferred assumption of large future reductions in CO_2 emissions. In fact, as Dr. Polasky pointed out, "we are not currently on an optimal path with regard to emissions and there is no guarantee that we will be on an optimal path in the future . . . [and t]o assume that [coordinated global policies to reduce emissions] will be in place any time soon . . . seems highly unrealistic." Ex. 101 at 46. In addition, there is a significant time lag between the emission of CO_2 and the temperature related effects of those emissions, meaning that decision-makers may be slow to act. Ex. 801 at 26. And, as Dr. Hanemann notes, significant emission reductions will require worldwide collective action, a task "fraught with problems." *Id.*

In any case, the IWG *did* include a future scenario in which significant emission reductions are achieved. This choice was reasonable given what we know today and was based on a preponderance of evidence, rather than an optimistic, albeit ironic, hope for international cooperation and resolution.

4.   The discount rates used by the IWG were reasonable.

The IWG's decision to run the models at three discount rates and report three different SCC estimates was reasonable. Although this parameter is not uncertain per se, the IWG notes discounting "raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law." Ex. 100 sched. 2 at 17. As Dr. Polasky explained, "[b]ecause climate change impacts go so far into the future, what one assumes about the discount rate matters hugely." Ex. 100 at 11. There are generally two main approaches to discounting—one that is focused on actual market behavior and the long-term market rate of return on capital, and one

that involves value judgments about the weight that should be given to future generations'

welfare versus the welfare of the current generation. Ex. 100 at 11-12; *Id.* sched. 2 at 17-19.

When used together, the working group's chosen discount rates satisfy both parameters. Ex. 100

sched. 2 at 23. The working group's final SCC presents the values at different discount rates

separately "[b]ecause the literature shows that the SCC is quite sensitive to assumptions about

the discount rate, and because no consensus exists on the appropriate rate to use in an

intergenerational context[.]" *Id.* at 25. The IWG reasonably assessed controversy in the literature

and the final SCC does not obscure this parameter's impact on costs.

Several witnesses argued that the IWG should have included an SCC value at a 7 percent

discount rate, relying primarily on the OMB Circular A-4 Guidance document. *See, e.g.,* Ex.

236; ex. 217; ex. 228. Dr. Polasky explained why the IWG's decision to exclude the 7 percent

rate in this context was reasonable:

> First, Dr. Tol himself in his meta-analysis found that only two papers used a
> discount rate above 5 percent while 10 studies used a discount rate below 3
> percent. A 7 percent discount rate is outside the range of discount rates used by
> researcher studying climate change. Second, OMB was an active participant in the
> IWG process . . . [and] agreed on using discount rates of 2.5 percent, 3 percent,
> and 5 percent and not using 7 percent. Third, Circular A-4 itself states that the
> discount rates are suggestions 'designed to assist analysts' and offer guidance but
> that it does not define or require a particular approach. OMB has stated there are
> two conditions for setting lower rates than 3 percent and 7 percent: i) long time
> frames that give rise to ethical considerations, and ii) considerable uncertainty
> about future conditions. Both of these conditions hold for climate change.

Ex 104 at 8-9. The evidence supports the IWG's use of 2.5 percent, 3 percent, and 5 percent

discount rates to establish an externality value for a pollutant which, while emitted today, will

have consequences for many generations well into the future.

5. **The model time horizon used by the IWG was reasonable.**

MLIG, Peabody, and Xcel Energy offered testimony critical of modeling the costs of carbon over a very long period of time. *See* Ex. 300 at 22 (Dr. Smith asserting predictions over such a time horizon are too speculative to be useful); Ex. 601 at 44 (Mr. Martin noting that the further out in time, the more disconnected the models become to empirical bases); Ex. 235 at 58-60 (Dr. Bezdek asserting that forecasting to 2300 is like creating "science fiction") These parties criticize the Federal SCC because its model horizon, which extends to 2300, must incorporate too much uncertainty.

The IWG's response to comments directly addressed this issue: "[B]ecause of the long atmospheric lifetime of CO_2, using too short a time horizon could miss a significant fraction of damages under certain assumptions about the growth of marginal damages." Ex. 101 sched. 1 at 29; *accord* ex. 100 sched. 2 at 25. CO_2 remains in the atmosphere for hundreds of years, and negative effects likely outlast the gas itself. Ex. 101 at 15. When assessing the damages CO_2 causes, the IWG reasonably let the nature of the gas guide its model horizon. Witnesses promoting the Federal SCC, and the IWG itself, acknowledge that there is uncertainty inherent in making future predictions, but reject the alternative, which is to ignore likely but uncertain damages altogether. *See* Ex. 101 at 15. As Dr. Polasky noted, "[i]t is also not valid to conclude that the proper response to large uncertainty is to just ignore it." Ex. 101 at 6. A shorter model horizon, as Dr. Smith applied, effectively assumes that damages past that horizon are zero. Ex. 101 at 20. The IWG's model horizon reasonably incorporates likely future damages from present emissions of CO_2.

6. The damage functions in the models are conservative and the IWG's use of these damage functions was reasonable.

The IWG did not alter the damage functions built into the three models it used to calculate the Federal SCC. This decision means that the damages calculated by the models are conservative. The models used by the IWG place minimal weight on catastrophic changes and incompletely account for several processes that are difficult to quantitatively assess, including ocean acidification, species loss, increased precipitation, and extreme weather. Ex. 100 at 19-20, 23; ex. 801 at 55. Furthermore, the models assess Gross Domestic Product effects as contemporaneous rather than continuing, i.e., the damage functions do not assess the damages' impacts on growth *rate*. Ex. 100 at 20; ex. 801 at 55-56. Dr. Hanemann also points out that the models are likely to underestimate damages specifically because of the literature they draw from. Ex. 801 at 48. According to a study by the Electric Power Research Institute, DICE and FUND in particular favor studies before 2002, while PAGE favors studies before 2010. *Id.* at 47. Newer studies tend to find higher damages, so these models' reliance on older studies would cause them to underestimate damages. *Id.* at 48. For these reasons, it is far likelier that the models underestimate than overestimate damages. Dr. Polasky notes: "The position not to change the damage functions reflects the IWG's desire to not want to alter the original models, but this decision is conservative and lowers the estimate of the SCC." Ex. 100 at 19.

Parties opposed to the Federal SCC argued that the damage functions overstate the likely damage resulting for climate change, asserting that the models do not account for the benefits of CO_2 emissions and temperature increases, that the damage functions lack sufficient empirical basis, and that the models do not specifically track dose of CO_2 to economic response. These arguments are incorrect and do not establish that the IWG's choice with regard to damage functions was unreasonable.

a. Assertions regarding the benefits of CO₂ fertilization and warming are inaccurate.

Peabody witnesses Bezdek, Happer, Lindzen, and Mendelsohn argue incorrectly that the models inadequately account for the benefits of CO_2 emissions and increased temperature. These witnesses assert that plant life worldwide already flourishes due to current increased levels of CO_2, and that even greater increases will improve agricultural productivity, especially in cooler areas like Minnesota. Ex. 228 at 11, 16-17(Bezdek); ex. 200 at 10-11 (Happer); ex. 209 at 16 (Lindzen); ex. 216 at 12-14 (Mendelsohn). The models do account for potential benefits to agriculture from increased CO_2 concentrations, but those benefits are outweighed by other costs. Ex. 101, at 54-55; *see also* Ex. 801, at 4. The fertilization benefit is not as simple as Peabody's witnesses assume. Under controlled or laboratory conditions, CO_2 does fertilize plants. Ex. 101 at 53; ex. 803 at 19. But increases in atmospheric CO_2 affect other aspects of plants' and crops' real-world habitats. Ex. 101 at 53; ex. 107 at 4; ex. 801 at 12; ex. 803 at 20. As Dr. Gurney testified, the IPCC has evaluated climate impacts on agriculture and found a net negative impact. Ex. 803 at 21. As regards effects of CO_2 and warming on Minnesota plant life in particular, after research into this area, Dr. Reich has concluded that "negative effects [will] likely [ ] outweigh positive effects in the near-term and [ ] the aggregate impact [will become] increasingly negative [ ] further into the future." Ex. 107 at 4. Thus, although Dr. Mendelsohn claims to rely on "two decades of empirical study," Ex. 220, at 7, what he has said about Minnesota forests is wrong, according the Minnesota's leading forest expert.

b. The damage functions are reasonably based upon available empirical evidence.

Witnesses for Peabody and MLIG argued that the models' damage functions have an insufficient evidentiary basis. Dr. Bezdek asserts that the functions—that is, the formulae

themselves—were made up entirely. Ex. 228 sched. 2 at 105-108. Dr. Smith argues that the

damage functions lack an empirical basis beyond 3° C warming. Ex. 300 at 18. Critics have cited

the work of Dr. Robert Pindyck, an economist at MIT. Dr. Hanemann sets out a point for point

response to these criticisms of the damage functions used in the models. *See* Ex. 801 at 38 - 41.

He also notes that Dr. Pindyck, while acknowledging the uncertainties and shortcoming of

current models, actually supports use of the Federal SCC or a higher estimate of damages. Ex.

801 at 36-37.

The damage functions used in the models are based on the best available evidence and the

most informed judgments of the model authors. The fact that there is uncertainty in the functions

does not make the IWG's reliance on these three models unreasonable. As the IWG noted in its

2015 response to comments:

> [D]amage functions are not simply arbitrary representations of the modelers'
> opinions about climate damages. Rather they are based on a review by the
> modelers of the currently available literature on the effects of climate change on
> society. The conclusions that the modelers draw from the literature, and the bases
> for these conclusions are documented, and all three models are continually
> updated as new information becomes available.

Ex. 101 sched. 1 at 8. Although modelers must make some reasonable assumptions, the models

are based on empirical evidence, as is appropriate given the context.

c. The models reasonably simplify the complicated mechanics of climate damages.

Dr. Smith argued that the models' damage functions lack sufficient specificity of dose-

response relationships. Although the models do not assess physical impacts as a direct result of

emissions and then relate these into damages, such an analysis is not possible for the complicated

processes of climate change. No modeler could perform dose-response analysis for carbon. Ex.

801 at 39-40. As Dr. Hanemann explains, analysts use dose-response functions to assess

narrowly defined outcomes calibrated to specific conditions, rather than the large spatial and temporal scales or complicated feedback mechanisms in situations such as climate change. *Id.* Model writers and the IWG reasonably chose other means to assess damages.

7. Despite inherent uncertainty and witness criticisms, the IWG's Federal SCC is reasonable.

The Federal SCC is a reasonable measure of the external costs of carbon. The IWG relied on the best available scientific and economic research on climate change to guide its decisions. It selected not one but all three most commonly used models to assess climate damages, and standardized them so as to compare results. The working group reasonably accounted for uncertainty in the field when it incorporated multiple values for the standardized parameters of sensitivity, socioeconomic and emissions projections, and discount rate. For each of these parameters, it selected reasonable inputs that neither assumed the impossible nor ignored available evidence. It assessed its own efforts, and pulled out the 95th percentile value at a 3 percent discount rate to represent an unlikely but higher risk scenario. The four final summary values represent a synthesis of the best available science in the field and reasonably account for the uncertainty inherent in the task. As Dr. Polasky explained:

> Uncertainty in assessing the social cost of carbon cannot be avoided. It is not valid to say that because uncertainty is large that attempts to deal with it are excessively speculative. It is also not valid to conclude that the proper response to uncertainty is to just ignore it.

Ex. 101 at 6. The IWG did not ignore uncertainty, but addressed it in a reasonable manner.

II. NO PARTY HAS MET ITS BURDEN TO SHOW, BY A PREPONDERANCE OF THE EVIDENCE, THAT AN ALTERNATIVE EXTERNALITY VALUE FOR CO₂ IS PREFERABLE TO THE FEDERAL SCC.

The Commission asked, in addition to whether the IWG's Federal SCC is reasonable, whether it is the "best available" measure. 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.

A. Xcel Has Failed To Show That Its Proposed Value Is Reasonable Or Preferable To The Federal SCC.

Xcel Energy's alternative is not preferable to the Federal SCC because, although it used the IWG's data, Xcel manipulated the model outputs to prioritize the *median* value over the *mean*. As demonstrated in the rebuttal testimony of several experts, including Drs. Polasky, Haneman, and Smith, Xcel's statistical manipulation is unreasonable and unwarranted in this context.

To develop an alternative to the social cost of carbon, Mr. Martin, Xcel's Environmental Policy Manager, engaged the Brattle Group to calculate a range of estimates around the central value, or median, of all outputs from the IWG's model runs. Ex. 600 at 28, 56-60. He selected the 25th percentile values for each of the three discount rates, 2.5 percent, 3 percent, and 5 percent, and then averaged these three values to reach the low-end of the range. *Id.* at 56-60. He selected the 75th percentile values at the three discount rates, and averaged those values to reach the high-end of the range. *Id.*

Xcel's proposed range is less useful than the Federal SCC and unreasonable because (1) the mean better represents the IWG's data than the median; (2) the choice of end points was arbitrary and subjective; and (3) averaging across discount rates is inappropriate.

First, as Dr. Polasky pointed out in his rebuttal testimony, the mean is a more appropriate tool for the Social Cost of Carbon data. Ex. 101 at 36-37. The IWG chose to represent the distribution of data from model runs using the mean and not the median. As the IWG explained in response to comments:

> the median will often give a more 'typical' outcome, while the mean will give full weight to the tails of the distribution. . . . In the climate change context, sound decision-making requires consideration . . . of less likely outcomes that could have very large (or small, or even negative) damages (the tails of the distribution).

Ex. 101 at 37, *quoting* schedule 1 at 26. In other words, the median is not useful to assess climate damage scenarios because there is no "typical" future amongst many—Minnesota will experience only one future. Cutting out the worst possible damage scenarios would prevent the Commission from preparing for unlikely but more dangerous climate outcomes. Ex. 101 at 37. Unlike a median, or Xcel's range that prioritizes the median, "[t]he mean incorporates information about both the magnitude of damages and the likelihood of these damages[.]" *Id.*

Dr. Polasky analogized this situation to buying insurance—decision-making related to climate change has to account for information about unlikely but catastrophic events. *See id.* at 38-39. According to Dr. Polasky, with climate change, the high damage outcomes are the ones that are of most concern. Martin's approach, based on the median values, ignores the magnitude of damages other than at the midpoint of the probability distribution. In the context of climate change, this is particularly problematic. *Id.* at 37. Dr. Hanemann agreed. Ex. 801 at 69.

Second, Xcel's choice of range is arbitrary and subjective. Martin's only principle in selecting this range was to establish a range whose end points would not point the Commission

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in opposing directions. Ex. 602 at 12-13; *see* ex. 600 at 57 (calling a wider range not practicable). Martin chose the endpoints based on whether a desired result was achieved, rather than attempting to describe the IWG data. *See* ex. 101 at 42. As Dr. Polasky pointed out, "endpoints should not be selected based on whether the desired result is achieved, rather the endpoints should be chosen based on the best way to describe the distribution of outcomes." *Id.* Dr. Smith agreed that the endpoint selection was arbitrary, with "no foundation in statistical theory or decision theory, nor any objective principle[ ]to support the way a narrower range . . . [was] chosen." Ex. 303 at 3. Dr. Mendelsohn also believed Martin's methods were arbitrary. Ex. 217 at 8-9. Dr. William Wecker, another witness for Peabody, further argued that the choice of percentiles to describe the data was undocumented and that Martin did "not identify any specific method by name or citation, or justify its choice in light of scholarship . . . [or] the 'individual situation." Ex. 242 sched. 2 at lines 206-8.

Third, there is general agreement among the experts that averaging across discount rates, which Xcel did to reach a single "low" and "high" value for its range, is inappropriate. The IWG chose to apply multiple discount rates to each model in order to provide those applying the SCC with information from all three discount rates. Averaging data from three separate discount rates prevents the Commission from comparing the SCC at different discount rates and obscures the discount rates' strong effect on the SCC. Ex. 101 at 43. As Dr. Polasky pointed out in his direct testimony, "[b]ecause climate change impacts go so far into the future, what one assumes about the discount rate matters hugely." Ex. 100 at 11. Furthermore, "[a]veraging the results across the three discount rates has no theoretical basis [because] we are not considering the entire range of possible discount rates, nor are we applying any probability distribution to the likelihood of any rate being the 'true' social discount rate." Ex. 101 at 43. In spite of other disagreements, Drs.

Hanemann, Smith, Mendelsohn, and Wecker all echoed this criticism. Ex. 802 at 39; ex. 303 at

3-6; ex. 217 at 9; ex. 242 sched. 2 at lines 338-40. Dr. Wecker also emphasized that reducing

such complicated data will "*suppress* rather than present decision-makers with information." Ex.

242 sched. 2 at lines 190-92. Xcel's averaging data across different discount rates is not

consistent with scientific understanding of discounting.

   As Dr. Polasky and others pointed out, the evidence does not support Xcel's proposed

value range because the company's analysis excludes half of the IWG's assessed outcomes, or

distributions, at each discount rate. Ex. 101 at 41. This exclusion means that there is a 50 percent

chance that damages from climate change will fall outside Xcel's proposed range. *Id.* Martin

argues, to the contrary, that because the range encompasses around 75 percent of Xcel's

consultant's distribution combining all discount rate model runs, it has a 75 percent likelihood of

encompassing damages from climate change. Ex. 602 at 11-12. But this is only true if the 3

percent discount rate distribution is far likelier than either the 2.5 percent or 5 percent discount

rate distributions, because combining data from all three distributions centralizes the 3 percent

discount rate. *Cf.* ex. 101 at 41 (applying arbitrary parameters for analysis of the IWG's discount

rate distributions can mislead).[1] As Dr. Hanemann described, trimming the data in this way is

inappropriate because the smaller and "larger damage estimates that Mr. Martin is characterizing

as outliers . . . are within the accepted distribution." Ex. 801 at 66-68; ex. 802 at 39-40.

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[1] This point stands out strongly when comparing individual discount rate values with the
combined discount rate distribution that Martin used at Martin's chosen percentile end points.
For 2010, the 25th to 75th percentile range for all discount rates combined, $6 to $35.59,
encompasses all of the 25th to 75th percentile range for the 3 percent discount rate, $9.87 to
$34.74. *See* schedule 9, ex. 600, at 5 (chart presenting data). For that same year, in contrast this
range for all discount rates very nearly cuts out the higher half of the 2.5 percent distribution
(median of $32.65), as well as the lower half of the 5 percent distribution (median of $6.03). *See
id.*

Xcel's proposed value for the external cost of carbon dioxide is unreasonable and unsupported by the evidence, despite the company's reliance on the IWG's data sets. Prioritizing the median ahead of the mean is unreasonable for the climate change context, the proposed range was chosen arbitrarily and subjectively, and Xcel distorted the IWG's data by improperly averaging across discount rates. The Federal SCC, as the IWG presented it, remains a better available measure of the external costs of CO_2.

B. **Minnesota Large Industrial Group, Ottertail Power, Minnesota Power, And Great River Energy Have Failed To Show That Their Proposed Values Are Reasonable And Preferable To The Federal SCC.**

1. **Dr. Smith's proposal is not reasonable or preferable to the Federal SCC.**

Great River Energy, Minnesota Power, Otter Tail Power, and the Minnesota Large Industrial Group's primary witness, Dr. Anne E. Smith, recommends the Commission adopt a per-ton CO_2 externality value range from $1.62 to $5.14. Ex. 300 sched. 2 at 47. Dr. Smith reached her recommendation by changing 4 key characteristics of the models used by the IWG and re-running the models. The four major assumptions Dr. Smith changed were: (1) the future emission scenario; (2) the calculation of damages after 2100 and 2140; (3) the discount rates; and (4) the geographic scope of damages calculated. All of Dr. Smith's changes to the models lower the estimated externality value. None of Dr. Smith's changes is justified or preferable to the process used by the IWG.

a. **Dr. Smith's changes to reflect different emission projection scenarios are not reasonable.**

Dr. Smith presents a long and complicated discussion of what she labels "marginal ton" analysis in which she coins terms such as "first ton" and "last ton." Ex. 300 at 20-22; *id.* sched. 2

at 50-64. As Dr. Polasky explains, Dr. Smith's complicated discussion obfuscates what is a simple point: She disagrees with the future emission projections used by the IWG and she therefore changes them. Ex. 101 at 10.

The low-end value of Dr. Smith's proposed externality value range is based on a future emissions scenario in which no CO_2 is emitted after 2020. As Dr. Polasky noted, this is "a completely absurd projection of the future." Ex. 101 at 14. Dr. Hanemann agreed, noting that Dr. Smith's analysis seeks to treat greenhouse gases as a "flow" (i.e., like criteria pollutants) rather than the "stock" pollutant which it is. He described her approach as a "category error." Hrg transcript vol. 2B at 33. Indeed, Dr. Smith herself admitted that a scenario in which emissions cease in 2020 has absolutely no evidentiary support. Hrg transcript vol. 2A at 91.

The high-end value of Dr. Smith's range is based on a future emissions projection that lies midway between zero emissions after 2020 and the emission projection distribution used by the IWG. Hrg transcript vol. 2A at 83 ("I calculated the marginal cost per ton at the halfway point across all of the emissions, starting from no further emissions. . . up to a . . . projection of emissions as encapsulated in the IWG's forecasts."). This is not, however, the "optimal" level of emissions that Dr. Smith alleges is the appropriate baseline on which to estimate external costs. *Compare* ex. 300 Sched. 2 at 63 ("I make no attempt to assess the optimal emissions trajectory that should be the baseline against which optimal [ ] damage[s] should be estimated."), *with id.* 59 ("[T]he appropriate estimate of marginal damages to apply . . . [when modeling the external costs of] CO_2 . . . would be an estimate [based on an optimal] . . . level of emissions[.]").

In contrast to Smith, the IWG used estimates of emissions projections based on population, economic growth, and international climate policies currently in place. Ex. 101 at 11. Dr. Hanemann and Dr. Polasky both agree that "[f]or the time being . . . the IWG emission

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projections best reflect the current understanding of the likely potential trajectories of future emissions." Ex. 802 at 45 (quoting ex. 101 at 12). Dr. Smith unreasonably ignores the available evidence on climate action to establish both ends of her suggested range, either to set emissions at zero after 2020, or to "approximate" a currently unlikely optimal emission rate. The approach to both ends of her suggested range is unreasonable.

b. Dr. Smith's decision to ignore all damages after 2100 and 2140 is not reasonable.

Dr. Smith's second change to the IWG's modeling shortens the model time horizon and fails to assess the full scope of long-lasting carbon pollution. The low-end of Smith's proposed range is based on damage calculations only through 2100—all damages that occur after 2100 are completely excluded. Hrg transcript vol. 2A at 89. The high-end estimate excludes damages after 2140. *Id.* at 88. Dr. Smith admits that each of the models show damages after 2100 and 2140 but justifies her decision to exclude those damage costs as too speculative. Hrg. transcript vol. 2A at 79. Smith's approach to uncertainty of future damages is unreasonable.

Dr. Polasky acknowledges Dr. Smith's point that calculating damages that will occur over 100 years from today involves uncertainty, but rejects her decision to simply ignore such damages: "Smith correctly identifies an area of uncertainty, predicting damages from CO_2 emissions for hundreds of years, but the proposed solution, namely to assume there will be no impacts far into the future, has no bearing in reality." Ex. 101 at 16. Dr. Hanemann agreed with Dr. Polasky's statement. Ex. 802 at 45. In fact, Smith's approach unreasonably substitutes a falsely certain number: $0.

Additionally, Dr. Smith's selection of 2100 and 2140 is arbitrary, appearing to be based on a recommendation from an MPCA staff member in proceedings before the Commission in 1997. Ex. 101 at 19. The IWG's time horizon, in contrast, is reasonable given how long CO_2

persists in the atmosphere. As Dr. Polasky explained, assuming an arbitrary end date and

truncating the analysis at 2100 reduces damages significantly, whereas extending the analysis

beyond 2300 would have little impact on the external cost both because there will be little CO_2

emitted today still in the atmosphere and because of discounting of whatever damages do remain.

Ex. 101 at 16. Dr. Smith's decision to exclude all damages after 2100 and 2140 was not

reasonable and her recommended externality values are not preferable to the Federal SCC.

c. Dr. Smith's exclusion of the 2.5 percent discount rate is not reasonable.

Dr. Smith's recommended low-end and high-end externality values are based on 5

percent and 3 percent discount rates respectively—she eliminated the IWG's consideration of a

2.5 percent discount rate. This decision fails to account for many SCC researchers' practices as

well as the uncertainty and ethical considerations of long forecasting. As Dr. Polasky and the

IWG pointed out, many SCC researchers use discount rates lower than 3 percent. Ex. 101 at 22-

23. Smith's focus on the IWG's two higher discount values also ignores many available

economic projections of slowed future growth and the reasonable principle that "longer time

frames [ ] involve[ing] uncertainty about future conditions should have lower discount rates," as

federal agencies recognize. *Id.* at 24.[2] Dr. Hanemann concurred. Ex. 802 at 46. Furthermore, as

OMB guidance suggests:

> Although most people demonstrate time preference in their own consumption
> behavior, it may not be appropriate for *society* to demonstrate a similar preference
> when deciding between the well-being of current and future generations. Future

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[2] Although the agency does not explicitly define how many years a longer time frame entails,
OMB's Office of Information and Regulatory Affairs suggests that market rates are unreliable to
assess inter-generational values. Office of Management and Budget, Office of Information and
Regulatory Affairs, Circular A-4: Regulatory Impact Analysis: A Primer at 12 (Aug. 15, 2011),
available at https://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-
4_regulatory-impact-analysis-a-primer.pdf.

citizens who are affected by such choices cannot take part in making them, and today's society must act with due consideration of their interests.

Ex. 101 at 24 (quoting Office of Management and Budget, Office of Information and Regulatory Affairs, Circular A-4: Regulatory Impact Analysis: A Primer at 11-12 (Aug. 15, 2011), *available at* https://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf). Eliminating the IWG's 2.5 percent discount rate unreasonably ignores much of the field of research on the SCC, as well as the rational ethical and economic principles that favor low discount rates for long-term analysis.

> **d.   Dr. Smith's decision to exclude damages from outside the United States is not reasonable.**

Finally, Dr. Smith's decision to exclude damage costs from outside the United States lacks theoretical and practical justification. There is no real dispute that CO_2 is a global pollutant and therefore "that the emission of CO_2 in Minnesota will lead to damages well outside of Minnesota [and] the U.S." Ex. 101 at 25. That is, the preponderance of the evidence points towards global, rather than domestic, external costs. As Dr. Hanemann described, "[a] molecule of emitted [greenhouse gas] contributes to damages from climate change experienced everywhere around the globe, regardless of where it is emitted." Ex. 800 at 12.

Dr. Smith's decision to exclude non-U.S. damages is also contrary to Commission precedent. Minnesota's current values for CO_2 recognize that CO_2 is a global pollutant and are based on an assessment of worldwide damages. Ex. 801 at 15-16. Specifically, in 1997, the Commission recognized that CO_2 "causes damages globally rather than regionally or locally[.]" Order Establishing Environmental Cost Values, Pub. Util. Comm'n Docket No. E-999/CI-93-583 at 15 (Jan. 3, 1997) (Ex. 306). Limiting the scope of damages assessed "would ignore the vast

majority of the external costs." Ex. 101 at 26; *see also* ex. 300 at 98 ("Restricting the damages to the U.S. reduces the SCC by 81 percent to 84 percent[.]").

As a matter of policy, the Commission's decision is sound. As Dr. Polasky explained, "[i]f every state, province, or other political territory only considered the damages of their own CO_2 emissions within their own political boundaries then there would be virtually no correcting for externalities." Ex. 101 at 26. Such a value would also fail to provide Minnesota with a tool that prepares it for a future in which emitting carbon is not free. *Id.* Assessing only damages within the U.S. is unsupported by the preponderance of the evidence on greenhouse gases, and resulting values are unreasonable.

In sum, Dr. Smith's recommended externality value range from $1.62 to $5.14 per ton CO_2 is unreasonable and not preferable to the IWG's Federal SCC. It appears that Dr. Smith approached her task with the objective of lowering the SCC. As Dr. Polasky noted, Dr. Smith's testimony "attempts to highlight only those possible areas a plausible sounding argument could be made that would lower the SCC." Ex. 101 at 30. Dr. Hanemann agreed with Dr. Polasky's assessment that her approach is "not credible." Ex. 802 at 46. Furthermore, as Dr. Polasky explains:

> Given that the Smith testimony in this hearing is arguing against a modest valuation of the SCC intended to limit future emissions, it is particularly incongruent that [she] argues that there will be substantially larger emission reductions of CO_2 than the IWG projections indicate.

Ex. 101 at 14. MLIG, Ottertail Power, Minnesota Power, and Great River Energy have failed to establish by a preponderance of the evidence that Dr. Smith's proposed values are reasonable or preferable to the Federal SCC.

2. Dr. Gayer's proposal is not reasonable or preferable to the federal SCC.

Similar to Dr. Smith, Dr. Ted Gayer on behalf of the Minnesota Large Industrial Group offered SCC values based on constricting the geographic scope of damages. Dr. Gayer reduced the federal SCC values by a percentage corresponding to the U.S.'s share of global GDP, resulting in $2.53, $7.36, $11.73, and $20.47. Ex. 400 app. 2 at 15-16. He also restricted these values further, corresponding to Minnesota's share of global GDP, suggesting a high-end estimate of $0.37. *Id.* at 17. As explained in response to Dr. Smith's proposal above, "environmental costs, or damages, do not follow political boundaries." Ex. 101 at 27. Dr. Gayer's geographic myopia is as unreasonable as Dr. Smith's.

C. Peabody Energy Has Failed To Show That Its Proposed Alternative Values Are Reasonable And Preferable To The Federal SCC.

Although Peabody submitted testimony from seven witnesses, only three arguably responded to the second part of the Commission's question in this proceeding: "what measure is better supported [than the Federal SCC] by the available evidence?" Notice and Order for Hearing, Pub. Util. Comm'n Docket Nos. E-999/CI-00-1636, E-999/CI-14-643/ at 8 (Oct. 15, 2014). The three values proposed by Drs. Mendelsohn, Tol, and Bezdek are not reasonable or preferable to the Federal SCC.

1. Dr. Mendelsohn's suggested range is not reasonable or preferable to the federal SCC.

Dr. Mendelsohn made several contradictory recommendations. His own modeling supports a per ton CO_2 externality value of $4.00 to $6.00 based on calculations he performed using the DICE model, one of the three models used by the IWG. Ex. 214 at 2. He concludes that "the original estimate of the damage of a ton of CO_2 made by the PUC of $5/ton remains a

reasonable value[.]" Ex. 220 at 33. But also states that "a reasonable and 'the best available measure' for the SCC is between $0.30 and $2.00/ton." *Id.* at 34. Mendelsohn's proposed ranges are unreasonable and unsupported by a preponderance of the evidence because they are conditioned on unjustified assumptions about future emissions and the "beneficial" effects of temperature increases. Additionally, although the Equilibrium Climate Sensitivity value Dr. Mendelsohn chose in his primary testimony and a declining discount rate are among reasonable model choices, the IWG modeled multiple possibilities for both parameters, which provides a more reasonable SCC. Even if Dr. Mendelsohn had made more reasonable assumptions, it is difficult to imagine that one model run by one individual could be preferable to the considerable effort several federal agencies have undertaken over many years to aggregate the best scientific and modeling information available in developing the Federal SCC.

a. Dr. Mendelsohn's decision to model optimal emissions is not supported by evidence.

Dr. Mendelsohn's decision to run DICE using the model's "optimized" emissions projection skews his results and is not well-supported by existing evidence. Without a global effort to achieve optimal emissions, there is no basis for concluding future emissions will be optimal. As Dr. Polasky pointed out, "we are not currently on an optimal path with regard to emissions and there is no guarantee that we will be on an optimal path in the future . . . [and t]o assume that [coordinated global policies to reduce emissions] will be in place any time soon . . . seems highly unrealistic." Ex. 101 at 46. As discussed above regarding Dr. Smith's testimony, a reasonable external cost of carbon would not incorporate counter-factual assumptions. Dr. Mendelsohn's reliance on optimization to model the external costs is not reasonable or preferable to the choice made by the IWG.

b. **Dr. Mendelsohn's assumption that temperature rise between 1.5°C and 2°C above pre-industrial levels will be beneficial is not reasonable.**

Dr. Mendelsohn unreasonably altered the DICE model's damage function to erase significant damages. Dr. Mendelsohn argues that climate change will be beneficial until it surpasses 1.5°C or 2°C above pre-industrial levels, but this is not supported by a preponderance of the evidence. Mendelsohn claims that global ecosystems will, on net, benefit from climate change, especially in northern areas such as Minnesota. Ex. 216 at 12-14. His claims regarding Minnesota's northern forests paint an incomplete picture, as Dr. Reich pointed out, "because negative effects [will] likely [ ] outweigh positive effects in the near-term and [ ] the aggregate impact [will become] increasingly negative [ ] further into the future." Ex. 107 at 4. As Dr. Reich discusses, different tree species respond differently to temperature increases alone, with a few important species for northern forests growing more poorly under warmer temperatures, and mainly southern Minnesota trees benefitting from increased temperatures only if they can spread and grow quickly enough to keep up with changes. *Id.* at 5. Other climate impacts complicate the picture, such as decreased soil water availability and higher evaporation rates. *Id* at 6. Climate change will also increase invasive plant and animal species, harmful insect populations, diseases, and forest fires. *Id.* at 8-9. Overall, the picture for climate change in Minnesota is much more complicated than Dr. Mendelsohn, an economist, describes. The articles that he relies on are not Minnesota-specific, and "are far from the most recent or relevant publication on the topic." *Id.* at 10.

Further, Dr. Dessler points out that although small global temperature changes may seem insignificant, "temperatures a few hundred years ago were about 1°C cooler than today—a large enough difference that we refer to that period as the Little Ice Age." Ex. 103 at 7. Dr. Hanemann

examined Mendelsohn's argument about global climate benefits and found it similarly wanting. Ex. 801 at 12. Specifically, his sources for finding a net benefit to humans either did not assess benefits for ecosystems or were based on laboratory experiments and the scientists that undertook them recognized "that results in open fields could be different." *Id.*; *see* ex. 101 at 53 (stating that CO_2 fertilization figures based on controlled laboratory conditions are not directly applicable to large-scale agriculture). Dr. Mendelsohn's argument that temperature increases are beneficial to both Minnesota and the world is unsupported by a preponderance of the evidence.

> ### c. Dr. Mendelsohn's use of the DICE model's declining discount rate is not preferable to the IWG discount rates.

Although the DICE model's discount function is reasonable for some purposes, the IWG's multiple discount rates are more reasonable. The IWG ran all models at three commonly used discount rates, and the final SCC presents values for each. Because of "the uncertainty and disagreement regarding the discount rate[,]" this method is more appropriate than a value corresponding to a single (albeit declining) discount rate. Ex. 101 at 50. As Dr. Polasky pointed out with regard to Dr. Smith's proposed value, researchers in this area use discount rates lower than 2.5 percent, 3 percent, and 5 percent in large numbers. *Id.* at 22.

In sum, adopting Dr. Mendelsohn's recommendation would base Minnesota externality values on one report from one researcher using his own assumptions applied to one model. Dr. Polasky noted that other researchers, all of whom benefited from peer review, came to significantly higher results (e.g., $220 per ton; $197 per ton) using the same model but with different assumptions. Ex. 101 at 51. Dr. Polasky explained that the fact that different applications of the DICE could result in such different values is a function of uncertainty. He concludes: "The IWG's process is preferable to using the values from one researcher because it

takes into account the wide variability among the different models and different assumptions that

go into the models." *Id.* at 52.

2.   The externality values offered by Drs. Tol and Bezdek are not reasonable or preferable to the federal SCC.

Dr. Tol purported to run the FUND model "under the same parameters" as Professor

Mendelsohn ran the DICE model. Ex. 238 at 8. Dr. Tol did not explain whether his model runs

modified FUND's damage function to zero out damages before a temperature change of 1.5˚C, a

change of 2˚C, or retained FUND's original damage function.[3] He summarily presented results

for various equilibrium climate sensitivities, and found \$20.05 for a change of 3˚C, \$7.06 for a

change of 2.5˚C, -\$4.05 for a change of 2˚C, -\$12.06 for a change of 1.5˚C, and -\$17.97 for a

change of 1˚C. *Id.* at 9 tbl. 3. Because these figures rely upon Mendelsohn's assumptions in

whole or in part, they fail for the same reasons that Mendelsohn's recommended values fail.

Bezdek, in rebuttal testimony, recommended the Commission retain the current values

for CO_2 external costs, or adopt values "in the range of about \$0.20 to \$2.00 per ton, or lower."

Ex. 233 at 48. In contrast, his own expert report submitted as direct testimony "finds that the

benefits exceed the costs by orders of magnitude." Ex. 230 at 9. To reach this conclusion the

report itself cherry picks data and misapplies laboratory experiments to large-scale agriculture.

Ex. 102 at 15, 27; ex. 101 at 53. In spite of these deficiencies, Bezdek's own testimony

contradicts his recommendation of any positive value, and also fails to introduce evidence into

the record for this proceeding that supports retaining the Commission's current values for CO_2.

His recommendations are unsupported by the preponderance of the evidence.

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[3] As explored by the federal Inter-Agency Working Group, FUND's original damage function
does produce very small and negative values for the SCC at an ECS of 3˚C and low temperature
changes. Ex. 100 sched. 2 at 10 fig. 1B (representing low value curve as a function of
temperature change).

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CONCLUSION

Because the preponderance of the evidence shows that the IWG's Federal SCC is

reasonable and the best available measure of external costs for CO_2, the ALJs should recommend

adoption of the Federal SCC by the Commission.

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

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

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

STATE OF MINNESOTA   )
)ss.
COUNTY OF RAMSEY   )

Erin Mittag being duly sworn, says that on the 24th day of November, 2015 she served via electronic service the following:

- Initial Post-Hearing Brief filed on behalf of Clean Energy Organizations

on the following persons, in this action, by filing through e-dockets:
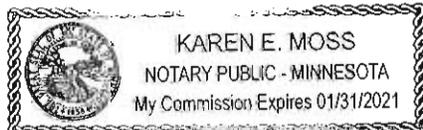
Attached Service List

Erin Mittag

Subscribed and sworn to before me
this 24th day of November, 2015

Karen Moss

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