BEFORE THE MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS
600 North Robert Street
St. Paul, Minnesota 55101

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION
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In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minn. Stat. § 216B.2422, Subd. 3	PUC Docket No. E-999/CI-14-643 OAH Docket No. 80-2500-31888

INITIAL BRIEF OF PEABODY ENERGY CORPORATION

Carbon Dioxide

November 24, 2015

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

CASES

RULES

STATUTES

OTHER AUTHORITIES

PEABODY ENERGY CORPORATION'S INITIAL BRIEF
ON EXTERNALITY VALUES FOR CARBON DIOXIDE

I. Introduction and Summary

Determining a reasonable and the best available externality value for carbon dioxide requires a thorough analysis of scientific data and economic theory. Any thorough analysis must include all available data and understandings. The "Federal Social Cost of Carbon" ("FSCC") as calculated by the federal Interagency Working Group ("IWG") is neither reasonable nor the best available measure for Minnesota, not only because it was conceived for a completely different purpose than state-level utility resource planning, but also because it is not rooted in current scientific data or appropriate economic principles. The evidence submitted by Peabody Energy Corp. ("Peabody") and other parties supplies a more complete understanding of existing climate science, a clear delineation of economic analysis, and an appropriate methodology to show that the reasonable and best available value is less than the current Commission values. The record shows:

- The evidence does ***not*** support adopting the FSCC.
- A preponderance of the evidence supports a zero (or even negative) value for CO_2.
- If the Commission does not accept a zero value (as the evidence supports), it should (at most) retain its existing externality value for CO_2.
- Under no circumstances should the externality value be increased at all, much less 25 times to the level of the current FSCC.

When the Commission last held a contested case proceeding 20 years ago to determine externality values for carbon dioxide, it adopted "conservative" values based on the acknowledged uncertainty in science and economics concerning future impacts. The Commission rejected higher values promoted by the Minnesota Pollution Control Agency

("MPCA") and others[1], finding the scientific and economic underpinnings of those models to be too speculative. ALJ Allan Klein warned 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. ***Given the current uncertainty regarding the estimation process, overestimating the damages is a distinct possibility***." (Ex. 305, Findings of Fact, Conclusions, Recommendation, and Memorandum, at 17 (Mar. 22, 1996) [hereafter, "1996 ALJ Recommendation"].) And although the Commission set values for carbon dioxide at that time, there was recognition that "any number recommended herein must be recognized as an approximation, which is subject to refinement ***as new and better data become available***."(*Id.* at ¶34 (emphasis added).) Nearly 20 years later, we have new and better data, which shows that scientific support underlying predicted future damages is now even **more *uncertain***. In light of this increasing uncertainty, the Commission should lower the values, not raise them 25 times[2] higher than the current levels by adopting the FSCC.

The increasing uncertainty justifies a zero value at this point, because there is insufficient factual foundation to conclude that any greater value would more accurately reflect the true externality value for carbon dioxide. As ALJ Klein noted, "While using reasonably accurate estimates is better than imputing no values, not all estimates are better than zero. [Overvaluation] may lead to a worse allocation of resources than imputing no value." (Ex. 305, 1996 ALJ Recommendation, at ¶ 34.) This humility impacts the legal standard at stake: **"[a]t some point, the degree of uncertainty associated with a proposed value becomes so great**

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[1] The Minnesota Department of Commerce had also proposed values but the Commission struck the testimony supporting those values from the record. (Ex. 306, 1997 Commission Establishing Order, 25 [hereafter, "1997 Commission Establishing Order"].)

[2] Current range of $0.44 to $4.53 (2014$/ton) to FSCC range of $12.56 to $119.89 (2014$/ton). The July 2015 FSCC range was updated from 2007 dollars using the U.S. Department of Labor Bureau of Labor Statistics' CPI Inflation Calculator (http://data.bls.gov/cgi-bin/cpicalc.pl).

that there is insufficient evidence to meet the preponderance standard, and the value cannot be adopted." (*Id.* at ¶ 31 (emphasis added).)

The Commission must recognize that any externality value for carbon dioxide emissions would be based on predictions that fail to distinguish between the Earth's own natural climate variability and climate changes alleged to be caused by human activity. The models used in this case wholly fail to distinguish between the two. As explained by Dr. Richard Tol, the primary author of the FUND Integrated Assessment Model ("IAM") (one of the three IAMs on which the FSCC is based), "current models **do not disaggregate the effects of human-induced warming and natural variability**" (Ex. 238, Tol Rebuttal Report, 9:187-188 (emphasis added)), and in fact assume "that there is no long term natural climate variability." (Ex. 238, Tol Rebuttal Report, 9:183-185.) But every indication shows that short-term natural variation is at least as large as any anthropogenic contribution. (Ex. 207, Lindzen Direct, 3:25-4:6; Ex. 209, Lindzen Direct, Ex. 2 (Report) at 7:209-225, 8:266-280; *see also* Section III-K below.) It is therefore incumbent on the Commission to avoid overstating the externality values by relying on models (such as those used by the FSCC) that fail to establish, based upon a preponderance of the evidence, the requisite causal link between anthropogenic CO_2 emissions and purported future damages. Because this externality proceeding is about quantifying ***the degree of harm*** attributable to anthropogenic CO_2 emissions ***from utilities***, this "contested proceeding" must disaggregate "the effects of human induced warming and natural variability"; the Commission cannot lump them both together and call it a day. This evidentiary requirement for proof of causation cannot be dismissed as being the tool of a "denier," "skeptic," or "contrarian"; rather, this requirement is inextricable from the preponderance of evidence standard.

Overlooking this insurmountable hurdle, the proponents of higher values have submitted testimony to the Commission urging it to follow the FSCC. Yet all of this testimony is second-hand. None of the proffered witnesses participated in the IWG process, and none has created or even operated an IAM to calculate the social cost of carbon. The proponents' witnesses seek to describe, without any personal or direct knowledge beyond that available in publicly released reports, how the IWG treated IAMs such as the FUND and DICE models. As a consequence, their evidence is entitled to virtually no weight. Their proffer of proof fails to satisfy evidentiary requirements for a contested proceeding.

The only witnesses in this proceeding who have actually calculated values of the social cost of carbon according to peer-reviewed models are Dr. Tol (FUND's creator), Dr. Robert Mendelsohn of Yale, who has extensive experience working with DICE alongside its author, Dr. William Nordhaus (a Yale colleague), and Dr. Anne Smith. Drs. Tol and Mendelsohn have testified with first-hand knowledge that the IWG made fundamental errors in operating the FUND and DICE models. The FSCC proponents ask the Commission to disregard this compelling testimony and rely instead on second-hand hearsay descriptions of how the IWG treated the FUND and DICE models, by witnesses who were not even involved in the IWG process.

The proponents of the FSCC also defend the IWG's reliance on the 2007 Fourth Assessment report ("AR4") of the Intergovernmental Panel on Climate Change ("IPCC").[3] But the subsequent report of the IPCC undermines the FSCC proponents' arguments and instead ***supports a much lower value***. Most importantly, the IPCC's 2013 Fifth Assessment report ("AR5") ***lowered*** the IPCC's predicted range for equilibrium climate sensitivity, or ECS — i.e.,

[3] The Commission has previously found that "IPCC reports are the most authoritative sources available for information on climate change issues." 1997 Commission Order, at 24.

projected temperature increases associated with doubling carbon dioxide emissions concentrations from pre-industrial concentrations — and in light of the increasing uncertainty in the studies of ECS, ***the IPCC abandoned its former attempt to provide a "best estimate" of ECS***.[4]

In 1997, the Commission based its CO_2 externality values ($0.30 - $3.10) on the IPCC's then-"likely" ECS range of 1.5°C to 4.5°C, with a "best estimate" of 2.5°C.[5] Now, in AR5, IPCC still estimates a "likely" range of 1.5°C to 4.5°C. That means that after nearly 20 years of observational data and further research, the IPCC determined in AR5 that the range has not increased (as the FSCC proponents would have the world believe) and further concluded that there is increasing uncertainty in this range. In AR4 in 2007, the IPCC had raised its range to 2°C to 4.5°C with a "best estimate" of 3.0°C. In AR5 in 2013, ***the IPCC conceded that there was no longer support for any best estimate***.

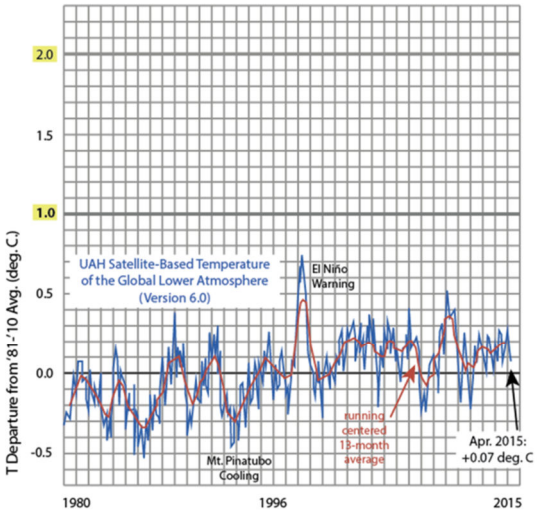
The FSCC is based on the outdated 2007 IPCC projections, not the most recent IPCC estimates. The IWG used 3.0°C as the midpoint for its probability assessment as a key input to the IAMs. This is no longer valid, under AR5. Not only is there now insufficient evidence to support the Commission's past values, much less the FSCC, but the preponderance of the evidence also demonstrates that we know even less than we did in 1997 about the causal pathways between CO_2 emissions and climate change. It is undisputed that the uncertainty regarding the proper ECS value has increased, not decreased. (Ex. 801 (Hanemann Rebuttal Testimony) at 31:11-32:7.) The uncertainty has reached that point that ALJ Klein said is the point at which uncertainty is too great and accordingly requires a "zero" value. (1996 ALJ

[4] This case concerns the estimation and projection of potential future damages resulting from anthropogenic carbon dioxide emissions. Estimating the timing and any resulting damages and benefits that will occur as a result of the temperature change is central to the calculation of the externality value for carbon dioxide.

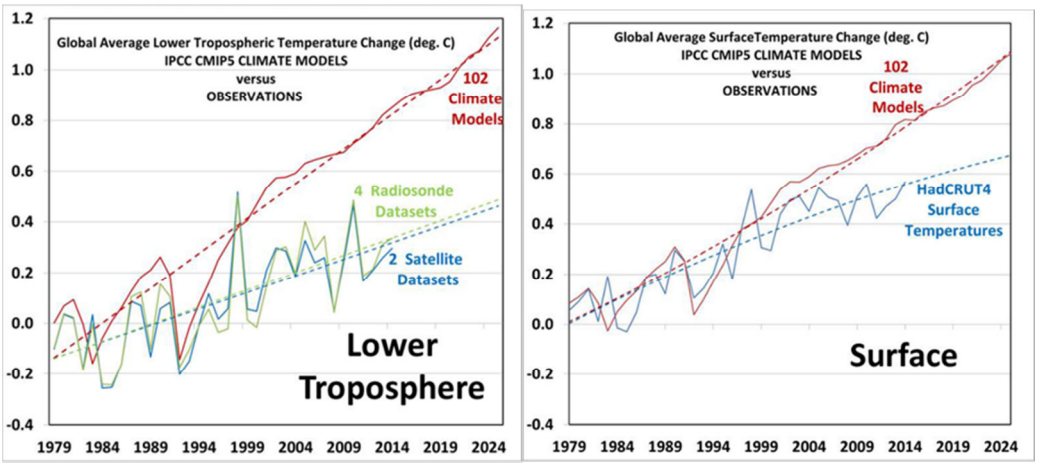
[5] 1996 ALJ Recommendation at ¶ 91.

Recommendation, at ¶ 31) ("[a]t some point, the degree of uncertainty associated with a proposed value becomes so great that there is insufficient evidence to meet the preponderance standard, and the value cannot be adopted.").

AR5's acknowledgment of lower ECS values is supported by the following scientific evidence. First, in the last 35 years, global average temperature has increased less than half of one degree C. Moreover, the rate of warming during this entire period has consistently remained under 1.0 degree C above pre-industrial levels, despite substantial increases in CO_2 levels.



And it is irrefutable (as the FSCC proponents concede) that temperatures have not risen nearly as fast in relation to the increase in carbon dioxide emissions, as had been predicted by the IPCC's collection of models. In other words, while carbon dioxide emissions have increased, the rate of warming has not increased ***to the degree predicted***, suggesting there may not be the kind of causal relationship between CO_2 and warming as originally assumed, or that other phenomena may be offsetting the assumed warming relationship, which scientists have not yet been able to explain:



The climate projection models (on which the FSCC is based) obviously are "running hot," and cannot support the projections of climate sensitivity in AR4 (as the IPCC itself admits in AR5). It follows that if the proponents of the FSCC want to continue to rely on these model projections, rather than actual temperature data, they must prove that the models are right, which requires an explanation of the discrepancy between the projections and actual data. Yet the response of the FSCC proponents is to acknowledge the discrepancy (because they have to, as the IPCC has), and to offer explanatory theories with no accepted scientific support or agreement. Indeed there is no widely accepted explanation for the acknowledged significant discrepancy between the models and actual temperature data. And it is irrefutable (as the FSCC proponents concede) that temperatures have not risen nearly as fast in relation to the increase in carbon dioxide emissions, as had been predicted by climate models.

In reality, a lower value for ECS is not surprising, because the direct "greenhouse" effect of doubling CO_2 is only 1°C. The record evidence shows that in order to reach an ECS value greater than the baseline of 1°C, one must show ***additional*** positive feedback mechanisms such as clouds and water vapor. And it is not enough to vaguely point to clouds and water vapor and assert without foundation that they must be intensifying — in some unspecified way — the effect of CO_2. Despite references by FSCC proponents to "radiative forcing" during this proceeding,

they failed to come forward with a proven, concrete explanation of a positive feedback effect. Indeed, evidence showed that no one has been able to prove large positive feedbacks in the real world, and no peer-reviewed scholarship has validated sufficient positive feedback mechanisms to get to 3 °C. In this proceeding the FSCC proponents have provided no specific evidence or testimony on any identified positive feedbacks, how they work, or how they specifically translate existing CO_2 levels into warming beyond the less than 1 °C above pre-industrial levels that we see today. The feedbacks needed for the IWG's assumed ECS simply have not been shown; the FSCC is therefore based on supposition rather than science.

AR5 includes numerous other key findings that undermine the FSCC:

- Minimal Temperature Increase: In 2007, AR4 predicted temperature increases of 0.2°C per decade.[6] Instead, AR5 acknowledged a hiatus in warming since 1998.[7] Other, unrefuted observational data shows there has been virtually no warming for the last two decades – at a time of rising CO_2 emissions. Even Dr. Dessler (the Clean Energy Organizations' witness) testified that there has been no statistically significant warming since the year 2000. (Dessler, 3A Tr. at 20:14-16.) Yet the temperature models on which the FSCC is based predicted far greater warming by this time. The models have been proven to overstate significantly the relationship between carbon dioxide emissions (which have risen) and temperatures (which have not).

- Sea Level Rise: AR5 shows that ocean sea levels are **not rising any faster now** than they were in the early half of the last century (during pre-industrial times), calling into serious doubt the claims that any sea level rise is attributable to anthropogenic CO_2 emissions.[8]

- Extreme Weather: AR5 states that IPCC has **"low confidence"** that extreme weather events (e.g., hurricanes, droughts, tornadoes, floods, heat waves) are attributable to anthropogenic CO_2 emissions.[9]

- Arctic and Antarctic Sea Ice: Far from proving that the planet's sea ice is melting and decreasing world-wide, AR5 recognizes the opposite, that there are ***increasing*** **levels**

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[6] Ex. 268, AR4 Synthesis Report at 45 ("For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emissions scenarios."). A collection of excerpts containing the cited material from AR4 is included as an addendum to this brief.

[7] Ex. 405, Intergovernmental Panel on Climate Change, Working Group I, *Climate Change 2013: The Physical Science Basis*, at 37, 63 (Box TS.3) [hereafter, "AR5"]. A collection of excerpts containing the cited material from AR5 is included as an addendum to this brief.

[8] AR5, at 289-90.

[9] AR5, at 42, 44, 50, 73.

of *Antarctic* sea ice.[10] It further describes significant uncertainties in the cause of any declines in Arctic sea ice, noting that warm temperature "anomalies" similar to those being recorded now were also observed in the early half of the last century.[11] This evidence tends to disprove the theory that anthropogenic CO_2 is actually causing the melting of the Artic sea ice. The proponents of the FSCC must come forward with something more to satisfy the preponderance of the evidence standard and carry their burden of proof.

- Catastrophic Events: In AR5, the IPCC noted that there is low confidence and little consensus over predictions of catastrophic events occurring during this century, and finds that there is no support for predictions of catastrophic sea level rise.[12]

But rather than attempt to adjust their proposed externality values in accordance with AR5's ***downward*** projections, the proponents of the FSCC in this case rest entirely on the ***outdated*** and ***overstated*** predictions and modeling from AR4, as used by the IWG. Despite the admitted changes in scientific thought described in AR5, the FSCC proponents do not seek to adjust their proposal but instead resort to an unfortunately common tactic: to attempt to discredit those who raise questions or disprove their long-held opinions and political agendas. They falsely claim that there is a scientific "consensus," implying unanimity of thought on the contribution of anthropogenic emissions to climate change. In fact, Dr. Dessler (one of the experts for the Clean Energy Organizations) testified at trial that "all scientists are skeptics. . . . I think all good scientists are skeptics." (Dessler, 3A Tr. 56:3-5.)

In reality, there remains wide disagreement among scientists about the extent of any impacts of emissions on climate change. **And it is the *extent* of impacts, if any, that is the very issue in this case.** The studies purporting to find agreement among "97% of climate scientists" have been thoroughly debunked; a more credible study shows that a statement that human activities caused more than half of the observed increase in global average surface temperature from 1951 to 2010 commands only **minority support (43%)**. Unfortunately, the

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10 AR5, at 25, 40.
11 AR5, at 907.
12 AR5, at 25, 70.

enforcement of the "consensus" has had adverse consequences, including a very real publication bias in favor those who favor larger carbon cost values. Prioritizing "consensus" over the evidence threatens to degrade scientific inquiry into a polarized and politicized exercise in marginalizing people who think differently-- and worse yet, risks undermining independent thought, the backbone for academic freedom and integrity. Dr. Richard Tol, who has been active in the IPCC since 1994, serving in various roles in all its three working groups, most recently as a convening lead author for a working group for the Fifth Assessment report, testified, "Studies are praised because the results are politically expedient rather than scientifically valid. Research scandals are covered up. Whistleblowers are vilified." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 10:219-221.) This is not the scientific method, nor is it a basis for reasoned decisionmaking by the Commission.

Compounding their errors, the FSCC proponents also rest on the IWG's admittedly flawed economic assumptions and model manipulation. The most glaring example of this is the IWG's manipulation of the FUND and DICE models. The FUND model's primary author, Dr. Richard Tol, found the IWG's modifications rendered his model virtually unrecognizable and the results un-replicable. And Dr. Mendelsohn showed that the IWG gutted the DICE model by removing its core function that accounts for adjustments to the rates of economic growth over time, thus rendering the IWG's results from that model invalid. And among the most significant economic errors by the IWG is its reliance on different discount rates than those used by DICE and FUND. Dr. Tol testified IWG's approach puts a premium on the impacts in countries that grow faster than the United States. For instance, under the FUND scenario as used by the IWG, a $1 loss in the United States is counted as $1; but a $1 loss in China is counted as $1.46 to $1.87. The result of this approach is that the IWG effectively places more value on the

circumstances in China than on those in the United States. Favoring China over the United States has broad policy implications, which should not be embedded in an externality proceeding as if it is a mechanical, mathematical exercise rather than what it is: a substantive policy judgment upon which reasonable minds could disagree. In a democratic society, our elected representatives should be the judge.

While the proponents of the FSCC try to squelch dissenting opinion through name-calling, through claims of a "consensus" that does not exist, through falsely alleging lack of peer review, and through smuggling high level value judgments in the guise of mathematical precision, it is actually the FSCC itself that suffers from a lack of consensus, peer review, transparency, and rigor. The IWG is composed of essentially unknown, unnamed government employees from multiple political federal agencies who have no accountability or recognition in the scientific community. In other words, to be blunt about it, the IWG is composed of political appointees, not independent scientists.

The peer-review standard undermines rather than supports the FSCC. In this proceeding, Peabody witnesses have cited 1,457 peer-reviewed papers, compared to only 169 peer-reviewed papers cited by the DOC and CEO witnesses combined. That amounts to almost ***nine times*** more peer-reviewed research.

The FSCC proponents acknowledge the significant uncertainties inherent in determining an externality value for carbon dioxide. But their approach is to err on the (inordinately) high side, even though the Commission has instructed that the values must be conservative because "the possibility of utilities paying more for resources than their environmental benefits justify is just as bad as paying less than their benefits justify." (Ex. 305, 1996 ALJ Recommendation, at

17.) But the preponderance of the evidence standard and fundamental due process principles prevent this Court from adopting such high values, which are so devoid of evidentiary support.

The Commission should require more than the non-peer reviewed, second-hand, politicized work of unidentified, unknown persons to support any Minnesota externality values, especially where the experts most familiar with the models used by the IWG show that the IWG improperly manipulated the models in a manner that generates improper, politically influenced, and overinflated values. Indeed, using the models properly and using the most current AR5 data would result in SCC values ***below*** current levels.

In short, the preponderance of the evidence shows that the uncertainty between 1998 and today has increased, not decreased, and that the reasonable and best available measure is therefore zero, because the high degree of uncertainty in any positive value would threaten the integrity of future resource allocations and would unfairly and arbitrarily favor certain industries over others.

ALJ Klein acknowledged in 1996 that he was recommending a value at a time when a value for CO_2 had never before been adopted in Minnesota. As a consequence, the last 20 years have involved a trial period of sorts. What we now know is the predictions upon which he and the Commission relied then were overstated; the climate models have since proven to diverge from reality. The actual data that we now have, and which he lacked then, suggests this Commission should take the 1997 Commission at its word and adjust the value downward to reflect the new, better evidence. In other words, it cannot be true that the 1997 findings were only a floor and that the values can only go up, but not down. It must be the case that if the evidence supports a lower value, as the evidence here does, then that value will, in fact, be adjusted downward. Otherwise, the institutional integrity of the proceeding will be in doubt.

The Minnesota Department of Commerce, and the Pollution Control Agency (hereafter, "Department" or "State Agencies") repeatedly urges that the values can always be adjusted with better evidence, implying that the Court should go ahead and accept the higher FSCC now and if the assumptions upon which it is based don't prove to be true, then the values can be adjusted downward sometime in the future. The proponents of the FSCC tell this Court, that the IWG is committed to adjusting the values in accordance with future proof. But that trial period already has occurred. If we are to take the Department at its word, then that adjustment should occur ***now***. Indeed, the IWG had the opportunity in 2013 and again in 2015 to do that very thing and adjust the FSCC to be consistent with the most current—and best available information—the AR5. But the IWG did not do so. Thus, IWG's refusal to adjust the FSCC to be consistent with the AR5 demonstrates that the Commission should not adopt the FSCC.

In sum, the preponderance of the evidence supports a zero value, which can be adjusted upward if and when a preponderance of the evidence is established for a higher value. The preponderance of the evidence demonstrates we have crossed that line between tolerable and intolerable uncertainty, and as ALJ Klein acknowledged, we now have uncertainty that simply is "so great that there is insufficient evidence to meet the preponderance standard for" any value at all. Therefore, a "zero value" is appropriate.

In fact, as described herein, and as the results of the FUND model show, the evidence even supports a negative value. At most, the Court should maintain the current values. As Professor Mendelsohn testified:

> Based on my analysis of the case before Minnesota and decades of research on climate impacts and adaptation, the original estimate of the damage of a ton of CO_2 made by the PUC of $5/ton remains a reasonable value to place on carbon. It is consistent with values being used by other states and countries implementing carbon regulations. It is sufficiently close to the values used by neighboring states to limit leakage. It is already

clear that this price is working and encouraging Minnesota utilities to reduce their carbon emissions as they have done the last several years.

Advocates of more stringent mitigation have argued that the SCC could be much higher than $5/ton. However, the SCC could also be much lower. In advocating for the current SCC value of $5/ton, I have assumed the same climate sensitivity value (3.0 °C) as was used by the Interagency Working Group (IWG) based on earlier reports of the Intergovernmental Panel on Climate Change (IPCC). But recent evidence, as discussed in the testimony of Professors Lindzen, Happer, and Spencer, suggests that the climate sensitivity assumed by the IWG is overstated. As Dr. Roy Spencer notes, the historical observed warming has been much less than climate models predicted. Indeed, even the IPCC's Fifth Assessment reduced the low end of the likely range from 2.0 to 1.5, with high confidence. All of this raises questions about whether the climate sensitivity value of 3.0 used by the IWG is too high. If the climate sensitivity is 1.5 (as Dr. Lindzen and others have suggested and as now lies within the IPCC's assessed likely range of "high confidence"), the SCC lies between $0.30 and $0.80/ton, as shown in Table 2 of my Report. If the climate sensitivity value is 2.0, the SCC lies between $1.10 and $2.00/ton, as shown in Table 2. **Given the strong scientific evidence above, a reasonable and the "best available measure" for the SCC is between $0.30 and $2.00/ton.**

If Minnesota takes a risk and chooses a much higher value for the SCC, the state will immediately run into problems. 1) Leakage will most certainly occur. Tons removed by Minnesota will be compromised by tons added by other states. 2) Minnesota will impose a large fiscal burden on their residents. 3) Minnesota will set an example that other states and countries cannot afford to follow. Not only will Minnesota be paying more than their share for climate mitigation, but more importantly the effort will be futile. No one else will follow and there will be no measurable effect on climate.

(Ex. 220, Mendelsohn Surrebuttal 33:19-35:4 (emphasis added).) If the Commission respects Judge Klein's admonition of conservatism in the face of uncertainty, then the Commission will have room to adjust in accord with evidence drawn from what actually happens (rather than what is modeled to happen). The more the Commission hews to the evidence and holds Parties properly to the preponderance of the evidence standard, the more it will demonstrate that it has properly safeguarded the interests of the People of the State of Minnesota.

II. Standard of Review and Criteria of Review

A. Burden of Proof

In this proceeding, a party proposing that the Commission adopt a new environmental cost value for CO_2, including the FSCC, bears the burden of showing by a preponderance of the

evidence that the value being proposed is reasonable and the best available measure of the environmental cost of CO_2. A party proposing that the Commission retain any environmental cost value as currently assigned by the Commission bears the burden of showing by a preponderance of the evidence that the current value is reasonable and the best available measure to determine the applicable environmental cost. A party opposing a proposed environmental cost value must demonstrate that the evidence offered in support of the proposed values is insufficient to amount to a preponderance of the evidence. (Order Regarding Burdens of Proof, *In re Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3*, at pp. 2-3 (Mar. 27, 2015).) Peabody submits that the preponderance of the evidence shows that the FSCC is neither reasonable nor the best available measure, and that the most reasonable and best available measure is zero or, at most, current values.

B. Criteria for Adoption of Externality Values: ALJ Klein's 1996 Recommendations

When the Commission first held a contested case proceeding to set the externality value for CO_2, ALJ Klein addressed the criteria by which the Commission would evaluate proposed externality values. ALJ Klein listed five "criteria" for "determining which environmental impacts to value and whether and how to value these impacts," all of which are consistent with his recommendation that the Commission respond to uncertainty by adopting conservative values:

- Only the most significant and relevant environmental impacts should be quantified.
- Only impacts created during the operational phase should be quantified.
- The adopted values should be conservative.
- Whenever possible, a damage-cost approach should be used.
- At least some of the adopted values should be geographically sensitive.

(Ex. 305, 1996 ALJ Recommendation, at ¶ 36 (emphasis added).) ALJ Klein recommended that the Commission adopt conservative values because "the quantification of environmental costs is still in its infancy." (*Id.* at 17.) He further emphasized the need for caution in setting externality values where the underlying scientific assumptions are unsettled: "***At some point, the degree of uncertainty associated with a proposed value becomes so great that there is insufficient evidence to meet the preponderance standard, and the value cannot be adopted***." (*Id.* at ¶ 31 (emphasis added).)

> While using reasonably accurate estimates is better than imputing no values, ***not all estimates are better than zero***. For instance, valuing an impact at more than twice its "true" residual damage may lead to a worse allocation of resources than imputing no value. In other words, the possibility of utilities paying more for resources than their environmental benefits justify is just as bad as paying less than their benefits justify. . . . ***A better alternative is to err on the side of conservatism initially, then increase the values gradually if better information in the future confirms the need for higher values.***

(*Id.* at 17-18 (emphasis added).)

In that proceeding, ALJ Klein recommended rejection of cost values based on speculation and extreme discount rates: "The MPCA's proposed range of environmental costs of CO_2 of $4.28 to $28.57 per ton is unreliable because it is based on a ***speculative measure of damage*** (2% of global GDP) and uses an ***unreasonably low discount rate*** to reduce the stream of damages to present value." (*Id.* at ¶ 112 (emphasis added).)

Instead, ALJ Klein recommended lower CO_2 values as a reflection of this conservatism: "The range of costs for CO_2 emissions, when using Ciborowski's lower damage function (1% of global GDP) discounted at rates of 3% to 5%, is $0.28 to $2.92 per ton. Based on the available evidence, this range represents a reasonable estimate of costs. It is also consistent with the

policy goal of ***using conservative values in the face of uncertainty***." (*Id.* at ¶ 114 (emphasis added).)[13]

The Commission adopted ALJ Klein's recommendation, and specifically agreed that the "uncertainties inherent in the research" justified more conservative estimates of future damages and discount rates. *In re Quantification of Environmental Costs*, 578 N.W.2d 794, 800 (Minn. Ct. App. 1998). As the Commission stated:

> While the Commission finds the methodology used by MPCA witness Ciborowski sufficient to provide a meaningful estimate of the potential costs from carbon dioxide emissions, the uncertainties related to the assumptions used and uncertainty related to bringing back to present value the significant damage costs assumed to occur many years into the future certainly make the quantification more complex than for the criteria pollutants.

Order Affirming In Part and Modifying In Part Order Establishing Environmental Cost Values, at p. 4 (July 2, 1997). It follows that if ***more uncertainty*** exists now than existed 20 years ago, the values should be ***more conservative***, or lower. That is exactly the case with CO_2 in this proceeding. It is undisputed that the uncertainty regarding the proper ECS value has increased, not decreased. (Ex. 801 (Hanemann Rebuttal Testimony) at 31:11-32:7. *See also* Section III-D, *infra*.)

The FSCC values proposed in this proceeding bear a stunning resemblance to the values that were considered and rejected by the Commission in 1997. In the earlier proceeding, the state agency expert proposed a range of $4.28 to $28.57 per ton of CO_2 emissions, based on the following:

- **Climate Sensitivity** – In 1996, climate sensitivity as listed by the IPCC as "likely" was between 1.5°C and 4.5°C. At that time, the IPCC had a "best estimate" of climate sensitivity of 2.5°C. The MPCA's expert used a damage function based on

[13] These values were adjusted by the Commission to 1995 dollar values, resulting in a final range of $0.30 to $3.10 for CO_2. (Ex. 306, Order Establishing Environmental Cost Values, at pp. 4-5, n.1 (Jan. 3, 1997) [hereafter "Commission 1997 Establishing Order"].

this "best estimate." (1996 ALJ Recommendation, at ¶ 104.) Now, the IPCC has no best estimate of climate sensitivity, and has reverted back to the same "likely" range that it had in 1996. (*See* Section III-D-1-a, *infra*.)

- **Damage Function** – In the 1996 proceeding, the MPCA expert's damage function was based on studies by several economists, including Dr. William Nordhaus, who estimated global damages at 1.0% GDP. (1996 ALJ Recommendation at ¶ 105.) This was the MPCA expert's "lower damage function." The MPCA expert alternatively assumed a "higher damage function" of 2% GDP, which he believed was justified because "various costs (such as costs to unmanaged ecosystems, species diversity and air pollution) were omitted from the studies upon which he relied; because assumptions were made about linear warming; and because certain 'inherent risks' of global warming were excluded." (*Id.* at ¶ 106.) But the 2% GDP damage function was found to be "highly speculative given the available evidence" (*id.*) and thus was rejected by the ALJ and by the Commission. By comparison, in this case the proponents of the FSCC rely on damage functions embedded in three integrated assessment models ("IAMs"), but these functions are based, *inter alia*, on the assumption (as imposed by the IWG, not by the authors of the models themselves) that there will be no reduction in future damages due to mitigation or adaptation. This assumption contradicts the determination of the authors of at least two of the three models relied upon by the proponents of the FSCC. (*See* Section III-E, *infra*.)

- **Time Horizon** – In 1996, the MPCA expert assumed damages would occur in the period from 2010 through 2100, based on the IPCC's 1990 report that expected CO_2 concentrations to quadruple from preindustrial levels by 2100. (*Id.* at ¶¶ 94, 108.) The Commission adopted this recommendation. (Ex. 306, Commission 1997 Establishing Order, at 25-26.) In the current proceeding, proponents of the FSCC calculate damages occurring 200 years longer, through 2300, although they admit that there is no basis in fact to presume what may occur that far into the future, much less by 2100. (*See* Section III-G-2, *infra*.)

- **Discount Rate** – In 1996, the MPCA expert proposed a discount rate of 1.5%, based on studies maintaining that rates of 1-2% are appropriate when discounting across generations. (Ex. 305, 1996 ALJ Recommendation at ¶¶ 110-11.) The Commission considered discount rates of 1%, 2%, 3% and 5%. (*Id.* at ¶ 100; Ex. 306, Commission 1997 Establishing Order, at 27.) As the ALJ recommended, the Commission found that a discount rate of 1% was not supported by the record. (Ex. 306, Commission 1997 Establishing Order, at 27.) The Commission found that "the weight of authority on the record supports a range of at least 3 – 5 percent for reducing future environmental damages to present value." (*Id.*)[14] In the current proceeding, the

[14] *See also* 1996 ALJ Recommendation, at ¶ 113:

> The weight of authority in the record suggests that discount rates in the range of 3% to 5% are more appropriate in reducing future environmental damages to present value. Ex. 13 (3% rate used by the New York State Environmental Cost Study in valuing environmental externalities); Ex. 83 (DICE model uses 6% discount rate, then declines to about 3% as growth

proponents of the FSCC argue that constant discount rates of 2.5%, 3% and 5% are appropriate (which result in a low, middle and high value for their proposed range). However, federal OMB guidance requires use of a 7% discount rate, and the record instead supports adoption of the internal FUND and DICE discount rates, which are not constant over time. (*See* Section III-G-4, *infra*.)

The evidence introduced in this proceeding shows that there is no greater evidence today supporting longer time horizons, higher climate sensitivity, lower discount rates, or greater damage predictions, than there was the support the Commission's 1997 order. In fact, the preponderance of the best evidence compellingly points in the opposite direction on each of these issues.

C. Governing Statutory and Constitutional Standards for This Contested Proceeding.

When the proof is insufficient to support an externality value, statutory and constitutional principles prevent the Commission from going forward to impose a value based on speculation or unsubstantiated assumptions about climate change.

First, the Commission's statutory mandate circumscribes the scope of its power. The legislature in Minn. Stat. § 216B.2422 subd. 3 did not grant the Commission open-ended authority to adopt whatever regulatory intervention it wanted regarding CO_2 emissions. Rather, the Commission's mandate is specific and limited: simply to determine whether it is "practicable" to quantify an environmental externality value for CO_2 and whether there is a "reasonable" and "best available" measure. Such standard precludes establishment of values based on "best guesses," "guesstimates," or surmises. The seriousness of the resource decisions that will be affected by the outcome of this proceeding demands that the standard for establishing environmental cost values be equally serious. The Commission should not establish an

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slows; Lind model recommends 4.6% discount rate); Tr. 12 at 74 (Nordhaus contends rates of 4% to 5% are appropriate); Tr. 11 at 196 (National Academy of Sciences used discount rates of 3%, 6%, and 10% without recommending any single rate as being most appropriate).

environmental cost value unless it is confident that it is "practicable" to do so, based on solid, quantifiable, and reliable scientific evidence.

Second, constitutional principles fortify the statutory limits on the Commission's authority. If the Commission adopts a value in the absence of sufficient proof of causation and sufficiently rigorous scientific evidence, it crosses the line between lawful decisionmaking and arbitrary action. The Commission would be engaging in a freewheeling exercise untethered to any legal standards and safeguards. In *Honda Motor Co. Ltd. v. Oberg*, 512 U.S. 415, 430-31 (1994), the Supreme Court made clear that the absence of traditional procedural safeguards against arbitrary and abusive decision-making violates due process guarantees. "When the absent procedures would have provided protection against arbitrary and inaccurate adjudication, this Court has not hesitated to find the proceedings violative of due process." *Id.* at 430.

Legislation enacted after careful deliberation and debate is usually the way Americans address national problems and confront difficult trade-offs. The Commission should not aggrandize its authority to make quintessentially political judgments about climate change. It should not undertake a unilateral end-run around the democratic political process. Indeed, a system that would permit an agency to make decisions of this sort would be a recipe for abuse and arbitrary decision-making. In *Hampton v. Mow Sun Wong*, 426 U.S. 88, 116 (1976), for example, the Supreme Court invalidated a Civil Service Commission regulation denying federal employment to non-citizens because, even though the agency was not found to have acted beyond its statutory mandate, the decision to bar non-citizens from federal employment was not a decision that administrative officials were competent to make.[15]

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[15] *See National Cable Television Ass'n v. United States*, 415 U.S. 336, 341–42 (1974) (opining that "constitutional problems" would arise if statute were construed as vesting administrative agency with the discretionary authority to impose a tax); see also Hans A. Linde,

The Parties urging adoption of the FSCC have failed to provide manageable standards regarding proof of causation and reliable scientific evidence to ensure compliance with due process and avoidance of arbitrary action. The Commission should not adopt the FSCC.

III. The Federal SCC is Neither Reasonable Nor the Best Available Measure

The FSCC is fatally flawed and is neither reasonable nor the best available measure of the externality value of CO_2. The FSCC is simply too speculative to meet the standard of proof in this proceeding. It is constructed on the back of uncertainty and a plea to "just trust us." Such an entreaty is not sufficient under applicable law. The Commission's decision must be grounded in science and fact, not supposition or preconceptions untethered to the evidence.

Uncertainties are fatal: The FSCC draws on three integrated assessment models ("IAMs") that rely on a chain of assumptions that magnifies the uncertainty built into the process. Uncertainties pile upon uncertainties. Importantly, ***the Parties to this proceeding concede the uncertainty inherent in the determination of the FSCC***. As Judge Klein recognized, at some point the level of uncertainty simply becomes too great to permit the selection of a value. The evidence in this proceeding shows that we are well past that point.

The FSCC rests on obsolete data: The FSCC is based on old data from 2007 and earlier, which has been invalidated by more recent science. The FSCC relies on AR4's 2007 projection that doubling CO_2 concentrations from preindustrial levels would increase equilibrium temperatures by 2°C to 4.5°C, with a "best estimate" of 3.0°C (this is known as an "Equilibrium Climate Sensitivity" value or "ECS"). The IWG used 3.0°C as the midpoint for its probability assessment of ECS that it used as a key input to the IAMs. Yet the IPCC's AR5 in 2013

Due Process of Lawmaking, 55 NEB. L. REV. 197 (1976) (stressing the need in constitutional adjudication to focus on the ***procedure*** of lawmaking as well as the ***substantive*** limits on the legislative power).

significantly dialed back its projections of climate change. AR5 abandoned 3.0°C as its "best estimate" and concluded that doubling CO_2 concentrations might increase global temperatures by as little as 1.5°C – a moderate amount that would significantly lower the cost figures generated by the FSCC's IAMs. Indeed, the IAMs showed that the impact could be on balance ***beneficial*** rather than harmful. Thus, the more recent science shows that the temperature increase will be much lower than the FSCC's assumption and that the IWG should have used a much different probability assessment, with a midpoint far below 3.0°C.

In fact, dozens of recent studies and papers have invalidated the FSCC's assumptions of a large temperature increase, and leading scientists have found that the correct value is very unlikely to exceed 2.0°C. The models on which the FSCC relies have consistently "run hot" and overestimated climate change during the only period when they have been tested: 1998 to today. It does not matter what mode of measurement is consulted – ground thermometers, weather balloons, or satellites – because all show actual temperature changes running approximately three times below what the models have predicted. The models used by the IWG failed to predict a nearly two-decade-long "hiatus" in warming during the very period when CO_2 emissions have been greatest. Observational data is key, for the reasons stated by the CEOs' witness, Dr. Reich: "a model is not direct evidence, ever." (Reich, 5 Tr. 68:17.) According to Dr. Reich, the Commission must follow actual data, not models: "Some people believe no model is reliable." (Reich, 5 Tr. 54:20.) While a model can be "a reasonable representation of our understanding of certain processes," "almost every single model" will "totally ignore[] other processes." (Reich, 5 Tr. 54:23-55:1.) By nature, Dr. Reich testified, models are always outdated, "always chasing the tail of the recent research and the model is just a bunch of zeros and Os in a computer, whereas if someone measured something directly in the field, it's direct

evidence." (Reich, 5 Tr. 70:17-25.) Dr. Reich cautioned about using models to predict the future because of their inherent limitations (Reich, 5 Tr. 61:25-62:3), but that is what the FSCC does by nature. It uses climate models from ten years ago (or more) rather than direct evidence in the form of observational data. Dr. Reich, the CEOs' witness, argued that empirical evidence always trumps a model, and he fatally undermined the basis for the FSCC by showing the inherent weaknesses of its model-based approach to prediction.

The best available data refute the FSCC: Despite this new empirical evidence, the IWG has twice failed to revise the FSCC (in November 2013 and July 2015) to account for new science. This runs directly counter to the IWG's pledge in the first paragraph of the first document introducing the FSCC: "The estimates are presented with an acknowledgement of the many uncertainties involved and ***with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts***." (Ex. 100, Polasky Direct Schedule 2 (Feb. 2010 TSD), 1 (emphasis added).) Proponents of the FSCC made a similar argument that the FSCC should be adopted because it could be updated based on improved science:

> [The FSCC] is based on the most up-to-date and comprehensive science and economic research available at the time the value is set, and importantly, from the practicability standard, it's one that's easily updated by the federal government if it chooses to do so, and easily and practicably available for the state to similarly ***update as science continues to progress and we know more about this experiment that we're in***.

(Attorney for Agencies, 1 Tr. 54:20-55:3 (emphasis added).) While the IWG has selectively updated the FSCC to incorporate research that in its view support higher values, it has ignored new science that supports lower values. The IWG updated the FSCC in May 2013 primarily to include sea level damages, changes that increased the FSCC. (Ex. 100, Polasky Direct, Sched. 3

(May 2013 TSD), at 4.)[16] But when AR5 lowered the climate sensitivity range in September 2013 based on improved science, the IWG twice failed to make this significant change that would decrease the FSCC, indicating instead that more study was needed:

> The IWG will continue to follow and evaluate the latest science on the equilibrium climate sensitivity and seek external expert advice on the technical merits and challenges of potential approaches prior to updating the ECS distribution in future revisions to the SCC estimates, including (but not limited to) using the AR5 climate sensitivity distribution for the next update of the SCC.

(Ex. 101, Polasky Rebuttal, Sched. 1 (July 2015 Response to Comments), at 12.) The FSCC is not the "best available" measure, because it does not incorporate the most recent and best available science. Indeed, AR5 not only lowered its ECS range, but also retreated from other findings of AR4, with respect to severe weather, Antarctic sea ice, and many other aspects of climate change. The IWG ignored all of this evidence and refused to update the FSCC. Minnesota is being asked to adopt the FSCC on the premise that the federal government will update the FSCC to match the science, but that has not been the case to date.

Thus, Peabody is not a climate science "denier." The crucial climate science issues in this proceeding are not whether Earth's climate is static or might be changing in some ways – it is always changing – but the magnitude and speed of any anthropogenic contribution to climate change and whether the FSCC properly measures those impacts. On ***those*** questions, AR5 undermines rather than supports the FSCC. As Dr. Spencer testified, the "issue is not so much whether some warming has occurred – I believe it has – it is that the warming has been at a slower rate than can currently be explained by the IPCC models, and those models provide the ultimate quantitative basis for social cost of carbon calculations." (Ex. 227, Spencer Surrebuttal,

[16] The IWG also updated the FSCC in November 2013 and July 2015 to correct modeling issues, which made little difference in the FSCC. (Ex. 600, Martin Direct Schedule 2 (Nov. 2013 TSD), 22; Ex. 601, Martin Rebuttal Schedule 1 (July 2015 TSD), 21.)

4:10-12). Climate science shows that the FSCC is riddled with theoretical and evidentiary defects, rests on models and assumptions that have been disproven by real-world observations, and vastly overestimates the social cost of carbon. The State Agencies and CEOs have described a simplistic and exaggerated picture of the scientific literature on global warming.

Indeed, one of the more remarkable aspects of this proceeding is the flip-flop by the State Agencies and CEOs regarding the IPCC's AR4 and AR5 reports. Pre-trial, the State Agencies and CEOs touted the IPCC as the authoritative source on climate change.[17] Dr. Gurney insisted that "the IPCC assessments are the best resource for providing a comprehensive synthes[i]s of what is known and not know[n] on the topic of climate change." (Ex. 803, Gurney Rebuttal, 28:2-4.) The State Agencies went so far as to call out AR5 as "the single most authoritative work on climate science and the economics of climate change." (Agency In Limine Response at 17.) But their approach changed once they were confronted at trial with the IPCC's actual findings, caveats, and admissions of uncertainty. The MLIG, not the State Agencies or CEOs, introduced AR5 into evidence at trial. Dr. Dessler, an expert witness of the CEOs, openly disagreed with AR5 in his testimony, declaring "I will disagree with them on that point," regarding AR5's departure from AR4's ECS estimates. (3A Tr. 49:12.) The State Agencies and CEOs ***opposed*** the admission of the AR4 Synthesis Report into evidence, relenting only after Peabody's counsel pointed out, "it seems a little astounding that the Department, who is relying on the AR4 to the

[17] *See* Response of Agencies to Peabody and MLIG Motions in Limine to Exclude Expert Witness Direct and Rebuttal Testimony, *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3*, MPUC Dkt. No. E-999/CI-14-643, at 13-18 (Sep. 12, 2015) [hereafter "Agency In Limine Response"]; CEO's Response to Peabody's Motion to Exclude Dr. Stephen Polasky, *In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3*, MPUC Dkt. No. E-999/CI-14-643, at 5-6; Ex. 803, Gurney Rebuttal 7:1-2, 17:16-18 ("a thorough and comprehensive review of this important metric of the climate system"), 25:21-28:17 (describing the importance of the IPCC; concluding that it is "the best resource for providing a comprehensive synthes[i]s of what is known and not know[n] on the topic of climate change").

extent that the IWG relied on the AR4 is not wanting it admitted into evidence." (5 Tr. 101:10-13.) Like the IWG, the proponents of the FSCC seek to ignore the best available science because it does not support the current FSCC values.

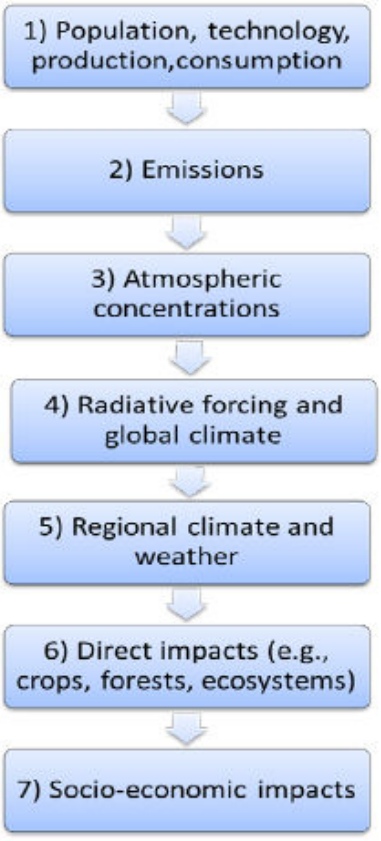
Appeals to "consensus" lead nowhere: The constant refrain of the State Agencies and the CEOs that the Commission should follow the "consensus" is profoundly misplaced. If there is any "consensus" on the precise issues involved in this proceeding, it is in favor of Peabody, not the FSCC. For example, even Dr. Dessler (the Clean Energy Organization's witness) testified that there has been no statistically significant warming since the year 2000. (3A Tr. at 20:14-16.) The so-called "consensus" of scientists — especially the often-quoted (but entirely made-up) "97% of climate scientists" who agree with an overly generalized and meaningless statement not specific to the FSCC — is a media confabulation that is unsupported by the actual data or the views of actual scientists. The false "consensus" is enforced by schoolyard antics such as name-calling ("denier," "contrarian," "conspiratorial"), which was evident during trial. Distinguished scientists with impeccable credentials, who have devoted their careers to advancing human knowledge, are answered not with facts but epithets. Dr. Tol observed that careful scientists who point out flaws in climate research are often shouted down; in his words, that is what is "wrong with climate research. Studies are praised because the results are politically expedient rather than scientifically valid. Research scandals are covered up. Whistleblowers are vilified." (Ex. 236, Tol Report, (Ex. 2 to Tol Rebuttal), at 10:219-223). This is not the scientific method, nor is it a basis for reasoned decision-making by the Commission. The FSCC should be rejected.

A. The FSCC's Reliance on IAMs Does Not Provide a Reasonable or Best Available Measure of the Externality Value

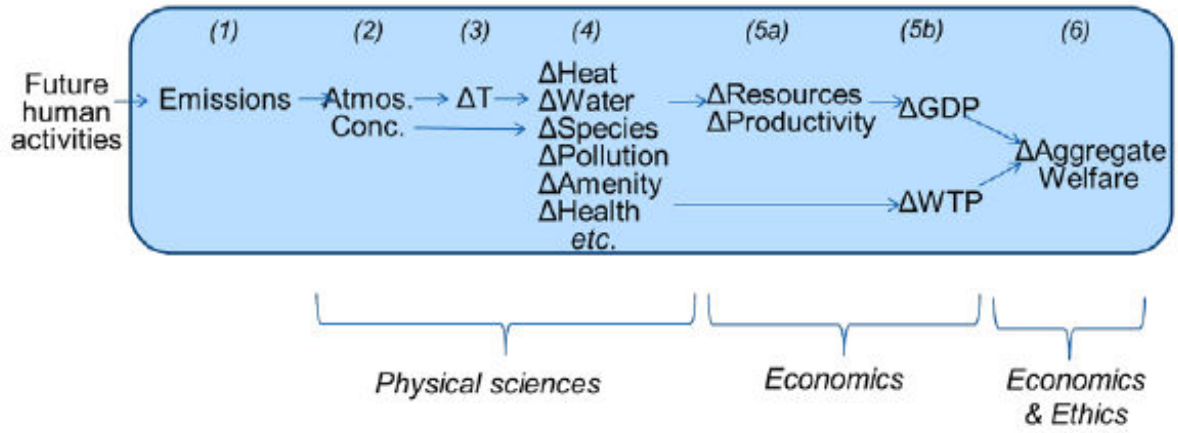
1. ***The FSCC is a Cascade of Uncertainties***

The IAMs used to calculate the federal SCC are built upon multiple layers of uncertainty. The uncertainty does not go away, but rather multiplies. The IAMs used by the FSCC are built on sets of model assumptions that set up a speculative chain from start to finish. Dr. Hanemann and Dr. Smith described the major steps of an IAM:

Figure 1. Elements of an IAM



(Ex. 800, Hanemann Direct, 25 (Fig. 1), 25:3-4, 25:10-26:13.)



(Ex. 300, Smith Direct, Ex. 2 (Report) 3-4, 23.)

- Uncertainty in population, technology, production, consumption and emissions: The first two steps — combined into one here — "correspond to the representation of how economic activity generates emissions, and how much those emissions are abated and at what cost." (Ex. 800, Hanemann Direct, 25:3-4.) The IWG chose to use some of the Stanford Energy Modeling Forum emissions scenarios (Hanemann, 2B Tr. 32:8-11), which correlate three major variables, each of which carries uncertainty: population, GDP, and CO_2 emissions. These are not just measurable point estimates, but projections of future global population growth, future productivity, and how much CO_2 that productivity will generate. All of these projections carry large amounts of inherent uncertainty.

- Uncertainty in atmospheric concentrations from emissions: Once a given level of emissions is known, models must determine how much of those emissions will remain in the atmosphere, "a representation of the carbon cycle." (Ex. 800, Hanemann Direct, 25 n.18.). As Dr. Hanemann explained, this step and the next two "correspond to the representation of how the resulting emissions lead to climate change." (Ex. 800, Hanemann Direct, 25:5-6.) The relationship between emissions concentrations is not well established, and both the ocean and plant life provide carbon sinks that absorb a percentage of the emissions before they become concentrations. All of these factors produce more uncertainty, and are changing on both short-term and long-term cycles.

- Uncertainty in climate sensitivity: Once an atmospheric concentration is established, the model must determine how the temperature changes in response. This step and the next are focused on "the change in global annual average temperature." (Ex. 800, Hanemann Direct, 25:8-9.) As these proceedings have highlighted, there is considerable uncertainty over how the temperature will respond to carbon concentrations, represented by ECS, and the probability range supported by science has shifted. Thus there is not only first-order uncertainty as to the proper value of ECS, resulting in a probability distribution rather than a point estimate or "best estimate," but also second-order uncertainty regarding the direction that probability

range is shifting. Uncertainty regarding ECS is increasing rather than decreasing; to the extent there is any trend to the change, it reflects a greater emphasis on the lower end of the range.

- Uncertainty in reaction by and to regional weather differences: Once a model determines a degree of warming, it then must compute how different regions will react to that change. This includes local changes in temperature, moisture levels, agricultural productivity, precipitation, weather, and other ecological factors. A great deal of uncertainty attends these changes: mild warming may dry out some wetter areas and make drier ones moister. Overall it will increase agricultural productivity and help plants become more resistant to these negative effects, as well as improving water use efficiency.

- Uncertainty in resulting benefits or costs: Once the global and regional shifts in weather and climate are estimated, the impacts of those changes must be monetized. These two steps (combined here) "correspond to the representation of the resulting impacts of the change in climate and their economic valuation." (Ex. 800, Hanemann Direct, 25:6-7.) Converting to a dollar amount incorporates uncertainty due to the difficulty of valuation and measuring economic impacts. Moreover, these changes will also increase the uncertainty of other steps: greater agricultural productivity will change the amount of carbon absorbed by plants by some amount, and greater prosperity will permit greater adaptation (resulting in less damage suffered by future generations). These two steps "are combined into a single function (or set of functions) characterizing the economic value associated with particular groups of impacts at a point in time as a function of the increase in global average annual temperature occurring at that time." (Ex. 800, Hanemann Direct 27:3-6.)

- Time value uncertainty: Last of all, a model must project all of these different steps (and the inherent uncertainty in each) into the future — magnifying the uncertainty even more — and then discount those impacts to present values. Dr. Hanemann described the steps the IWG took to discount the IAM output. (Ex. 800, Hanemann Direct 46:21-23, 53:5-14.) All methods of discounting make broad generalizations about risk aversion, concern for the future, and growth effects, each of which is subject to uncertainty.

These uncertainties do not cancel out when aggregated but multiply. (Ex. 230, Bezdek Direct Report, 110-13.) Each step affects the next, producing a "cascade of uncertainties" (Ex. 230, Bezdek Direct Report, 111) that yields a final outcome — a seemingly precise dollar figure — that hides so much uncertainty it is completely arbitrary. As Mr. Martin testified:

> The SCC is inherently uncertain and speculative. Deriving the SCC relies on making assumptions – from now until the year 2300 – about population and GDP growth, the emissions that result from that growth, the temperature change that results from emissions,

> the damages that result from temperature change, and the appropriate discount rates to apply to those damages. Each of these assumptions is uncertain, and uncertainty builds from one step to the next.

(Ex. 600, Martin Direct, 3:11-17.) At the hearing, ***basically all Parties conceded the level of uncertainty involved***. (Polasky, 1 Tr. 90:4-11 ("[u]ncertainties are inherent in the task of developing an externality value for CO_2"); Martin, 3B Tr. 132:18-20 ("The problem remains highly uncertain. I think all the parties have acknowledged that ….").) Dr. Hanemann and Dr. Dessler admitted that uncertainty has increased. (Ex. 801, Hanemann Rebuttal, 32:6-7; Dessler, 3A Tr. 70:1-12.) In its calculation of the FSCC, the IWG "effectively assumed that uncertainty never gets resolved. [The IWG] assume[d] society is just as uncertain in 2300 about the various parameters of the model as it is today." (Ex. 214, Mendelsohn Direct, 16:21-23.) As Professor Mendelsohn testified, the effect of greenhouse gases "on temperature is uncertain," "the impact of temperature change on the economy and nonmarket sectors is uncertain," and "it is uncertain how effects will be distributed across the planet": "**uncertainty haunts the measurement of climate damage**." (Ex. 220, Mendelsohn Surrebuttal, 30:19-31:2 (emphasis added).) The Parties' statements reflect the widespread recognition in the academic literature that the FSCC piles conjecture upon conjecture to produce what is essentially an arbitrary number. Professor Robert Pindyck, an economist at MIT, has written that the calculation of the FSCC using the IAMs is "close to useless" and "misleading." (Ex. 228, Bezdek Direct, 26:27-27:6; Ex. 230, Bezdek Direct Report, at 95.) Professors Jonathan Masur and Eric Posner, economic experts at the University of Chicago, stated: "We believe that agencies conducting cost-benefit analysis cannot use the IWG's SCC. The SCC is highly arbitrary. Even the choice of which of the IWG's four SCCs to use is arbitrary." (Ex. 233, Bezdek Rebuttal Report, 79.) A study for the National Academies of Science (NAS) found that the SCC assessment suffers from uncertainty,

speculation, and lack of information about future emissions, the effects of past and future emissions on the climate system, the impact of changes in climate on the physical and biological environment, and the translation of these environmental impacts into economic damages. (Ex. 233, Bezdek Rebuttal Report, 77-78.) In the end, the FSCC is impermissible guesswork.

2. *Uncertainty Prevents Adoption of the FSCC for Minnesota.*

The Commission should respect Judge Klein's teaching that uncertainty requires a conservative approach: such a great degree of uncertainty represents a failure of the proponents of the FSCC to carry their burden of proof.

An enabling act such as Minnesota Statute Sec. 216B.2422 subd. 3 must be interpreted so as to authorize only reasonable decisions. *Lee v. Delmont*, 228 Minn. 101, 114 (1949). Additionally, the agency must explain on what evidence it is relying and how that evidence connects rationally with the agency's choice of action to be taken. *Manufactured Housing Institute v. Pettersen*, 347 N.W.2d 238, 244 (Minn. 1984). Picking a value arbitrarily does not generate a reasonable number and will not withstand judicial scrutiny on appeal. *Id.*

Further, the Order on the Standard of Proof provides that parties proposing an environmental cost value have the burden to prove their value by a preponderance of the evidence. *See* Minn. R. 1400.7300, subp. 5 (burden of proof falls on the parties proposing an environmental cost value for each particular pollutant to prove the facts at issue by a "preponderance of the evidence"). Uncertainty prevents the advocates of the FSCC from meeting their burden.

Separately, under Minnesota law, "An agency's decision is arbitrary and capricious if it represents its will and not its judgment." *Hiawatha Aviation of Rochester, Inc. v. Minn. Dept. of Health,* 375 N.W.2d 496, 501 (Minn.App.1985) (citation omitted), *aff'd,* 389 N.W.2d 507 (Minn.1986). "When an agency entirely fails to consider an important aspect of a problem, this

is a signal that the decision is arbitrary and capricious." *Alich v. Dakota Cty. Cmty. Dev. Auth.*, No. C4-02-818, 2003 WL 230726, at *1 (Minn. Ct. App. Feb. 4, 2003) (citing *White v. Minn. Dep't of Natural Res.,* 567 N.W.2d 724, 730 (Minn. App. 1997), *review denied* (Minn. Oct. 31, 1997)); *see also id.* at *2 ("This failure to consider all relevant circumstances suggests that the CDA's determination to terminate assistance was arbitrary and capricious."). Indeed, an agency's decision is arbitrary or capricious if it entirely failed to consider an important aspect of the problem, if it offered an explanation for the decision that runs counter to the evidence, or if the decision is so implausible that it could not be ascribed to a difference in view or the result of agency expertise. *Trout Unlimited, Inc. v. Minnesota Dep't of Agric.*, 528 N.W.2d 903, 907 (Minn. App. 1995). "Where the evidence reveals that the agency has ignored or failed to consider 'a serious environmental consequence' or 'swept stubborn problems or serious criticism . . . under the rug,' the district court may consider new evidence. *Clean Water Action All. of Minnesota v. Minnesota Pollution Control Agency*, No. A06-1054, 2007 WL 1599156, at *2 (Minn. Ct. App. June 5, 2007) (citing *White*, 567 N.W.2d at 735).

Congress has directed agencies to use "(i) the best available, peer-reviewed science and supporting studies conducted in accordance with sound and objective scientific practices; and (ii) data collected by accepted methods or best available methods (if the reliability of the method and the nature of the decision justifies use of the data." 42 U.S.C. § 300g-1(b)(3)(B).

Federal courts have routinely invalidated administrative agency decisions for using weak scientific evidence or speculation, or for failing to address conflicting scientific evidence. For example:

- In *Appalachian Power Co. v. EPA*, 249 F.3d 1032, 1054 (D.C. Cir. 2001), the D.C. Circuit found that EPA acted arbitrarily in failing to "address[] what appear[s] to be stark disparities between its projections and real world observations." The D.C. Circuit opined that "model assumptions must have a 'rational relationship' to the real

world." *Id.* at 1053 (quoting *Chemical Mfrs. Ass'n v. EPA*, 28 F.3d 1259, 1265 (D.C. Cir. 1994)). The court pointed out that EPA projections of negative growth in electricity generation "appear arbitrary, and the EPA can point to nothing in the record to dispel this appearance." *Id.* Moreover, when EPA defended its reasoning simply by stating that the choice was reasonable, the D.C. Circuit replied "simply to state such a claim does not make it so. There must be an *actual reason* articulated by the agency at some point in the rulemaking process. There is none here." *Id.* at 1053-54 (emphasis added). The court explicitly rejected "just trust us" reasoning.

- In *Tex Tin Corp. v. EPA*, 992 F.2d 353, 354-55 (D.C. Cir. 1993), the Court of Appeals held that EPA's reliance upon generic studies in face of conflicting detailed and specific scientific evidence was arbitrary and capricious. The D.C. Circuit rejected EPA's "conclusory statements" based on generic studies of arsenic in waste piles when they were countered by specific studies. *Id.* at 355. Relying on generic reasoning in the face of conflicting scientific evidence is effectively the same as conclusory arbitrary and capricious reasoning.

- In *Chlorine Chemistry Council v. EPA*, 206 F.3d 1286 (D.C. Cir. 2000), the court found that EPA's decision to act in contravention of the "best available" science was arbitrary and capricious. *Id.* at 1290-91. Specifically, the D.C. Circuit rejected EPA's argument that it could not complete its scientific investigations before a deadline, arguing that "that is no reason for acting against its own science findings in the meantime." *Id.* at 1290. Yet that is precisely what the IWG has done in creating the FSCC: presented with the best available scientific evidence, it simply stood pat and stated that it might update in the future. The D.C. Circuit specifically rejected this position. *Id.* at 1290-91.

- In *Illinois Commerce Comm'n v. FERC*, 576 F.3d 470, 477 (7th Cir. 2009), the court reversed an agency adjudicatory decision because of a failure to take into account contrary evidence, and because of a lack of evidence to support the decision. The Seventh Circuit specifically rejected a "just trust us" argument: "Rather desperately FERC's lawyer … reminded us at argument that the Commission has a great deal of experience with issues of reliability and network needs, and they asked us therefore (in effect) to take the soundness of its decision on faith. But we cannot do that because we are not authorized to uphold a regulatory decision that is not supported by substantial evidence on the record as a whole, or to supply reasons for the decision that did not occur to the regulators." *Id.* The proponents of the FSCC are effectively asking for the same blind deference to the IWG, asking for faith in its (otherwise invisible) procedure. That plea should be rejected.

The FSCC cannot meet the legal standard of reasoned decision-making. Nevertheless, the State Agencies and the CEOs urge higher values now even though there is (if anything) ***less*** certainty than there was in 1997. As shown below, in fact there is more uncertainty than ever about effects of higher CO_2 emissions. The more we study climate science, the more we realize

how large the uncertainties are. Even Dr. Dessler, an expert for the CEOs, testified as to increases in uncertainty between AR4 and AR5: "I think there were additional studies that came out. I don't think that improved our understanding, it added to the range. ***In fact, if anything, it added some uncertainty.***" (3A Tr. 49:12-16 (emphasis added).)

Even the IPCC — the core authority to which the State Agencies and the CEOs point — has *lowered* its bottom bound of the ECS range and has scaled back predictions of climate change. There is even less certainty of the connection between human activity and CO_2 concentrations and a correspondingly greater likelihood that we are simply responding to a matter of natural variation. Under the uncertainty levels known in 1997, the Commission adopted a range of values from $0.30 to $3.10 and rejected proposals for a much higher range ($4.28 to $28.57). Since then, uncertainty has only increased and Judge Klein's teaching has grown even more salient.

Far from warranting an extreme, unbalanced increase in externality values, the uncertainty involved with the IAMs warrants a cautious approach. Every step of the IAM process adds in new layers of uncertainty, and those uncertainties multiply rather than cancel out, even though they are reduced to a dollar figure that falsely implies a level of certitude that does not exist. No rational basis supports choosing a high externality value in the face of such a mountain of uncertainties.

B. Step One of Speculation: Uncertainty in Emissions Predictions — Unsubstantiated Predictions That Extrapolate Energy Consumption to the Year 2300 for Which There Is No Basis In Fact

The FSCC starts with guesswork regarding future emissions scenarios — not for the next five to ten years but for the ***next 300 years***, through the year 2300. Never before has an externality value been predicated on what may or may not happen 300 years into the future. The IWG used four Stanford Energy Modeling Forum scenarios and a fifth scenario invented by the

IWG, but those ***forecast*** possible population, GDP growth and CO_2 emissions ***only out to the year 2100***. (Ex. 600, Martin Direct, 33:1-9.) The IWG used its own, non-peer-reviewed methods to extrapolate these forecasts ***even farther--to the year 2300***. (Ex. 600, Martin Direct, 33:1-9.) The IWG made largely arbitrary assumptions about population, GDP population, and CO_2 emissions, which drove all subsequent modeling steps (in terms of temperature response and damage estimation) after the year 2100. (Ex. 600, Martin Direct, 33:1-9.) **No proponent of the FSCC explained or gave *any evidence* to substantiate these extrapolations.** The IWG did not account for the possibility of technological change and adaptation, such as the possibility that future societies would develop new technologies with lower CO_2 intensity. (Ex. 600, Martin Direct, 34:8-17.) The IWG did not take technological change into account even though the period in question (from now until 2300) is actually longer than the time that has elapsed from the Industrial Revolution to the present. (Ex. 600, Martin Direct, 34:8-17.) Just as it would have been impossible in the year 1715 to accurately predict energy use patterns and emissions in the year 2015, it is the epitome of conjecture to attempt to project emissions to the year 2300.[18] Yet the FSCC relies on such unbridled speculation, more fit for science fiction than reasoned decision-making.

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[18] Dr. Polasky admitted that society in 1715 could not predict today's temperature and the effect on GDP, and that uncertainty increases with the length of the projection.

> Peabody counsel: I'm just trying to get my head, at least, wrapped around that idea. And so I am thinking back to 300 years ago, so 1715. Is it actually realistic to think that somebody back in 1715 could predict what the temperature would be today and what the effect of the temperature would be on our current GDP?
>
> Dr. Polasky: Certainly not with the science they had in 1715. But realistically … **the further out you go the more difficult it is. The greater the range of uncertainty, that is correct**.

(1 Tr. 90:2-11 (emphasis added).)

C. Step Two of Speculation: Uncertainty in Carbon Cycle Predictions — Predictions Based on Faulty Evidence

The next step of the IWG's estimate of the FSCC is the carbon cycle response – the relationship between (i) human emissions and (ii) atmospheric concentrations of CO_2. Models must determine how much of those emissions will actually remain in the atmosphere, as opposed to being absorbed by plants, oceans, or other carbon sinks. The State Agencies and the CEOs offered only speculation regarding the relationship between fossil fuel emissions and atmospheric CO_2 levels, plus a "trust me" assertion from Dr. Gurney that the connection is "well established through multiple lines of evidence" (Ex. 803, Gurney Rebuttal, 8:21-23; Gurney, 4 Tr. 131:16-132:2), ***none of which he ever produced***. Professor Lindzen explained that the IWG's assumptions are unproven because "the fraction of human induced CO_2 is small compared to the total CO_2 in the atmosphere, and natural emission and sink rates are about 20 times greater than anthropogenic emissions." (Ex. 213, Lindzen Surrebuttal, 29:9.) Further, "as the accumulation rises, the sink rate is increasing. . . . The sinks respond dynamically to the overall CO_2 concentration in the atmosphere, whether it is due to anthropogenic or natural input. As a result, the simple mass-balance arguments supporting the IPCC conclusions are based on circular reasoning . . . ." (Ex. 213, Lindzen Surrebuttal, 29:11-16.)

The IWG's calculations depend on untested assumptions regarding the amount of fossil-fuel-derived CO_2 in the atmosphere measured by using the ratio of $^{14}CO_2$, a specific variety of CO_2 with a slightly heavier carbon atom, which is not emitted by fossil fuel combustion. The ratio between $^{14}CO_2$ and stable CO_2 is known as the Suess Formula (which Dr. Gurney incorrectly gave as "Seuss"). (Ex. 213, Lindzen Surrebuttal, 29:21-30:7.) The only evidence given by the State Agencies to support their position was Dr. Gurney's reference to an article

written by Tans, et al. (1979),[19] which actually found that during an 11-year period (1936-1950), there was an *almost constant level* of ^{14}C despite "a total of 16.6 G ton of carbon from fossil fuels" which was released and "should have resulted in a 4-6% decrease of the atmospheric $^{14}C/C$ ratio during this decade." (Ex. 213, Lindzen Surrebuttal, 30:9-13.) In other words, the article *undermined* the FSCC, as Professor Lindzen explained. (Ex. 213, Lindzen Surrebuttal, 31:9-16.) In contrast to Dr. Gurney, Professor Lindzen also cited numerous peer-reviewed publications undermining the FSCC's assumptions. For example:

- One recent study found that only a very small residual fraction of anthropogenic CO_2 emissions is not captured by carbon sinks and remains in the atmosphere, and further that the anthropogenic CO_2 additional warming extrapolated to the year 2100 was lower than 0.1°C in the absence of feedbacks. (Ex. 213, Lindzen Surrebuttal, 32:1-4.)

- Another study found that the present anthropogenic CO_2 fraction in the atmosphere is 7.7%, which is substantially smaller than the IPCC's estimate. The study noted: "The IPCC's latest value for the anthropogenic CO_2-percentage in the atmosphere is 28%. This huge gap with the other research results originates from the long residence time calculation method of IPCC." (Ex. 213, Lindzen Surrebuttal, 32:5-9.)

- Another study found that CO_2 always lags changes in surface temperatures and that changes in atmospheric CO_2 are not tracking changes in human emissions. (Ex. 213, Lindzen Surrebuttal, 32:10-11.)

- A team of researchers in the U.S. found that "climate models used to predict the rise in CO_2 concentrations in the atmosphere are approximately 17 percent too high because they incorrectly approximate how much CO_2 plants pull from the atmosphere." (Ex. 213, Lindzen Surrebuttal, 32:12-14.)

- Another study found a reverse relationship between atmospheric CO_2 and global temperature: "The primary ingredient of the Anthropogenic Global Warming hypothesis, namely, the assumption that additional atmospheric carbon dioxide substantially raises the global temperature, is studied. This is done by looking at the data of temperature and CO_2, both in the time domain and in the phase domain of periodic data. . . . **These results indicate a reverse function of cause and effect**, with temperature being the cause for atmospheric CO_2 changes, rather than their effect. These two hypotheses are discussed on basis of literature, where it was also reported that CO_2 variations are lagging behind temperature variations." (Ex. 213, Lindzen Surrebuttal, 33:1-9 (emphasis added).)

[19] P.P. Tans, *Natural Atmospheric 14C Variation and the Suess Effect*, 280 Nature 826, 827 (Aug. 30, 1979).

There was no effective rebuttal to any of this evidence other than Dr. Gurney essentially saying "trust me" and presenting no peer-reviewed support for that trust. The second step of the FSCC's chain of calculation – the carbon cycle response – is impermissibly conjectural.

D. Step Three of Speculation: Uncertainty in Climate Predictions — Predictions That Have Been Disproven By the Data

The next step in the estimation of the FSCC – climate modeling – is also excessively speculative. The FSCC fails to reflect a significant reduction by AR5 in its ECS estimate, which is a critical input to the IAMs. As Professor Happer explained, the correct climate "[s]ensitivity value makes all the difference. Low sensitivity value means modest warming that will be net beneficial. Warming will occur more at night than during the day and more during winter than summer." (Ex. 257, Happer Opening Statement, 3.) Moderate warming will be "[e]specially beneficial in places like Minnesota." (*Id.*)

The scientific evidence strongly supports the IPCC's reductions, and if anything shows that it did not go far enough. Climate models have failed to forecast future temperatures accurately for almost two decades now, predicting much higher temperature increases than have been observed. There has been a "hiatus" in global warming for almost two decades, with warming not significantly greater than zero. Importantly, this hiatus is evident no matter how the temperature is measured (ground sensors, balloons/radiosondes, satellites).

Yet the IWG has continued to rely on outdated science and has refused to update the FSCC. Accordingly, adoption of the FSCC would be arbitrary and capricious.

1. ***AR5 Renders the FSCC Unreasonable and Not the Best Available Measure***

(a) AR5 Rejects the FSCC's Obsolete Assumptions of Climate Sensitivity Values

In AR5, the IPCC substantially reduces its predictions of climate change. In 2007, AR4 gave 2.0°C as the low end of the range for ECS (up to 4.5°C) with a "best estimate" of 3°C.[20] AR4 stated that ECS values below 1.5°C were "very unlikely,"[21] meaning that they were "<10% probability."[22]

In AR5, the IPCC significantly dials back its predictions of climate change. It lowers the bottom of the "likely" ECS range to 1.5°C (without raising the top of the range), now stating that it was "likely"[23] (>66% probability) with "high confidence"[24] that doubling CO_2 concentrations might increase global temperatures by as little as 1.5°C. AR5 states as its reason for the downward adjustment: "This assessment reflects improved understanding, the extended temperature record in the atmosphere and ocean, and new estimates of radiative forcing" – in other words, better science.[25] AR5 explains that new "studies suggest a ***best fit*** **to the observed surface and ocean warming** for ECS values ***in the lower part of the likely range***."[26]

AR5 also notes that increased uncertainty prevents the IPCC from giving a "best estimate" as it had in AR4: "In contrast to AR4, no best estimate for ECS is given because of a

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20 Ex. 268, Intergovernmental Panel on Climate Change, Fourth Assessment, *Climate Change 2007: Synthesis Report* at 38 (2008) [hereafter, "AR4"].
21 *Id.*
22 *Id.* at 27.
23 Ex. 405, AR5, 16.
24 AR5 at 83 (Box 12.2).
25 AR5 at 16.
26 AR5 at 84 (emphasis added).

lack of agreement on the best estimate across lines of evidence and studies and an improved understanding of the uncertainties in estimates based on the observed warming."[27]

AR5 also cites evidence to support lower ECS values. Figure 1 of Box 12.2 in the AR5 report shows that 11 out of 19 observational-based studies of ECS have values below 1.5°C in the range of their ECS probability distribution. (Ex. 213, Lindzen Surrebuttal 16:10-14.) Further, the chart shows 22 studies (of all kinds) with sensitivity values below the IWG's value of 3°C and only 11 at or above that value. In other words, the chart shows twice as many studies favoring sensitivity values below 3°C.

Despite all the caveats in AR5 and the numerous respects in which it retreated from AR4, the IWG has refused to revisit its calculation of the FSCC on the basis of AR4 estimate of ECS, published in 2007.[28] In its response to comments, published July 2015, the IWG noted the dramatic changes but said only that it would "continue to follow and evaluate the latest science on the equilibrium climate sensitivity." (Ex. 101, Polasky Rebuttal, Sched. 1 (IWG, *Response to Comments: Social Cost of Carbon for Regulatory Impact analysis Under Executive Order 12866* (July 2015)) at 12.) The IWG deliberately closed its eyes to what it acknowledged as the source of "the most authoritative statement about equilibrium climate sensitivity."[29] The IWG has unreasonably failed to update its methodology to account for these dramatic changes to a key parameter, including the probability of the low end of the ECS range shifting from less than 10%

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[27] AR5, 85. *See also* AR5 at 16 n.16: "No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies."

[28] Ex. 100, Interagency Working Group on the Social Cost of Carbon, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* at 12-13 (February 2010) [hereafter, "2010 TSD"]. The 2010 TSD was updated in May 2013 and then revised in November 2013 based on two corrections. Interagency Working Group on the Social Cost of Carbon, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* App. B at 22 (May 2013, rev. Nov. 2013, 2d rev. Jul. 2015).

[29] 2010 TSD at 12.

to greater than 66%. This change would significantly alter the ECS input into the IAMs even under the IWG's own probabilistic approach to ECS. The number that it has computed is no longer the best available measure of an externality value.

(b) AR5 and the Evidence Presented Shows That There Has Been a Warming "Hiatus" Since 1998

AR5's reduction of its ECS estimate is consistent with a broader pattern of admissions and caveats. For example, in 2013 AR5 noted the slowdown in warming since 1998: "[T]he rate of warming over the past 15 years (1998–2012) [is] 0.05 [–0.05 to +0.15] °C per decade) which is smaller than the rate calculated since 1951 (1951–2012) [of] 0.12 [0.08 to 0.14] °C per decade."[30] AR5 thus expressly recognized a "hiatus": "the observed recent warming hiatus [is] defined as the reduction in GMST trend during 1998–2012 as compared to the trend during 1951–2012."[31] "The observed GMST [Global Mean Surface Temperature] has shown a much smaller increasing linear trend over the past 15 years than over the past 30 to 60 years. Depending on the observational data set, the GMST trend over 1998–2012 is estimated to be around one third to one half of the trend over 1951–2012. For example, in HadCRUT4 [an observational dataset of ground-based temperature readings] the trend is 0.04°C per decade over 1998–2012, compared to 0.11°C per decade over 1951–2012."[32] As Dr. Spencer put it, "Contrary to almost all expectations, there has been no statistically significant warming in either the RSS or UAH satellite data for the last 18 years, nor in the weather balloon data, leading to the well-know[n] 'hiatus' in global warming." (Ex. 221, Spencer Direct, 16:21-24; *see also* Ex. 200, Happer Direct, 8:17-18 ("Global warming basically stopped about the time of the last large El Niño event in 1998. There has been no significant warming since.").)

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30 AR5 at 37.
31 AR5 at 63 (Box TS.3).
32 AR5 at 61 (Box TS.3).

In contrast, IPCC AR4 predicted that the Earth would warm at a much faster rate: ***"For the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios."***[33] In other words, after expecting an increase of 0.2°C per decade in the early decades of the 21st century (according to AR4), AR5 finds that the rate of warming over the past 15 years **had slowed dramatically and was only approximately *0.05°C*** (or about **1/6** of the 0.3°C that was **projected to occur** in a decade-and-a-half).

(c) AR5 Finds Growing Discrepancies between Observational Data and Climate Model Projections

AR5 notes that models are "running hot" and substantially over-predicting warming: "Almost all CMIP5 historical simulations do not reproduce the observed recent warming hiatus."[34] "[A]n analysis of the full suite of CMIP5 historical simulations (augmented for the period 2006–2012 by RCP4.5 simulations) reveals that 111 out of 114 realizations show a GMST trend over 1998–2012 that is higher than the entire HadCRUT4 trend ensemble," i.e., actual surface temperature data.[35] "The discrepancy between simulated and observed GMST trends during 1998–2012 could be explained in part by a tendency for some CMIP5 models to simulate stronger warming in response to increases in greenhouse-gas concentration than is consistent with observations."[36]

AR5 notes further flaws in how models simulate cloud processes and their effects on temperatures: "Climate models now include more cloud and aerosol processes, and their interactions, than at the time of the AR4, but there remains low confidence in the representation and quantification of these processes in models."[37] These cloud process and their complex

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33 AR4 at 45 (emphasis added).
34 AR5 at 63.
35 AR5 at 61.
36 AR5 at 62.
37 AR5 at 16.

effects are central to the calculation of ECS, however. Clouds not only hold in heat by insulating the Earth, they also reflect it back out into space. In order to reach an ECS value greater than the baseline of 1 °C, one must show positive "feedback mechanisms" — phenomena that augment warming — from clouds and water vapor. (Ex. 200, Happer Direct, 7:22-8:2.) Scientists who argue for high climate sensitivity bear the burden of proving large positive feedback mechanisms (Ex. 221, Spencer Direct 8:22-25; Ex. 200, Happer Direct, 7:14-20), and no one has been able to prove large positive feedbacks in the real world (Ex. 207, Lindzen Direct 5:6-22; Ex. 213, Lindzen Surrebuttal).

These feedback mechanisms are sufficiently complex that the IPCC itself has only "low confidence" in their values. "Uncertainty in the sign and magnitude of the cloud feedback is due primarily to continuing **uncertainty in the impact of warming on low clouds**."[38] "Although trends of cloud cover are consistent between independent data sets in certain regions, substantial ambiguity and therefore low confidence remains in the observations of global-scale cloud variability and trends."[39] **AR5 adds: "cloud feedbacks continue to have larger uncertainties."**[40] The fact that AR5 found such a high degree of uncertainty in feedbacks — the key factor in proving an ECS value greater than 1 °C — cripples the case for the IWG's calculations based on outdated science.

AR5 also contains charts showing the discrepancy between climate models and observational data. (*See* Ex. 213, Lindzen Surrebuttal, 8:14-9:7.) For example, the chart below compares climate model simulations with the recent historical temperature record:

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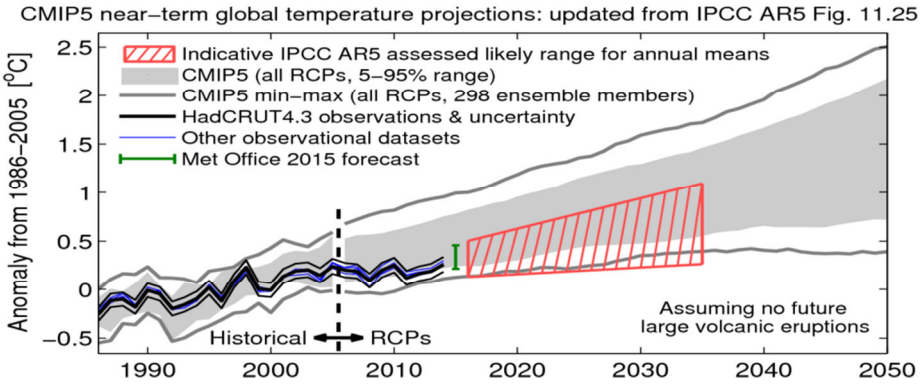
[38] AR5 at 16.
[39] AR5 at 40.
[40] AR5 at 58.



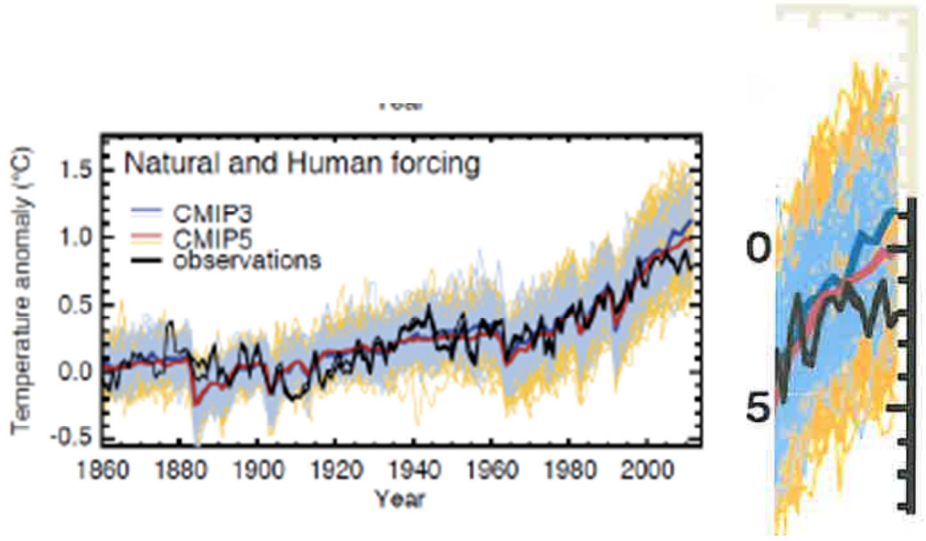
The observed global temperatures, particularly since 2011, are below or just at the bottom bound of the 5-95% envelope of the climate model simulations. Overall, the trend in the model simulations is substantially larger than the observed trend over the past 15 years. Note the hatched red area: the IPCC cited "expert judgment" as the rationale for lowering the projections (indicated by the red hatching), to account for the apparent oversensitivity of the models. (*See* Ex. 213, Lindzen Surrebuttal, 9:5-7.)

AR5 explains that "the implied rates of warming over the period from 1986–2005 to 2016–2035 are lower as a result of the hiatus: 0.10°C–0.23°C per decade, suggesting the AR4 assessment was near the upper end of current expectations for this specific time interval."[41] In other words, **AR5 recognizes that AR4 had overestimated warming.**

Thus, climate models have failed the only test to which they have been given: to predict future temperature. Testing climate models by looking at known historical temperatures – known as "backcasting" – is not a rigorous test because it involves simply fitting the curve of existing data. (Ex. 206, Happer Surrebuttal, 5:12-6:3). Dr. Dessler agreed that predicting temperatures in the future is a much more uncertain exercise than curve-fitting to past historical data. (3A Tr. 26:12-20.) The climate models have failed their only test.

[41] AR5 at 1010.

Further, even though backcasting is a much simpler exercise than predictions, in fact the models have not been able to accurately simulate the 20th century historical record. Figure FAQ10.1 from the IPCC AR5 shows:[42]



This chart shows that climate model simulations (CMIP3, CMIP5) fail to track the strong warming trend from 1910-1945, the cooling from 1945-1970, or the flat temperature trend in the 21st century. The only feature that the climate models accurately simulate is the warming in the last quarter of the 20th century — and as the edge of the graph shows, that accord is falling apart.

(d) AR5 Scaled Back Other Exaggerated Climate Change Predictions.

In addition to dialing back its ECS estimate and acknowledging the discrepancy between climate models and real-world observational data, AR5 noted the uncertainties regarding many

[42] AR5 at 895 (FAQ 10.1, Fig. 1). Exhibit 258, the enlargement of this figure, was excluded from evidence as unnecessary. The enlargement is included here for demonstrative aid purposes.

other climate change predictions. In many important respects, AR5 rejected the exaggerated claims of the State Agencies and the CEOs in this proceeding:[43]

(i) AR5 shows evidence the sea level rise is part of a long-term trend and that sea level rise in 1920-1950 is of the same magnitude as in 1993-2012.

AR5 explains that sea level rise is a part of a long-term, centuries-long trend: "The results are consistent and indicate a significant acceleration that started in the early to mid-19th century, although some have argued it may have started in the late 1700s."[44] AR5 finds that "[t]he trend in GMSL [Global Mean Sea Level] observed since 1993, however, is not significantly larger than the estimate of 18-year trends in previous decades (e.g., 1920–1950)."[45] This observation from AR5 is crucial because ***human CO_2 emissions are reckoned to have increased dramatically only from about 1950 and beyond***. (*See* Ex. 209, Lindzen Direct, Ex. 2 (Report) 10:340-367 (comparing warming in the period 1895-1946 and 1957-2008 and showing equivalent amounts — even though only the latter could have been human-generated forcing).) If the acceleration in sea level rise began before the mid-19th century, then *a fortiori* it could not have been "caused" by human CO_2 emissions because they were insignificant at that point. Sea level rise — like other measures such as ice melt and temperature — is a natural phenomenon. The AR5 statement that the rise began to accelerate before CO_2 emissions began to increase substantially demonstrates that sea level rise is not driven by human CO_2 emissions.

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[43] Although the State Agencies and CEOs have attempted to point to sea level change, extreme weather events, and droughts as proof of climate change, they fail to tether these arguments to the FSCC. The IAMs on which the FSCC are based contain an input for ECS; if that input is flawed (as the evidence demonstrates), the State Agencies and CEOs have failed to demonstrate how the other indicia of climate change could compensate for the defect.

[44] AR5 at 289.

[45] AR5 at 290.

The rate of change in global mean sea level is shown in the figure below, which indicates that the rate of rise during 1920-1950 was comparable to, if not larger than, the value in recent years:[46]

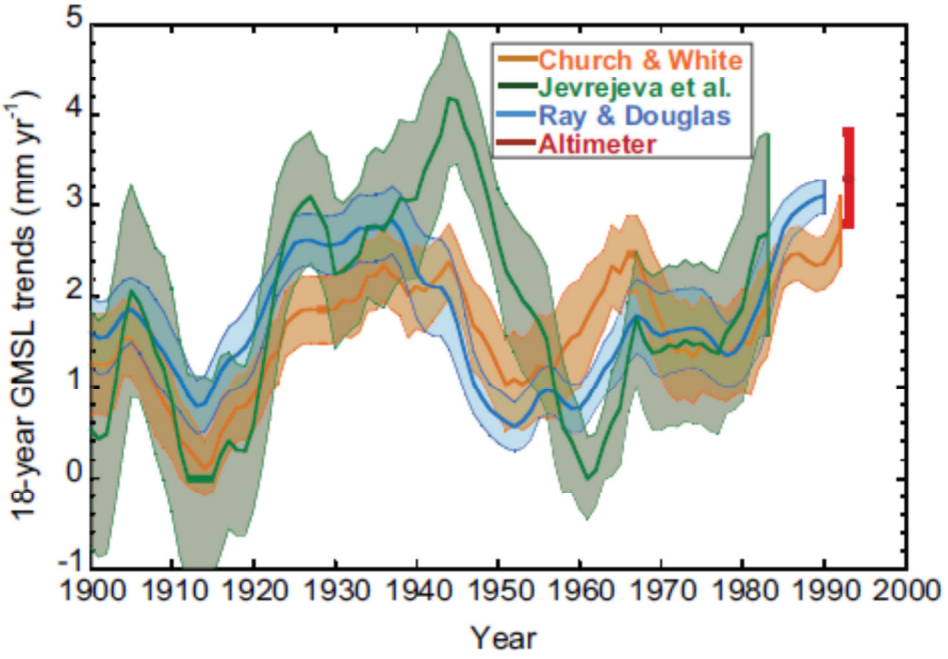

Figure 3.14 | 18-year trends of GMSL rise estimated at 1-year intervals. The time is the start date of the 18-year period, and the shading represents the 90% confidence. The estimate from satellite altimetry is also given, with the 90% confidence given as an error bar. Uncertainty is estimated by the variance of the residuals about the fit, and accounts for serial correlation in the residuals as quantified by the lag-1 autocorrelation.

Additional scientific evidence supports shows there is no link between sea level rise and CO_2. Sea level has been rising for as long as there has been instrumentation. Actual observations do not support a statistically significant acceleration in the rate of sea level rise over the past century. (Ex. 233, Bezdek Rebuttal Report, 11:345-12:383; Ex. 235, Bezdek Surrebuttal, 13:10-19; Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 154-160.) The potential sea level rise mentioned by Dr. Dessler (1 meter in a century (Ex. 103,

[46] AR5 at 289 (Fig. 3.14).

Dessler Rebuttal, 7:14-15)) was disproven by the evidence as outside the realm of possibility. The amounts under discussion are in the realm of 1-2 mm per year (10-20 cm per century) and there is no sign humans have caused that to accelerate. (Ex. 213, Lindzen Surrebuttal, 36:1-37:4.) Dr. Bezdek cited 18 peer-reviewed articles supporting this point. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 154-160.) The proponents of the FSCC had no answer.

(ii) Sea ice is most likely increasing over the long term and reversing short-term declines.

AR5 finds that "[i]t is very likely that the annual Antarctic sea ice extent *increased* at a rate of between 1.2 and 1.8% per decade (0.13 to 0.20 million km2 per decade) between 1979 and 2012 (very high confidence)."[47] The increase in Antarctic sea ice is significant, since global warming should result in the opposite. AR5 adds that "[w]hile surface melting will remain small, an increase in snowfall on the Antarctic ice sheet is expected (medium confidence), resulting in a negative contribution to future sea level from changes in surface mass balance."[48] In other words, the Antarctic ice sheet will grow as well.

As for the Arctic, AR5 notes important uncertainties: "Arctic temperature anomalies in the 1930s were apparently as large as those in the 1990s and 2000s. There is still considerable discussion of the ultimate causes of the warm temperature anomalies that occurred in the Arctic in the 1920s and 1930s."[49] Temperature similarities between the 1920s and today suggests causes unrelated to CO_2 levels.

AR5 found that the loss of sea ice was not irreversible: "The reversibility of sea ice loss has been directly assessed in sensitivity studies to CO_2 increase and decrease with Atmosphere–

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47 AR5 at 40 (emphasis added).
48 AR5 at 25.
49 AR5 at 907.

Ocean General Circulation Models (AOGCMs) or Earth System Models (ESMs). None of them show evidence of an irreversible change in Arctic sea ice at any point."[50] The uncertainty as to the reason for the anomalies indicates that there is a high probability that the shrinking ice is part of a natural cycle rather than caused by humans (much less specifically CO_2 emissions), which is supported by the increase in Antarctic sea ice.

Indeed, AR5 even places uncertainty at the center of these measures. Given the unknowns involved, AR5 stated that it could not even find the sea ice loss in Greenland to be permanent or even inevitable. "Considering the present state of scientific uncertainty, a likely range cannot be quantified. The complete loss of the Greenland ice sheet is not inevitable because this would take a millennium or more; if temperatures decline before the ice sheet has completely vanished, the ice sheet might regrow."[51] The purported losses here are sufficiently uncertain that they cannot be simply assumed, as the State Agencies and CEOs do.

In fact, the reduction in summer Arctic ice cover has reversed. (Ex. 209, Lindzen Direct Report, 14:550-555.) There is a mechanism (the Wyatt-Curry "stadium wave") to support the argument that the increase is the longer-term trend that will win out. (Ex. 213, Lindzen Surrebuttal, 34:13-35:14.) Moreover, even if sea ice were still decreasing, no convincing connection to human causes has been demonstrated. (Ex. 213, Lindzen Surrebuttal, 34:7-11.)

The same uncertainty exists with respect to land-based glaciers. Even when John Muir, founder of the Sierra Club, found Glacier Bay in 1879, most of the glaciers he saw on 18th century maps were already gone: **90% of the melting had taken place before 1900 — long before human causes could be blamed**. (Ex. 206, Happer Surrebuttal, 15:13-17:3.) Dr. Bezdek produced 31 peer-reviewed articles supporting this argument. (Ex. 231, Bezdek

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[50] AR5 at 71.
[51] AR5 at 72.

Compendium of Scientific Literature on Climate Change, 160-165.) Again, the proponents of the FSCC had no answer.

(iii) AR5 finds low confidence in attributing extreme weather events to anthropogenic global warming.

AR5 scales back AR4's predictions in terms of floods, droughts, and other kinds of extreme weather. For example:

- AR5 finds no evidence of changes in global precipitation trends since 1990.[52]
- AR5 finds no change in river runoff.[53]
- AR5 finds no evidence that floods are worse in the post-industrial age.[54]
- AR5 finds no increase in droughts over the past 40 years,[55] and that 20th century droughts are smaller in magnitude and shorter in duration than other droughts during the last millennium.[56]
- AR5 finds little evidence for changes in tropical cyclone activity.[57]

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[52] "Changes in precipitation are harder to measure with the existing records, both because of the greater difficulty in sampling precipitation and also because it is expected that precipitation will have a smaller fractional change than the water vapour content of air as the climate warms. Some regional precipitation trends appear to be robust, but when virtually all the land area is filled in using a reconstruction method, the resulting time series of global mean land precipitation shows little change since 1900." (AR5 at 42.)

[53] "The most recent and most comprehensive analyses of river runoff do not support the IPCC Fourth Assessment Report (AR4) conclusion that global runoff has increased during the 20th century." (AR5 at 44.)

[54] "With high confidence, floods larger than recorded since the 20th century occurred during the past five centuries in northern and central Europe, the western Mediterranean region and eastern Asia." (AR5 at 50.)

[55] "New results also indicate that the AR4 conclusions regarding global increasing trends in droughts since the 1970s are no longer supported." (AR5 at 44.) "Although the AR4 concluded that it is more likely than not that anthropogenic influence has contributed to an increased risk of drought in the second half of the 20th century, an updated assessment of the observational evidence indicates that the AR4 conclusions regarding global increasing trends in hydrological droughts since the 1970s are no longer supported. Owing to the low confidence in observed large-scale trends in dryness combined with difficulties in distinguishing decadal-scale variability in drought from long-term climate change, there is now low confidence in the attribution of changes in drought over global land since the mid-20th century to human influence." (AR5 at 73.)

[56] "There is high confidence for droughts during the last millennium of greater magnitude and longer duration than those observed since the beginning of the 20th century in many regions." (AR5 at 50.)

[57] "Confidence remains low for long-term (centennial) changes in tropical cyclone activity, after accounting for past changes in observing capabilities." (AR5 at 50.) "Globally, there is

- **In general, AR5 finds little evidence for increases in severe weather.**[58]

These AR5 findings directly contradict the argument that anthropogenic sources of CO_2 are causing increases in severe weather frequency, duration, and intensity. If anything, the historical record referenced by AR5 suggests that natural variability is responsible. The FSCC is not supported by the extreme weather evidence presented by AR5.

Moreover, the State Agencies and CEOs fail to establish by a preponderance of the evidence that these other events are even ***happening***, much less that they are due to human effects on the climate. (Ex. 207, Lindzen Direct, 6:24-7:7, 10:21-11:2; Ex. 209, Lindzen Direct Report, 14:544-15:567; Ex. 213, Lindzen Surrebuttal, 33:3-4, 45:10-16; Ex. 206, Happer Surrebuttal, 17:5-18:7; *see also* Ex. 235, Bezdek Surrebuttal, 13:1-16:11.) As Dr. Mendelsohn explained:

> The popular press and therefore the public are confused about weather versus climate change. Every hurricane that hits a major city is reported in the news today as evidence of climate change. Although the damage per storm has increased because there is more in harm's way today than in the past (Pielke et al. 2008), **extreme events such as tropical cyclones have not changed in either their intensity or their frequency in the last 100 years** (Landsea et al. 2006). That is, hurricanes are not yet evidence of climate change.

(Ex. 216, Mendelsohn Direct Report, 3 (emphasis added).) None of these concerns is "proof" of global warming — climate is always changing. (Ex. 206, Happer Surrebuttal, 15:7-11.) In fact, the State Agencies and CEOs present an exaggerated picture of climate change that is ***not consistent with the scientific evidence described in either AR5 or peer-reviewed literature***.

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low confidence in attribution of changes in tropical cyclone activity to human influence. This is due to insufficient observational evidence, lack of physical understanding of the links between anthropogenic drivers of climate and tropical cyclone activity, and the low level of agreement between studies as to the relative importance of internal variability, and anthropogenic and natural forcings." (AR5 at 73.)

[58] "There is low confidence of large-scale trends in storminess over the last century and there is still insufficient evidence to determine whether robust trends exist in small-scale severe weather events such as hail or thunderstorms." (AR5 at 50.)

Instead, only the most exaggerated accounts are cherry-picked for consideration. Examination of the entire record shows a more balanced picture. The question is whether human activities have accelerated any of these changes outside natural variation, and the preponderance of the evidence is that they have not.

- **No evidence of unprecedented temperatures.** AR5 acknowledges that contemporary temperatures are not necessarily the highest in human history: "Continental-scale surface temperature reconstructions show, with high confidence, multi-decadal periods during the Medieval Climate Anomaly (year 950 to 1250) that were in some regions as warm as in the late 20th century."[59] The year 2014 was not the warmest year on record. (Ex. 235, Bezdek Surrebuttal, 17.) **Besides, as Dr. Abraham testified, "[T]he temperature in any single year is not a meaningful development."** (Abraham, 3B Tr. 93:20-21.) Instead, Dr. Abraham advised to look at long-term trends, with 17 years being the lower bound. (*Id.* at 91:13-18, 92:9-23.) In any event, reports of the "hottest year on record" look at only recent history. Temperature records have been kept only since the late 19th century, and historical cycles of warming (such as the Medieval Warm Period) have been more significant than predicted temperatures today. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 21-33.)

- **No evidence of extreme weather from CO_2.** There has been no credible evidence of an increase in extreme weather events or storms. There have been fewer hurricanes and fewer landfalls. (Ex. 213, Lindzen Surrebuttal, 44:2-12.) There have been fewer severe tornadoes and the damage they have caused (normalized for GDP) has fallen — and even the number of severe thunderstorms that may spawn tornadoes has dropped. (Ex. 213, Lindzen Surrebuttal, 44:14-17, 45:1-8; Ex. 206, Happer Surrebuttal, 17-18.) This is consistent with climate science: storms arise from temperature and moisture gradients, and climate change should be expected to decrease both. (Ex. 209, Lindzen Direct Report, 14:555-15:562.) Dr. Bezdek gave 93 articles making this point. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 7-21.)

- **No evidence of droughts from CO_2.** Current droughts are still within ordinary patterns of severe drought. (Ex. 213, Lindzen Surrebuttal, 40:10-41:3.) Even the current drought in California is suspected to be only 20% due to anthropogenic forcings, with natural variability the dominant cause. (Ex. 213, Lindzen Surrebuttal, 41:1-3.) According to the EPA, the number of heat waves was markedly greater in the 1930s (the Dust Bowl), and those were hotter as well. (Ex. 213, Lindzen Surrebuttal, 41:5-43:11.) While Dr. Dessler points to the heat wave in Paris as proof of climate change, that is a confusion of weather and climate. The deaths were due to a *very quick* spike of warming (approximately 18 °C), not a gradual shift in average temperatures (3°C). (Ex. 206, Happer Surrebuttal, 11:12-12:2.) Dr. Bezdek cited 65

[59] AR5 at 5.

peer-reviewed articles supporting this thesis. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 21-33.)

Accordingly, the FSCC is not supported by a preponderance of the evidence.

(iv) AR5 expresses substantial doubts regarding catastrophic climate scenarios.

AR5 undermines the argument that anthropogenic sources of CO_2 will cause catastrophic scenarios.

- AR5 generally dismisses catastrophic scenarios without scientific basis.[60]
- AR5 finds that catastrophic scenarios of sea level rise are not supported by the evidence.[61]
- AR5 finds that "runaway" warming from melting permafrost is not supported by the evidence.[62]
- AR5 finds that "runaway" warming from release of methane deposits is not supported by the evidence.[63]

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[60] "Abrupt climate change is defined in this IPCC Fifth Assessment Report (AR5) as a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades and causes substantial disruptions in human and natural systems. There is information on potential consequences of some abrupt changes, but in general there is low confidence and little consensus on the likelihood of such events over the 21st century." (AR5 at 70.)

[61] "Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the likely range during the 21st century. However, there is medium confidence that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century." (AR5 at 25.) "The basis for higher projections of global mean sea level rise in the 21st century has been considered and it has been concluded that there is currently insufficient evidence to evaluate the probability of specific levels above the assessed likely range. Many semi-empirical model projections of global mean sea level rise are higher than process-based model projections (up to about twice as large), but there is no consensus in the scientific community about their reliability and there is thus low confidence in their projections." (AR5 at 26.)

[62] "The existing modelling studies of permafrost carbon balance under future warming that take into account at least some of the essential permafrost-related processes do not yield consistent results, beyond the fact that present-day permafrost will become a net emitter of carbon during the 21st century under plausible future warming scenarios (low confidence). This also reflects an insufficient understanding of the relevant soil processes during and after permafrost thaw, including processes leading to stabilization of unfrozen soil carbon, and precludes any quantitative assessment of the amplitude of irreversible changes in the climate system potentially related to permafrost degassing and associated feedbacks." (AR5 at 71.)

[63] "Deposits of CH_4 clathrates below the sea floor are susceptible to destabilization via ocean warming. However, sea level rise due to changes in ocean mass enhances clathrate stability in the ocean. While difficult to formally assess, initial estimates of the 21st century

- AR5 finds that tropical rainforest collapse is not supported by the evidence.[64]

- AR5 finds that loss of Arctic sea ice is not irreversible.[65]

- AR5 finds that loss of the Greenland ice sheet is not irreversible.[66]

Scientific evidence also refutes a potpourri of additional claims by proponents of the FSCC:

- **No evidence of ocean acidification harms from CO_2.** The potential ocean acidification from CO_2 is much weaker than the natural variation of pH among habitats, seasons, days, and even hourly changes. Ocean life already undergoes more pH change than would be expected from CO_2 absorption.[67] Dr. Bezdek cited 150 peer-reviewed studies, to which the opposing Parties never responded, explaining (for example) that warmer ocean waters would benefit corals by allowing them to shift poleward and that corals can adapt to acidification. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 69, 132-154.) Researchers from the Wildlife Conservation Society found that the impacts of warming and acidification on corals are more complex than models assume, and corals can withstand more stress than expected. (Ex. 206, Happer Surrebuttal, 12.) Further, researchers from Singapore and the Woods Hole Oceanographic Institute found that ocean acidification is driven much more by changes in ocean currents than anthropogenic CO_2. (*Id.*)

- **No evidence of ocean ecosystem harm from CO_2.** Dr. Bezdek cited numerous peer-reviewed studies, to which the opposing Parties never responded. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 126-132; *see also* Ex. 233, Bezdek Rebuttal Report, 18-19.)

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feedback from CH4 clathrate destabilization are small but not insignificant. It is very unlikely that CH_4 from clathrates will undergo catastrophic release during the 21st century (high confidence)." (AR5 at 71.)

[64] "The existence of critical climate change driven dieback thresholds in the Amazonian and other tropical rainforests purely driven by climate change remains highly uncertain." (AR5 at 71.)

[65] "The reversibility of sea ice loss has been directly assessed in sensitivity studies to CO_2 increase and decrease with Atmosphere–Ocean General Circulation Models (AOGCMs) or Earth System Models (ESMs). None of them show evidence of an irreversible change in Arctic sea ice at any point." (AR5 at 71.)

[66] "Considering the present state of scientific uncertainty, a likely range cannot be quantified. The complete loss of the Greenland ice sheet is not inevitable because this would take a millennium or more; if temperatures decline before the ice sheet has completely vanished, the ice sheet might regrow." (AR5 at 72.)

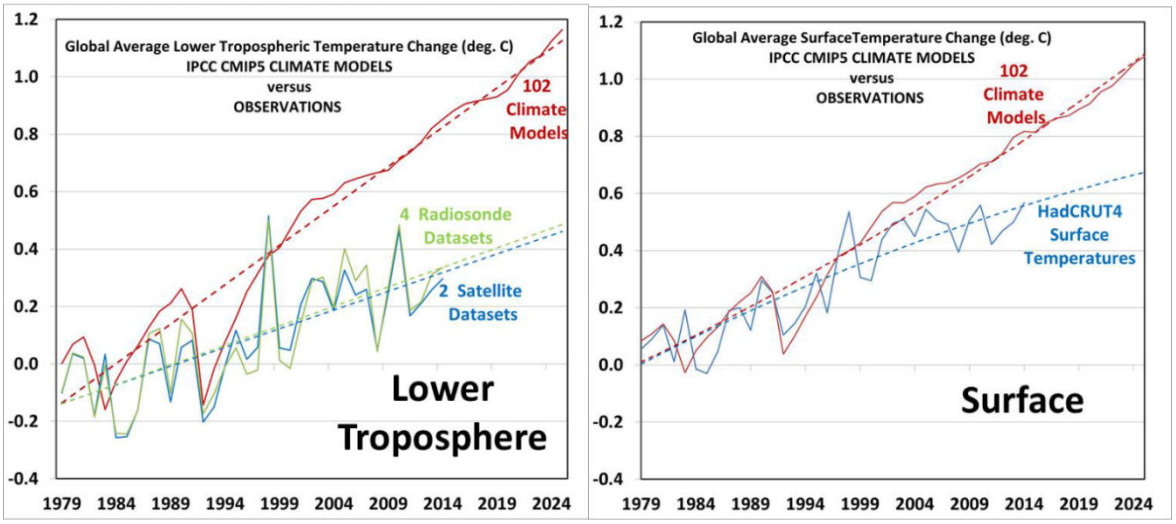
[67] Ex. 235, Bezdek Surrebuttal, 15:4-16:2 (quoting Prof. Robert Carter, Prof. Ross McKitrick, Prof. Vincent Courtillot, Prof. Ian Plimer, Prof. Freeman Dyson, Dr. Matt Ridley, Prof. Christopher Essex, Sir Alan Rudge, Dr. Indur Goklany, Prof. Nir Shaviv, Prof. Will Happer, Prof. Fritz Vahrenholt, Prof. Richard Lindzen, "The Small Print: What The Royal Society Left Out" 13 (Global Warming Policy Foundation March 2015).

- **No evidence of terrestrial ecosystem harm from CO_2.** Dr. Bezdek cited 44 peer-reviewed articles, to which the opposing Parties never responded. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 107-114; *see also* Ex. 206, Happer Surrebuttal, 13-14.)

The 95th percentile value for the FSCC was included to account for "low-probability, high-impact damages." (Ex. 100, Polasky Direct Schedule 2 (Feb. 2010 TSD), 30.) However, AR5 demonstrates that these damages are inconclusive at best and unsupportive of the FSCC at worst.

2. ***Observational Data Refute Climate Models***

The scientific evidence strongly supports AR5's scaling-back of its climate predictions. If anything, the IPCC did not go far enough. The models are running substantially hotter than observed temperatures, whether measured by surface sensors, balloon/radiosonde, or satellite. (Ex. 221, Spencer Direct, 6:21-26; Ex. 233, Bezdek Rebuttal Report, 5:168-180; Ex. 227, Spencer Surrebuttal, 1:17-3:1.)



As Dr. Spencer observed, "The discrepancy is generally a factor of 2 to 3, that is, models tend to produce at least twice as much warming as the observations over the last several decades, which is the period during which human emissions and atmospheric concentrations have been the greatest." (Ex. 223, Spencer Direct, Ex. 2 (Report), at 1.) "Nearly all of the IPCC climate

models have predicted several hundred percent more warming over the past twenty years than has actually been observed. There is something seriously wrong with the models." (Ex. 200, Happer Direct, 7:10-12.) Observed temperature trends for the past 30 years have run below the range encompassing 95% of climate models. (Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 5:182-6:211 & Fig. 2; Ex. 209, Lindzen Direct, Ex. 2 (Report), at 9 (Fig. 9); Ex. 202, Happer Direct, Ex. 2 (Report), at 7 (Fig. 5), from Fig. 1 of Fyfe, et al. (2015).)

Further, there is a manifest consensus on the existence of a hiatus in warming, which AR5 accepted. (Ex. 213, Lindzen Surrebuttal, 20:1-6, quoting AR5 at 40.) As Dr. Abraham put it, "[t]he climate science community has reached a near consensus that the warming rate of global surface temperature has exhibited a **slowdown** over the last decade to decade and a half."[68] Dr. Dessler has conceded that the hiatus exists: "Dr. Spencer is correct. . . . **[I]t is correct to say that there has been no statistically significant warming since 2000.** . . . [T]he trend is smaller than the uncertainty." (Ex. 103, Dessler Rebuttal, 15:5-9 (emphasis added).) IPCC authors such as Kevin Trenberth (IPCC author/editor and father of anthropogenic global warming theory), Rajendra Pachauri (former president of IPCC), and Hans von Storch (IPCC lead author) have all recognized that this hiatus exists and poses a question that requires explanation. (Ex. 235, Bezdek Surrebuttal, 3:9-5:7.) All of the data are pointing in the same direction, and scientists must follow the observational data. (Ex. 206, Happer Surrebuttal, 1:14-20.) That direction is the opposite from what the FSCC assumes. That direction is that the rate of warming is slowing, not increasing, notwithstanding the increase in CO_2 levels. In short, the current temperature evidence supports a lower externality value, not a higher one. The causal

[68] Ex. 262, Grant Foster and John Abraham, "Lack of Evidence for a Slowdown in Global Temperature," in U.S. CLIVAR, 13 *Variations* (Summer 2015) (emphasis added).

assumptions upon which the FSCC is based are just demonstrably wrong and the Minnesota externality value needs to be adjusted downward to comport with the current evidence.

The hiatus refutes the FSCC because the models upon which the IWG relied failed to predict that it could happen. "The hiatus was not predicted by the models or by the IPCC reports, and it remains largely unexplained." (Ex. 221, Spencer Direct, 5:6-7; *see also* Ex. 200, Happer Direct, 9:13-14; Ex. 207, Lindzen Direct, 10:10-15.) As Dr. Spencer noted, NOAA essentially conceded that a hiatus of more than 15 years would invalidate current climate models: "even NOAA has admitted that 'The simulations rule out (at the 95% level) zero trends for intervals of 15 yr or more,' and yet we now stand at 18 years without warming in the real climate system." (Ex. 223, Spencer Direct Report, 4.) **In other words, the models have been wrong long enough to be rejected as unreliable and an insufficient basis upon which to allocate resources and to favor one industry over another (e.g., wind vs coal).** Before the government can take action that will drive out jobs and raise electricity rates, the government should be required to come forward with conclusive evidence that the result is justified. The warming hiatus proves the opposite.

Other Parties to this proceeding concede that the climate models are flawed. Dr. Dessler admitted that "over the last decade," the models have "run 'hot.'" (Ex. 103, Dessler Rebuttal 25:16-18.) His proposed cause is that the models assumed that the sun was hotter than it really is, which caused the models to run too hot for about a decade. (Ex. 103, Dessler Rebuttal 25:16-18; Dessler, 3B Tr. 10:11-18.) But in the end, the explanation for why the models are wrong is neither here nor there. The relevant point is: the models are wrong. That means the proponents of the FSCC are asking the ALJ and the Commission to adopt a basis for allocating resources that they themselves effectively admit is based on inaccurate and incorrect assumptions. Even if

one shared Dr. Dessler's view as to the cause, his admissions mean ***the models were wrong when the IWG based its federal SCC calculation on them. The models have been wrong for at least a decade, and during that time the IWG depended on them to formulate the FSCC.***

3. *The FSCC Depends on Unproven "Positive Feedback" Mechanisms*

A low value for ECS is not surprising, because the direct "greenhouse" effect of doubling CO_2 is only 1°C. As discussed above (Section III-D-1-c), in order to reach an ECS value greater than the baseline of 1 °C, one must show positive feedback mechanisms such as clouds and water vapor. (Ex. 200, Happer Direct, 7:22-8:2.) Scientists who argue for high climate sensitivity bear the burden of proving large positive feedback mechanisms (Ex. 221, Spencer Direct 8:22-25; Ex. 200, Happer Direct, 7:14-20), and no one has been able to prove large positive feedbacks in the real world. (Ex. 207, Lindzen Direct 5:6-22; Ex. 213, Lindzen Surrebuttal 17:2-19:8.)

The positive feedbacks that have been proposed, such as the water vapor feedback, can account for only about 0.5°C of further warming. (Ex. 209, Lindzen Direct Report, 11:418-423.) In order to reach values of ECS any higher — such as the central values used by the IWG — one would need to demonstrate (by a preponderance of the evidence, for this proceeding) a feedback sufficiently high. No peer-reviewed scholarship has validated sufficient positive feedback mechanisms to get to 3°C. (Ex. 206, Happer Surrebuttal, 2:14-20.) "If there were strong positive feedbacks to give a large sensitivity, we would not have experienced lack of warming for the past 18 years, when CO_2 emissions were steadily increasing." (Ex. 257, Happer Opening Statement, 3.) The IPCC has overstated feedback mechanisms due to an incomplete and incorrect understanding, which has resulted in excessively high ECS figures. (Ex. 207, Lindzen Direct, 2:13-19, 5:6-22.) Without a validated feedback mechanism, the argument for a high ECS

collapses. The most recent science validates lower feedbacks and therefore a lower ECS. (Ex. 206, Happer Surrebuttal, 3:1-16.) The feedbacks needed for the IWG's assumed ECS have not been shown; the FSCC is therefore based on supposition rather than science.

The "Iris Effect," first discussed by Dr. Lindzen in 2001, has come under renewed discussion as a possible source of negative feedbacks. It proposes that increased sea surface temperatures in tropics results in ***reduced*** cirrus cloud cover and thus more heat leaking into space, like light through the iris of an eye. (Ex. 209, Lindzen Direct Report, 12:447-457; Ex. 213, Lindzen Surrebuttal, 10:19-11:2; Lindzen, 2A Tr. 17:4-18:10.) The Iris Effect has not been disproven,[69] but is instead gaining renewed interest. (Ex. 213, Lindzen Surrebuttal, 11:6-13:14.) The Ringberg15 conference, which Dr. Dessler attended, had presentations on the Iris Effect, validating its existence and evaluating the degree of possible negative feedback it could yield. (Ex. 213, Lindzen Surrebuttal, 13:1-14.) A recent paper by Mauritsen and Stevens[70] reviews the scientific literature on the subject and found that the Iris Effect was both robust and validated. (Lindzen, 2A Tr. 34:20-35:4, 35:19-36:4.) Even Dr. Dessler had to concede, under cross examination, that he published a blog post admitting that the Iris Effect might not be wrong (Dessler, 3A Tr. 35:5-13) and that a recent study found that "cloud cover is reduced as the climate warms" and that "for runs with the strong 'iris' the model's climate sensitivity is reduced from 2.8°C for doubled carbon dioxide to 2.2°C"[71] – well below the IWG's assumed value of 3.0°C.

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[69] Even in this proceeding, attempts to perpetuate the "discrediting" of the Iris Effect were based on incomplete renditions of the available literature, ignoring published responses by Dr. Lindzen and his co-authors and misinterpreting the critiques listed. (Ex. 213, Lindzen Surrebuttal, 11:6-12:16.)

[70] Thorsten Mauritsen & Bjorn Stevens, *Missing Iris Effect As A Possible Cause Of Muted Hydrological Change And High Climate Sensitivity In Models*, 8 Nature Geosci. 346 (April 20, 2015), available at http://www.nature.com/ngeo/journal/v8/n5/full/ngeo2414.html.

[71] Ex. 259, Andy Dessler, *The Return of the Iris Effect?*, RealClimate (Apr. 24, 2015).

As Professor Lindzen testified, the Iris Effect should be kept in perspective: it is a ***negative*** feedback. (Ex. 255, Lindzen Opening Statement, 4.) Even without the Iris Effect, the State Agencies and CEOs still have failed to identify any ***positive*** feedbacks strong enough to support a high sensitivity value by a preponderance of the evidence.

4. *New Evidence of Aerosol Cooling Refutes the FSCC's Assumptions*

Professor Lindzen testified that, even apart from AR5, 14 studies and 20 experiments validated a lower range for ECS between the 2010 issuance of the FSCC and its 2013 update. (Ex. 213, Lindzen Surrebuttal, 17:2-3.) Since then, robust new findings about aerosols indicate that a lower value is more likely. The greatest uncertainty in external forcing of climate is aerosols, and a new paper by Stevens (2015)[72] shows that it is much smaller than the models assume. (Ex. 213, Lindzen Surrebuttal, 10:11-15.) Climate modelers have used the uncertain negative feedback effect of aerosols to "cancel" excess warming produced by models, bringing those models more in line with observations. But recent scholarship (Stevens 2015) has reduced the uncertainty surrounding aerosols, which prevents their use as a "fudge factor." "These studies point to low climate sensitivity values which would imply minimal danger or even net benefit from climate change." (Ex. 207, Lindzen Direct, 9:17-25; *see also* Ex. 209, Lindzen Direct Report, 6:191-7:204 & Fig. 7 & Table 1 (showing the canceling in graphs).) Nicholas Lewis, who has published papers (both as sole author and jointly with IPCC contributors) cited by the IPCC in its latest report, has used the new aerosols research by Stevens to validate a climate sensitivity value of 1.64°C. (Ex. 213, Lindzen Surrebuttal, 17:6-10.)

[72] Bjorn Stevens, *Rethinking the Lower Bound on Aerosol Radiative Forcing*, 28 J. Climate 4794 (2015), available at http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00656.1.

5. ***Attempts to "Disprove" the Hiatus Have Proven Fruitless***

Despite this evidence-based consensus, some scientists have attempted to deny the uniform observations of the hiatus. But a closer observations shows that none of these attempted rescues save the models from their drastic overpredictions of warming: they remain broken despite the best attempts to revive them by redescribing reality to fit the models' output. For example, a much-hyped paper by Thomas R. Karl[73] (the "Karl Paper") claims to "refute[] the notion that there has been a slowdown or 'hiatus.'" (Ex. 102, Abraham Rebuttal, 10:8-9 (quoting a NOAA summary of the Karl Paper).) The paper does not draw on new observations of data, but instead manipulates existing data sets, which makes it uniquely prone to bias and motivated reasoning (adjusting the data in order to reach a predetermined result, rather than following where the data lead). The Karl Paper manipulates existing observations into showing that there has been warming by "adjusting" earlier measurements downward in comparison to current temperatures, producing an artificial warming trend. (Ex. 213, Lindzen Surrebuttal, 23:10-24:3.) The Karl Paper has been heavily criticized for its methods and especially the seemingly outcome-driven nature of its results:

- The adjustments were not random, but rather uniformly nudged the data in favor of warming — a sign of a biased and questionable adjustment. (Ex. 211, Lindzen Rebuttal Report, 3:33-50; Ex. 213, Lindzen Surrebuttal, 26:1-13.)
- The Karl Paper takes strong data from sea surface buoy and homogenizes it with questionable data gathered from engine intake channels known to be warmer than other waters. (Ex. 211, Lindzen Rebuttal Report, 3:53-4:58.)
- The Karl Paper also refused to use the highly credible Argo buoy dataset. (Ex. 213, Lindzen Surrebuttal, 24:5-25:12.)

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[73] Thomas R. Karl, *et al.*, *Possible Artifacts of Data Biases in the Recent Global Surface Warming Hiatus*, 348 Science 1469 (June 26, 2015), DOI: 10.1126/science.aaa5632, available at http://www.sciencemag.org/content/early/2015/06/05/science.aaa5632.abstract.

- In order to interpolate the data between buoys, the Karl Paper used temperatures from nearby landmasses, which also served to skew the measurements warmer. (Ex. 213, Lindzen Surrebuttal, 26:18-27:8.)

- To make matters even worse, the Karl Paper cherry-picked start and end dates in order to artificially manufacture a warming trend. (Ex. 211, Lindzen Rebuttal Report, 4:58-59; Ex. 213, Lindzen Surrebuttal, 27:11-17.)

Yet despite all of this manipulation, the Karl Paper still found only minute levels of warming. (Ex. 211, Lindzen Rebuttal Report, 4:60-5:71 & Fig. 1.) The Karl Paper finds warming consistent with only the 2.4th percentile of IPCC climate models (Ex. 213, Lindzen Surrebuttal, 23:1-8): in other words ***97.6% of climate models still overpredict the minute warming that the Karl Paper purports to have found***.

Dr. Lindzen is not the only scientist who has noticed the serious deficiencies and limited value of the Karl Paper: other scientists from the National Center for Atmospheric Research, the University of Leeds, and the International Research Institute for Climate and Society have rejected the Karl Paper's conclusions. (Ex. 213, Lindzen Surrebuttal, 27:19-28:17 (and sources listed therein).) Indeed, if the Karl Paper is correct, then the global warming models were themselves wrong to predict warming through most of the 20th century (when unquestionably anthropogenic CO_2 emissions were at their greatest). (Ex. 213, Lindzen Surrebuttal, 23:10-24:3.)

Other scientists have attempted to find the "missing" warming in the ocean, but have failed. NASA itself has found no evidence of heat being stored in the deep ocean. (Ex. 235, Bezdek Surrebuttal, 11:15-12:14; Ex. 227, Spencer Surrebuttal, 13:11-14:8.) The upper ocean (down to 700 m depth) appears to show mixed results, warming on some measures and cooling on others.[74] (Ex. 213, Lindzen Surrebuttal, 20:9-21:6 (and sources cited therein).) The deep ocean (below 700 m) is more of a mystery because observational measures were not available

[74] The study cited by Dr. Dessler to show warming in the upper ocean (Balmaseda et al. 2013) is based on models of the upper ocean, not actual observations.

until 2005; since then actual observations show the deep ocean cooling. (Ex. 213, Lindzen Surrebuttal, 21:7-21 (rejecting model-based theories for warming in favor of actual measured cooling).) Even Dr. Abraham's own research finds that heat is being stored in the ocean at roughly one-third the rate predicted by models. (Ex. 206, Happer Surrebuttal 7:21-8:3.)

E. Step Four of Speculation: Uncertainty in "Damages Functions" — Predictions That Overstate Harms of Climate Change

The damages functions built into IAMs — the equations that calculate overall harms based on a given rise in temperature — are highly uncertain and both overstate the harms of climate change while underestimating the potential benefits. Dr. Mendelsohn testified that "[i]mplicit damage in IWG estimates predict near-term (next 30-60 years) damage that is too high." (Ex. 261, Mendelsohn Opening Statement, 3.) In some cases these assumptions lead to ridiculous scenarios that literally could not happen. "For example, an $18 dollar SCC implies that a 1 degree warming in 30 years will cause damage equal to $2 trillion per year. ***There is no known mechanism that can cause such high damages so soon from such a small change in temperature***." (Ex. 261, Mendelsohn Opening Statement, 3 (emphasis added).) In fact, he testified that "you can't even get within an order of magnitude of that." (3B Tr. 41:22-23.)

Dr. Mendelsohn also testified that the "IWG ignored longer time lags of higher climate sensitivity" (Ex. 261, Mendelsohn Opening Statement, 3): the higher the ECS value, the slower the adjustment will be — but the IWG assumed exactly the opposite, that damages would be fast and inevitable. Those assumptions are false, however. Damages calculations reach these irrational levels because they are untethered to reality: the IAMs assume there will be essentially no mitigation of CO_2 emissions and that humans will not adapt to higher temperatures. In addition, the IAMs fail to properly account for a basic fact of biology: CO_2 is plant food that has beneficial impacts as well as potentially adverse ones.

1. ***Failure to Consider Mitigation***

The IWG failed to adequately consider mitigation in its models. (Mendelsohn 3B Tr. 35:12-37:12; Ex. 261, Mendelsohn Opening Statement, at 2.) AR5 and the best available science demonstrate that the FSCC is not the correct policy choice at this time. But even if additional mitigation were necessary, the IWG incorrectly assumed that the implementation of the FSCC would have no impact on emissions rates in the vast majority of scenarios. (Ex. 220, Mendelsohn Surrebuttal, 24:10-12.) Four of the five emissions models used by the IWG were business-as-usual scenarios through the year 2100 that were then extrapolated for 200 years. (Ex. 100, Polasky Direct Schedule 2 (Feb. 2010 TSD), p. 15.) The fifth scenario, which was invented by the IWG, arbitrarily capped emissions in 2100 by assuming they stabilized and did not exceed a certain threshold for 200 years. (*Id.*) "By assuming zero future mitigation, the IWG is exaggerating the damage of carbon emissions." (Ex. 220, Mendelsohn Surrebuttal, 25:12-13.)

"Because the IWG did not take into account mitigation, they also failed to capture how society will likely react as it learns more about climate change." (Ex. 214, Mendelsohn Direct, 16:20-21.) As Professor Mendelsohn explained:

> Future mitigation policies will certainly respond to how serious climate change reveals itself to be. If climate damage turns out to be more serious than we currently believe, the obvious policy response is to mitigate more. If damage is less than expected, we will mitigate less. The resulting expected damage across all possible outcomes is much lower. Evaluating uncertainty in an optimal regime causes uncertainty to have a much smaller effect than with a zero mitigation policy.

(Ex. 220, Mendelsohn Surrebuttal, 31:5-10.) If future reports and best evidence indicate that mitigation becomes necessary, society can respond accordingly. Although mitigation by the FSCC is not appropriate based on the current evidence, the IWG's assumption that mitigation

would never occur even with the FSCC caused it to overestimate the FSCC. (Ex. 214, Mendelsohn Direct, 17:4-6.)

2. *Failure to Consider Adaptation*

The IWG also "implicitly underestimated adaptation." (Ex. 261, Mendelsohn Opening Statement, 3; *see also* Mendelsohn, 3B Tr. 39:1-40:1.) Not accounting for adaptation "effectively assume[s] that climate change occurs overnight with no warning." (Ex. 220, Mendelsohn Surrebuttal, 18:8-9.) Instead, climate changes are gradual and slow, and are not likely to be a surprise. (*Id.* at 18:10-16; *see also* Ex. 600, Martin Direct, 29:18-19 ("the IAMs do not fully capture adaptation to climate change, which could lead them to over-estimate damages").)

Dr. Mendelsohn testified that society will react and adapt to any changes caused by climate. (Ex. 220, Mendelsohn Surrebuttal, 18:20-21.) Dr. Mendelsohn, who has studied adaptation for the last 20 years, testified that "[a]daptation is an essential and inevitable aspect of climate change." (*Id.* at 17:11.) Dr. Mendelsohn reported "extensive evidence that people have already adapted to the climate that they live in across the planet." (*Id.* at 17:11-13.) "Adaptation will cause the actual damage from climate change to be a small fraction of potential damage." (*Id.* at 19:4-5.) Dr. Bezdek cited numerous peer-reviewed papers for adaptation, to which the opposing Parties never responded. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 107-114.) Not accounting for adaptation caused the IWG to vastly overestimate the social cost of carbon.

3. *Inadequate Consideration of Benefits of Carbon*

The IWG did not adequately consider the benefits of CO_2. (Mendelsohn, 3B Tr. 38:12-23.) More CO_2 would be a major overall benefit to the Earth through mild warming. (Ex. 200, Happer Direct, 9:22-10:3; Ex. 207, Lindzen Direct, 7:21-23; Ex. 228, Bezdek Direct, 2:21-3:20.)

Even Dr. Gurney stated, "All available scientific evidence supports the general concept of a CO_2 fertilization effect." (Ex. 803, Gurney Rebuttal, 3:4.) CO_2 benefits plants and agriculture by extending growing seasons, increasing photosynthetic efficiency of plants, decreasing water dependency of plants, and increasing tree growth rate. (Ex. 200, Happer Direct, 10:4-11:11; Ex. 204, Happer Rebuttal Report, 3:29-36; Ex. 220, Mendelsohn Surrebuttal, 4:6-15.) The record of this proceeding contains hundreds of peer-reviewed articles and papers confirming the benefits of CO_2 fertilization (not limited to lab experiments)[75] and showing that its positive effects on plant growth outweigh any impact on plants from reduced moisture or higher temperatures. (Ex. 235, Bezdek Surrebuttal, 37-40.) Empirical evidence proves the point: CO_2 fertilization has increased crop yields around the world much more than any decreases. (Ex. 216, Mendelsohn Direct Report, 12; *see also* Ex. 200, Happer Direct, 10-12; Ex. 202, Happer Direct, Ex. 2 (Report), at 10-11; Ex. 206, Happer Surrebuttal, 18-21.) "Greening has increased despite other potential obstacles such as wildfires, disease, pest outbreaks, demonstrating a robustness even if other negative climate changes are assumed to occur." (Ex. 235, Bezdek Surrebuttal, 32:1-3.) Mild warming also benefits people by reducing winter mortality and winter heating bills. (Ex. 206, Happer Surrebuttal, 10:9-13; Ex. 207, Lindzen Direct, 7:8:-26.)

Dr. Reich, the Clean Energy Organizations' witness, agreed that there is a CO_2 fertilization effect (Reich, 5 Tr. at 37:10-11) and that increased levels of CO_2 can lead to increased crop and forest productivity. (Id. at 37:15-17). A study that he co-authored concluded that: "Our results suggest that, with rising CO2 and without changes in forest type, average regional productivity [in the Great Lakes area] could increase from 67% to 142% . . . . Increased

[75] Ex. 228, Bezdek Direct, 9-11; Ex. 231, Bezdek Direct, Ex. 3 (Compendium), at 69-107; Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 13-19; Ex. 234, Bezdek Rebuttal, Ex. 2 (Discovery Responses), Ex. A, at 2-52; Ex. 235, Bezdek Surrebuttal, 24-42.

productivity was almost entirely driven by CO_2 fertilization effects . . . ."[76] He agreed that "from 67 percent to 142 percent, that's almost a doubling of the forest regional productivity." (5 Tr. at 39:4-6.) The study further found that "[r]educed stomatal conductance to water value is also well-documented under elevated CO_2, with little evidence of acclimation."[77] Dr. Reich testified that "what this is saying is that plants will have their stoma, which are openings on the leaves through which the water vapor escapes, slightly more closed under higher CO_2." (5 Tr. at 56:10-13.) In layman's terms, trees lose less water and thereby become more drought-resistant. The study noted "the important role that CO_2 fertilization plays in allowing forests to overcome warming-induced drought stress through increased water-use efficiency."[78] Dr. Reich agreed with the statement that "the presence of CO_2 is important in this model and is shown to be of benefit in this model." (5 Tr. at 58:21-23.)

Nevertheless, the "IWG implicitly undervalued CO_2 fertilization." (Ex. 261, Mendelsohn Opening Statement, 3.) Undervaluing carbon fertilization, an error in itself, also amplifies other errors regarding the carbon cycle (the relation between emissions and concentrations) and results in too high of a value for ECS. More plant growth means a greater carbon sink, which reduces the degree to which more emissions drive higher concentrations, and also reduces the fluctuations in temperature. Underestimating carbon fertilization may be one factor in climate models running hot as well. (Ex. 235, Bezdek Surrebuttal, 40:18-43:6.) The effects of carbon fertilization are indeed complex, as Drs. Hanemann and Polasky point out, but complexity does not make them less true. The uncertainty arising from their complex effect was not factored into the IWG's calculations, which magnifies the unsupportability of the FSCC.

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[76] Ex. 266, Emily B. Peters, *et al.*, *Potential Climate Change Impacts on Temperature Forest Ecosystem Processes*, 43 Can. J. For. Rsch. 939, 939 (2013) (abstract) [hereafter, "Reich Article"].

[77] Reich Article at 939.

[78] Reich Article at 946.

Because the IWG did not consider the benefits of CO_2, the FSCC estimates are unreliable.

4. ***Medical Impacts Such as Respiratory Disorders Will be Lessened by Any Warming***

Proponents of the FSCC attempt to portray CO_2 as a traditional pollutant that causes various health effects. However, these alleged health effects – asthma and respiratory disorders – are not connected to CO_2 emissions. If CO_2 caused asthma directly, nobody would be able to breathe. Professor Happer showed the CO_2 levels present in daily life, including in the Public Utilities Commission hearing room. Ordinary exhalation contains 40,000-50,000 ppm CO_2; a classroom can reach 5,000 ppm, which is the level the U.S. Navy tries not to exceed on a submarine. (Ex. 202, Happer Direct Report, 2.) The room where testimony was given in Minnesota measured 1,000 ppm right before Professor Happer's testimony, "and that's because we're all breathing. You know it you want to bring it down to . . . outside levels, we have to stop breathing." (Happer, 2B Tr. 19:22-25.) The relationship between CO_2 and respiratory problems is illusory. Instead, proponents of the FSCC are attempting to blame CO_2 for unproven harms threatened by other pollutants that already are regulated.

As far as inclusion in IAMs is concerned, the potential for adverse health effects is already included in the DICE damage function. (Ex. 220, Mendelsohn Surrebuttal, 5:14.) Dr. Mendelsohn points out that the IAMs as they were used by the IWG overestimate adverse human health effects by undercounting the benefits of mild warming and both adaptation and mitigation that will take place. (Ex. 220, Mendelsohn Surrebuttal, 5:15-20.)

Contrary to Dr. Rom's assertions, AR5 found uncertainty regarding effects on air quality:

- "There is high confidence that globally, warming ***decreases*** background surface ozone."[79]

- "For PM2.5, climate change may alter natural aerosol sources as well as removal by precipitation, but no confidence level is attached to the overall impact of climate change on PM2.5 distributions."[80]

And the evidence shows that mild warming will reduce asthma. "Dr. Rom's claim that global warming will lead to more asthma and respiratory illness is backwards; it will actually reduce them." (Ex. 206, Happer Surrebuttal, 22:10-11.) Daily mean temperature correlates negatively with hospital admissions for respiratory problems. (Ex. 206, Happer Surrebuttal, 22:11-17.) Mild warming would alleviate the problems caused by cold weather, which are a greater respiratory threat than heat. (Ex. 206, Happer Surrebuttal, 22:18-23:2.) Warming will also increase resistance because of the wider variety of pollens and microbes available. (Ex. 206, Happer Surrebuttal, 23:3-5.) Also, insofar as asthma and respiratory illness correlate with poverty, regulatory policies that increase the cost of energy would worsen respiratory health. (Ex. 206, Happer Surrebuttal, 24:9-12.)

Cold is by far a worse threat to human health in general. (Ex. 206, Happer Surrebuttal, 23:6-24:8.) Dr. Bezdek testified that "there is a large peer-reviewed, scientific literature" showing that "global warming would reduce, not increase, human mortality and disease." (Ex. 235, Bezdek Surrebuttal, 20:5-8.) Dr. Bezdek cited 47 articles supporting the argument that mild warming will be on balance beneficial for humans healthwise. (Ex. 231, Bezdek Compendium of Scientific Literature on Climate Change, 107-114.)

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[79] AR5 at 24 (emphasis added).
[80] AR5 at 24.

F. Step Five of Speculation: Uncertainty in Discount Rates – Arbitrary Choices That Overstate Harms of Climate Change

The discount rate one of the central variables to the calculation of a social cost of carbon and, as it was in 1997, remains a very controversial input to an IAM. (Ex. 600, Martin Direct, 19:1-2.) The IWG's method made unsupported, arbitrary decisions about the discount rate by assuming away uncertainty for highly uncertain variables, and by assuming that the ethical arguments regarding future generations pointed in only one direction. (The IWG also inappropriately changed the function of discount rates in the FUND and DICE models, as described further *infra* at Section III-G-7.)

1. *The IWG Did Not Follow OMB Guidance.*

The IWG violated OMB guidance in undertaking its discount rate analysis. Federal agencies are required to follow OMB Circular A-4 in a regulatory impact analysis. (Polasky, 1 Tr. 148:8-11.) OMB Circular A-4 directs using 3 and 7 percent discount rates.[81] OMB Circular A-4 instructs federal agencies that "[f]or regulatory analysis, you should provide estimates of net benefits using both 3 percent and 7 percent."[82] OMB provided an important reason to use a discount rate of 7 percent: "The 7 percent rate is an estimate of the average before-tax rate of return for private capital in the U.S. economy. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital."[83] Professor Mendelsohn warned that using an artificially low discount rate for the FSCC would cause distorting effects:

> The IWG argues that policy makers can choose whatever discount rate pleases them. However, if policy makers choose one discount rate for greenhouse gases and another discount rate for every other public investment, they are implicitly arguing that climate change

[81] Ex. 417, OMB Circular A-4, 33-34.

[82] *Id.* at 34. OMB Circular A-94 (Oct. 29, 1992) ("Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs") is to the same effect: "Constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent."

[83] *Id.* at 33.

> should have a different "price of time". There is no theoretical support for this idea. If a lower discount rate is used for greenhouse gases than other investments, policy makers are effectively arguing that greenhouse gas mitigation should have a lower rate of return than other public investments in national security, health, education, safety, and infrastructure. It is not at all clear why this is socially desirable.

(Ex. 216, Mendelsohn Direct Report, 17.)

Dr. Polasky conceded that 3 percent and 7 percent are the only two numbers recommended by the OMB in Circular A-4. (Polasky, 1 Tr. 93:18-20.) However, the IWG did not include a 7 percent discount rate in its social cost of carbon estimates. (*Id.* at 93:21-24.) The IWG provided very little explanation for rejecting a 7 percent discount rate. (Ex. 230, Bezdek Direct Report, 110.)

Instead, the IWG chose three lower discount rates: 2.5%, 3%, and 7%. The IWG justified the 3% rate by pointing to its use by OMB Circular A-4 to estimate the consumption rate of interest, but the IWG did not use 7%, the other rate recommended by OMB Circular A-4. (Ex. 100, Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 23.) The IWG justified the 5% rate as representing "the possibility that climate damages are positively correlated with market returns" (*Id.*), but it did not include the 7% rate, which is to be used "when a regulation is expected to displace or alter the use of capital in the private sector." (*Id.* at 19.) Mr. Martin admitted that adopting the FSCC could lead to a diversion of private capital and potentially strand investments. (Martin, 4 Tr. 25:3-8, 85:16-86:14.) Finally, the IWG justified the 2.5% rate as representing "the concern that interest rates are highly uncertain over time" and responding to "ethical objections" to rates higher than 3%. (Ex. 100, Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 23.) However, as discussed in the following section, ethical considerations support a higher discount rate, as does the uncertainty in the climate science.

By not including a 7 percent discount rate, the IWG artificially inflated the FSCC by excluding lower estimates. (Martin, 3B Tr. 145-10-15.)

2. *Ethical Considerations Support a Lower, Not Higher, Externality Value.*

The Parties proposing the FSCC cited a supposed need to use an artificially low discount rate in order to protect "future generations." But this argument is backwards. Economically productive activities that generate CO_2 also produce wealth that will benefit future generations. (Ex. 228, Bezdek Direct, 15:12-19; Ex. 230, Bezdek Direct, Ex. 2 (Report), at 7-70; Ex. 235, Bezdek Surrebuttal, 43:10-47:12.) Impoverishing current and future generations in a misguided attempt to address speculative (and scientifically disproven) climate scenarios will hurt future generations, not help them.

Moreover, future generations are already protected by market interest rates, which should encourage proper investments. (Ex. 220, Mendelsohn Surrebuttal, 31:13-32:4.) OMB Circular A-4, which directs use of 3 percent and 7 percent discount rates, explains that "using the same discount rate across generations is attractive from an ethical standpoint. If one expects future generations to be better off, then giving them the advantage of a lower discount rate would in effect transfer resources from poorer people today to richer people tomorrow."[84]

There is no ethical reason to increase the amount the present generation must pay. "Forcing the current generation to adopt a lower interest rate would imply that it is necessary for us to sacrifice even more for the future. Would each future generation also agree to sacrifice for remaining 'future generations'? Why is that desirable if it makes every single generation worse off?" (Ex. 220, Mendelsohn Surrebuttal, 32:8-12.) Indeed, future generations will almost certainly be better off than we are now. (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 7:151-8:162.) "It is not clear why the present relatively poor generation should have to bear

[84] Ex. 417, OMB Circular A-4, 35.

more than their fair share of the cost of this intergenerational policy. It is not at all clear why a low discount rate is 'ethical.'" (Ex .218, Mendelsohn Rebuttal, Ex. 1 (Report), at 8:160-162.)

Future generations are also protected by investment in technologies and methods of adaptation and mitigation that will make society more resilient to the potential effects of climate change. We know people adapt to climates that have swings as much as 20°C (Ex. 220, Mendelsohn Surrebuttal, 17:13-15), and there is no reason to think future generations will be unable to adapt. This adaptation will mitigate the negative effects of climate change, including agricultural shifts, drought, sea level rise, and temperature increases. (Ex. 220, Mendelsohn Surrebuttal, 19:8-21:4.) Rather than promoting austerities that will only make future generations worse off, the better answer would be to focus more on promoting investment in adaptation, mitigation, and resilience.

G. Step Six of Speculation: Manipulation of IAMs

The uncertainties are compounded by the IWG's errors in operating the three IAMs on which it relied – FUND, DICE, and a third IAM known as "PAGE." The IWG significantly and arbitrarily altered the IAMs designed by their creators. (Ex. 214, Mendelsohn Direct, 16:3-17.) Operation of any IAM involves inherent uncertainty, but the IWG greatly magnified and exacerbated the uncertainty, because of its errors in operating the IAMs and in making untested and non-peer-reviewed changes to them.

In particular, the IWG changed critical inputs – emissions rates, discount rates, climate sensitivity, GDP growth, and other factors – in all three models in favor of the IWG's non-peer-reviewed assumptions. (*Id.* at 16:7-15; Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 4:63-5:97; Ex. 220, Mendelsohn Surrebuttal, 3:3-9, 17:6-21:4, 27:5-28:14; Mendelsohn, 3B Tr. 59:5-18.) Even more significantly, the IWG changed the structure of the DICE model and ran the FUND model in such a manner that its creator could not replicate the high results. (*Id.*; Ex. 238,

Tol Rebuttal Report, 6:115-7:133.) Professor Mendelsohn testified that the "IWG made substantial changes to IAMs that altered their internal integrity." (Ex. 261, Mendelsohn Opening Statement, 3.) He testified that the IWG "made many mistakes." (Ex. 214, Mendelsohn Direct, 15:17.)

These changes fatally compromised the models and caused them to produce flawed and unreliable results. As Professor Mendelsohn opined: "The IWG has vastly overstated the social cost of carbon. It states that it uses the DICE and FUND model to calculate the social cost of carbon, but it really has substituted its own unfounded assumptions for both models." (Ex. 214, Mendelsohn Direct, 17:9-11.)

1. ***The IWG Created Internal Inconsistency and Error by Corrupting the Models.***

The IWG made significant changes to the model inputs and DICE's structure, manipulation it said was necessary to "standardize" the three models. This manipulation can create internal inconsistency in a model. (Polasky, 1 Tr. 94:19-24.) "There is value in having internal consistency in a model, something which is lost when using assumptions different than what the model dictates." (Ex. 104, Polasky Surrebuttal, 21:20-21.) Corrupting a model to "standardize it" may cause it to run differently than initially constructed and not how it was intended. (Polasky, 1 Tr. 95:12-20.) "Standardizing" a model can create error. (*Id.* at 96:18.)

Dr. Mendelsohn testified that the IWG "ruined both the FUND model and the DICE model by harmonizing the inputs." (3B Tr. 38:9-11.) The IWG "made substantial changes to the IAMs that effectively ruined their internal integrity." (*Id.* at 37:16-18.) He compared the error to putting gasoline in a diesel car. (*Id.* at 37:22-38:6.)

The IWG's manipulation indeed resulted in error, as evidenced by the fact that the IWG's assumptions are not consistent with each other. (Ex. 214, Mendelsohn Direct, 16:7-13.) For

example, different GDP paths imply different future interest rates. (*Id.*) However, because the IWG failed to take into account the effect of different GDP paths on the interest rates used in its models, the interest rates used by the IWG were not consistent with their assumptions about GDP. *Id.* Moreover, the model corruption by the IWG was inconsistent with the peer-reviewed models and caused the models to produce unreliable results. This manipulation ends up whitewashing important differences. (Ex. 600, Martin Direct, 39:2-5 ("The Federal SCC methodology aggregates and averages the SCC results regardless of IAM and socioeconomic/emissions scenario, obscuring their underlying differences and the broad range of results.").)

2. ***The IWG Arbitrarily Created, Selected, and Extrapolated Emissions Rate Scenarios.***

Emissions rates were the first key input changed by the IWG. The EMF-22 modeling exercise consisted of ten emissions models. (Ex. 100, Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 15.) To prepare its estimates of the FSCC, the IWG used five emissions models: four of the EMF-22 models, and a fixed scenario created by the IWG that averaged factors from the other four models. (*Id.*) The choice to use only four models has not been peer-reviewed. (Polasky, 1 Tr. 92:16-19.) The fifth scenario did not exist until the IWG invented it.

The EMF-22 models projected emissions to the year 2100. (Ex. 100, Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 15.) However, to suit its purposes, the IWG decided to extrapolate these emissions scenarios for 200 years, to the year 2300. (*Id.* at 24.) Dr. Polasky was not aware whether the IWG consulted with the EMF-22 authors and did not know how the IWG did the extrapolation. (Polasky, 1 Tr. 173:16-174:2.) No testimony was presented that independently justified the IWG's emissions scenario decisions.

The IWG corrupted the models by selecting emission scenarios that varied significantly from those already embedded in the models. With respect to DICE in particular, this is a major problem because future emission scenarios are already embedded in the model itself, and all equations inherent in the model depend on this function. As Dr. Mendelsohn stated, "DICE is very carefully calibrated to predict emissions depending on GDP and an observed decay rate in emission per unit of GDP. These assumptions are overridden in the IWG analysis. Emissions and GDP are assumed to be independent." (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 5.)

Because the IWG used only four of ten emissions models, created its own emissions scenario, and extrapolated emissions to a distance more than double the length of the original models, with no witness in this proceeding able to explain the IWG's reasoning for these choices, the FSCC estimates are unreliable.

3. ***The IWG Relies on Outdated IPCC Climate Sensitivity Estimates That Skew the FSCC High.***

Climate sensitivity was another key input changed by the IWG. To account for climate sensitivity, the IWG used a probability distribution based on AR4. The IWG's distribution was admittedly skewed high under AR4, and is skewed even higher in light of the IPCC's AR5.

Using its definitions,[85] AR4 estimated climate sensitivity with the following probabilities [added in brackets]:

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[85] AR4 used the following definitions for its estimates:

> Where uncertainty in specific outcomes is assessed using expert judgment and statistical analysis of a body of evidence (e.g. observations or model results), then the following likelihood ranges are used to express the assessed probability of occurrence: *virtually certain* >99%; *extremely likely* >95%; *very likely* >90%; *likely* >66%; *more likely than not* > 50%; *about as likely as not* 33% to 66%; *unlikely* <33%; *very unlikely* <10%; *extremely unlikely* <5%; *exceptionally unlikely* <1%.

(Ex. 268, AR4, at 27.)

> Progress since the TAR enables an assessment that climate sensitivity is *likely* [>66%] to be in the range of 2 to 4.5°C with a best estimate of about 3°C, and is *very unlikely* [<10%] to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values.[86]

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

> Although the calibrated Roe & Baker distribution, for which the probability of equilibrium climate sensitivity being greater than 1.5C is almost 99 percent, is not inconsistent with the IPCC definition of 'very likely' as 'greater than 90 percent probability,' it reflects a greater degree of certainty about very low values of ECS than was expressed by the IPCC.

(*Id.* at 14.)

AR5 makes the IWG's probability distribution even more inaccurate. Using its definitions,[87] AR5 estimated climate sensitivity with the following probabilities [added in brackets]:

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86 AR4, 38.

87 AR5 used the following definitions for its estimates:

> In this Summary for Policymakers, the following terms have been used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely: 95–100%, more likely than not >50–100%, and extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics, e.g., very likely (see Chapter 1 and Box TS.1 for more details).

> Equilibrium climate sensitivity is *likely* [66–100%] in the range 1.5°C to 4.5°C (*high confidence*), *extremely unlikely* [0–5%] less than 1°C (*high confidence*), and *very unlikely* [0–10%] greater than 6°C (*medium confidence*)[88]. The lower temperature limit of the assessed *likely* range is thus less than the 2°C in the AR4, but the upper limit is the same.[89]

Although AR5 no longer included a "best estimate" of climate sensitivity, the IWG refused to change its probability distribution in the updates released after AR5. (Ex. 101, Polasky Rebuttal, Sched. 2 (July 2015 IWG Response to Comments), at 12.) Under AR5, two-thirds of the distribution should have fallen between 1.5°C and 4.5°C, rather than the IWG's 2.0°C to 4.5°C range. (*Compare* Ex. 405, AR5, 16 *with* Ex. 100, Polasky Direct Schedule 2 (Feb. 2010 TSD, 13.) The lowest bound also should have changed. Under AR5, five percent of the distribution should have fallen at 1.0°C or lower, rather than the IWG's 5th percentile of 1.72. (*Id.*) Including more distributions between 1.5°C and 2.0°C and more distributions at 1.0°C and below would have shifted the distribution down and resulted in lower social cost of carbon estimates.

Because the IWG refused to update its climate sensitivity probability distribution to the IPCC's current scientific projections, the FSCC estimates are unreliable.

4. ***The IWG Arbitrarily Selected Discount Rates Inconsistent With the Models and OMB Guidance.***

Discount rates were another key input changed by the IWG. To prepare its estimates of the FSCC, the IWG used three fixed discount rates: 2.5%, 3% and 5% per year. (Ex. 100, Polasky Direct Sched. 2 (Feb. 2010 TSD), at 23.) These discount rates are arbitrarily low, (Ex.

(AR5, at 4 n.2.)

[88] No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies. (Ex. 405, AR5, at 16 n.16.)

[89] AR5, at 16.

218, Mendelsohn Rebuttal, 5:99-6:115), and as explained previously, they conflict with OMB guidance.

Even more problematic is the fact that these discount rates are inconsistent with the models themselves. As designed, DICE internally calculates the discount rate to be consistent with growth in GDP per capita. (Ex. 214, Mendelsohn Direct, 12:1-3.) However, the IWG's manipulation of DICE mandated a fixed discount rate that divorced the interest rate from the path of GDP, which is inconsistent with the DICE model and economic theory. (Ex. 220, Mendelsohn Surrebuttal, 30:6-7.) Thus, "[t]he IWG did not run the DICE model as it was originally designed." (*Id.* at 30:7-8.)

Similarly, the IWG did not use the FUND model as it was designed. The FUND model incorporates the Ramsey rule, under which the discount rate varies with economic growth, rather than the fixed discount rate approach used by the IWG. Professor Richard Tol, the author of FUND, testified that the Ramsey rule is "a more appropriate choice." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 2.) The IWG's approach puts a premium on the impacts in countries that grow faster than the United States. (*Id.* at 5.) The effect can be substantial. For instance, using the FUND scenario as used by the IWG, impacts in China are weighted 46% to 87% higher than impacts in the United States. In other words, a $1 loss in the United States is counted as $1; but a $1 loss in China is counted as $1.46 to $1.87. (*Id.* at 6.) The result of this approach is that the IWG effectively places more value on the circumstances in China than on those in the United States.

A top group of economic experts believe that the correct way to value intergenerational discounting is to use the Ramsey formula, adjusting the discount rate at which income (consumption) grows over time. (Ex. 218, Mendelsohn Surrebuttal, 29.) The choice of discount

rate and the projection of income cannot be treated independently. Even though the IWG itself assumes that income growth declines over time, the FSCC does not use a declining discount rate. (*Id.* at 29-30.) The IWG assumes that income, population and interest rate are all independent of each other. While accepted economic theory holds that interest rates are tied to growth of income per capita, the IWG abandons this assumption and de-links income growth and interest rates by setting a constant interest rate (discount rate) to apply over the next 300 years. (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 5.)

By not properly applying the models' discount rates, the IWG skewed the results and rendered the FSCC even more unreliable.

5. ***The IWG Erred in Running DICE as a "Simulation" Model and Assuming No Mitigation.***

In addition to making arbitrary changes to the model inputs, the IWG made arbitrary changes to the models themselves. DICE is primarily designed as an optimization model designed to determine the optimal level of mitigation that equates marginal cost to marginal damage at every moment. (Ex. 214, Mendelsohn Direct, 5:24-6:4; Ex. 220, Mendelsohn Surrebuttal, 21:6-24:2.) However, the IWG ran DICE as a simulation model rather than an optimization model. (Ex. 100, Polasky Direct, Sched. 2 (Feb. 2010 TSD), at 7 n.3.)[90] Converting to a simulation approach rather than an optimization approach effectively assumes there is no mitigation now or in the future anywhere in the world, and therefore significantly overestimated the social cost of carbon. (Ex. 214, Mendelsohn Direct, 16:18-17:20; Ex. 218, Mendelsohn Rebuttal, 3:26-34; Ex. 220, Mendelsohn Surrebuttal, 17:5-18:6.) DICE could have

[90] "We made two modifications to DICE to make it consistent with EMF GDP trajectories (see next section): we assumed a fixed rate of savings of 20% and we re-calibrated the exogenous path of total factor productivity so that DICE would produce GDP projections in the absence of warming that exactly matched the EMF scenarios." (Ex. 100, Polasky Direct Sched. 2 (Feb. 2010 TSD), at 7 n.3.)

been run to account for mitigation, as Dr. Mendelsohn did. (Ex. 218, Mendelsohn Rebuttal, Ex. 2 (Discovery Responses) at Bates No. Peabody 000014.) But instead, the IWG converted DICE to a simulation model and ignored mitigation.

Expert testimony demonstrated the significance of the IWG's action. When it ran DICE as a simulation model, the IWG made a critical conceptual error because it did not measure the FSCC by equating marginal cost and marginal damage, as economists do with every other damages cost model. (Ex. 261, Mendelsohn Opening Statement, 2.) By converting DICE to a simulation model, the IWG "is basically saying we don't really care about what the DICE model has to say, we're going to substitute something else for it, and it's not using the DICE model." (Mendelsohn, 3B Tr. 59:13-16.) According to Dr. Mendelsohn, "[t]he IWG did not run the DICE model as it was originally designed." (*Id.* at 30:7-8.) The IWG's errors in operating DICE are further reasons that the FSCC estimates are unreliable.

6. ***The IWG Generated Results from FUND That Its Creator Could Not Replicate and Doubted Were Reliable.***

The IWG also did not operate FUND properly. The author of FUND, Professor Tol, was surprised that the IWG's estimates of the SCC using the FUND model went up substantially between 2010 and 2013. According to the way in which he ran the FUND model, the numbers went down during that time frame. In 2011, FUND estimated a social cost of carbon of $8 per ton. In 2014, it was $6.60 per ton, using the IWG's parameters and estimate of climate sensitivity. (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 6:111-125.) "In other words," reported Professor Tol, "FUND as used by the FUND team shows a *lower* social cost of carbon, whereas FUND as used by the US Federal Government shows a *higher* social cost of carbon." (*Id.* at 6:121-123 (emphasis original).)

The IWG's lack of transparency prevented Professor Tol from determining why the IWG's results differed from his results. (*Id.* at 7:128-130.) The IWG's results caused Professor Tol to suspect the IWG had incorrectly operated FUND and had produced unreliable results:

> As the author of FUND, my assessment is the IWG may not have correctly operated FUND in generating its estimates. Because the IWG process and the calculations themselves are not immediately transparent, it is has not been possible for me to ascertain exactly how the IWG generated its estimates or whether they are economically and scientifically valid. However, the inconsistency between the numbers that my operation of the FUND model generates and those produced by the IWG raises serious questions as to whether the IWG's estimates lack economic and scientific reliability.

(Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 7:127-133.)

Because the IWG improperly used the FUND model, the FSCC estimates are unreliable.

7. ***The IWG Relied on PAGE Even Though It is Deeply Flawed.***

The IWG also erred by relying on the PAGE model, which is not transparent, reproducible, or designed for use in the United States. PAGE generates substantially higher damages than DICE or FUND (Ex. 100, Polasky Direct, Sched. 2, Tables A2-A4), yet its results were improperly afforded equal weight as those from DICE and FUND.

PAGE is far inferior to DICE and FUND for many reasons. Unlike DICE and FUND, PAGE is not well-grounded in economic theory or empirical evidence. (Ex. 214, Mendelsohn Direct, 7:18-20.) Unlike DICE and FUND, PAGE was not designed to optimize and is not reliable for predicting the optimal path of mitigation. (*Id.* at 7:11-12.) And unlike DICE and FUND, PAGE is not a cost-benefit tool, but instead relies on a "decision analysis" approach. (Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 38:1238-1242.)

PAGE suffers from other internal flaws as well. Although the IWG uses PAGE to predict global damages, PAGE was designed to focus on the European Union and not the entire world.

(*Id.* at 39:1259-1261.) PAGE calculates damages in the European Union and then extrapolates those damages to the rest of the world based simply on coastline length. (*Id.* at 39:1261-1264 (quoting Ex. 600, Martin Direct, 40:23-25).) PAGE also includes low probability scenarios that have been debunked by climate literature. (*Id.* at 39:1276-1282.) Finally, PAGE is a proprietary model that has been impossible for some researchers to obtain, making it the least transparent of the three models. (*Id.* at 39:1291-40:1296.)

Because of its many flaws, PAGE is not reliable and should not have been included in the IWG's estimate of the FSCC. (Ex. 214, Mendelsohn Direct, 7:11-12; Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 38:1236-1237.)

8. ***IWG Work Not Transparent or Peer Reviewed, as It Admits***

The changes to the model inputs and the models themselves have made the FSCC unreliable. Dr. Polasky acknowledged that "[s]ometimes governments make mistakes" and that it is possible that mistakes were made by the IWG. (Polasky, 1 Tr. 156:13-16.) Dr. Hanemann admitted the model codes were "susceptible to error." (Hanemann, 2B Tr. 69:12-17.) Dr. Polasky conceded that mistakes could be made in operating the models. (Polasky, 1 Tr. 72:11-13.)

Despite this risk of error, the public does not know the identity of the people who made the changes or their expertise to do so. With just a few exceptions, the IWG's members are unknown and their credentials are unknown. (Polasky, 1 Tr. 87:19-21, 87:24-88:1, 112:13-16, 113:4-9, 156:4-9.) The credentials of the IWG members are important because, as Dr. Polasky testified, models operated by inexperienced people can be misleading. (Polasky, 1 Tr. 74:13-15.) Regardless of the IWG's credentials, the authorities on the models – the authors of the DICE and FUND models manipulated by the IWG – do not appear to have been involved. (Polasky, 1 Tr. 97:14-17, 98:3-8.)

In general, the IWG's work has not been transparent and its many significant changes to the model inputs and model structure have not been peer-reviewed. (Polasky, 1 Tr. 109:5-9; Martin, 4 Tr. 213:9-24; Ex. 232, Bezdek Rebuttal, 45:1466-1478.) As Mr. Martin testified, "Most of the SCC development process has been a closed interagency process, with[] virtually no public input or scientific peer review." (Ex. 600, Martin Direct, 14:25-15:2.) In addition to a lack of peer review, the IWG's model alterations have not been validated. (Polasky, 1 Tr. 81:25-82:1, 83:6.)

The IWG has responded to public comments only in July 2015, long after it published its estimate of the FSCC. In other words, there is no evidence that the FSCC considered public comments at the proper time – ***before*** issuing its estimate. Its response on crucial issues such as the ECS probability distribution it uses consists of standing pat and assuring the reader that it will revisit the figures at some later point. (Ex. 101, Polasky Rebuttal Schedule 1 (IWG July 2015 Response to Comments, 11-12.) Of the approximately 140 sets of public comments received, in July 2015 the IWG adopted none. The IWG's head-in the-sand approach that refuses to consider the most relevant science produced an erroneous and inflated estimate of the SCC. This is the very definition of arbitrary and capricious decisionmaking.

The IWG's many significant changes to the model coupled with its lack of transparency and peer review render the FSCC wholly unreliable.

H. Adoption of FSCC Will Force Leakage

Action by Minnesota may result in lower, if any, damage reductions than anticipated due to leakage. Leakage is an increase in the emissions of other states that is likely to occur when a single state implements a pollution regulation that is very different from its neighbors. (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), 4:57-61; Ex. 220, Mendelsohn Surrebuttal, 32:16-17.) Minnesota's imposition of a high externality value could result in neighboring states exporting

lower cost electricity to Minnesota while increasing electricity generation from coal power plants in their states. (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), 3:53-4:58.) Thus, even though Minnesota may have reduced CO_2 emissions, the emissions from the region may not change overall (or may not change as much as predicted) because Minnesota emissions may merely be reassigned (in whole or in part) to neighboring states. (*Id.* at 4:57-60.)

Utilities with power plants in neighboring states could benefit because they would have cheaper electricity to sell to Minnesota. (*Id.* at 4:55-57; Ex. 220, Mendelsohn Surrebuttal, 32:18-33:2.) Surrounding states could benefit by luring businesses to their states to avoid the high price of carbon in Minnesota. (Ex. 214, Mendelsohn Direct, 5:12-16.)

Because of its effect on overall emissions, the social cost of carbon must be adjusted for leakage. (Ex. 220, Mendelsohn Surrebuttal, 33:9-11.) Dr. Mendelsohn testified that the "greater the difference between the price of carbon in Minnesota and the rest of the region, the more leakage one should expect." (*Id.* at 33:15-16.) This proceeding should consider leakage before adopting any externality value for CO_2.

I. Adoption of FSCC Will Unfairly Burden MN with No Resulting Benefits

The costs to Minnesotans from adoption of the FSCC will dramatically outweigh benefits. The judges in this proceeding have already recognized that a "total cost of carbon calculation" is relevant to this proceeding and have declined to exclude Dr. Bezdek's testimony regarding the environmental and social benefits of carbon. (Order on Motions by Peabody Energy Corporation, the Minnesota Department of Commerce, and the Pollution Control Agency to Exclude and Strike Testimony, 8 (Sept. 15, 2015).) That pretrial order also cited the Supreme Court's decision in *Michigan v. EPA*, 135 S. Ct. 2699 (2015), which opined that an agency must engage in a full consideration of all relevant costs in order to "ensure cost-effectiveness" of its regulations. *Id.* at 2711. As the Court opined, "[o]ne would not say that it is even rational, never

mind 'appropriate,' to impose billions of dollars in economic costs in return for a few dollars in health or environmental benefits." *Id.* at 2707.

Mild warming will benefit Minnesotans by longer growing seasons, increased crop productivity, and reduced winter heating costs. (Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 3:40-43.) These benefits will greatly outweigh any purported damage to Minnesota during this period. (*Id.* at 3:43-44.)

The benefits resulting from the federal social cost of carbon, if any, will be extremely small. Even without accounting for leakage, reducing Minnesota's emissions will make virtually no impact on global emissions and temperatures. (Ex. 214, Mendelsohn Direct, 5:4-7.) Yet Minnesotans would pay dearly for these nearly imperceptible benefits. (*Id.* at 5-7.) Customers would pay higher electricity rates. (Martin, 4 Tr. 17:12-14, 17:24-18:1.) Electricity could be more expensive for low-income ratepayers, translating into a lower standard of living for those people who have to spend more of their income on electricity. (Martin, 4 Tr. 18:16-20, 234:19-235:3.) Jobs could be lost and investments could be stranded. (Martin, 3B Tr. 159:21-160:2, 4 Tr. 25:3-8.)

As Dr. Mendelsohn observed, "Not only will Minnesota be paying more than their share for climate mitigation, but more importantly the effort will be futile. No one else will follow and there will be no measurable effect on climate." (Ex. 220, Mendelsohn Surrebuttal, 35:2-4.)

J. The State Agencies' and CEOs' Responses to Uncertainty Are Flawed – "Just Trust Us" is Not a Basis for Reasoned Decisionmaking.

The position of the State Agencies and CEOs at trial was essentially: trust us. They made little effort to engage in a substantive discussion of the scientific or economic questions before the Commission and relied on a misplaced appeal to the perceived authority of a supposed "consensus" on climate issues. This approach cannot provide the basis for reasoned

decisionmaking, particularly when AR5 supports Peabody's position, not that of the State Agencies or CEOs.

1. ***Peabody's Witnesses Are More Qualified than Those of The State Agencies, CEOs, or Xcel Energy.***

Without question, the witnesses presented by Peabody had more experience with the IPCC, with the IAMs involved in calculating the FSCC, and with the gathering of primary observational data than any of the other Parties.

- Professor Richard Tol is the creator of the FUND model — one of the three models from which the IWG constructed the FSCC — and has been active in the IPCC since 1994, longer than any other witness in this proceeding. (Ex. 238, Tol Rebuttal Report, 2:4-21.) He is also a regular participant in the Stanford Energy Modeling Forums, the group that produced emissions models on which the IWG based the FSCC. (*Id.* at 1:21-22.)

- Professor Robert Mendelsohn is the Edwin Weyerhaeuser Davis Professor at the School of Forestry and Environmental Studies at Yale University who has spent the past 22 years studying how to measure the benefits of mitigating greenhouse gas emissions, including 63 peer-reviewed articles and 8 books. (Ex. 214, Mendelsohn Direct, 1:15-20.) He is an expert regarding the DICE model (developed by his colleague William Nordhaus at Yale). (*Id.* at 6:6-10, 7:22-10:26.) Unlike Hanemann, Polasky, or Martin, Mendelsohn has published peer-reviewed work in which he operated an IAM (the DICE model).

- Together DICE and FUND represent 2/3 of the IAMs composing the IWG's FSCC.

- Dr. Roy Spencer received the NASA Exceptional Scientific Achievement Medal and the Special Award from the American Meteorological Society for "developing a global, precise record of earth's temperature from operational polar-orbiting satellites, fundamentally advancing our ability to monitor climate"; cited in the text of and referenced in endnotes in AR5 for his satellite data, which was used in AR5.[91] His temperature measurement data constitutes one of the foundations upon which the AR5 based its analysis.

- Professor Richard Lindzen of Harvard and MIT began his work with the IPCC as a contributing author in 1995, making his involvement almost as long as Professor Tol's. Professor Lindzen was a lead author of Chapter 7 (Physical Climate Processes and Feedbacks) of the Working Group I Report for the Third Assessment Report in

[91] AR5, 194-196, 591.

2001. (Ex. 207, Lindzen Direct, 8:6-8.) His scholarly work is still depended on by the IPCC, cited extensively in the text and endnotes of AR5.[92]

- Professor William Happer is the former chair of the physics department at Princeton University and chair of the University Research Board, Princeton's equivalent of Vice President for Research. He has published over 200 peer-reviewed scientific papers. (Ex. 201, Happer Direct, Ex 1 (CV), at 1.) He has done research in atmospheric physics and other areas. He is well known for his invention of the "sodium guide star" concept, used in all modern ground-based telescopes to compensate for deleterious effects of atmospheric turbulence on astronomical observations. (*Id.*) He is very familiar with the climate models used by the IPCC and funded some of the early models when he was Director of Energy Research at the United States Department of Energy from 1990 to 1993, where he supervised a research budget of some $3.5 billion, including environmental and climate science. (*Id.*; Happer, 2B Tr. 18:16-22.)

- Dr. Roger Bezdek was one of the founders of the Renewable Energy Program at the United States Department of Energy and served as a consultant to EPA, the National Science Foundation, and Al Gore. (Ex. 228, Bezdek Direct, 1:26-2:2.) He has published six books and more than 300 articles, including peer-reviewed scholarship in 91 different publications, including *Science* and *Nature*. (Ex. 228, Bezdek Direct, 1:10-12; Ex. 235, Bezdek Surrebuttal, 66:8-71:5.) He serves as an editorial board member and peer reviewer for multiple publications. (Ex. 228, Bezdek Direct, 1:12-14.)

- Dr. William Wecker has served on the faculties of the University of Chicago, the University of California—Davis, and Stanford University. He has served as an associate editor for the *Journal of the American Statistical Association* for four years and the *Journal of Business and Economic Statistics* for eighteen. (Ex. 240, Wecker Rebuttal, 1:19-22.) He has published 35 peer-reviewed articles on statistical methods. (Ex. 241, Wecker Rebuttal, Ex. 1 (CV), at 2-4.)

By comparison, none of the opposing witnesses has ever operated an IAM, none has designed an IAM used by the IWG to generate the FSCC, none has experience with the IPCC comparable to that of Drs. Tol or Lindzen, and none has ever received awards comparable to those bestowed on Peabody's witnesses. The imbalance in the credentials of the witnesses in this proceeding is striking:

- Dr. Abraham: He is not a professor of climate science and became a full professor of thermal science only two years ago. (3B Tr. at 69:1-11.) His work has never been cited by the IPCC. (*Id.* at 71:17-18.) His "peer-reviewed" work was published in "a

[92] AR5 at 402 (Box. 5.2), 589, 591, 922-924, 925 (Fig. 10.20), 1110 (Box 12.2 (Fig. 1)).

philosophy journal." (*Id.* at 73:16.) He was one of 2,000 reviewers for AR5 and was not selected to edit. (*Id.* at 69:20-70:25.) Before AR5, he had not worked in any previous IPCC reports. (*Id.* at 71:12-16.)

- Dr. Dessler: He participated in the U.S. government's review of the Third Assessment Report (AR3) (released 2001), but not the IPCC drafting or editorial process, and his participation in AR3 has been "wiped from [his] memory." (Dessler, 3A Tr. 19:23-25, 93:2-3.) He has not participated in either AR4 or AR5. (*Id.* at 19:24-25.) He has never been selected by the IPCC as a lead author, contributing author, or editor. (*Id.* at 20:1-9.)

- Dr. Gurney: He was a reviewer and contributor but was not selected as an editor of the climate science section of AR5. (Gurney, 4 Tr. 149:14-150:1.)

- Dr. Hanemann: He never developed or operated an IAM to calculate the social cost of carbon, and did not develop a measure of the FSCC separate from the IWG's work. (Hanemann, 2B Tr. 60:11-14, 62:13-18, 64:3-5.)

- Dr. Polasky: He also never developed or operated an IAM to calculate the social cost of carbon, and did not develop a measure of the FSCC separate from the IWG's work. (Polasky, 1 Tr. 63:24-64:2, 64:3-7, 71:12-15; 116:22-23.)

While other parties have (repeatedly) talked about the importance of relying on peer-reviewed research, rather than simply talking about it Peabody has actually provided it: Peabody witnesses have cited 1,457 peer-reviewed papers, compared to only 169 peer-reviewed papers cited by the DOC and CEO witnesses combined. That amounts to almost ***nine times*** more peer-reviewed research supporting Peabody.

The Agencies and CEOs are staking their positions in support of the FSCC on just trusting them; Peabody is providing peer-reviewed evidence to support its arguments.

2. ***There is No Scientific Consensus***

A false "consensus" has been manufactured and maintained in climate science. This "consensus" uses schoolyard tactics such as name-calling ("denier," "contrarian," and "conspiratorial" are popular choices) and ostracization to isolate scientists who disagree, discrediting their views without regard for merit.

At its foundation, the existence of a "consensus" should be irrelevant to the correctness or not of science. "[S]cience is based on evidence, not agreement." (Ex. 235, Bezdek Surrebuttal, 83:9.) Although experts supporting the FSCC criticized Peabody's witnesses as skeptics,[93] as Dr. Dessler stated, "all scientists are skeptics. . . . I think all good scientists are skeptics." (Dessler, 3A Tr. 56:3-5.) In fact, Dr. Dessler admitted he disagreed with the IPCC on AR5's climate sensitivity estimate (Dessler, 3A Tr. 49:9-50:5), putting him outside the "consensus" that resulted in AR5. Numerous findings published in peer-reviewed journals and presented in congressional testimony are beginning to question the argument that the evidence of anthropogenic climate change is strong enough to justify policy action. (Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 3:88-5:166.) The burden of proof in this proceeding is phrased as a preponderance of the ***evidence***, not a preponderance of the ***opinions***.

The vaunted "consensus" falls apart when probed. Dr. Bezdek pointed out that the "consensus" is usually framed so broadly that it is useless: "If the question is whether humans have had some impact on the environment, even I would be part of the consensus." (Ex. 235, Bezdek Surrebuttal, 85:8-9.) Using "consensus" is such a meaningless manner masks crucial differences. A study by Strengers et al. (2015) and Verheggan (2014) polled climate scientists directly on the statement: "It is extremely likely [95 to 100% probability] that human activities caused more than half of the observed increase in global average surface temperature from 1951 to 2010." (Ex. 213, Lindzen Surrebuttal, 46:7-47:3.) The study broke the proposition into two parts: the likelihood of human causation ("extremely likely") and human responsibility for more

[93] Ex. 804, Gurney Surrebuttal, 1:21-23 ("These Peabody witnesses used a series of argument patterns throughout their testimony that I have seen repeatedly over the last 30 years from the community I would call 'skeptics' of anthropogenic climate change (ACC)."); Abraham, 3B Tr. 77:22-24 ("I am sure that I have used descriptors to categorize scientists in a manner. I don't know if I used the word skeptic, but I use descriptive words like that."); Ex. 103, Dessler Rebuttal, 14:6-7 ("This episode is deeply revealing about climate skeptics in general and Dr. Lindzen in particular.").

than half of the observed increase in temperature. (*Id.*) Only 65.9% of surveyed scientists agreed with the second half (that humans caused more than half of the observed increase). (*Id.*) Of those who agreed with the second half, only 65.2% also agreed that the conclusion was "extremely likely" or "virtually certain." (*Id.*) In the end, therefore, ***only 43.0% of climate scientists actually agreed with the statement***. (*Id.*) Other studies show a range between 47% and 90% for the "consensus" usually given as 97%. (*Id.* at 47:8-21.) Upon closer examination, the scientific "consensus" is a manufactured myth.

The myth comes from a faulty article published by John Cook in 2013. The article is frequently mis-cited for the proposition that 97% of climate scientists agree on the topic of anthropogenic global warming, but the article only analyzes papers, not scientists. (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 9:202-203.) Furthermore, it contains extensive flaws discussed by Drs. Bezdek and Tol, including assembling an initial population of articles with many unrelated to climate science, unreleased and questionable datasets, biased ratings by readers, and reader collusion. In the peer-reviewed literature it has been refuted by Tol (2014) and Legates et al. (2013). (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 9:192-10:221; Ex. 233, Bezdek Rebuttal, Ex. 1 (Report), at 6:213-8:258; Ex. 235, Bezdek Surrebuttal 83:12-84:6.) "Cook's paper illustrates everything that is wrong with climate research." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 10:219-221.) Other similar studies cited by Dr. Abraham[94] are all flawed by bad design and hidden assumptions. (Ex. 235, Bezdek Surrebuttal, 85:12-89:27.) The agreement simply is not as strong as claimed, and becomes notably weaker once one specifies what the agreement is about. In other words, it feels easy even for scientists to say they all agree about climate change, but what one actually digs to see what that means, the agreement evaporates. There is no significant consensus.

[94] Zimmerman (2008), Doran and Zimmerman (2009), Cook et al. (2013), Oreskes (2004).

Nevertheless, such a manufactured "consensus" becomes self-reinforcing and has serious consequences. Such a manufactured consensus has distorted the science and promoted clashes between scientists in a manner than undermines science as a whole. (Ex. 235, Bezdek Surrebuttal, 90:4-15 (quoting Judith Curry); *see also* 92:14-95:15 (quoting Steven Koonin, Michael Kelly, and Rajendra Pachauri).) Dr. Lindzen pointed out that "[p]olitics and playground antics have begun to infect reasoned scientific discourse." (Ex. 213, Lindzen Surrebuttal, 49:11.) When it comes to articles in the economic literature regarding the SCC, there is a documented publication bias favoring higher values for the FSCC. (Ex. 213, Lindzen Surrebuttal, 50:8-51:9.) Believing there is a "consensus" and trying to enforce it has negative consequences that undermine scientific inquiry.

This banding-together has permitted the hasty dismissal of reasoned argument without meeting it head on: "It is possible to question catastrophism without denying climate change, yet far too many people — politicians, advocacy groups, even scientists hoping for grants — have a vested interest in ensuring the two are conflated because it allows them to demonize people who disagree with them." (Ex. 213, Lindzen Surrebuttal 49:13-16.)

These argumentative techniques have been on display in this proceeding:

- Dr. Dessler inappropriately referenced an irrelevant confrontation between Dr. Lindzen and a committee of the House of Commons, turning a valid disagreement founded on a faulty URL into an indictment of Dr. Lindzen's credentials and honesty. (Ex. 213, Lindzen Surrebuttal 48:13-50:5.)

- Dr. Abraham claimed that Dr. Lindzen miscited an article about global warming's effect on diurnal temperature range (daily temperature ranges) but was forced to admit on cross-examination that the article in fact stated that the diurnal temperature range is decreasing in most regions of the world and that "[l]ower diurnal temperature ranges are beneficial." (3B Tr. at 76:4-13.) Thus, the article supported Dr. Lindzen's testimony.

- Dr. Dessler attacked opposing witnesses in his rebuttal testimony on the ground that ocean heat conduct "has increased rapidly since 1998" (Ex. 103, Dessler Rebuttal, at 19:6), but the study on which he relied was only a ***model*** of ocean heat content and

ignored observational evidence of deep ocean cooling since 2005. (Ex. 213, Lindzen Surrebuttal, at 20:9-21:21.) At trial, Dr. Dessler first insisted that that the study he cited was "an observational data set" (3A Tr. at 30:2), then stated "it's what's called a reanalysis" (*id.* at 30:5), and finally admitted, "[W]hat it does, it takes a model and uses the model as essentially a physics-based interpolation. . . . [T]he model actually has the physics." (*Id.* at 30:12-13, 17). When pressed about ocean temperatures, he conceded, "I probably should not answer that. I don't know, I'm not an expert on ocean temperatures." (*Id.* at 32:4-5.)

- Dr. Gurney manipulated a quotation of a peer reviewed article in order to make it appear that Dr. Happer miscited the paper. In fact, Dr. Gurney had miscited it, and one of the authors confirmed that Dr. Happer was correctly citing it. (Ex. 206, Happer Surrebuttal 20:1-21:14.)

- Dr. Gurney also repeatedly chided Dr. Bezdek for not relying on peer-reviewed literature, but Dr. Gurney cited only to one peer-reviewed source in his own criticism of Dr. Bezdek and ignored the 181-page compendium and numerous other lists of sources provided by Dr. Bezdek. (Ex. 235, Bezdek Surrebuttal 32:9-19, 33:5-8, 66:4-7.)

- Dr. Gurney also had to correct his testimony to reflect that the IPCC cites extensively to grey literature and advocacy organizations. (Ex. 213, Lindzen Surrebuttal 51:11-61:9.)

- Dr. Abraham repeatedly argued that it is improper to rely on grey literature and advocacy organizations, usually citing to his own paper,[95] itself published in a philosophy journal far afield from climate science and authored with at least two members of advocacy groups. (Ex. 235, Bezdek Surrebuttal, 84:9-85:4.) Worse, he used the incomplete and inaccurate summary of the literature in this article to attempt to prove a *substantive* scientific argument about Dr. Lindzen's Iris Effect. (Ex. 213, Lindzen Surrebuttal 10:6-12:18.)

The overarching claims frequently appended to Peabody's experts either are simply false or are practiced by the person making the statement.

There is no real scientific "consensus," only one enforced by peer pressure and adolescent tactics. Unfortunately the enforcement of the "consensus" has had adverse consequences, including a very real publication bias. Prioritizing the "consensus" above

[95] J.P. Abraham, *et al.*, Review of the Consensus and Asymmetric Quality of Research on Human-Induced Climate Change, 2014-1 Cosmopolis 3 (2014). *See* Ex. 102, Abraham Rebuttal at 29 (p. i) (citing to article).

following the evidence threatens to degrade scientific inquiry into a polarized exercise and is inconsistent with the scientific method.

K. Statutory and Due Process Implications Counsel Against Adopting FSCC on this Evidentiary Record

Establishing an externality value for CO_2 emissions requires attributing "responsibility" to the emitters by a preponderance of the evidence. As Dr. Hanemann testified, "a party responsible for causing pollution is also responsible for paying for the damage caused by that pollution." (Ex. 800, Hanemann Direct, 8:14-15.) The presence of *cause* in Dr. Hanemann's definition is crucial: the responsible party must cause the pollution, and the pollution must cause the damage. Ultimately the Commission must make its decision based on the full record of evidence before it — not based on political preconceptions or biased reasoning — and there is no basis for finding that either cause exists.

Initially, the Commission faces one insurmountable fact: "current models do not disaggregate the effects of human-induced warming and natural variability." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 9:187-188.) No matter how much the other Parties attempt to skate past this problem, it is central to establishing an externality value. "Current estimates of the social cost of carbon are based on the assumptions that short term natural climate variability is irrelevant in that it averages out, and that there is no long term natural climate variability." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 9:183-185.) To the contrary, however, every indication shows that short-term natural variation is at least as large as any anthropogenic contribution. (Ex. 207, Lindzen Direct, 3:25-4:6; Ex. 209, Lindzen Direct, 7:209-225, 8:266-280.) Expanding consideration of natural variation to longer periods of time only diminishes the ability to attribute the effects to humans. (Ex. 213, Lindzen Surrebuttal, 22:1-9.) It would defy due process and reasoned decisionmaking simply to assume that such a causal link exists.

Moreover, the Commission could not disaggregate any harms caused by Minnesota utility emissions from harms caused by other sources of CO_2 – including non-utility sources in Minnesota (such as mobile sources), as well as national and worldwide sources. CO_2 is the byproduct of virtually all human activities. *See American Elec. Power Co. v. Connecticut*, 131 S. Ct. 2527, 2538 (2011) ("After all, we each emit carbon dioxide merely by breathing."). Atmospheric CO_2 is the intermingled result of all human activity and Mother Nature. CO_2 is different in kind from traditional air emissions because it is not unique to the regulated source. Yet the Parties advocating adoption of the FSCC proceed on the assumption that no other source will engage in mitigation and the SCC should be computed as though Minnesota utilities and ratepayers must bear all of the burden of worldwide CO_2 emissions.

Further, the causal chains involved with the SCC are long and convoluted, with many confounding factors. The Parties have failed to prove that the supposed "pollution" actually causes the damage. As Professor Tol has explained, it is "rather difficult to estimate the climate effect of carbon dioxide emissions, and indeed that effect varies over time and is contingent on human choices within the domain of climate policy (*e.g.*, emissions, land use) as well as outside that domain (*e.g.*, fertilization)." (Ex. 238, Tol Rebuttal, Ex. 1 (Report), at 11:239-242.) For example, even if climate change increased the incidence of river flooding (and, as previously noted, the evidence does not support such a connection), damages from flooding are also traceable to decisions to build structures in flood plains, decisions not to build levees or floodwalls, and so on. Yet the SCC automatically attributes all conceivable damages to CO_2 emissions – without attempting to make any allocations, even when the damages are just as likely to be the "fault" of city planners, farmers, corrupt governments, or others.

The higher values the other Parties advocate would effectively assume this causation into existence: only that irrational assumption can support those higher values. Making such an assumption in a proceeding governed by a preponderance of the evidence standard would not only be arbitrary but would be "otherwise not in accordance with law." 5 U.S.C. § 706(2)(A).

Making a decision based that is not based on a preponderance of the evidence runs the risk of diminishing the Commission's credibility in future proceedings. If it caves into the overwrought rhetoric presented by some other Parties and adopts the IWG's federal SCC without substantiation of the key assumptions underlying it, it risks "crying wolf" and establishing a high value that may very well not be borne out over time. Minnesotans will rightly wonder about the integrity of a rulemaking process that caused their electricity rates to skyrocket while the hiatus in warming continues, Antarctic sea ice continues to grow, crops flourish, and the catastrophes forecast do not come to pass. They may wonder how people who sounded so certain ended up so wrong.

L. Legal and Jurisdictional Reasons Compel a Minnesota-Specific SCC.

Even if Minnesota were to adopt an externality value for CO_2 (and it should not), any such value should be specific to Minnesota, rather than reflecting global externality values. There is no provision in Minnesota law expressly directing or authorizing the Commission to take global effects into account in its calculation of social costs. OMB has instructed federal agencies undertaking regulatory analyses that "Your analysis should focus on benefits and costs that accrue to citizens and residents of the United States."[96] By the same token, the Commission should focus on benefits and costs that accrue to citizens and residents of Minnesota. Consideration of out-of-state effects is inconsistent with the principles of federalism that States generally must limit their regulatory jurisdiction to their own boundaries. As the U.S. Supreme

[96] Ex. 417, OMB Circular A-4, 15.

Court has explained, "No State can legislate except with reference to its own jurisdiction. . . . Each State is independent of all the others in this particular." *Bonaparte v. Tax Court*, 104 U.S. 592, 594 (1881); *see also BMW of North America, Inc. v. Gore*, 517 U.S. 559, 572 (1996) (noting "the autonomy of the individual States within their respective spheres") (internal quotation marks and citation omitted).

There are also practical reasons to limit consideration of costs to Minnesota. As Dr. Gayer noted, a Minnesota policy that considered global costs would demand a dramatic shift in all state policies, including state poverty programs. (Ex. 400, Gayer Direct, 9). Similarly, it would suggest that a policy that leads to the relocation of businesses and economic output from Minnesota to other states or countries should not be considered a cost of the policy, and in all likelihood (depending on which state or country the activity is shifted to) should be considered a benefit. (*Id.)*

There is no reason for Minnesota to adopt such a self-abnegating policy. As ALJ Klein observed, "One state, especially a state like Minnesota, can not make much of a difference. In fact, even if Minnesota's utilities stopped emitting any carbon dioxide, the global problem would be virtually unaffected by our act, except as our action, and similar actions of others in this country and abroad, cause national governments to take the kind of actions that will make a difference."[97]

The Parties proposing the FSCC did not propose a Minnesota-specific SCC. There is substantial evidence that Minnesota's geographical location means that it would be a net beneficiary of climate change. (Ex. 214, Mendelsohn Direct 4:15-5:16; Ex. 216, Mendelsohn Direct, Ex. 2 (Report), at 5, 14; Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 3:40-47; Ex. 220, Mendelsohn Surrebuttal 5:6-11, 6:10-22, 26:9-18; Ex. 204, Happer Rebuttal, Ex. 1 (Report),

[97] 1996 ALJ Recommendation, p. 37.

at 4:60-71; Ex. 228, Bezdek Direct, 3:18-20, 6:3-7:2; Ex. 235, Bezdek Surrebuttal, 52:4-13.) Even if the FSCC were extrapolated to Minnesota, it would amount to 0.4 percent of the global value, suggesting extremely small damage estimates, with a high-end estimate of $0.37 per metric ton of CO_2 (2010 damage value in 2007 dollars). (Ex. 400, Gayer Direct, 10.)

IV. The Preponderance of the Evidence shows Value of Zero is Proper at this Point.

The record shows that the level of uncertainty in climate science has increased, not decreased, since the 1997 proceeding. In the 1997 proceeding, ALJ Klein noted that a zero value could be appropriate when the level of uncertainty is too great, recognizing that values could be adopted later if better information justifies:

> While using reasonably accurate estimates is better than imputing no values, ***not all estimates are better than zero***. For instance, valuing an impact at more than twice its "true" residual damage may lead to a worse allocation of resources than imputing no value. In other words, the possibility of utilities paying more for resources than their environmental benefits justify is just as bad as paying less than their benefits justify. . . . ***A better alternative is to err on the side of conservatism initially, then increase the values gradually if better information in the future confirms the need for higher values.***[98]

The increase in uncertainty is demonstrated by the IPCC itself. AR5 no longer offers a "best estimate" of climate sensitivity, because the state of scientific study does not support one. The climate modeling on which the IPCC relies for its future temperature increases has been shown to vastly diverge from actual temperature ranges. The ***current***, unrefuted temperature information reflects that warming is not occurring as quickly as the IPCC models had predicted, and that the earth's climate sensitivity is therefore not as great as had been previously predicted by IPCC. It is undisputed that the uncertainty regarding the ECS has increased, not decreased. (Ex. 801 (Hanemann Rebuttal Testimony) at 31:11-32:7.) In short, climate predictions have

[98] 1996 ALJ Recommendation, at pp. 17-18 (emphasis added).

become *less certain*, not more certain, since 1997. Accordingly, the Commission should refrain from adopting any value for CO_2 at this time.

V. If The Commission Does Not Adopt A Zero Value, Then In The Alternative It Should Use A Range Near The Status Quo Values Of $0.44 To $4.53 (2014$/Ton) – A Range Of $0.30-$2.00/Ton, And In No Case Higher Than $4.00- $6.00/Ton.

If the Commission were compelled to establish or retain a CO_2 externality value, the best evidence shows that it should be no greater than the current values. In fact, the very models used by the IWG, when run with inputs supported by the current evidence, show that CO_2 values below the current range are appropriate.

A. If The Commission Establishes An Externality Value, It Should Use Dr. Mendelsohn's Improved Model Inputs Yielding a $0.30-$2.00 /Ton Range, or At Most A $4.00-6.00/Ton Range.

Dr. Mendelsohn testified that using the IWG's assumed ECS value of 3.0°C, "a more accurate model in terms of trying to predict damages" would lead to a social cost of carbon measure of $4.00-$6.00/ton in current dollars. (Mendelsohn, 3B Tr. 43:9-13; *see also* Ex. 261.) He testified that, "[g]iven the strong scientific evidence" for lower ECS values, "a reasonable and the 'best available measure' for the SCC is between $0.30 and $2.00/ton." (Ex. 220, Mendelsohn Surrebuttal 33:19-35:4.) Significantly, these values include non-market damages, health and ecosystem effects, and the possibility of catastrophes. (Mendelsohn, 3B Tr. 43:20-25.)

Dr. Mendelsohn used the DICE model (2013 version), with improvements for the damage function and adjusted ECS values. He is the only expert in this proceeding whose operation of the DICE model has been peer-reviewed. (Mendelsohn Surrebuttal at 7:20-14:21.) The IWG's operation of its version of the DICE model (with its many changes and standardizations) has not been peer-reviewed. (Mendelsohn Rebuttal, Ex. 1, at 5:89-97.) As among all the experts in this proceeding, Dr. Mendelsohn has the best credentials for operation of the DICE model.

Dr. Mendelsohn used DICE's original emission and GDP forecasts and internal sliding discount rate that is calculated to be consistent with the growth in GDP per capita (starting at 5 percent and declining to 3.5 percent in the year 2100 and 2.7 percent in the year 2200). Dr. Mendelsohn therefore provided ranges if the ECS is assumed to be 1.5°C ($0.30 to $0.80 per ton) or 2°C ($1.10 to $2.00 per ton). Dr. Mendelsohn pointed out that his recommended values are consistent with values used by other states and countries, and sufficiently close to the values of neighboring states to limit leakage. (Ex. 220, Mendelsohn Surrebuttal 33:19-35:4.) Rather than using a "last ton" methodology that assumes no future mitigation globally, the SCC should be measured based on the optimal path (optimal SCC), since this equates the marginal cost of mitigation to the SCC, which is the only measure that can lead to an efficient mitigation program. (Mendelsohn 3B Tr. 35:12-37:12.)

1. ***Future Emission Scenarios and Mitigation***

Dr. Mendelsohn recommends using the emission scenarios inherent in the DICE model itself. The IWG itself described how the DICE emission scenarios function: "For purposes of estimating the SCC, carbon dioxide emissions are a function of global GDP and the carbon intensity of economic output, with the latter declining over time due to technological progress." (Ex. 100, Polasky Direct Sched. 2 (Feb. 2010 TSD), at 6.)

2. ***Equilibrium Climate Sensitivity***

Dr. Mendelsohn explored several climate sensitivity values, including 1°C , 1.5°C , 2°C , 2.5°C , and 3°C. Because there is convincing evidence that the ECS is lower than 3°C and because the IPCC 5th Assessment Report lowered the "likely" range to 1.5°C and no longer recommends a "best estimate" of 3 °C, Dr. Mendelsohn also provided ranges for an ECS at 1.5°C or 2°C.

3. ***Damage Function***

The damage function in DICE assumes that the percent of GDP lost per year to climate change damage increases with the square of temperature change. When temperatures are 2°C warmer than preindustrial global temperatures, the model assumes climate damage would be equal to 1% of GDP. When temperatures are 4°C higher, the model assumes damages would be 4% of GDP; 8°C increase would yield 16% of GDP damage. However, current empirical evidence supports modification of these assumptions in the DICE damage function. (Ex. 216, Mendelsohn Direct, Ex. 2 (Report), at 11.)

Today, global temperature is about 0.8°C warmer than the preindustrial temperature. According to DICE2013, there therefore should already be a global damage from climate change in 2015 equal to $173 billion annually. However, it is very difficult to detect this annual global damage today, even with careful scientific measurements. (*Id.*) In order to measure the damage from climate change over time, one must discern what changes over time are due to the underlying growth in the economy and the human population, versus what is due to the change in carbon dioxide, rainfall and atmosphere. (*Id.* at 12.)

Empirical evidence to date shows that the magnitude of global benefit to date is slightly higher than the magnitude of global loss to date. The immediate impact of a warmer, wetter and carbon dioxide enriched environment is likely to be beneficial from 1.5°C to 2°C above preindustrial levels. (*Id.* at 14.) But the existing DICE damage function over-predicts damage in the near term. It assumes that the preindustrial temperature in 1900 was optimal for mankind and all warming since then has been harmful. (*Id.*) Because the weight of peer-reviewed evidence shows that in fact any warming since that time has been a net benefit to society, including through increased agricultural and ecosystem productivity and carbon fertilization, Dr. Mendelsohn adjusted his damage function in the DICE model for two scenarios: that net damage

does not begin until temperatures warm to 1.5°C above preindustrial levels, and at 2°C above preindustrial levels. (*Id.*; *see also* Ex. 220, Mendelsohn Surrebuttal, 7:3-15:6 (listing peer-reviewed works supporting his modifications to the damage function).)

In addition, Dr. Mendelsohn's adjustment is based on current observations about the rate at which damages are occurring and likely to occur in the near future. "Looking at the sum of the damage across each sector of the economy with a 2 °C warming, the net damage should be minimal. [However] the current DICE model predicts $2 trillion of damage in 2050 alone [when the DICE model predicts the temperatures will be 2 °C higher than preindustrial levels] and yet the mechanism that will deliver such damage in 35 years is not known. It is not clear how warming one more degree than today could possibly have an impact this large." (Ex. 220, Mendelsohn Surrebuttal at 16:19-17:1.) Indeed, the IPCC itself has acknowledged the lack of observational data linking increased emissions to extreme temperature and precipitation events. (Ex. 213, Lindzen Surrebuttal, 37:8-38:11; *see also id.* at 39:3-45:16 (discussing lack of observed increases in extreme temperature and precipitation events from increases in global GHG emissions).)

4. *Optimization—Measuring Marginal Cost*

Dr. Mendelsohn testified that a damages model for determining the externality value of carbon should measure the marginal damage associated with each policy choice. (Ex. 220, Mendelsohn Surrebuttal, 21:9-11.) Measuring marginal damages is the conventional and universally accepted method that environmental economists use for all pollutants, not just carbon dioxide. (*Id.* at 21:10-11, 24:4-5.) Indeed, as an optimization model, DICE was designed to calculate the optimal solution to climate change, which maximizes the net benefit to society. (*Id.* at 22:9-10). Marginal damages reflect the level of damage that would occur in the future after application of mitigation measures or policies. (Ex. 214, Mendelsohn Direct, 5:24-6:4; Ex. 220,

Mendelsohn Surrebuttal, 21:6-24:2.) The marginal damage depends on the level of mitigation that will be caused by the policy. (Ex. 220, Mendelsohn Surrebuttal, 22:5-6.) The social cost of carbon (or externality value of carbon dioxide) should be measured as the marginal cost of abatement to the marginal damage, in order to maximize the net benefits to society. (*Id.* at 22:8-10.)

5. *Discount Rates*

DICE has its own internal measure of the discount rate that depends on the path of global consumption over time. The discount rate changes as the growth of per capita consumption changes; in other words, the discount rate internal to DICE changes over time as the economy changes. DICE assumes that because damages in a given year reduce investment in that year, damages propagate forward in time and reduce GDP in future years. DICE assumes that interest rates will fall as per capita income falls. (Ex. 100, Polasky Direct Sched. 2 (Feb. 2010 TSD), at 7.) DICE therefore estimates that the current discount rate is 5%; however, as the rate of GDP growth slows over time, the DICE model predicts that the discount rate should fall to about 3.5% in 2100 and 2.7% in 2200. (Ex. 216, Mendelsohn Direct, Ex. 2 (Report), at 16-17; Ex. 218, Mendelsohn Rebuttal, Ex. 1 (Report), at 6.)

B. Dr. Tol's Testimony Supports Dr. Mendelsohn's Estimate.

The testimony of Dr. Tol, the FUND model's creator, strongly supported Dr. Mendelsohn's proposal. Dr. Tol testified that, under the climate sensitivity values used by Dr. Mendelsohn, and using the Ramsey Rule declining discount rates incorporated in FUND (which Dr. Tol believes is appropriate), FUND calculates the SCC as ***negative (-)*** $17.97 for an ECS value of 1°C, ***negative (-)*** $12.06 for an ECS value of 1.5°C, and ***negative (-)*** $4.05 for an ECS value of 2.0°C. (Tol Rebuttal, Ex. 2, at 9:179-180.)

Dr. Tol also testified that, under the IWG's parameters, FUND estimated a social cost of carbon of $8.00/ton in 2011 and $6.60/ton in 2014. In other words, using the same parameters as the IWG, FUND's estimates are trending ***downwards*** (when Dr. Tol operates the model) at the same time as the IWG's estimates are trending ***upwards***. (Tol Rebuttal, Ex. 2, at 8:120-123.)

C. Dr. Bezdek's Testimony Supports Dr. Mendelsohn's Estimate.

Dr. Bezdek further supported Dr. Mendelsohn's proposal. Dr. Bezdek noted that the best available measure for estimating CO_2 damages in resource proceedings should consider both the benefits and the costs of CO_2. He concluded that the Minnesota CO_2 values established in 1997 should be reduced to about $0.20 to $2.00 per ton or lower. These values are based on the benefits of carbon dioxide in the atmosphere in terms of increased crop production and in terms of worldwide economic growth.

Dr. Bezdek testified that all available scientific evidence supports the general concept of a CO_2 fertilization effect. Doubling of the atmospheric CO_2 content above the current level will increase the productivity of most herbaceous plants by about one-third. The total economic value of the CO_2 benefit for 45 crops cumulatively totaled $3.2 trillion, 1961-2012, and is forecast to total nearly $10 trillion, 2012 – 2050. The benefits of carbon dioxide emissions with respect to crop production worldwide are not explicitly included in the IWG's FSCC figures.

In addition, the benefits of CO_2 emissions with respect to economic growth exceed by orders of magnitude the FSCC figures. Fossil fuels are essential for world economic growth, and that significant CO_2 emission reductions will be associated with significant reductions in economic growth. This is due to the higher costs and decreased reliability of alternate forms of energy including wind and solar. The benefits of CO_2 emissions in terms of economic growth exceed the costs (as estimated by the IWG) by the following ratios:

- From 180:1 to 250:1 through year 2040, using a 5% discount rate

- Approximately 70:1 through year 2040, using a 3% discount rate
- Approximately 50:1 through year 2040, using a 2.5% discount rate

D. Mr. Martin's Proposed Range of Values Should be Rejected.

Mr. Martin strongly criticized the FSCC as calculated by the Interagency Working Group, yet his calculations were based on the model runs performed by the IWG, and the ultimate values he recommended were very close to the FSCC. The very defects Mr. Martin correctly identified in the FSCC also invalidate his recommended values.

1. ***Mr. Martin Properly Identified Fatal Flaws in the FSCC.***

Mr. Martin properly observed that "[t]he SCC is inherently uncertain and speculative," rests on "uncertain" assumptions as to future emissions, temperature change, damages, discount rates, and many other factors, and "uncertainty builds from one step to the next." (Ex. 600, Martin Direct, 3:11-17.) He quoted Professor Robert Pindyck, an economist at MIT, for the proposition that, "When it comes to the damage function, we know virtually nothing – there is no theory and no data that we can draw from. As a result, developers of IAMs simply make up arbitrary functional forms and corresponding parameter values." (Ex. 601, Martin Rebuttal, 19 n.9.)

Mr. Martin also acknowledged that climate sensitivity is one of the very most important uncertain parameters driving the social cost of carbon. (*See* Ex. 600, Martin Direct, 18:6-9 ("The most important uncertain parameter in this case is equilibrium climate sensitivity, or the change in temperature expected to result from a doubling of atmospheric CO_2 concentrations above pre-industrial levels.").) He explained that ESC values are highly uncertain. (*See* Ex. 600, Martin Direct, 39:7-10 ("Most importantly, there is little agreement on equilibrium climate sensitivity – the temperature change associated with a doubling of atmospheric CO_2 concentrations above pre-industrial levels – and little empirical data on which to base this key parameter of the models.").)

In fact, he quoted Professor Pindyck: "We know very little about climate sensitivity" and "over the past decade our uncertainty over climate sensitivity has increased." (Ex. 600, Martin Direct, 39:14-22.)

Further, Mr. Martin noted that the IAMs on which the FSCC is based do not fully take adaptation into account, which could lead them to over-estimate damages. (Ex. 600, Martin Direct, 29:18-19 ("the IAMs do not fully capture adaptation to climate change, which could lead them to over-estimate damages").) He added that "[t]he Federal SCC methodology aggregates and averages the SCC results regardless of IAM and socioeconomic/emissions scenario, obscuring their underlying differences and the broad range of results." (Ex. 600, Martin Direct, 39:2-5.) The FSCC simply averages results across the IAMs, obscuring their underlying differences and the broad range of results. In addition, Mr. Martin explained that the choice of discount rate "is highly controversial and has a greater effect on the SCC than any other single variable." (Ex. 600, Martin Direct, 19:1-2.)

2. *Mr. Martin's Recommendation is Invalidated by the Flaws in the FSCC.*

Despite Mr. Martin's recognition of the fatal flaws in the FSCC, his analysis is based on the raw SCC model results that are infected by all of the errors he previously acknowledged. The IWG data provides the foundation of his analysis, and the validity of his results depends on the validity of that data. (*See* Ex. 602, Martin Sur-Rebuttal, 25:5-8, 25:19-26:3.) Moreover, he acknowledged that he assumed that each IAM is equally accurate. (*See* Ex. 600, Martin Direct, 67:5-9 ("Our approach uses results from all three IAMs and five socioeconomic/emissions scenarios used in developing the Federal SCC, not claiming that any IAM is more accurate or any socioeconomic/emissions scenario is more likely than another.").) Thus, Mr. Martin's approach is flawed because (as noted previously) PAGE is not as accurate as FUND or DICE and because the IWG committed grave errors in its operation of FUND and DICE.

3. ***Mr. Martin's Criteria for Decisionmaking Do Not Support His Recommended Value.***

Mr. Martin proposes eight criteria for a methodology to estimate the social cost of carbon. (Ex. 600, Martin Direct, 2.) None of these criteria is specified in the statute or in the Order Regarding Burdens of Proof, *In re Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3* (Mar. 27, 2015). Moreover, his own criteria do not support adoption of his recommended value.

For example, Mr. Martin's first criterion is "[u]se of a damage cost approach to valuing environmental costs." But Peabody's proposal meets this criterion every bit as much as Mr. Martin's. Peabody's proposed values are based on the best scientific evidence as to the marginal damage cost of a ton of carbon.

Mr. Martin's second criterion refers to the "inherent uncertainty in estimating climate change damages over almost 300 years." As noted previously, the best way to address that criterion is simply to say that the uncertainty is too great to justify a value greater than zero, or a departure from the current Minnesota figure for the SCC. Mr. Martin agreed that one way of dealing with uncertainty is to say that it is too great to justify a departure from current values. (Martin, 3B Tr. 132:2-7, 134:5-7.) Another way to address the uncertainty would be to wait until better information exists. Uncertainty does not justify premising decisions on models that have been proven to lack predictive reliability. In fact, adopting a range of values for the SCC based on inaccurate information would simply aggravate the problem of uncertainty.

Mr. Martin's third criterion cites "the absence of consensus on discount rate choice," but his approach uses only the three discount rates selected by the IWG – 5%, 3%, and 2.5%. (Ex. 600, Martin Direct, 9:26-10:1.) He does not employ the 7% discount rate required by OMB Circular A-4, even though he recognized that "a 7 percent rate is required by applicable OMB

guidance, and would reflect the average before tax real rate of return to private capital." (Ex. 601, Martin Rebuttal 41:24-26.) Therefore, instead of reflecting "the absence of consensus on discount rate choice," Mr. Martin's approach simply adopts the IWG's choices of discount rate. (Ex. 602, Martin Surrebuttal 4:10-11.)

Mr. Martin's fourth criterion is use of "statistically sound methods." However, Mr. Martin is not a statistician. Dr. William Wecker, a statistician who has taught on the faculties of the University of Chicago, the University of California, Davis, and Stanford University and who has served as associate editor of the Journal of the American Statistical Association (Ex. 242, Wecker Rebuttal, Ex. 2 (Report), at 1:9-17), testified that the adoption of the IWG's averaging technique by Mr. Martin did not represent a well-founded, statistically sound method for aggregating the IWG outputs. (*Id.* at 2:57-2:66). It failed to consult or apply authoritative statistical literature on combining probabilistic forecasts and decision-making under uncertainty. (*Id.* at 6:122-11:266). It lacks any reference to the large body of peer-reviewed research literature in the mainstream of statistics and applied mathematics, and instead relies on novel ad hoc procedures of his own invention. (*Id.*) It is an unprincipled analysis of the uncertainties involved because it merely treated them all as equally probable. (*Id.* at 11:267-14:325). In addition, 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. (*Id.* at 15:329-16:334). In short, Dr. Wecker testified that Mr. Martin has failed to employ statistically sound methods, failed to apply his own stated criteria on a rigorous basis, and failed to provide any principled basis for the proposed CO_2 environmental cost values. (*Id.* at 2:57-66). Mr. Martin's proposed range is the product of entirely arbitrary subjective judgment. (*Id.)*

Mr. Martin's fifth criterion is "an appropriate level of risk tolerance." Yet he acknowledged that there is a risk on both sides, both in setting the SCC too low and too high. For example, he testified that setting a value of the SCC that is too high could influence the decision to invest in new generating capacity that is not actually in the public interest. (Ex. 600, Martin Direct, 13:22-25 ("if the Commission adopted a single SCC value that in fact overestimates the benefits of reducing emissions, that value could influence the decision to invest in new generating capacity that is not in fact in the public interest").) He also testified that "[t]he immediate cost impacts resulting from decisions using the SCC would be borne by utility customers in Minnesota." (Ex. 600, Martin Direct, 3:26-4:3.) And he expressed concern that setting the SCC too high could cause leakage – moving emissions to other states. (Ex. 601, Martin Rebuttal, 39:26-40:1.)

Mr. Martin testified that Minnesota has already made significant investments to reduce GHGs, and that a high SCC could lead to relatively high-cost further actions compared to mitigation options available elsewhere – meaning that the benefit would be negligible, while Minnesota utility customers (including low-income customers) could bear greater direct costs. (*See* Ex. 601, Martin Rebuttal, 40:1-9 ("because Minnesota has already made significant investments to reduce GHGs, a high SCC could lead to relatively high-cost further actions compared to mitigation options available elsewhere. This means the benefit (reduction in climate damages experienced by Minnesotans) would be small to negligible, while Minnesota utility customers could bear greater direct costs than they would under a resource plan that used a U.S. or Minnesota SCC value. This is a concern to the Company, particularly for our low-income and energy-intensive trade-exposed industrial customers.").)

Mr. Martin's sixth criterion is minimizing "subjective judgments," but a social cost of carbon based on the best available science (as Peabody's approach reflects) is the best way of minimizing subjective judgments. The IWG make a host of subjective judgments in changing the IAMs and generating the data on which Mr. Martin relied.

Mr. Martin's seventh criterion is whether the measure yields a "practicable range." But Peabody's proposed ranges are practicable – and better than Mr. Martin's. His ranges are far too broad to serve as useful tools for the Commission in making resource planning decisions. Schedule 3 to Mr. Martin's direct testimony shows that for emissions year 2020, for example, his proposed values range from $13.61 to $46.14. This is an extremely broad set of values that could raise difficulties for the Commission in making resource planning decisions like whether to operate or retire a power plant, what type of generation capacity to invest in, how to set solar tariffs and so on. Mr. Martin's own testimony acknowledges that an "imprecise SCC" is not helpful in making "individual resource allocation decisions," which are sometimes binary, difficult to reverse, and often have large and long-term implications for electricity rates, environmental impacts, and reliability." (Ex. 600, Martin Direct 6:12-19; *see also* Ex. 601, Martin Rebuttal 20:1-10 ("the SCC is designed for a specific, limited purpose: federal regulatory impact analysis under Executive Order 12866. It is intended to help evaluate whether the benefits of a proposed federal regulation outweigh its costs. In this application there is arguably greater tolerance for the imprecise nature of the estimates, since a regulation would be warranted as long as the benefits significantly exceed costs even if the SCC over- or underestimates the actual damages. Regulatory impact analysis is unlike resource planning, where the imprecise SCC would determine not whether to regulate, but could drive specific, binary decisions that are not easy to reverse and have significant costs.").

Mr. Martin's eighth criterion is whether the measure is "transparent, replicable, and updatable." Yet Mr. Martin has acknowledged that the IWG process (which generated the data on which Mr. Martin relied) was not transparent. (*See* Ex. 600, Martin Direct, 14:25-15:2.) Nor has the IWG data been updated to reflect current science. The IWG did not update its climate sensitivity value in November 2013 after AR5's Working Group 1's report was released in September 2013, nor did the IWG update its climate sensitivity value in July 2015. And replicating and updating an admittedly imprecise and invalid methodology only amplifies its flaws.

For all these reasons, Mr. Martin's proposal should be rejected.

4. ***Mr. Martin's Criteria for Decisionmaking Do Support Dr. Mendelsohn's Approach.***

Mr. Martin testified that Dr. Mendelsohn is "proposing ranges based on the DICE model that's been peer reviewed." (3B Tr. 128:25-129:1.) He agreed that "Dr. Mendelsohn's proposal is a damage cost approach." (*Id.* at 130:23-24.) Indeed, Dr. Mendelsohn's approach meets Mr. Martin's criteria: it addresses uncertainty and the risk of catastrophes by incorporating them into its calculations; it addresses discount rate issues by allowing for a changing rate over time; it uses statistically sound, peer-reviewed methods; it includes an appropriate amount of risk tolerance; it minimizes subjective judgments, yields a practicable range, and is transparent, replicable, and transparent.

VI. CONCLUSION

It is crucial that the Commission's decision regarding the CO_2 externality value be based on the best available evidence, not speculation, surmise, or outdated information.

- **No Evidence Supports Adopting the FSCC**: The proponents of the FSCC have failed to carry their burden of proving by a preponderance of the evidence that the FSCC is the reasonable or best available measure for an externality value. The models

on which they rely are, as Prof. Pindyck noted, "close to useless" for making policy decisions.

- The best available science — the IPCC's AR5, the actual observational data, and other recent evidence published since AR4 — contradicts the science on which the IWG based the FSCC (the AR4, vintage 2007). The information the IWG used is outdated.
- The best available science has shown that uncertainty regarding key variables in the FSCC has ***increased***, not decreased, as Dr. Hanemann conceded. (Ex. 801 (Hanemann Rebuttal Testimony) at 31:11-32:7.)
- As calculated, the FSCC is already a cascade of uncertainties, so that any chosen value would be arbitrarily based on conjecture rather than proof:
    - As Dr. Reich stated, "A model is not direct evidence, ever." (Reich: 5 Tr. 68:17.) The information from climate models cannot support a preponderance of the evidence, given contrary observational data.
    - The emissions predictions rely on science fiction assumptions about energy use through the year 2300.
    - The carbon cycle built into the IWG's calculations makes completely unsupported assumptions about the connection between CO_2 emissions and atmospheric concentrations — a point on which the proponents of the FSCC have introduced ***no evidence*** in this proceeding, only a "trust me" IOU.
    - The climate models on which the IWG based the FSCC are untethered to reality: they no longer reflect what actually happens in the world.
        - AR5 has rejected key elements of the FSCC, including critical ECS values.
        - There is no evidence for the high positive feedbacks required to make a high ECS possible. In other words, there is no scientific way — no mechanism based in actual science, as opposed to simply data manipulation — for the "hot" climate models to be correct.
        - Other observations either do not support the IWG's assumptions (e.g., no greater incidence of extreme weather) or even outright contradict them (e.g., an increase in Antarctic sea ice levels).
        - While better science has been published since 2007, the IWG ignored it.
    - The damage functions built into the IWG's FSCC calculation exaggerate the harms of climate change without scientific evidence to back them up. The damage functions omit important real-world effects such as human adaptation and mitigation.

        - The IWG also used arbitrary discount rates which violated OMB guidance and artificially inflated the FSCC value. In doing so, it made unwarranted ethical assumptions that have no basis in either fact or the administrative record.
        - The IWG twisted the IAMs it used to such a degree that the creator of FUND found it almost unrecognizable, and one of the leading experts in the use of DICE argued that the IWG effectively broke the model.
    - To make the uncertainties worse, the FSCC is effectively a black box. Nobody knows who actually made these decisions, and the record that has been produced is thin and arbitrary. Most importantly for the Commission, no member of the IWG could testify or be cross-examined.
    - Adoption of the FSCC will have unrefuted disastrous effects for Minnesota.
        - Adoption of the FSCC will force leakage as other states take advantage of Minnesota's decision and increase their CO_2 emissions.
        - Adoption of the FSCC will unfairly burden Minnesota's citizens with paying for the cost of other peoples' emissions.
    - "Just trust us" is not evidence sufficient to amount to a preponderance. Adopting the FSCC on such a thin record would compromise basic due process values.
        - The "consensus" is a manufactured myth, a schoolyard tactic designed to marginalize science that is not politically in favor. Simply repeating the incantation of the "consensus" does not amount to proof.
        - With such thin support, adopting the FSCC would effectively be selecting an arbitrary value with no basis in the record.

- **<u>A Preponderance of Evidence Supports a Zero Value</u>:** A preponderance of the evidence supports setting the externality value at zero. This position matches the basic insight that **clear attribution of global warming to anthropogenic CO_2 has not been established <u>at all</u>, much less by a preponderance of the evidence.** No value can command a preponderance of the evidence because the degree of uncertainty is simply too great:
    - The amount of uncertainty has increased, not decreased, since the MPUC decision in 1997 setting a value of $0.30 to $3.10.
    - Indeed, the uncertainty has made very salient ALJ Klein's admonition that "not all estimates are better than zero." There are no longer the same "reasonably accurate estimates" on which ALJ Klein could rely.
    - AR5 found that there is insufficient evidence for a "best estimate" for ECS because of the high (and increasing) levels of uncertainty surrounding the variable. *A fortiori*, there is insufficient evidence to establish an externality value based on the ECS assumed by the IWG.
    - The climate models are still broken. They have not reached the point where they can reliably *predict* temperatures, which is what the externality value requires.

Their failures have made their predictions too uncertain to rely on. Models are not direct evidence, and cannot and should not be used as a basis for policymaking.

- The models cannot explain the hiatus in warming. That global mean temperatures could see no statistically significant increase ***over 18 years, while emissions have been increasing substantially*** shows that the connection between emissions and increased temperatures has not been established with any certainty.
    - While many phenomena have been attributed to human CO_2 emissions, especially in the popular media, those connections have not been established with reliable scientific evidence (and certainly not by a preponderance of the evidence). Indeed, most of these phenomena, such as drought and storm activity, are not outside ordinary natural variation. Moreover, other lines of evidence ***contradict*** the supposed connection, such as the increase in Antarctic sea ice.
- The deep uncertainty underlying the connection between human CO_2 emissions and the negative effects of global warming makes it effectively impossible for any chosen externality value to be anything other than arbitrary. The IAMs used by the IWG are "close to useless" for policymaking that must be based on reasoned judgment rather than intuition or guesstimates.

- **In the Alternative, a Preponderance of the Evidence Supports a Negative Externality Value**: An honest view of the science actually suggests that a negative externality value would be reasonable and supported by the best available evidence:
    - Prof. Tol, the creator of FUND, ran the IAM properly using a range of ECS values supported by the best available evidence and a more reasonable discount rate, as suggested by Prof. Mendelsohn, and found that the best externality value lies between ***negative*** **(-)** $17.97 (for ECS = 1°C) and ***negative*** **(-)** $4.05 (for ECS = 2°C.
        - Keeping in mind that ECS of 1°C is a baseline figure and that no significant positive feedbacks have been demonstrated to push it much higher, the upper end of Prof. Tol's range is conservative.
    - Dr. Mendelsohn discussed the science behind carbon fertilization, which not only means that CO_2 emissions will increase crop productivity, but also means that increased plant growth will also absorb more carbon (so atmospheric CO_2 concentrations will not increase as quickly as expected). These two factors together support an argument for a negative externality value.
        - Dr. Mendelsohn's argument was supported strongly by a peer-reviewed article published by Dr. Reich showing that CO_2 was a key factor that not only increase plant productivity but also insulated those plants from the potentially harmful side effects of warming.
        - In addition to Dr. Reich's evidence, hundreds of peer-reviewed laboratory and open-air experiments validate these findings.
    - Dr. Bezdek presented extensive evidence that CO_2 has collateral benefits that outweigh its harms by a ratio of approximately 250:1 (and no less than 50:1 for

the improperly low discount rate of 3%). CO_2 is not an ordinary pollutant, and adopting an externality value to curtail its production will mean curtailing the productive activities that drive our economy and our societal well-being.

- **In the Further Alternative, a Preponderance of the Evidence Supports Retaining Status Quo Externality Values**: In the face of such a mountain of uncertainty, Peabody believes a preponderance of the evidence supports a zero or negative externality value. But if those options are excluded, if the fear of unproven consequences drives the Commission to do *something* rather than the right thing, then the Commission should simply retain its current status quo values because no preponderance of the evidence supports changing from it:

  - Dr. Mendelsohn's discussion of adaptation and mitigation — all left out of IAM damage functions — shows that people can and will adapt to slow, mild warming. The results are highly unlikely to be as catastrophic as the proponents of the FSCC contend. In light of realistic views, supported by 20 years of peer-reviewed research, the Commission can have faith in our ability to adapt over time and can adjust the value when or if real damages become apparent (i.e., once real evidence is available, rather than fear-based speculation).
    - The status quo values are also by Dr. Mendelsohn's modifications to the DICE model but with a correct ECS of 1.5°C to 2.0°C. This yields an externality value of $0.30 to $0.80/ton at the low end of the ECS range (1.5°C) or $1.10 to $2.00/ton at the high end of the ECS range (2°C).
  - Setting any other value would not be applying a damages-cost methodology because such a value would not be tethered to real evidence. The Commission's last administrative record could support retaining the status quo externality values, but there simply is insufficient evidence to support a higher figure (and definitely not one as extreme as the FSCC).
  - In no case has the FSCC been supported by a preponderance of the evidence: it is an irretrievably broken metric for policymaking. While the Commission could decide to stand pat on status quo values (or those proposed by Dr. Mendelsohn, i.e., $4.00-$6.00/ton), a better reading of the evidence is to set an externality value of zero or below. In addition to being supported by the scientific evidence, this response is the most legally defensible.

Dated: November 24, 2015

Respectfully submitted,

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