S.Bezdek

https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={E0973306-EE25-4652-882E-DAA82B2C95C3}&documentTitle=20159-113912-02

RESPONSES TO: Martin, Polasky, Hanemann, Abraham, Dessler, Gurney

pp.25-26 offers interesting claim:

"It is called the "red team." Unfortunately, but not surprisingly, no such persons were included on the panel.

To be truly independent, rigorous, and objective, the panel should have included distinguished scientists such as Dr. Richard Linzden, Dr. Freeman Dyson, Dr. Fred Singer, Dr. Patrick Michaels, Dr. Robert Hirsch, Dr. Richard Tol, Dr. Roy Spencer, Dr. Judith Curry, Dr. Roger Pielke, Jr., Dr. Robert Mendelsohn, Dr. Craig Idso, Dr. John Christy, Dr. Patrick Moore, Dr. Nils-Axel Mörner, Dr. William Happer, Dr. Steven Hayward, Dr. Robert Balling, Dr. William Wecker, Dr. David Legates, Dr. Anne Smith, Dr. William Briggs, and Dr. Wei-Hock Soon – among others."

pp.85-193 invokes many names found in DeSmog profiles to claim nonexistence of consensus, including on p.91 Christopher Monckton, posted at fossil-funded SPPI blog.

STATE OF MINNESOTA

In the Matter of the Further Investigation in to

Environmental and Socioeconomic Costs

Under Minnesota Statute 216B.2422, Subdivision 3

OAH Docket No. 80-2500-31888

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

Sur-Rebuttal Testimony

Dr. Roger H. Bezdek

September 10, 2015

Roger H. Bezdek Sur-Rebuttal OAH 80-2500-31888 MPUC E-999/CI-14-643

DR. ROGER H. BEZDEK

OAH 80-2500-31888

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1	Q: Are you the same Roger Bezdek who testified previously in this
2	proceeding?
3	A: Yes I am.
4	Q: How will you organize your testimony?
5	A: I will address the following points:
6	• Temperature and weather trends, including the hiatus in warming, extreme
7	weather events (such as forest fires and drought) sea level rise, and sea
8	ice.
9	• The net benefits of carbon: carbon fertilization, and other benefits.
10	• Flaws in the integrated assessment models ("IAMs") used by the federal
11	Interagency Working Group ("IWG" to calculate the Social Cost of Carbon
12	("SCC").
13	"Consensus" science, use of non-peer reviewed material, and the IPCC.
14	Renewable Energy Sources.

I. <u>Temperature and Weather Trends</u>

2 Q: Drs. Dessler, Abraham, and Gurney all contest your argument that there 3 has been no hiatus in warming. Do you believe there has been a hiatus in 4 warming?

A: Yes, and I am not alone in that belief. I have presented overwhelming amounts of peer-reviewed and other scholarly research to support my position, which the opposing witnesses have simply ignored. Attached as Exhibit 3 to my direct testimony (filed June 1, 2015) was a compendium of hundreds of peer-reviewed articles detailing substantial scientific support for my position on the hiatus issue and other climate science questions, and yet the opposing witnesses incorrectly state that I have failed to offer peer-reviewed support. That assertion is simply false.

In particular, I refer to pp. 3-34 of Exhibit 3 to my direct testimony, which lists dozens of peer-reviewed articles demonstrating that climate trends show natural swings in temperature are common, that there has been a "hiatus" in warming, that extreme weather is not increasing, and that natural carbon sinks will mitigate impacts. I also deal with the issue on pp. 3-11 of my rebuttal testimony (filed Aug. 12, 2015), which cites a great deal of research supporting the hiatus point.

18 I further note that Professor Dessler concedes that there has been no statistically 19 significant warming since 2000 (despite the enormous CO₂ emissions that have 20 occurred): "Figure 1 shows that Dr. Spencer is correct: beginning around 2000, the 21 uncertainty in the trend expands and begins to encompass zero. Thus, it is correct to 22 say that there has been no statistically significant warming since 2000." (Dessler

1 Rebuttal Testimony at 15:5-7.) He also testified that the rate of warming slowed down 2 over the last decade or so, even though this has been the period of greatest CO_2 emissions: "Figure 1 shows that the warming since the beginning of the 21st century 3 has been smaller than that since the 1990s (although the differences are not statistically 4 5 significant)." (Dessler Rebuttal Testimony at 21:3-6.) Even Professor Dessler has 6 acknowledged that climate models "assumed incorrect 'forcing' over the last decade," 7 which has caused "the models to run 'hot" and over-predict warming. (Dessler Rebuttal 8 Testimony at 25:16-18.)

9 I also wish to point out that, when speaking among themselves, IPCC authors 10 acknowledge that there is a hiatus in warming that they cannot explain. Kevin 11 Trenberth, an IPCC author and one of the fathers of the theory of anthropogenic global 12 warming, wrote: "The fact is that we can't account for the lack of warming at the moment and it is a travesty that we can't."¹ In fact, climate scientists have conceded that a 13 pause of 15 years or more would invalidate current models. A 2008 NOAA report 14 explained: "The simulations rule out (at the 95% level) zero trends for intervals of 15 15 years or more."² This is significant, because the "pause" in global warming is, as of 16 17 September 2015, 18 years 8 months. Specifically, the Remote Sensing Satellite

¹ CRU email 1255523796.txt (Oct. 14, 2009). These emails were part of an email exchange among IPCC authors, described below, and reveal many problems the IPCC admits internally but covers up in public. Further discussion below.

² Peterson, T. C., and M. O. Baringer, Eds., 2009: State of the Climate in 2008. *Bull. Amer. Meteor. Soc.*, 90, S1–S196.

- dataset shows no global warming at all for 224 months from January 1997 to August
 2015 more than half the 440-month satellite record.³
- Further, even Dr. Rajendra Pachauri who until recently was the long-time head of 3 the IPCC, admits there has been a pause that is now nearly 2 decades old. For 4 5 example, in Melbourne for a 24-hour visit to deliver a lecture for Deakin University, Dr. 6 Pachauri said that people had the right to guestion the science, whatever their 7 motivations. "People have to question these things and science only thrives on the 8 basis of questioning," Dr. Pachauri said. He said there was "no doubt about it that it was good for controversial issues to be 'thrashed out in the public arena." 9 Dr. 10 Pachauri's views contrast with arguments in Australia that views outside the orthodox position of approved climate scientists should be left unreported. He stated that "Unlike 11 12 in Britain, there has been little publicity in Australia given to recent acknowledgment by 13 peak climate-science bodies in Britain and the US of what has been a 17-year pause in global warming. Britain's Met Office has revised down its forecast for a global 14 temperature rise, predicting no further increase to 2017, which would extend the pause 15 16 to 21 years."⁴
- IPCC lead author and noted climatologist Hans von Storch has admitted that climate models are having a difficult time replicating the lack of global warming during the past 15 years. He stated that "So far, no one has been able to provide a compelling

³ http://www.climatedepot.com/2015/09/02/a-new-record-pause-length-satellite-data-no-global-warmingfor-18-years-8-months/. ⁴ http://www.theaustralian.com.au/news/nothing.off limits in climate debate/story_e6fra6n6

⁴ http://www.theaustralian.com.au/news/nothing-off-limits-in-climate-debate/story-e6frg6n6-1226583112134.

answer to why climate change seems to be taking a break."⁵ Dr. Storch noted that the 1 2 models say the planet should be warming much more than it has. "According to most climate models, we should have seen temperatures rise by around 0.25 degrees 3 Celsius (0.45 degrees Fahrenheit) over the past 10 years. That hasn't happened. In 4 5 fact, the increase over the last 15 years was just 0.06 degrees Celsius (0.11 degrees Fahrenheit) – a value very close to zero. This is a serious scientific problem that the 6 IPCC will have to confront."⁶ 7

Finally, and most important, over the past decade numerous proponents of the 8 AGW (Anthropogenic Global Warming) theory have acknowledged, in the peer-9 10 reviewed literature, that there has been a "pause" (which lengthens every month) and 11 have come up with several dozen reasons to attempt to explain the reasons for this and 12 to argue that the existence of the pause does not invalidate their theory. The 13 researchers making these arguments include some of the most prominent AGW theorists and their attempted explanations have been published in some of the most 14 prestigious peer-reviewed scientific journals, including Nature, Science, Nature Climate 15 16 Change, Geophysical Research Letters, Earth System Dynamics, Geophysical Research Letters, Nature Geoscience, Proceedings of the National Academy of 17 18 Sciences, and Climate Dynamics. The reasons they have advanced to attempt to 19 explain the pause include low solar activity, oceans eating the global warming, Chinese 20 coal use, the Montreal protocol, volcanic aerosols, stratospheric water vapor, faster (or

⁵ "Climate Expert von Storch: Why Is Global Warming Stagnating?" Der Spiegel, June 20, 2013, available at http://www.spiegel.de/international/world/interview-hans-von-storch-on-problems-with-climate-changemodels-a-906721.html.

⁶ Ibid.

slower) pacific trade winds, pine aerosols, interdecadal Pacific oscillation, AMOC
 (Atlantic Meridional Overturning Circulation) ocean oscillation, fewer El Niños, and many
 others. For example, the "pause" in global warming has been attributed to, among other
 factors:

The Smell of Pine Trees. Writing the in journal *Nature*, Ehn, et al. suggested that
 there may be a strong link between the powerful smell of pine trees and climate
 change. They contended that they have found a mechanism by which these
 scented vapors turn into aerosols above boreal forests. These particles promote
 cooling by reflecting sunlight back into space and helping clouds to form a
 cooling effect.⁷

11 Fast Trade Winds. Writing in Nature Climate Change, England, et al. contended 12 that fast trade winds caused cooling and are responsible for the pause. They 13 claimed that strong trade winds have driven more of the heat from global 14 warming into the oceans; but when those winds slow, that heat will rapidly return 15 to the atmosphere causing an abrupt rise in global average temperatures.⁸ They contended that heat stored in the western Pacific Ocean caused by an 16 17 unprecedented strengthening of the equatorial trade winds appears to be largely responsible for the hiatus in surface warming observed over the past two 18 19 decades.

⁷ Mikael, Ehn, et al., "A large source of low-volatility secondary organic aerosol," *Nature*, Volume, 506, pages: 476–479, 27 February 2014, doi:10.1038/nature13032.

⁸ Matthew H. England, et al., "Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus," *Nature Climate Change* (2014) doi:10.1038/nclimate2106.

Slow Trade Winds. However, writing in Nature, Vecchi, et al. stated the exact opposite.⁹ They contended that the vast loop of winds that drives climate and ocean behavior across the tropical Pacific has weakened by 3.5% since the mid-1800s, and it may weaken another 10% by 2100. They indicated that this is the only plausible explanation for the hiatus.

6 El Niño. Writing in Geophysical Research Letters, Banholzer and Donner 7 examined three historical temperature data sets and classified past El Niño events as traditional or central Pacific. They found that global surface 8 9 temperatures were anomalously warm during traditional El Niño events but not 10 during the central Pacific El Niño events. They noted that in the past few 11 decades, the frequencies of the two types of El Niño events have changed, with 12 the central-Pacific type occurring more often than it had in the past, and suggested that this could explain recent decade-scale pause in global warming.¹⁰ 13

• *Stratospheric Water Vapor.* Writing in *Science*, Solomon, et al. found that stratospheric water vapor concentrations decreased by about 10% after the year 2000. They contended that this acted to slow the rate of increase in global surface temperature over 2000–2009 and thus contribute to the pause. They contended that their findings show that stratospheric water vapor is an important driver of decadal global surface climate change.¹¹

¹⁰ Sandra Banholzer and Simon Donner, "The influence of different El Niño types on global average temperature," *Geophysical Research Letters*, 28 March 2014, DOI: 10.1002/2014GL059520.

⁹ Gabriel A. Vecchi, et al., "Weakening of tropical Pacific atmospheric circulation due to anthropogenic forcing," *Nature* 441, 73-76 (4 May 2006), doi:10.1038/nature04744.

¹¹ Susan Solomon, et al., "Contributions of Stratospheric Water Vapor to Decadal Changes in the Rate of Global Warming," *Science*, 5 March 2010: Vol. 327 no. 5970 pp. 1219-1223.

1 AMOC Ocean Oscillation. Writing in Earth System Dynamics, Schleussner et al. contended that that the natural ocean oscillation the Atlantic meridional 2 overturning circulation (AMOC) can explain the "pause" in global mean 3 temperatures over the past two decades.¹² According to the authors, "[a]s a 4 consequence of multi-decadal AMOC variability, we report substantial variations 5 in North Atlantic deep-ocean heat content with trends of up to 0.7 × 1022 J 6 decade⁻¹ that are of the order of observed changes over the last decade and 7 8 consistent with the reduced GMT [Global Mean Temperature] warming trend over this period." They also described a potential mechanism that could be the 9 natural driver of multidecadal ocean oscillations, finding "robust negative 10 11 correlation between the AMOC and North Atlantic deep-ocean density with 12 density lagging the AMOC by 5 to 11 yr. in most models." However, the authors 13 did not address the question of, if natural multidecadal ocean oscillations can 14 explain the pause, why these oscillations could not also explain much of the 15 cause of the reputed global warming during the 1980s and 1990s.

Volcanic Aerosols. An NSF/NASA funded team led by the University of
 Colorado-Boulder assessed why Earth did not warm between 2000 and 2010
 and found, in a study published in *Geophysical Research Letters*, the reason for
 the pause to be dozens of volcanoes spewing sulfur dioxide.¹³ Small amounts of
 sulfur dioxide emissions from Earth's surface eventually rise 12 to 20 miles into

¹² C.F.Schleussner, et al., "The role of the North Atlantic overturning and deep ocean for multi-decadal global-mean-temperature variability, *Earth System Dynamics*, /5/103/2014, pp. 103-115.

¹³ Brian Toon, et al., "Volcanic aerosols, not pollutants, tamped down recent Earth warming," Cooperative Institute for Research in Environmental Sciences, published online in *Geophysical Research Letters*, March 1, 2013.

the stratospheric aerosol layer of the atmosphere, where chemical reactions create sulfuric acid and water particles that reflect sunlight back to space, cooling the planet. "This new study indicates it is emissions from small to moderate volcanoes that have been slowing the warming of the planet." The press release stated that the study results essentially exonerate Asia, including India and China, two countries that are estimated to have increased their industrial sulfur dioxide emissions by about 60 percent from 2000 to 2010 through coal burning.

The Montreal Protocol. Writing in Nature Geoscience Estrada, et al. noted that in
 1988, more than 40 countries, including the United States, signed the Montreal
 Protocol, an agreement to phase out the use of ozone-depleting gases like
 chlorofluorocarbons. CFC emissions have been reduced 90 percent since the
 Protocol, and the authors contended that reducing CFCs has been a major driver
 of the pause in global warming.¹⁴

14 Chinese Coal. Writing in the Proceedings of the National Academy of Sciences, 15 Kaufmann, et al. stated that it has been unclear why global temperatures did not 16 rise between 1998 and 2008. They found that this hiatus in warming coincides 17 with a period of little increase in the sum of anthropogenic and natural forcings. 18 They contended that the hiatus was caused by a rapid growth in short-lived sulfur 19 emissions from increased coal utilization in China. As such, they contended that 20 recent global temperature records are consistent with the existing understanding 21 of the relationship among global surface temperature, internal variability, and

¹⁴ Francisco Estrada, et al., "Statistically derived contributions of diverse human influences to twentiethcentury temperature changes, *Nature Geoscience* Volume: 6, Pages: 1050–1055 (2013).

radiative forcing, which includes anthropogenic factors with well-known warming and cooling effects.¹⁵

Unaccounted External Forcing Factors. Hans von Storch and his colleagues 3 4 observed that in recent years, the increase in near-surface global annual mean 5 temperatures has emerged as considerably smaller than many had expected and investigated whether this can be explained by contemporary climate change 6 7 scenarios. In contrast to earlier analyses for a ten-year period that indicated 8 consistency between models and observations at the 5% confidence level, they found that the continued warming stagnation over fifteen years, from 1998-2012, 9 10 is no longer consistent with model projections even at the 2% confidence level.¹⁶

Of the possible causes of the inconsistency, the underestimation of internal natural climate variability on decadal time scales is a plausible candidate, but the influence of unaccounted external forcing factors or an overestimation of the model sensitivity to elevated greenhouse gas concentrations cannot be ruled out.

Stadium Waves. Writing in Climate Dynamics, Wyatt and Curry noted that one of
 the most controversial issues emerging from the Intergovernmental Panel on
 Climate Change Fifth Assessment Report is the failure of global climate models
 to predict the hiatus in warming of global temperatures since 1998. The authors
 suggested that this "unpredictable climate variability" behaves in a more
 predictable way than previously assumed. They referenced the so-called

¹⁵ Robert K. Kaufmann, et al., "Reconciling anthropogenic climate change with observed temperature 1998–2008, Proceedings of the National Academy of Sciences, vol. 108 no. 29, (2011), pp. 11790–11793.

¹⁶ von Storch, H., A. Barkhordarian, K. Hasselmann and E. Zorita, "Can climate models explain the recent stagnation in global warming?" University of Hamburg Meteorological Institute, 2013.

"stadium-wave" signal that propagates like the cheer at sporting events whereby
sections of sports fans seated in a stadium stand and sit as a "wave" propagates
through the audience. In like manner, the "stadium wave" climate signal
propagates across the Northern Hemisphere through a network of ocean, ice,
and atmospheric circulation regimes that self-organize into a collective tempo.
The stadium wave hypothesis provides a plausible explanation for the hiatus in
warming and helps explain why climate models did not predict this hiatus.¹⁷

8 While some of these rationales appear to be contradictory and others almost 9 laughable, there is a very important salient point here. None of these prominent 10 researchers – unlike Drs. Dessler, Abraham, and Gurney – dispute the existence of the 11 pause, which is now nearly two decades long; rather, they are attempting to explain it 12 away.

Q: What about the claim that the hiatus is attributable to excess heat being "stored" in the oceans?

A: A 2014 NASA study debunked that theory.¹⁸ NASA's "latest data from satellite and direct ocean temperature measurements . . . found the ocean abyss below 17 1.24 miles (1,995 meters) *has not warmed measurably*."¹⁹ A joint study by the University of Washington and the National Oceanic and Atmospheric Administration, published in the *Proceedings of the National Academy of the Sciences*, examined some of the few long-term oceanic observations available (the Northeast Pacific Arc, bounded

¹⁷ M.G. Wyatt and J.A. Curry, "Role for Eurasian Arctic shelf sea ice in a secularly varying hemispheric climate signal during the 20th century," *Climate Dynamics*, 2013.

 ¹⁸ AFP, Lack of Ocean Heat Puzzles NASA Hunt for Warming "Hiatus," Oct. 21, 2014, available at http://news.yahoo.com/lack-ocean-heat-puzzles-nasa-hunt-warming-hiatus-201944793.html.
 ¹⁹ See id. (emphasis added, internal quotation omitted).

roughly by Alaska, California, and Hawai'i, going back to 1900).²⁰ When the time frame 1 2 is extended back to such a scope, the study shows that virtually all temperature changes can be explained by shifts in circulation and pressure: "dynamical forcing 3 accounts for virtually all of the observed warming in NE Pacific Arc SST over the 1900-4 2012 period."21 5

The study then applied a model for anthropogenic climate change and found that 6 it could not show any temperature impact from human influence.²² The largest changes 7 8 in temperature and circulation occurred before 1940 – before climate modelers claim a human impact.²³ If there has been a human impact, it has been vanishingly small, 9 prompting one commentator to note, "The man-made warming of the past 20 years has 10 11 been so feeble that a shifting current in one ocean was enough to wipe it out altogether."²⁴ Thus, if climate modelers are right that oceans can absorb warming 12 13 caused by greenhouse gases, then they have dramatically *underestimated* the ocean's capacity to store warmth. 14

Q: Dr. Abraham suggests that there have been more frequent or more 15 16 intense major events due to anthropogenic global warming, such as forest fires,

17 droughts, sea level rise, or loss of sea ice. What is your response?

http://www.sciencemag.org/content/345/6199/897 (subscription required).

²⁰ James A. Johnstone & Nathan J. Mantua, *Atmospheric Controls on Northeast Pacific Temperature* Variability and Change, 1900-2012, Proceedings of the Nat'l Acad. of Sciences Early Edition 1 (published ahead of print) (Sept. 22, 2014), available at http://www.pnas.org/content/early/2014/09/16/1318371111. short (subscription required).²¹ *Id.* at 5.

²² Id. ²³ Id.

²⁴ Matt Ridley, Whatever Happened to Global Warming?, WALL ST. J. (Sep. 4, 2014), available at http://online.wsj.com/articles/matt-ridley-whatever-happened-to-global-warming-1409872855. The study is Xianyao Chen and Ka-Kit Tung, Varying Planetary Heat Sink Led to Global-Warming Slowdown and Acceleration, 345 SCIENCE 897 (Aug. 2014), available at

1	A: Dr. Abraham's suggestion is wrong. Again, I have addressed this issue
2	extensively in my prior testimony, which the opposing witnesses have simply ignored.
3	Scientific research shows that:
4	• There is no evidence that extreme weather is increasing, and in any event
5	warming would moderate it further (Bezdek Direct Testimony at 32-24; Exhibit 3
6	to Bezdek Direct Testimony, at 7-21; Bezdek Rebuttal Testimony at 11-19);
7	• Historical cycles of warming (such as the Medieval Warm Period) have been
8	more significant than predictions today, and historical warming periods had
9	beneficial impacts for humanity (Exhibit 3 to Bezdek Direct Testimony, at 21-33);
10	• Any sea level rise has been overstated, is not linked to warming, and will not
11	pose a serious problem (Exhibit 3 to Bezdek Direct Testimony, at 154-160;
12	Bezdek Rebuttal Testimony at 11-12);
13	• The U.S. National Oceanic and Atmospheric Administration (NOAA) recently
14	(August 2015) estimated that the absolute global sea level rise is no more than
15	1.7-1.8 millimeters/year; ²⁵
16	• It has been conclusively shown that the water intrusion problems in Norfolk and
17	the Chesapeake Bay region are due not to "sea level rise," but to land
18	subsidence due to groundwater depletion and, to a lesser extent, subsidence
19	from glacial isostatic adjustment; ²⁶

 ²⁵ National Oceanic and Atmospheric Administration, "Global Regional Trends Comparison," http://tidesand currents. noaa.gov/sltrends/globalregional.htm.
 ²⁶ Jack Eggleston and Jason Pope, *Land Subsidence and Relative Sea-Level Rise in the Southern*

²⁶ Jack Eggleston and Jason Pope, Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region, U.S. Geological Survey, prepared in cooperation with the Hampton Roads Planning District Commission, Circular 1392, Reston, Virginia, 2013; L.F. Konikow, and C.E. Neuzil, "A Method to Estimate Groundwater Depletion From Confining Layers," Water Resources Research, v. 43,

1 Any Arctic and Antarctic impacts (including sea ice and non-Arctic glaciers) have 2 been overstated, are not linked to warming, and will not pose a problem (Exhibit 3 3 to Bezdek Direct Testimony, at 160-165); 4 • Warming will not harm terrestrial ecosystems (Exhibit 3 to Bezdek Direct Testimony, at 114-126; Bezdek Rebuttal Testimony at 16-17); and 5 6 Warming will not harm ocean ecosystems, whether through ocean acidification. 7 coral bleaching, and other means (Exhibit 3 to Bezdek Direct Testimony, at 126-154; Bezdek Rebuttal Testimony at 18-19). 8 9 Roger A. Pielke Jr.'s recent book, The Rightful Place of Science: Disasters and Climate Change, also refutes Dr. Abraham's assertions.²⁷ Carter, McKirick, etc next page 10 11 In addition, a group of 13 esteemed scientists (including the Assistant Director of Programs, Science and Technology Policy at the United States Department of the 12 13 Interior) published a monograph in March 2015 explaining: 14 Speculation that wet areas become wetter and dry areas become 15 drier are claims about increases in gradients and differences, which the 16 global warming hypothesis does not contain. In fact models call for a 17 decrease in gradients between equator and poles, which would imply a

no. 7, (2007); S.E. Engelhart and B.P. Horton, "Holocene Sea Level Database for the Atlantic Coast of the United States," *Quaternary Science Reviews*, v. 54 (2012), pp. 12–25; S.E. Engelhart, B.P. Horton, B.C. Douglas, W.R. Peltier, and T.E. Törnqvist, "Spatial Variability of Late Holocene and 20th Century Sea-Level Rise Along the Atlantic Coast of the United States," *Geology*, v. 37, no. 12 (2009), pp. 1115–1118; S.R. Holdahl and N.L. Morrison, "Regional Investigations of Vertical Crustal Movements in the U.S., Using Precise Relevelings and Mareograph Data," *Tectonophysics*, v. 23, no. 4 (1974), p. 373–390; R.A. Snay, and Tomás Soler, "Continuously Operating Reference Station (CORS) – History, Applications, and Future Enhancements," *Journal of Surveying Engineering*, v. 134, no. 4, (November 2008), pp. 95–104; A.H. Sallenger, K.S. Doran, and P.A. Howd, "Hotspot of Accelerated Sea-Level Rise on the Atlantic Coast of North America," *Nature Climate Change*, v. 2, no. 12 (2012), pp. 884–888.

reduction in storminess. Drought levels have, if anything, fallen worldwide in recent decades and there is little evidence of global changes in floods.²⁸

1

2

3

With respect to "ocean acidification," the scientists explain:

The oceans absorb some of the extra carbon dioxide released into 4 the atmosphere. It would form a weak acid if it were not already mostly 5 alkaline. Human emissions of carbon dioxide will tend to make sea water 6 7 less alkaline and more chemically neutral. The projected change over the next century is between 0.1 and 0.5 pH units. However, seawater pH 8 9 naturally varies from 7.5 to 8.5 between regions of the ocean, between 10 habitats, between days, and even between times of day. It is therefore misleading to talk of 'ocean acidification'. Shallow-water coral reefs are 11 12 already subjected to hourly, daily and seasonal changes in pH that 13 encompass the full range of ocean variability, hence the effects of changes in pH can be studied. Claims that corals and shellfish will find it 14 harder to grow in acidic water are overly simplistic, not only because the 15 16 water is not expected to be acidic but because the dissolved carbon dioxide forms bicarbonate and carbonate ions, the raw material for 17 18 shellfish shells. Most studies find mixed effects, with some groups of

²⁸ 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).

organisms thriving as a result of increased dissolved carbon dioxide and 1 some doing less well.²⁹ 2

With respect to sea level rise, the scientists observe: 3

[S]ea level has been rising for thousands of years - since long 4 5 before GHG emissions became significant. Claims of an acceleration in 6 sea level rise from 2 to 3mm per year and its attribution to mankind must 7 be treated with caution. In particular, it is not currently possible to 8 reconcile estimates of sea level rise with estimates of the factors that are 9 thought to contribute to it. The picture is even more unclear at the local 10 scale where, depending on the location, many contributions have nothing to do with climate, such as tectonics, vegetation cover, hydrology, etc.³⁰ 11

12

Q. Dr. Abraham (p. 9, In. 6) states that "A rising sea is a way to measure 13 global warming." Do you agree with this statement?

14 **A.** Not necessarily. However, assume that it is true. Since sea levels are rising 15 little, if at all, according to Dr. Abraham, then, global warming is not occurring. This lack 16 of warming is confirmed by the fact that the most reliable measure - the Remote Sensing Satellite system – has shown no warming for the past two decades. 17

18 Q: Dr. Abraham asserted that 2014 was the hottest year on record. Do you 19 agree?

²⁹ *Id.* at 15.

1	A: No. This announcement was based on flawed surface-level measurements
2	that are inaccurate and unreliable. ³¹ For example, the surface-level measurements are
3	corrupted by the urban heat island effect. ³² Satellite datasets, which on the other hand
4	are much more reliable, do not confirm the recent alarmist finding, and instead confirm
5	the continuing hiatus in warming. ³³ Indeed, satellite data show that the warmest year
6	was 1998. ³⁴ "The satellite and balloon data of the deep atmosphere have 2014 in a
7	cluster of warmish years well below the hottest two of 1998 and 2010."35 Overall,
8	however, even the surface-level data confirm that global warming has been on hiatus
9	for almost two decades."

- 10 The 2014 findings announcement became a political and media event but the
- 11 truth that the scientists found a less than 50% chance that 2014 was the hottest year

³² See Roy Spencer, 2014 a Record Warm Year? Probably Not, Global Warming (Dec. 4, 2014), available at http://www.drroyspencer.com/2014/12/2014-a-record-warm-year-probably-not/ ("2014 No Record").

³³ See Lubos Motl, *NOAA, NASA: 2014 Was Probably Not the Warmest Year on Our Record*, Climate Depot (Jan. 18, 2015), *available at* http://www.climatedepot.com/2015/01/18/breaking-noaa-nasa-quietlyconceded-2014-was-probably-not-the-warmest-year-on-record/ ("2014 Not the Warmest"); *see also* Marc Morano, *Scientists Balk at 'Hottest Year' Claims: Ignores Satellites Showing 18 Year 'Pause'—We Are Arguing Over the Significance of Hundredths of a Degree'—The 'Pause' Continues*, Climate Depot (Jan. 16, 2015) *available at* http://www.climatedepot.com/2015/01/16/scientists-balk-at-hottest-year-claims-weare-arguing-over-the-significance-of-hundredths-of-a-degree-the-pause-continues/ ("Scientists Balk") ("The satellites show an 18 year plus global warming 'standstill and the satellite was set up to be "more accurate" than the surface records."); Roy Spencer, *2014 as the Mildest Year: Why You are Being Misled on Global Temperatures*, Global Warming (Jan. 18, 2015), *available at*

http://www.drroyspencer.com/2015/ 01/2014-as-the-mildest-year-why-you-are-being-misled-on-globaltemperatures/ ("2014 the Mildest Year") ("our only truly global temperature measurements, the satellites, are ignored because they don't show a record warm year in 2014").

³⁴ See Motl, 2014 Not the Warmest, *supra*.

³¹ GAO, Climate Monitoring: NOAA Can Improve Management of the U.S. Historical Climatology Network, GAO 11-800 (Aug. 2011), which discusses the unreliable nature of the surface temperature data used for this finding.

 ³⁵ Morano, Scientists Balk, *supra* (quoting climatologist Dr. John Christy, professor of atmospheric sciences at the University of Alabama-Huntsville).
 ³⁶ David Whitebourse, 2014, Olabed Temperature Continued and the University of Alabama-Huntsville).

³⁶ David Whitehouse, 2014: Global Temperature Stalls another Year—Global Warming Pause Continues Despite Warm Year, The Global Warming Policy Forum (Jan. 16, 2015), available at http://us4.campaignarchive1.com/?u=c920274f2a364603849bbb505&id=c8bbc1ccfe&e=f4e33fdd1e ("2014 Global Warming Pause") ("The addition of 2014 global temperature data confirms that the post-1997 standstill seen in global annual average surface temperature has continued for one more year making it now about 17 years in duration.").

on record rather than a definitive conclusion based on the data – was obfuscated.³⁷ 1 2 The scientists were not sure, even, that 2014 was truly the warmest year; rather, they stated that it was statistically probable.³⁸ But this "conclusion" was based on a 3 4 differences of hundredths of a degree, which is not even within the margin of error for the faulty surface temperature measuring gauges.³⁹ 5

6 Most importantly, it is clear that despite this data and the claims regarding 2014, computer-modeled climate projections continue to be disproven by real-world data.⁴⁰ 7

8 To be clear, even with 2014 being slightly warmer than other years – and statistically

9 similar in temperature to 2005 and 2010, demonstrating no impactful trend between

10 2005 and 2014 – any temperature increase is still inconsistent with computer model

forecasts.41 11

Not only is global warming not occurring, but, rather, the world may instead be 12

13 entering an era of global cooling. For example, German climate scientists Horst-

14 Joachim Lüdecke, Alexander Hempelmann, and Carl Otto Weiss analyzed climate

- 15 changes of the past and concluded that 1) the recent changes (of the last 40 years) are
- 16 nothing out of the ordinary, and 2) the real concern is a global cooling that will persist

³⁹ See Morano, Scientists Balk, supra; see also Mercelo Gleiser, Was 2014 the Hottest Year on Record— Or Not?, NPR Commentary on Science and Society (Jan. 21, 2015), available at

http://www.npr.org/blogs/13.7/2015/01/21/378665687/was-2014-the-hottest-year-on-record-or-not ("the difference of only 0.02 degrees Celsius 'is within the uncertainty of the measurement.") (citing Hansen et al., Global Temperature in 2014 and 2015, Climate Science, Awareness and Solutions (Jan. 16, 2015)); see also David Rose, NASA Climate Scientists: We Said 2014 Was the Warmest Year on Record ... But We're Only 38% Sure We Were Right, THE DAILY MAIL (Jan. 17, 2015), available at

³⁷ See Motl, 2014 Not the Warmest, *supra*.

³⁸ See id.

http://www.dailymail.co.uk/news/article-2915061/Nasa-climate-scientists-said-2014-warmest-year-record-38-sure-right.html.
 ⁴⁰ See Whitehouse, 2014 Global Warming Pause, supra.

⁴¹ See Jason Samenow, Scientists React to Warmest Year: 2014 Underscores "Undeniable Fact" of Human-Caused Climate Change, the Washington Post, (Jan. 16, 2015) (quoting Judith Curry); see also Roy, 2014 No Record, supra.

1	until 2080.42 They found that climate is often cyclic. Their first study was published in
2	February 2013 and it examined six of the longest existing thermometer data series
3	recorded in Europe, as well as one dataset from an Antarctic ice core and another from
4	a data series extracted from stalagmites. The datasets covered the period of 1757 -
5	2010. The second publication appeared in February 2015 and examined the past 2500
6	years. Compared to the maxima and minima of the past, the current minima and
7	maxima show that there is nothing unusual happening today. The scientists say today's
8	temperature changes are within the normal range. They concluded that "[e]specially the
9	20th century shows nothing out of the ordinary."43 The German scientists write that one
10	result of the well-established cyclic behavior over the past 2500 years is that it is
11	justified to assume that the De Vries/Suess solar cycle will continue in the future. They
12	warned that this means that "global cooling is to be expected over the next 60 years."44

13 Numerous other studies have also been published warning of imminent global cooling.⁴⁵ http://www.desmogblog.com/horst-joachim-ludecke not a climate scientist

⁴² Thev published two papers on the subject in the journal European Geophysical Union (EGU): H.-J. Luedecke, A. Hempelmann, and C. O. Weiss: Multi-periodic climate dynamics: spectral analysis of long term instrumental and proxy temperature records, Clim. Past 9, 447 - 452 (2013), http://www.clim-past. net/9/447/2013/cp-9-447-2013.pdf; H.-J. Luedecke, C. O. Weiss, and H. Hempelmann: Paleoclimate forcing by the solar De Vries / Suess cycle, Clim. Past Discuss. 11, 279 (2015); http://www.clim-pastdiscuss.net/11/279/2015/cpd-11-279-2015.pdf. ⁴³ *Ibid.*

⁴⁴ Ibid.

⁴⁵ See. for example Solar Cycle 25 Peaking Around 2022 Could be One of the Weakest in Centuries," Physorg.com, http://www.physorg.com/pdf; W. Livingston and M. Penn, "Sunspots May Vanish by 2015, http://wattsupwiththat.files. wordpress.com/2008/06/livingston-penn sunspots2.pdf; Kh. I. Abdusamatov, "Optimal Prediction of the Peak of the Next 11-Year Activity Cycle and of the Peaks of Several Succeeding Cycles on the Basis of Long-Term Variations in the Solar Radius or Solar Constant." Kinematics and Physics of Celestial Bodies, Vol. 23, No. 3 (June 2007), pp. 97-100; Roger H. Bezdek, "Climate Change: But in Which Direction?" World Oil, November 2010; C. de Jager and S. Duhau, "Forecasting the Parameters of Sunspot Cycle 24 and Beyond," Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 71, No. 2 (February 2009), pp. 239-245; D. Archibald, "Solar Cycles 24 and 25 and Predicted Climate Response," Energy and Environment, Vol. 17, No. 1 (2006); M.A. Clilverd, E. Clarke, T. Ulich, H. Rishbeth, and M.J. Jarvis, "Predicting Solar Cycle 24 and Beyond," Space Weather, Vol. 4, 2006. I.G. Usoskin, S.K. Solanki, and G.A. Kovaltsov, "Grand Minima and Maxima of Solar Activity: New Observational Constraints, Astronomy and Astrophysics, Vol. 471, 2007, pp. 301-309; Kjeld C.

II. Net Benefits of Carbon

2 Q. Dr. Rom's rebuttal testimony discusses the health impacts of CO₂ and 3 warming. What is your response to that?

A. Dr. Rom's premise is wrong; he assumes that CO₂ will lead to significant warming, when it will not. Further, there is a large peer-reviewed, scientific literature on this issue, which I cited at pp. 107-114 of Exhibit 3 to Bezdek Direct Testimony. This literature shows that global warming would reduce, not increase, human mortality and disease. I refer the reader to pp. 107-114 of Exhibit 3 to Bezdek Direct Testimony for a discussion of the studies.

Q. Dr. Rom (Rebuttal 3:22) contends that he is qualified to testify about the health impacts of global climate change because he has an M.D. degree, a Masters in Public Health, and decades of experience in medical practice and research, whereas you are only an economist. He further states (Rebuttal 6:17) "Nor can an economist be expected to meaningfully ascertain trends in the medical literature, a field in which he has no training or experience." Do you agree with his opinion?

A. No. I have extensively researched and documented any statements I have made concerning potential health impacts. Further, Dr. Rom contradicts himself (Rebuttal 20:1) where, in response to the question "Is this conclusion based on your professional background and experience?" He replies "My understanding of what health impacts are included in the IAMs is based on my reading from secondary

Engvild, "A Review Of The Risks Of Sudden Global Cooling And Its Effects On Agriculture," *Agricultural and Forest Meteorology*, Vol. 115, No. 3-4 (2003), pp. 127-137.

sources. I am not an environmental economist or a climatologist." This statement
 implies that, by his convoluted logic, we should disregard his conclusions – but accept
 mine because I qualify as an environmental economist.

Q: Dr. Rom (Rebuttal 7:50) cites evidence on the physical and monetary benefits of greenhouse gas emission reductions from the U.S. EPA's report from its Climate Change Impacts and Risk Analysis (CIRA) project which, he contends, was subject to a level of peer review that "is well beyond typical review for a journal article" (Rebuttal 7:13). Do you agree with this statement?

9 **A**. No. I examined the peer-review process for this report and found it to be 10 deficient. The EPA report contends that "The methods and results of the climate 11 change impacts analyses described herein have been peer reviewed." In its technical 12 appendix, it states that "The peer review charge directed reviewers to provide 13 responses to the following questions:"

14 1. Does the introductory chapter clearly explain the purpose of the report?

Does the report adequately explain its relationship to other significant and well known climate change risk analysis efforts (e.g., the National Climate
 Assessment), and are these descriptions properly placed in the report?

The report has been written for an educated but not overly technical audience,
 including decision makers, stakeholders, and engaged members of the public.
 Are the writing level and graphics appropriate for these audiences? Are there
 sections that are too technical for this audience? Does the report adequately
 explain the overall analytic framework of the project, such that results across
 multiple sectors can be communicated in a consistent manner?

1	4.	the text, figures and tables in the sector specific chapters clearly
2		ommunicate the modeling results from the underlying research papers?
3	5.	re the conclusions in the Key Findings and Synthesis sections supported by the
4		esults of the sector specific chapters? Is the draft report missing important
5		ndings or messages?

6 6. Do the figures and tables clearly communicate the key points in the Key Findings7 and Synthesis section?

This is not peer review, rather it is confirmation and report editing. I have had 8 9 many of my papers go through extensive peer review prior to publication, I have served 10 as a peer-reviewer for many published studies and reports, and I have served as a journal editor. Legitimate peer review is *not* simply agreeing with and tidying up the 11 12 findings of the research. Rather, and importantly, it should challenge and rigorously 13 assess them. Further, most of the review panel members are probably competent and 14 are probably serious professionals, and there is nothing wrong with having several true 15 believers with strong AGW opinions on the panel. However, to be a truly independent 16 and objective "peer-review" panel, the panel should have included distinguished 17 scientists and researchers who would question the EPA report assumptions, 18 hypotheses, and forecasts and act as vigorous devil's advocates. It is called the "red 19 team." Unfortunately, but not surprisingly, no such persons were included on the panel. 20 To be truly independent, rigorous, and objective, the panel should have included 21 distinguished scientists such as Dr. Richard Linzden, Dr. Freeman Dyson, Dr. Fred 22 Singer, Dr. Patrick Michaels, Dr. Robert Hirsch, Dr. Richard Tol, Dr. Roy Spencer, Dr. 23 Judith Curry, Dr. Roger Pielke, Jr., Dr. Robert Mendelsohn, Dr. Craig Idso, Dr. John

Most of these have entries at DeSmogBlog, so people can assess whether or not they are "distinguished" or relevant or even scientists. Many have long gotten fossil funding.

Christy, Dr. Patrick Moore, Dr. Nils-Axel Mörner, Dr. William Happer, Dr. Steven
 Hayward, Dr. Robert Balling, Dr. William Wecker, Dr. David Legates, Dr. Anne Smith,
 Dr. William Briggs, and Dr. Wei-Hock Soon – among others. More generally, this failing
 is indicative of the invalid, self-serving, incestuous, "peer-review" process followed by
 AGW advocates and by the IPCC – as discussed below.

Q: Dr. Hanemann criticizes you for relying on Idso and Idso (2000), which
he says is predominantly made up of laboratory experiments rather than field
experiments and only yields an estimate of gross, not net, revenue. Do you agree
with his criticism?

10 A: No, not at all. Dr. Hanemann criticizes me for depending on Dr. Idso's lab experiments regarding carbon fertilization, generating an estimate of increased gross 11 12 revenue. He further notes that net revenue is an order of magnitude smaller for 13 agricultural commodities, but provides no source for this assertion. My analysis was conducted in order to assess the *net* benefits of carbon, so the comparison of the gross 14 15 revenue gained in the agricultural sector is appropriate to weigh against the gross social 16 cost of that carbon. Dr. Hanemann's method would improperly double-count the effects of carbon. 17

18 Q: Dr. Hanemann faults your assessment for not "comport[ing] with 19 assessments in the generally-accepted literature." What materials in the 20 "generally-accepted literature" do you cite?

A: The generally accepted literature accepts the fact of CO2 fertilization. In fact, even Dr. Gurney (Rebuttal 3:4) states "All available scientific evidence supports the general concept of a CO₂ fertilization effect."

1	In my rebuttal testimony (Bezdek Rebuttal at 15-17), I pointed out that the effects
2	of carbon fertilization have been validated by other researchers more recently, including
3	several who have examined crop yields in China over decades - a far cry from the
4	small, isolated lab experiments Drs. Hanemann and Gurney criticize. These studies
5	have been published in the peer-reviewed literature, including international scientific
6	journals such as Global Change Biology, Journal of Environmental Sciences, Journal of
7	Experimental Botany, Theoretical and Applied Climatology, Environmental Pollution,
8	Aquatic Biology, Journal of Plant Growth Regulation, Journal of the American Society of
9	Horticultural Science, Proceedings of the National Academy of Sciences USA, Global
10	Change Biology, Evolutionary Ecology, Journal of Environmental Management, and
11	Marine Ecology Progress. For example:
12 13 14	1. Piao, et al., determined that China had experienced increased CO ₂ fertilization for three decades now, and that this emphasizes CO ₂ 's positive impacts ⁴⁶
16 17 18 19 20	2. Guo, et al., analyzed increased rice yields and found that "elevated CO ₂ stimulated rice aboveground biomass and nitrogen accumulation by 19.1 percent and 12.5 percent, respectively" and that "averaged across the rice growing period, elevated CO ₂ greatly increased TOC and TN contents in the surface water by 7.6 percent and 11.4 percent, respectively." ⁴⁷
22 23 24 25	 Li, et al., found increased CO₂ has health benefits in plants combatting diseases. Specifically, they concluded that "this information is important for making proper predictions with regard to disease pressure and for designing strategies to improve plant pathogen resistance."⁴⁸

 ⁴⁶ Piao, S, Yin, G., Tan, J., Cheng, L., Huang, M., Li, Y., Liu, R., Mao, J., Myneni, R.B., Peng, S., Poulter, B., Shi, X., Xiao, Z., Zeng, N., Zeng, Z. and Wang, Y. 2015. Detection and attribution of vegetation greening trend in China over the last 30 years. *Global Change Biology* 21: 1601-1609.
 ⁴⁷ Oug, J., Zhang, M., Wang, Y. and Zhang, W. 2015. Et al. (2015). The second statement of the second stateme

⁴⁷ Guo, J., Zhang, M., Wang, X. and Zhang, W. 2015. Elevated CO2 facilitates C and N accumulation in a rice paddy ecosystem. *Journal of Environmental Sciences* 29: 27-33.

⁴⁸ Li, X., Šun, Z., Shao, S., Zhang, S., Ahammed, G.J., Zhang, G., Jiang, Y., Zhou, J., Xia, X., Zhou, Y., Yu, J. and Shi, K. 2015. Tomato-Pseudomonas syringae interactions under elevated CO2 concentration: the role of stomata. *Journal of Experimental Botany* 66: 307-316.

- 4. Song, et al., found that CO₂ has significantly increased rice yields in China, and reported that "38 percent of the yield increases can be related to climatic variation and the remaining 62 percent to changes in rice varieties."⁴⁹
- 5. de Rezende, et al., determined that elevated CO₂ helped certain species produce tannins, which "may result in higher protection of this species against herbivores and pathogens." This demonstrates that increased CO₂ would enhance plants' ability to thrive and green the planet.⁵⁰
- 6. Cao, J. and Ruan studied the impacts of CO₂ on plant life and found that "greater resource allocation to creeping stems may allow V. natans to capture more resources, and reduce competition for soil nutrients with neighboring plants" and that "more buds will likely lead to higher productivity in waters with high CO₂ concentrations." This verifies the argument that increased CO₂ would benefit plant life.⁵¹
- Lee, Woo, and Je studied CO₂ fertilization effects and concluded that "photosynthetic rate was higher," "stomatal resistance increased," "transpiration rates declined," and "water-use efficiency rose."⁵²

8. Song and Huang demonstrated the carbon sequestration argument by finding that elevated CO₂ would decrease risks of heat and drought: "The ratio of root to shoot biomass increased by 65 percent to 115 percent under doubling ambient CO₂ across all treatments," "high CO₂ may enhance the capacity of water uptake by the root system, supplying water to maintain leaf hydration," "the positive carbon gain under doubling ambient CO₂ was the result of both increases in net photosynthesis rate and suppression of respiration rate," and "leaf net photosynthesis increased by 32 percent to 440 percent with doubling ambient CO₂."

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 9. Thomas and Palmer challenged the impact that invasive species may have in a warmer world. They reported that out of a wide variety of plants, "Total cover increases by native species are more than nine times greater than

⁵⁰ de Rezende, F.M., Souza, A.P., Buckeridge, M.S. and Furlan, C.M. 2015. Is guava phenolic metabolism influenced by elevated atmospheric CO2? *Environmental Pollution* 196: 483-488.

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⁴⁹ Song, Y., Wang, C., Ren, G., Zhao, Y. and Linderholm, H.W. 2015. The relative contribution of climate and cultivar renewal to shaping rice yields in China since 1981. *Theoretical and Applied Climatology* 120: 1-9.

 ⁵¹ Cao, J. and Ruan, H. 2015. Responses of the submerged macrophyte Vallisneria natans to elevated CO₂ and temperature. *Aquatic Biology* 23: 119-127.
 ⁵² Lee, S.H., Woo, S.Y. and Je, S.M. 2015. Effects of elevated CO2 and water stress on physiological

⁵² Lee, S.H., Woo, S.Y. and Je, S.M. 2015. Effects of elevated CO2 and water stress on physiological responses of Perilla frutescens var. japonica HARA. *Journal of Plant Growth Regulation* 75: 427-434. ⁵³ Song, Y. and Huang, B. 2014. Differential effectiveness of doubling ambient atmospheric CO2

concentration mitigating adverse effects of drought, heat, and combined stress in Kentucky Bluegrass. *Journal of the American Society of Horticultural Science* 139: 364-373.

those by non-native species." This is significant because it refutes the hypothesis that invasive species will overwhelm native ones.⁵⁴

10. Sendall, et al., assessed the impacts of warming on plants and found that "direct negative impacts of modest climate warming on photosynthesis will be ameliorated as plants come near to optimizing photosynthesis with respect to temperatures experienced." This is important because one of the key points that climate change alarmists make is that climate change would overwhelm plants.⁵⁵

- 11. Preite, et al., examined the ability of plant life to adapt to warming and found 12 that "selection analyses and trait-trait correlations showed that most traits can 13 respond to selection under a warmer climate." They also disproved the 14 hypothesis that warming may overwhelm plants by also finding that "these 15 populations may in reality have time to respond to selection appropriately."⁵⁶
 - 12. Costanza, et al., focused specifically on the link between climate change and wildfires and concluded that "While climatic warming had little effect on the wildfire regime, and thus on longleaf pine dynamics, urban growth led to an 8 percent reduction in annual wildfire area."⁵⁷
 - 13. Mohring, et al., determined that certain species have fully benefitted from warming temperatures, keeping "a positive relationship between in situ temperature and thermal optima for performance."⁵⁸
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Q: Dr. Gurney criticizes Idso (2013) Idso and Idso (2000) for not being peer

27 reviewed. What is your assessment of the basis on which these researchers

28 reached their conclusion?

⁵⁴ Thomas, C.D. and Palmer, G. 2015. Non-native plants add to the British flora without negative consequences for native diversity. *Proceedings of the National Academy of Sciences USA* 112: 4387-4392.

⁵⁵ Sendall, K.M., Reich, P.B., Zhao, C., Jihua, H., Wei, X., Stefanski, A., Rice, K., Rich, R.L. and Montgomery, R.A. 2015. Acclimation of photosynthetic temperature optima of temperate and boreal tree species in response to experimental forest warming. *Global Change Biology* 21: 1342-1357.

⁵⁶ Preite, V., Stocklin, J., Armbruster, G.F.J. and Scheepens, J.F. 2015. Adaptation of flowering phenology and fitness-related traits across environmental gradients in the widespread Campanula rotundifolia. *Evolutionary Ecology* 29: 249-267.

⁵⁷ Costanza, J.K., Terando, A.J., McKerrow, A.J. and Collazo, J.A. 2015. Modeling climate change, urbanization, and fire effects on Pinus palustris ecosystems of the southeastern U.S. *Journal of Environmental Management* 151: 186-199.

⁵⁸ Mohring, M.B., Wernberg, T., Wright, J.T., Connell, S.D. and Russell, B.D. 2014. Biogeographic variation in temperature drives performance of kelp gametophytes during warming. *Marine Ecology Progress* Series 513: 85-96.

Roger H. Bezdek Sur-Rebuttal OAH 80-2500-31888 MPUC E-999/CI-14-643

1	A: Idso (2013) ⁵⁹ and Idso and Idso (2000) ⁶⁰ rely on numerous peer-reviewed
2	sources in the literature that Dr. Gurney ignores, including some of the most prestigious
3	international scientific journals such as Science, Nature Geoscience, Global Change
4	Biology, Environmetrics, Climatic Change, Geophysical Research Letters, Journal of
5	Agronomy & Crop Science, Journal of Climate, Climate Dynamics, Agricultural and
6	Forest Meteorology, and International Journal of Environmental Research and Public
7	Health. These sources include, for example:
8 9 10 11 12 13	 Aldrin, M., Holden, M., Guttorp, P., Skeie, R.B., Myhred, G. and Berntsen, T.K. 2012. Bayesian estimation of climate sensitivity based on a simple climate model fitted to observations of hemispheric temperature and global ocean heat content. <i>Environmetrics</i> 23: 253-271. Allen, L.H., Jr., Boote, K.J., Jones, J.W., Jones, P.H., Valle, R.R., Acock, B.,
14 15 16 17	Rogers, H.H. and Dahlman, R.C. 1987. Response of vegetation to rising carbon dioxide: Photosynthesis, biomass, and seed yield of soybean. <i>Global Biogeochemical Cycles</i> 1 : 1-14.
18 19 20	 Annan, J.D. and Hargreaves, J.D. 2011. On the generation and interpretation of probabilistic estimates of climate sensitivity. <i>Climatic Change</i> 104: 324-436.
20 21 22 23	 Barrett, D.J., Richardson, A.E. and Gifford, R.M. 1998. Elevated atmospheric CO₂ concentrations increase wheat root phosphatase activity when growth is limited by phosphorus. <i>Australian Journal of Plant Physiology</i>25: 87-93.
24 25 26 27	 Boretti, A.A. 2012. Short term comparison of climate model predictions and satellite altimeter measurements of sea levels. <i>Coastal Engineering</i> 60: 319- 322.
29 30 31	 Christidis, N., Donaldson, G.C. and Stott, P.A. 2010. Causes for the recent changes in cold- and heat-related mortality in England and Wales. <i>Climatic</i> <i>Change</i> 102: 539-553.

 ⁵⁹ Craig Idso, "The Positive Externalities of Carbon Dioxide," Center for the Study of Carbon Dioxide and Global Change, 2013
 ⁶⁰ Craig D. Idso and Keith E. Idso, Forecasting World Food Supplies: The Impact of the Rising Atmospheric CO₂ Concentration, 7S Technology 33, 51-55 (2000). The chart I cite is drawn from a table reflecting the results of peer-reviewed studies, not from the opinions expressed in the body of the report.

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- 11. Egondi, T., Kyobutungi, C., Kovats, S., Muindi, K., Ettarh, R. and Rocklov, J. 2012. Time-series analysis of weather and mortality patterns in Nairobi's informal settlements. *Global Health Action* **5**: 23-31.
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- 13. Hargreaves, J.C., Annan, J.D., Yoshimori, M. and Abe-Ouchi, A. 2012. Can the Last Glacial Maximum constrain climate sensitivity? *Geophysical Research Letters* **39**: L24702, doi: 10.1029/2012GL053872.
- 14. Harlow, B.E. and Spencer, R.W. 2011. An Inconvenient burden of proof? CO2 nuisance plaintiffs will face challenges in meeting the Daubert standard. *Energy Law Journal* **32**: 459-496.
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- 16. Houston, J.R. and Dean, R.G. 2011. Sea-level acceleration based on U.S. tide gauges and extensions of previous global-gauge analyses. *Journal of Coastal Research* **27**: 409-417.
- 17. Jevrejeva, S., Grinsted, A., Moore, J.C. and Holgate, S. 2006. Nonlinear trends and multiyear cycles in sea level records. *Journal of Geophysical Research* **111**: 10.1029/ 2005JC003229.

- 18. Jwa, N.-S. and Walling, L.L. 2001. Influence of elevated CO2 concentration on disease development in tomato. *New Phytologist* **149**: 509-518.
- 19. Kim, H.-Y., Lieffering, M., Kobayashi, K., Okada, M., Mitchell, M.W. and Gumpertz, M. 2003. Effects of free-air CO2 enrichment and nitrogen supply on the yield of temperate paddy rice crops. *Field Crops Research* **83**: 261-270.
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- 21.Kyei-Boahen, S., Astatkie, T., Lada, R., Gordon, R. and Caldwell, C. 2003. Gas exchange of carrot leaves in response to elevated CO2 concentration. *Photosynthetica* **41**: 597-603.
 - 22. Lewis, N. 2013. An objective Bayesian, improved approach for applying optimal fingerprint techniques to estimate climate sensitivity. *Journal of Climate*, doi: 10.1175/JCLI-D-12-00473.1.
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- 22 Q: Has Dr. Idso published other research on this topic?
- A: Yes. For example, he published a meta-analysis of peer-reviewed literature,
- ²⁴ synthesizing the most recent science.⁶¹ In that analysis, he found that the peer-
- 25 reviewed literature showed:
- A distinct "greening" since the 1980s due to higher CO₂ emissions.
- No support for the model-based claim that carbon uptake would diminish
 - indeed the opposite seems to be the case.

⁶¹ Craig Idso, *The State of Earth's Terrestrial Biosphere: How is It Responding to Rising Atmopsheric* CO₂ *and Warmer Temperatures?* (Dec. 5, 2012), *available at* http://www.co2science.org/education/reports/ greening/ TheStateofEarthsTerrestrialBiosphere.pdf.

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 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.

The study included over 450 articles from peer-reviewed journals including *Nature, Science, Journal of Geophysical Research, Proceedings of the Royal Society, Proceedings of the National Academy of Science, and Geophysical Research Letters.*

Q: Is Dr. Gurney's criticism of a lack of peer-reviewed sources limited to
your reliance on Idso (2013) Idso and Idso (2000)?

9 A: No. Dr. Gurney also repeatedly criticizes my testimony for citing non-peer-10 reviewed research, completely ignoring the 181-page annotated appendix included with 11 my original testimony (Bezdek Testimony, Ex. 3) and in the discovery responses appended to my rebuttal testimony (Bezdek Rebuttal, Ex. A at 2-52). He then criticizes 12 13 the peer-reviewed studies I cite for being unreliable, but provides no useful analysis of 14 why they are unreliable. His argument presents an unanswerable Catch-22 because he 15 appears to find literature unreliable simply because he disagrees with its conclusions. 16 Further, in my testimony I relied on various "non-peer-reviewed" official U.S. Federal 17 government and international agency reports as statistical and data sources. This is a 18 strength, not a weakness, since these reports contain the most reliable data available 19 and are publicly available.

20 Q: Besides the studies cited in Idso (2013) Idso and Idso (2000), are there 21 other studies corroborating the results they found?

1 A: Yes. In my discovery responses to the Clean Energy Organizations, I 2 provided citations to nearly 450 additional studies corroborating Idso's findings. I refer to Exhibit 2 to Bezdek Rebuttal Testimony. I will not re-list them here. 3 Q: How has Dr. Gurney responded to this scholarship? 4 5 A: In response to all of these publications, Dr. Gurney cites (only) to McGrath and Lobell (2013), claiming that it is "[a] recent peer-reviewed study" (Gurney Rebuttal 6 7 4:10). What Gurney does not acknowledge is the number of studies since then that 8 conclude the opposite, referenced above. 9 Q: Dr. Gurney stated (Rebuttal 5:14) "In my judgment, the CO₂ fertilization 10 effect is included appropriately in reviews of climate change impacts on plants, 11 and food crops in particular." Do you agree with this statement? 12 **A.:** No. In my judgement, and in the judgement of many other researchers, this 13 is not the case. I have extensively documented this in my testimonies in this proceeding, citing numerous peer-reviewed sources. 14 15 Q: Dr. Gurney stated that "the question of relevance to an assessment of 16 the SCC should not be centered on whether not there is a CO₂ fertilization effect. 17 The question should be centered on assessing the total net impact on plants, 18 particularly food crops, from anthropogenic climate change." Do you agree? 19 A: Dr. Gurney is trying to "move the goal posts." He states "The question of 20 relevance to an assessment of the SCC should not be centered on whether or not there 21 is a CO₂ fertilization effect." (Gurney Rebuttal 4:19-21.) Thus, after I have exhaustively 22 shown – citing hundreds of peer-reviewed studies – that there is an overwhelmingly 23 positive CO₂ fertilization effect on plants and agricultural productivity, it suddenly no 33

longer matters? Further, he then states that question should be centered on assessing
 the total net impact from anthropogenic climate change. He assumes here that CO₂ is
 causing global warming. This is very much in doubt. His question is thus invalid and

4 illogical.

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Q: Dr. Hanemann cites to the IPCC's Fifth Assessment Report, calling it

6 "[t]he most authoritative contemporary source" and saying that it argues that

7 negative impacts outweigh the benefits. Is that an accurate rendition of what the

- 8 IPCC says about CO₂ fertilization?
- 9 A: No. The IPCC's findings were much more strongly supportive of the carbon

10 fertilization thesis than Dr. Gurney states. Working Group I specifically addressed

11 carbon fertilization:

Elevated atmospheric CO₂ concentrations lead to higher leaf photosynthesis and reduced canopy transpiration, which in turn lead to increased plant water use efficiency and reduced fluxes of surface latent heat. The increase in leaf photosynthesis with rising CO₂, the so-called CO₂ fertilisation effect.

- Field experiments provide a direct evidence of increased photosynthesis rates and water use efficiency (plant carbon gains per unit of water loss from transpiration) in plants growing under elevated CO_2 . These physiological changes translate into a broad range of higher plant carbon accumulation in more than two-thirds of the experiments and with increased net primary productivity (NPP) of about 20 to 25% at double CO_2 from pre-industrial concentrations.⁶²
- The IPCC Working Group II, covering impacts and adaptation, also noted:
- Plants with a C3 photosynthetic system, which includes most species but
 excludes warm-region grasses, show an increase in photosynthesis under
 elevated CO₂, the precise magnitude of which varies between species. ...
 The C4 photosynthetic system found in most tropical grasses and some

⁶² AR5 WG1 at 502 (Box 6.3).
1 important crops is not directly affected by elevated CO₂, but C4 plant 2 productivity generally increases under elevated CO₂ because of increased 3 water use efficiency (WUE). Transpiration is decreased under elevated 4 CO₂ in many species, due to reduced opening of stomatal apertures, leading to greater WUE⁶³ 5 6

7 Satellite observations from 1982–2010 show an 11% increase in green 8 foliage cover in warm, arid environments (where WUE is most important) 9 after correcting for the effects of precipitation variability (Donohue et al., 2013); gas exchange theory predicts 5 to 10% greening resulting from 10 rising CO₂ over this period.⁶⁴ 11

- 13 The interactive effects of elevated CO₂ and other global changes (such as 14 climate change, nitrogen deposition, and biodiversity loss) on ecosystem function are extremely complex.⁶⁵ 15
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17 The IPCC presents a much more complex picture than Dr. Gurney's selective citation.

18 Extensive peer-reviewed research also provides a strong basis for the proposition that

19 CO₂ emissions present a significant net benefit because of the effects they have on

- 20 plant growth and the resilience they confer.
- Q: Dr. Polasky argues that your calculation of the benefits to CO_2 21 22 emissions "is not reliable" because it is based on lab experiments rather than field experiments, and presents evidence from Schlenker and Roberts (2009) 23 24 showing that rising heat will negate those benefits. Do you agree with his 25 analysis?

26 A: Not at all. First, Dr. Polasky is in error when he states that this is my 27 calculation. It is not my calculation. It is an estimate I cite from the literature and I

⁶³ IPCC Working Group II, Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects 287 (2014), available at https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-PartA FINAL.pdf [hereafter, "AR5 WG2"] (citations omitted). ⁶⁴ Id.

provided references for this estimate. Not knowing the difference is a serious error on
 Polasky's part.

3 Second, and more important, none of the sources Polasky cites show lower yields because of rising CO₂ levels. Conversely, increased CO₂ concentrations alleviate 4 5 some of the problems of higher temperatures (including drought), resulting in overall greater yields.⁶⁶ In other words, not only does CO₂ help plants grow better, but it also 6 7 helps them to be more resilient to the potentially damaging side-effects of rising 8 temperatures. In one study, "scientists artificially elevated CO₂ levels in a US prairie 9 grasslands ecosystem for eight years. They found that the added carbon had increased 10 the overall volume of the plants and promoted the ecosystem's stability by reducing the growth of normally dominant plant species."⁶⁷ A recent meta-analysis of 90 studies 11 involving wheat found that the beneficial effects of increased CO₂ concentrations would 12 outweigh any harm on growth from higher temperatures or decreased precipitation.⁶⁸ 13 Other studies have confirmed that plants have accelerated growth patterns when higher 14 concentrations of CO₂ are present in the atmosphere.⁶⁹ 15

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⁶⁷ See Mark Prigg, *Climate Change Is Being Slowed by Plants Far More than Expected, Researchers Reveal*, Mail Online, Oct. 13, 2014, *available at* http://www.dailymail.co.uk/sciencetech/article-2791771/climate-change-slowed-plants-far-expected-researchers-reveal.html.

 ⁶⁶ In addition to Li (2015), Lee (2015), and Song (2014), cited above, other studies validate this principle. Cox, P. M., et al. (2013) "Sensitivity of Tropical Carbon to Climate Change Constrained by Carbon Dioxide Variability." *Nature* 494 (February): 341–44.; Huntingford, C., et al. (2013) "Simulated Resilience of Tropical Rainforests to CO2-Induced Climate Change." *Nature Geoscience Letters* 6 (March): 268–73; Roger A. Sedjo & Brent Sohngen, *What are the Impacts of Global Warming on U.S. Forests, Regions, and the U.S. Timber Industry*?, 12 PENN ST. ENVTL. L. REV. 95, 97 (2004).
 ⁶⁷ See Mark Prigg, *Climate Change Is Being Slowed by Plants Far More than Expected, Researchers*

⁶⁸ Wilcox, J. and Makowski, D. 2014. A meta-analysis of the predicted effects of climate change on wheat yields using simulation studies. Field Crops Research 156: 180-190.

⁶⁹ See generally CSIRO, *Deserts "Greening" from Rising CO2*, July 3, 2013, *available at* http://www.csiro. au/Portals/Media/Deserts-greening-from-rising-CO2.aspx (summarizing recent study by Donohue, et al.).

1	For example, Donohue, et al. writing in Geophysical Research Letters reported
2	that "Using gas exchange theory, we predict that the 14% increase in atmospheric CO_2
3	(1982–2010) led to a 5 to 10% increase in green foliage cover in warm, arid
4	environments. Satellite observations, analyzed to remove the effect of variations in
5	precipitation, show that cover across these environments has increased by 11%." Their
6	results thus confirmed that the anticipated CO ₂ fertilization effect is occurring alongside
7	ongoing anthropogenic perturbations to the carbon cycle and that the fertilization effect
8	is now a significant land surface process. Their findings also confirmed that the direct
9	biochemical impact of the rapid increase in CO2 concentrations over the last 30 years
10	on terrestrial vegetation is an influential and observable land surface process. ⁷⁰

Thus, as I have already mentioned, the studies documenting the benefits of CO_2 fertilization are not limited to lab experiments or greenhouse trials. This impact has been recognized worldwide, particularly in areas with tropical forests.⁷¹ A review of recent studies concluded that "forest productivity has been growing ever greater with the passing of time, rising hand-in-hand with the increasing CO_2 content of the air."⁷²

As one study explained, "the recent increase in plant productivity has been attributed to the CO_2 fertilization effect," citing a wealth of studies that have come to this conclusion, including those of Amthor (1995), Lloyd and Farquhar (1996), Cao et al. (2001), Lewis et al. (2004), Friedlingstein et al. (2006), Stephens et al. (2007), Ciais et

⁷⁰ Randall J. Donohue, Michael L. Roderick, Tim R. McVicar, Graham D. Farquhar, "Impact of CO2 fertilization on maximum foliage cover across the globe's warm, arid environments," *Geophysical Research Letters*, Volume 40, Issue 12, 28 June 2013, Pages 3031–3035.

⁷¹ See Center for the Study of Carbon Dioxide and Global Change, *Biospheric Productivity in South America*, Mar. 5, 2014, *available at* http://www.co2science.org/subject/g/summaries/samergreen.php. ⁷² *Id.*

al. (2009), Lewis et al. (2009), Malhi (2010), Ballantyne et al. (2012) and Higgins and 1 Scheiter (2012).⁷³ And the study notes that African researchers similarly "found that 2 3 gross primary production increased over the past 30 years even though soil moisture decreased."⁷⁴ "[P]eer-reviewed scientific literature" indicates that "the ongoing rise in 4 5 the air's CO₂ content will likely lead to substantial increases in plant photosynthetic rates and biomass production, even in the face of stressful environmental conditions 6 imposed by less-than-optimum soil moisture conditions."⁷⁵ For this reason. 7

8 Evidence to date implies that the view that global temperature is far less 9 sensitive to CO_2 than many fear, is likely correct. Simultaneously, 10 demonstrated experimental evidence on plant growth predicted exactly what the now extensive empirical literature shows: Enhanced CO₂ is 11 associated with greatly increased biomass production, even in dry 12 13 climates. The extent of increased CO₂ sequestration both in soil and in biomass associated with increased atmospheric concentration has also 14 been documented.⁷⁶ 15

⁷³ Fisher, J.B., Sikka, M., Sitch, S., Ciais, P., Poulter, B., Galbraith, D., Lee, J.-E., Huntingford, C., Viovy, N., Zeng, N., Ahistrom, A., Lomas, M.R., Levy, P.E., Frankenberg, C., Saatchi, S. and Malhi, Y. 2013. African tropical rainforest net carbon dioxide fluxes in the twentieth century. Philosophical Transactions of the Royal Society B 368: 10.1098/rstb.2012.0376.

⁷⁵ Center for the Study of Carbon Dioxide and Global Change, Growth Response of Grassland Species to Elevated CO2 when Water Stressed, Jul. 9, 2013, available at http://www.co2science.org/subject/g/ summaries/growthwatergrass.php.

⁷⁶ See Paul Ballonoff, A Fresh Look at Climate Change, Cato Journal, Feb. 24, 2014, p. 117, available at http://www.insideronline.org/summary.cfm?id=21673 (citation omitted).

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Plants also utilize hydration more efficiently in an atmosphere containing 1 increased amounts of CO₂.⁷⁷ Enhanced photosynthesis occurs because when there is 2 "more CO₂ in the air outside the leaf, then the diffusion of water molecules inward 3 appears to be greater."⁷⁸ The conclusion regarding plant growth is telling, because 4 5 increased atmospheric carbon dioxide would offset negative effects even if precipitation decreased:⁷⁹ 6

7 The empirically demonstrated evidence on water use by plants in an enhanced CO₂ environment is the opposite of the commonly claimed 8 9 effect from models that look only at assumed increased heating due to 10 CO₂ increases. Empirically, CO₂ has recently been associated with 11 warming only until increased green growth set in. That increased growth 12 however continues so long as the extra CO_2 is present. Despite reluctant 13 rhetoric, other climate modelers recently studying the process have also created models that show higher CO₂ concentration increases biomass.⁸⁰ 14 Greater concentrations of CO₂ "generally result in higher net photosynthetic rates 15 16 and may also reduce transpiration losses from plants (i.e. water loss). photosynthetic rate is enhanced as additional carbon is available for assimilation; thus, 17 productivity and yields generally rise."81 Many studies have demonstrated this effect, 18

⁷⁷ Paul Ballonoff, A Fresh Look at Climate Change, Cato Journal, Feb. 24, 2014, p. 115-16, available at http://www.insideronline.org/summary.cfm?id=21673.

⁷⁸ See Roger A. Sedjo & Brent Sohngen, What are the Impacts of Global Warming on U.S. Forests, Regions, and the U.S. Timber Industry?, 12 PENN ST. ENVTL. L. REV. 95, 97 (2004). ⁷⁹ Id.

⁸⁰ Ballonoff, *supra*, p. 123 (citations omitted).

⁸¹ See Michael Bastasch, Studies: Increased CO2 Emissions are Greening the Planet, Daily Caller, Mar. 14, 2014, available at http://dailycaller.com/2014/03/14/studies-increased-co2-emissions-are-greeningthe-planet/; see also Pew Center on Global Climate Change, supra, at 12.

and although different crops respond differently, "the overall effect was certainly found
 to be favorable."⁸²

Q: Dr. Polasky states that "Schlenker and Roberts in a 2009 article find that temperature increases above the optimum growing temperature leads to severe drops in yields for corn and soybeans in the U.S. Crop yields show declines in hot, dry years." (Polasky Rebuttal 54:4-7.) Does this prove his point?

7 A: No, it does not. This statement refers to temperature variations - not to variations in the levels of CO₂. Dr. Polasky made an error here in confusing the two. If 8 not, he implicitly and erroneously assumed that CO₂ emissions cause global warming – 9 10 a theory which I have refuted in my testimonies here. Dr. Polasky makes the same 11 mistake when he states "Lobell, Schlenker and Costa-Roberts in a 2011 article in 12 Science show that climate changes from 1980 to 2008 had a negative effect on corn 13 and wheat yields, mainly due to increased temperatures." (Polasky Rebuttal 54:11-13.) The negative effects reported were due to changes in temperature, not to CO_2 14 emissions, and Dr. Polasky again confuses the two causal factors. 15

Q: Does CO₂ fertilization have relevance for climate models' failure to match observational data?

A: Yes. CO_2 fertilization helps explain why the computer models have been incorrect, with plant absorption of CO_2 being much higher than expected or integrated into such models.⁸³ According to a recent study, "a 16 per cent 'correction' would be

⁸² Ballonoff, *supra*, p. 116; *see also id.*, p. 116-17.

⁸³ See Mark Prigg, *Climate Change Is Being Slowed by Plants Far More than Expected, Researchers Reveal*, Mail Online, Oct. 13, 2014, *available at* http://www.dailymail.co.uk/sciencetech/article-2791771/climate-change-slowed-plants-far-expected-researchers-reveal.html.

'large enough to explain the persistent overestimation of growth rates of historical 1 atmospheric CO₂ by earth system models.³⁸⁴ 2 Indeed, the research shows that 3 "[p]revious climate models have not fully accounted for how much carbon dioxide plants actually absorb."⁸⁵ For this reason, Lianhong Gu, from the Climate Change Institute at 4 5 Oak Ridge National Laboratory, has said "most carbon-cycle models had over-predicted the growth rate" of CO₂.⁸⁶ Plants not only perform the function of stripping the CO₂ out 6 7 of the atmosphere, which decreases net CO_2 , but the CO_2 that they take in actually 8 helps the plants grow.

9 All of this helps explain why global climate models have been incorrect for almost 10 two decades:

11 A distinct kind of greenhouse effect is also predicted from increased 12 CO_2 concentration – namely, the aerial fertilization effect, which is that 13 plants grow better in an atmosphere of higher CO₂. Many analysts, such as the IPCC, clearly thought the greater effect would be from heating, not 14 plant growth. One must assume this was an intentional judgment, as the 15 16 IPCC was aware of the CO₂ aerial fertilization effect from its 1995 Second 17 Assessment Report, which contained empirical evidence of increased 18 greening in enhanced CO_2 environments (Reilly 2002: 19). In contrast, 19 climate analysts such as those with the Cato Center for the Study of

⁸⁴ Id.

⁸⁵ Paul Fiddian, *Plant CO2 Absorption Levels Underestimated*, Enviro News, October 14, 2014, *available at* http://www.enviro-news.com/news/plant-co2-absorption-levels-underestimated.html.

⁸⁶ Mark Prigg, *Climate Change Is Being Slowed by Plants Far More than Expected, Researchers Reveal,* Mail Online, Oct. 13, 2014, *available at* http://www.dailymail.co.uk/sciencetech/article-2791771/climatechange-slowed-plants-far-expected-researchers-reveal.html.

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Science have argued since 1999 that atmospheric temperature is much less sensitive to increased concentration of CO₂ (Michaels 1999b).

While in fact heating has not occurred as the IPCC forecasted, 3 greatly increased global biomass is indeed demonstrated. 4 Well 5 documented evidence shows that concurrently with the increased CO₂ 6 levels, extensive, large, and continuing increase in biomass is taking place 7 globally – reducing deserts, turning grasslands to savannas, savannas to forests, and expanding existing forests (Idso 2012). That survey covered 8 9 400 peer-reviewed empirical studies, many of which included surveys of 10 dozens to hundreds of sources. Comprehensive study of global and 11 regional relative greening and browning using NOAA data showed that 12 shorter-term trends in specific locations may reflect either greening or 13 browning, and also noted that the rapid pace of greening of the Sahel is due in part to the end of the drought in that region. Nevertheless, in nearly 14 all regions and globally, the overall effect in recent decades is decidedly 15 16 toward greening (de Jong et al. 2012). This result is also the opposite of what the IPCC expected.⁸⁷ 17

18 At the same time, even more CO_2 emissions could help agriculture even further.

[A] doubling of the air's CO₂ concentration likely would lead to a
 50% increase in photosynthesis in C3 plants, a doubling of water use
 efficiency in both C3 and C4 plants, significant increases in biological

⁸⁷ Ballonoff, *supra*, p. 114-15 (emphasis added).

nitrogen fixation in almost all biological systems, and an increase in the
ability of plants to adapt to a variety of environmental stresses. . . . [M]any
other studies have been conducted on hundreds of different plant species,
repeatedly confirming the growth-enhancing, water-saving, and stressalleviating advantages that elevated atmospheric CO₂ concentrations
bestow upon Earth's plants and soils.⁸⁸

Q: You also link CO₂ to prosperity more broadly. Dr. Hanemann argues that
this link is merely a correlation and that you have not proved causation. Do you
agree that the relationship is not causal?

10 A: No. Despite the biological mechanism that is validated by recent science 11 described above, Dr. Hanemann complains that I only show a correlation between world GDP growth and energy consumption, but not causation. First and foremost, judging by 12 13 the potential alternate causes Dr. Hanemann proposes – "changes in human life span, 14 education, scientific and technical knowledge, or the stock of physical capital" (Hanemann Rebuttal at 7:10-13) - he has the entire causal relationship reversed. All of 15 16 the factors he lists are precisely what fossil energy development and consumption have 17 permitted to support and expand - they are the causal mechanism, not competing 18 explanations. Increased energy consumption expands GDP by extending life span 19 (refrigeration, home climate control), expanding educational opportunities (the internet,

⁸⁸ Idso, et al., *Climate Change Reconsidered II: Biological Impacts*, Nongovernmental International Panel on Climate Change, 2014, *available at* http://heartland.org/media-library/pdfs/CCR-IIb/Summary-for-Policymakers.pdf (citations omitted).

1 communications technology), and creating the technology and physical capital that GDP

- 2 is built on. He has essentially proven my point.
- 3 Second, the causal relationship is not anecdotal, but demonstrated. Available energy consumption is causally linked to GDP growth in the United States and China, 4 for oil as well as coal.⁸⁹ The Industrial Revolution began in England rather than Italy 5 6 because England was able to exploit its stocks of energy (in the form of coal) earlier and more easily - that was "a necessary condition" for the growth of economies beyond 7 farming.⁹⁰ Other sources for this argument in peer-reviewed literature include: 8 9 Numerous empirical studies published in the peer-reviewed literature show the strong relationship between energy consumption and economic growth. 10 Among them was the pioneering study by J. Kraft and A. Kraft consisting of 11 12 an analysis of the U.S. economy between 1947 and 1974. They were the first to demonstrate the existence of a uni-directional causality in the United States 13 14 where gross national product (GNP) causes energy consumption.⁹¹ 15 • The Kraft and Kraft research was followed by that of Abosedra and 16 Baghestani who confirmed the uni-directional causality of GDP to energy 17 18 consumption for the United States that originally was highlighted by Kraft and Kraft. The findings of Abosedra and Baghestani concluded that that causality 19 can come from two directions and is bi-directional; that is, GDP requires 20 21 energy and energy drives GDP.⁹² 22 23 Vaclav Smil, who is arguably the world's foremost authority on the subject, • 24 has conducted decades of extensive research and has concluded: "The most 25 fundamental attribute of modern society is simply this: Ours is a high energy
- 26 civilization based largely on combustion of fossil fuels."⁹³

 ⁸⁹ Gail E. Tverberg, *Oil Supply Limits and the Continuing Financial Crisis*, 37 Energy 27 (2011); Jianlian Wang, *et al.*, An Analysis of China's Coal Supply and Its Impact on China's Future Economic Growth, 57 *Energy Policy* 542 (2013).
 ⁹⁰ E.A. Wrigley, *Energy and the English Industrial Revolution*, 371 Phil. Transactions of the Royal Society

⁹⁰ E.A. Wrigley, *Energy and the English Industrial Revolution*, 371 Phil. Transactions of the Royal Society A (2013), *available at* http://dx.doi.org/10.1098/rsta.2011.0568.

⁹¹ John Kraft and Arthur Kraft, "On the Relationship between Energy and GNP," The *Journal of Energy and Development*, vol. 3, no. 2 (spring 1978), pp. 401–3.

⁹² S. Abosedra and H. Baghestani, "New Evidence on the Causal Relationship between United States Energy Consumption and Gross National Product," *Journal of Energy and Development*, vol. 14, no. 2 (spring 1989), pp. 285–92.

⁹³ Vaclav Smil, Energy at the Crossroads: Global Perspectives and Uncertainties, MIT Press, 2005.

- Robert Ayres another noted expert concluded: "The rather standard assumption that economic growth is independent of energy availability must be discarded absolutely. It is not tenable. It implies, wrongly, that energyrelated emissions (GHGs) can be reduced or eliminated without consequences for growth."⁹⁴
 - James Brown, et al. found that "The bottom line is that an enormous increase in energy supply will be required to meet the demands of projected population growth and lift the developing world out of poverty without jeopardizing current standards of living in the most developed countries."⁹⁵
- David Stern found that "The theoretical and empirical evidence indicates that energy use and output are tightly coupled, with energy availability playing a key role in enabling growth. Energy is important for growth because production is a function of capital, labor, and energy, not just the former two or just the latter as mainstream growth models or some biophysical production models taken literally would indicate."⁹⁶ He also investigated the time-series properties of GDP, a quality-weighted energy, labor, and capital series, estimating a dynamic cointegration model using the Johansen methodology, and found that the co-integration analysis showed that energy is significant in explaining GDP.⁹⁷
 - Robert Ayres and Benjamin Warr find that economic growth in the past has been driven primarily not by "technological progress" in some general and undefined sense, but specifically by the availability of ever cheaper energy – and useful work – from coal, petroleum, or gas."98
- Mohamed Ben Amar found that "Energy consumption is an essential component of economic development. According to economic theory, an increase in energy consumption has an effect on economic growth. We notice a double correlation between economic growth and energy consumption: A correlation in time (the consumed energy increases in the

²⁰ Robert U. Ayres and Benjamin Warr, *The Economic Growth Engine: How Energy and Work Dr. Material Prosperity*, Northampton, MA: Edward Elgar. 2009.

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 ⁹⁴ Robert U. Ayres, Jeroen C.J.M. van don Bergh, Dietmar Lindenberger, and Benjamin Warr, "The Underestimated Contribution of Energy to Economic Growth," INSEAD, Fontainebleau, France, 2013.
 ⁹⁵ James H. Brown, William R. Burnside, Ana D. Davidson, John P. DeLong, William C. Dunn, Marcus J. Hamilton, Jeffrey C. Nekola, Jordan G. Okie, Norman Mercado-Silva, William H. Woodruff, and Wenyun Zuo, "Energetic Limits to Economic Growth," *BioScience*, January 2011, Vol. 61, No. 1.
 ⁹⁶ David I. Stern, "The Role of Energy in Economic Growth," The United States Association for Energy

⁹⁰ David I. Stern, "The Role of Energy in Economic Growth," The United States Association for Energy Economics and the International Association for Energy Economics, USAEE-IAEE WP 10-055, November 2010.

 ⁹⁷ David I. Stern , "A multivariate cointegration analysis of the role of energy in the US macroeconomy," *Energy Economics*, 22 _2000. 267]283; and David I. Stern and Cutler J. Cleveland, "Energy and Economic Growth," Rensselaer Working Papers in Economics, Number 0410, March 2004.
 ⁹⁸ Robert U. Ayres and Benjamin Warr, *The Economic Growth Engine: How Energy and Work Drive*

But Ayres has written often on the need to reduce GHGs via non-carbon energy sources. I reviewed a draft of this book and its cover includes a blurb by me..

- same way as production measured by the gross domestic product) and a
 correlation in space (more developed countries are also those in which the
 energy consumption is the highest). Our results show that GDP causes the
 level of energy consumption."⁹⁹
 - Nicholas Apergis and James Payne examined the relationship between energy consumption and economic growth for a panel of nine South American countries over the period 1980–2005 within a multivariate framework. They found both short-run and long-run causality from energy consumption to economic growth. Their results provides support for the growth hypothesis, which confirms the importance of energy consumption in the growth process of South America.¹⁰⁰
 - Hüseyin Kalyoncu, et al. investigated the relationship between energy consumption and economic growth and, as part of this research, reviewed existing literature related to the energy-GDP nexus. They identified 24 studies in the peer-reviewed literature that found a causal relationship between energy and GDP.¹⁰¹
 - Jude Clemente noted that CO₂ is not released in a socioeconomic vacuum; it is emitted as the inevitable by-product of combusting fossil fuels, which comprise 85% of U.S. energy and 70% of U.S. electricity. This energy production results in CO₂ emissions, but it also yields significant benefits for the health and welfare of all the U.S. population. Thus: "It is critical to strike a balance in the equation both an assessment of the dangers posed to the atmosphere by CO₂ emissions and the powerful benefits created by the energy usage that results in these emissions."¹⁰²
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- 29 Significantly, the two major international organizations concerned with economic
- 30 development, the UN and the World Bank, recognize the importance of energy for
- 31 economic development; for example:

⁹⁹ Mohamed Ben Amar, "Energy Consumption and Economic Growth: The Case of African Countries," *The Journal of Energy and Development*, Vol. 38, Nos. 1 and 2, 2013.

¹⁰⁰ Nicholas Apergis and James E. Payne, "Energy consumption and growth in South America: Evidence from a panel error correction model," *Energy Economics*, 32 (2010) 1421–1426.

¹⁰¹ Hüseyin Kalyoncu, Faruk Gürsoy, and Hasan Göcen, "Causality Relationship between GDP and Energy Consumption in Georgia, Azerbaijan and Armenia," *International Journal of Energy Economics and Policy*, Vol. 3, No. 1, 2013, pp.111-117.

¹⁰² Jude Clemente, "Energy as a Foundation of Modern Life," *The Journal of Energy and Development*, Volume 35, Number 1, 2011, pp. 33-48.

1 The UN stated that "Although access to energy for the poor sectors is not one of the Millennium Development Goals, it is undoubtedly a vital prerequisite for 2 3 their attainment. If the Millennium Development Goals are to be attained, the 4 energy policy of States must give priority to the goal of providing access to energy services for the poor, at prices they can afford."¹⁰³ 5 6 7 Jim Yong Kim, President of the World Bank stated "It's a situation that I have • referred to as Energy Apartheid. We have to be really serious about what we 8 are going to do to increase energy supply. If we find ourselves in a situation 9 where we say no coal then we're really not serious. We know that intermittent 10 11 energy has never led to economic development in any other country, and we shouldn't think it's going to happen in Africa."104 12 13 14 Gail Tverberg extensively documented what would happen if the world achieved a pledge to reduce fossil fuel use by 80%.¹⁰⁵ She regressed out other potential effects 15 and found that such a reduction would cause the following effects:¹⁰⁶ 16 17 World per capita energy consumption in 2050 would be about equal to world 18 • 19 per capita energy consumption in 1905. 20 21 World economic growth would average a negative 0.59% per year between 22 2012 and 2050, meaning that the world would be more or less in perpetual 23 recession through 2050. Given past relationships, this would be especially the case for Europe and the U.S. 24

¹⁰³ United Nations Development Programme, October 2009, "Contribution of Energy Services to the Millennium Development Goals and to poverty alleviation in Latin America and the Caribbean," available at:

http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Sustainable%20Energy/E nergy_services_LAC region.pdf

¹⁰⁴ Speech by Jim Yong Kim, World Bank, at "GE: Africa Ascending: Powering Inclusive Growth," August 4, 2014, available at. http://geafricaascending.economist.com.

¹⁰⁵ Gail Tverberg, "An Energy/GDP Forecast to 2050," Resilience (Aug. 14, 2012), available at http://www.resilience.org/stories/2012-08-14/ energygdp-forecast-2050. The 80% reduction is an actual goal discussed by multiple groups: The idea of reducing world fossil fuel use 80 percent by 2050 may be unrealistic, but it is a widely advocated goal. See, for example: European Commission, "Roadmap For Moving to a Low-Carbon Economy in 2050," Brussels, March 2011; Jane C. S. Long and Jeffery Greenblatt, "The 80% Solution: Radical Carbon Emission Cuts for California," Issues in Science and Technology, September 2012; U.S. National Academies of Science, Transitions to Alternative Vehicles and Fuels, Washington, D.C., National Academies Press, 2013; World Energy Council, "Goal of Fossil Fuel Independence by 2050," 2013, www. worldenergy.org/wp-content/uploads/2013/09/ Pack-Leadersgoals-A4.pdf. ¹⁰⁶ *Id.*

- Per capita GDP would decline by 42% for the world between 2010 and 2050, on average.
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- The decrease in per capita GDP would likely be greater in higher income countries, such as the U.S. and Europe, because a more equitable sharing of resources between rich and poor nations would be needed, if the poor nations are to have enough basic resources.
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The emissions reductions being recommended by EPA, the White House,¹⁰⁷ and 9 10 numerous environmental organizations "to keep global warming below 2°C or 3°C," 11 when compared to the forecast emissions for a given future year are draconian to the 12 point of being ludicrous. For example, the recommendation to reduce GHG emissions 13 by 80 percent below 1990 levels by 2050 actually implies that 2050 emissions - and 14 world GDP - would have to be reduced more than 95 percent below what they are 15 actually forecast by EIA and IEA to be in 2050 – forecasts that *already incorporate* very significant energy efficiency improvements, large increases in renewable energies, 16 17 substantial decarbonization, and massive energy/GDP de-coupling. Accordingly, 2050 18 fossil fuel utilization and world GDP (and hence living standards) would have to be 19 reduced to a very small fraction of what they would otherwise be. Such an outcome will be unacceptable to any and every country in the world. 20

21 What are the economic, social, and political implications of the aggressive 22 reductions in future GHGs below the levels forecast, which are implied by these 23 proposals? Under the EIA reference case, world CO₂ emissions will total 51,722 MMT

¹⁰⁷ The White House, "Fact Sheet: U.S. Reports its 2025 Emissions Target to the UNFCCC." March 31, 2015.

in 2050.¹⁰⁸ Assume that the goal is a 90 percent reduction below 1990 levels by 2050.
Accordingly:

3 1990 world CO₂ totaled 21,223 MMT 4 10 percent of this 1990 level is 2,120 MMT 5 • 2,120/51,722 = 4.1 percent 6 Thus, to reduce GHGs to 90 percent below 1990 levels by 2050 will require that 7 GHGs in 2050 be 96 percent lower than they are currently projected to be. According to EIA the relationship between GDP growth and CO₂ emissions is relatively fixed among 8 9 its low growth, reference, and high growth scenarios. Further: 10 EIA's reference case implies that world GDP in 2050 will be \$292 trillion (2005\$).109 11 The UN "medium" population forecast for world population in 2050 is 9.551 12 billion.¹¹⁰ 13 14 • Thus, the world per capita GDP in 2050 will be about \$30,600. 15 Four percent of this is about \$1,200. Assuming that the relationship between GDP growth and CO₂ emissions is 16 17 relatively fixed – as does EIA, then to achieve the goal to reduce GHGs to 90 percent 18 below 1990 levels by 2050 will require that world 2050 GDP be reduced to about four percent of what it is projected to be in that year. That is, 2050 world GDP would be 19 20 about \$12 trillion instead of \$292 trillion, and per capita world GDP will be about \$1,200

¹⁰⁸ EIA, International Energy Outlook 2013

¹⁰⁹ Extrapolated by MISI based on EIA forecasts through 2040.

¹¹⁰ United Nations, World Population Prospects: The 2012 Revision, Volume I: Comprehensive Tables, New York, 2013.

instead of \$30,600. What does per capita world GDP of \$1,200 instead of \$30,600imply?

In purely statistical terms, we can utilize the seminal work of Angus Maddison, 3 who has estimated historical per capita GDP.¹¹¹ Using these data, a world per capita 4 5 GDP of about \$1,200, equals about what per capita GDP was in the two wealthiest 6 regions of the world – the USA and Western Europe – in about 1820 or 1830. In other 7 words, to achieve the goal of reducing GHGs to 90 percent below 1990 levels by 2050 8 implies that world living standards in 2050 would be reduced to a level they were more 9 than two centuries prior. That is, virtually all of the economic gains of the industrial 10 revolution and everything that followed would be nullified. Thus, instead of people enjoying the living standards of the 2050s, they would have to endure the living 11 12 standards of the 1820s. In other words, even with heroic assumptions about decoupling 13 GDP growth from energy consumption and GHG growth, to achieve the goal to reduce GHGs to 90 percent below 1990 levels by 2050 implies that world living standards 14 15 would be reduced to a level they were nearly two centuries prior.

If we were to try to reduce emissions to 80% below 1990 levels by 2050, we would enjoy roughly 4% of the GDP we would otherwise have in that same year. That is level comparable to the United Kingdom in 1800 or contemporary Yemen, Bangladesh, North Korea, or Haiti.¹¹² Energy consumption is causally related to GDP, and reducing that consumption will regress our economy to a pre-industrial level.

¹¹¹ Angus Maddison, *Contours of the World Economy, 1–2030 AD: Essays in Macro-Economic History*, Oxford University Press, 2007.

¹¹² Economic and Social Implications of Potential UN Paris 2015 Global GHG Reduction Mandates," Management Information Services, Inc., 2015.

Q: Dr. Hanemann points out that your estimate "implies that humankind obtains benefit from CO₂ emissions directly and not, say, from the use of energy." (Hanemann Rebuttal 8:12-13.) Do you agree?

4 A: No. Dr. Hanemann straightforwardly contradicts himself regarding how I 5 calculate the benefits of CO₂. First he (correctly) asserts that I calculate the *indirect* 6 benefits from CO_2 , namely how energy use that generates CO_2 causes many of the 7 massive benefits our growing prosperity depends on, as discussed above. (Hanemann 8 Testimony at 7:3-7.) Then he inexplicably misinterprets my testimony as describing 9 *direct* benefits from CO₂ "and not, say, from the use of energy." (Hanemann Testimony at 7:12-13.) I explicitly state the opposite, giving "a reasonable defensible estimate of 10 11 the indirect benefit of CO_{2} – indirect because it is the result of energy produced by the fossil fuels from which CO₂ derives." (Bezdek Testimony, Ex. 2 (Report) at 76.) Yet 12 13 again, Dr. Hanemann seems not to understand the causal relationship between CO_2 emission and GDP, which depends on the causal link provided by those indirect 14 15 benefits.

Q: Dr. Hanemann claims that it is not "plausible that generating CO₂ emissions per se benefits humankind." (Hanemann Rebuttal 8:15-16.) Do you agree?

A: No. CO_2 is plant food, as detailed extensively above. The world today is in a relative CO_2 deficiency, and most plants evolved at a time when CO_2 levels were substantially greater. Further, the Earth's climate has often been significantly warmer than it is today, and such times have traditionally been associated with a great proliferation of life and with the flowering of human culture. Dr. Hanemann's assertions

- 1 about the lack of direct benefits from CO_2 make no sense, and the indirect benefits – 2 e.g., increased GDP, basic electrical services, longer life spans, increased guality of life 3 are so core to our day-to-day lives that they can be easy to overlook.
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Q: Dr. Hanemann points out that the benefits from CO_2 may accrue unequally, while it is "reasonable to assume" that the harms are global. Does 5 6 your analysis still hold true if the benefits of CO_2 are spread unequally?

7 A: Dr. Hanemann does not cite evidence for his speculation. Even if there is a regional adjustment, the benefits are such a large multiple of the costs that they would 8 9 still predominate by a large margin. Certainly Minnesota stands to benefit enormously 10 from a warmer climate.

11 Indeed, predictions of warming project that it will occur predominantly in the Northern Hemisphere.¹¹³ So, even the proponents of global warming do not predict that 12 13 its effects will fall predominantly on the poorer areas of Earth south of the equator.

Q: Dr. Hanemann faults you for not controlling for other factors, stating 14 that your analysis is "meaningless" without those controls. Do you adequately 15 16 control for other factors?

A: Yes, through regression as well as the inputs I use. Dr. Hanemann's central 17 18 argument is that I do not control for other explanatory factors, notably prices. I have 19 addressed other factors above - factors such as longer lifespan and capital stocks are 20 accounted for because they are the causal mechanism. Prices are a separate question: 21 the EIA forecasts already explicitly assume that there will be significant increases in

¹¹³ Sandrine Bony, Presentation, "Do Climate Models Over-Estimate Cloud Feedbacks?," at 9 (Mar. 23-27, 2015), available at http://www.mpimet.mpg.de/fileadmin/atmosphaere/WCRP Grand Challenge Workshop/Ringberg 2015/Talks/Bony 26032016.pdf.

energy efficiency over the next three decades. That is, EIA already assumes that world
GDP will increase at a rate that is much faster than the rate of increase in primary
energy consumption, and that CO₂ emissions will increase at a lower rate than either
GDP or energy consumption. Specifically, EIA projects that:¹¹⁴

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- World GDP increases 3.6 percent annually.
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• World primary energy consumption increases 1.5 percent annually.

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• World CO₂ emissions increase 1.3 percent annually.

In other words, EIA has already incorporated into its forecasts a very significant "decoupling" of GDP, energy, and CO_2 emissions and very significant, continuing "decarbonization" of the world economy. Thus, the EIA "Reference Case" already has large decarbonization incorporated into it: It is not a simple "business as usual" case or an extrapolation of past trends. This implies that further CO_2 reductions beyond those already incorporated into the forecasts will be increasingly difficult and expensive to achieve.

Q: Dr. Hanemann argues that your estimate of benefits per ton of CO₂ are
 irrelevant because you are addressing a pecuniary, not a real, externality. Do you
 agree?

A: Not at all – I am addressing a real externality. Dr. Hanemann argues that I focus on a mere pecuniary externality, but ignores the fact that higher energy costs caused by regulation produce real externalities as well. Higher energy costs verifiably impact lower-income people, forcing tradeoffs with food, medical, and rent/mortgage

¹¹⁴ U.S. Energy Information Administration, *International Energy Outlook 2013, With Projections to 2040*, July 2013.

payments.¹¹⁵ Even the EPA admits that its regulations will have a disproportionately 1 2 harmful effect on low-income persons and minorities. For example, while discussing the 3 Environmental Protection Agency's Clean Power Plan, Administrator Gina McCarthy admitted who would be hit the "hardest" by the federal climate regulations. "We know 4 that low-income minority communities would be hardest hit," McCarthy stated.¹¹⁶ Dr. 5 6 Hanemann seems to assume that the government can never create an externality, 7 which is manifestly ridiculous given that even EPA understands that regulations impose costs.¹¹⁷ 8

9 Q: Dr. Polasky stated "Bezdek states that '[i]n reality, the "scientific 10 consensus" is a manufactured myth' (page 28) and that 'there is no empirical 11 scientific evidence for significant climate effects of rising CO₂ levels' (page 30). 12 Bezdek's testimony also includes a conspiratorial claim that the SCC '[a]re 13 artificial constructs designed by Obama administration to penalize fossil fuels' 14 (page 27). Based on his beliefs in the lack of harm from CO₂ emissions Bezdek 15 calculates that the ratio of benefits to costs of CO₂ emissions 'range up to more

¹¹⁵ This phenomenon is amply documented. Caroline Bruff, Inst. for Energy Rsch., *The Poor and the Sicik Suffer under Obama's Climate Rule*, Institute for Energy Research, August 13, 2015),; The Affordable Power Alliance, Potential Impact of the EPA Endangerment Finding on Low Income Groups and Minorities (March 2010); Roger Bezdek, *Maximum Burden: The Electricity Price Increases From the Proposed EPA Utility MACT Will Act as a Regressive Tax on the Elderly*, Pub. Utils. Fortnightly, (Dec. 2012); Roger Bezdek, *Florida Will be Hit Hard by MACT*, Modern Power Systems, 15—16. (Sept. 2012); Mgmt. Info. Svcs., *Potential Impact of Proposed EPA Regulations on Low Income Groups and Minorities* (June 2015), *available at* http://nbccnow.org/wp-content/uploads/2015/06/Minority-Impacts-Report-June-2015-Final.pdf.

¹¹⁶ Monica Sanchez, "EPA Chief Admits 'Low-Income Minority' Families Will Be 'Hardest Hit' by New Climate Regs," MRC TV, August 20, 2015, http://www.mrctv.org/blog/epa-chief-admits-low-incomeminority-families-will-be-hardest-hit-new-climate-regs#.ury81o:SaQR.

¹¹⁷ For example, EPA has stated that "people's wealth and health status, as measured by mortality, morbidity, and other metrics, are positively correlated. Hence, those who bear a regulation's compliance costs may also suffer a decline in their health status, and if the costs are large enough, these increased risks might be greater than the direct risk-reduction benefits of the regulation." U.S. Environmental Protection Agency, "On the Relevance of Risk-Risk Analysis to Policy Evaluation," August 16, 1995.

than 200-to-1' (page 28)." (Polasky Rebuttal 53:3-9.) Do you agree with these statements?

A: No. First, I never used the words "conspiracy" or "conspiratorial" anywhere in my testimony. Dr. Polaksy should to identify where in the Bezdek testimony these words are used and, if he cannot, he should explain why he invented them.

Second, in stating "Based on his beliefs in the lack of harm from CO₂ emissions
Bezdek calculates that the ratio of benefits to costs of CO₂ emissions 'range up to more
than 200-to-1'' Dr. Polasky is, once again, absolutely wrong. I must question how
thoroughly Dr. Polasky even read my testimony.

10 The benefit-cost ratios have nothing to do with my "beliefs in the lack of harm from CO₂ emissions." On p. 28, In. 19 of the Bezdek Direct Testimony, I state: "While 11 12 the federal SCC estimates are of questionable validity, I nevertheless compared the 13 CO_2 costs and benefits (on a normalized per ton basis) using the federal SCC estimates and assumptions. I found that the current benefits clearly outweigh any hypothesized 14 15 costs by, literally, orders of magnitude: The benefit-cost (B-C) ratios range up to more 16 than 200-to-1." In other words my "beliefs" have nothing to do with this. Rather, even 17 though I questioned the validity of the federal SCC estimates, I used them intact as a 18 measure of "harm." Nevertheless, even accepting the invalid federal SCC estimates, 19 the B-C ratios are still in the range of 200-to-1.

The words Dr. Polasky uses, such as "conspiratorial" and "beliefs" are inaccurate, pejorative, and misleading. They evidence a lack of professionalism and should not be used in this proceeding.

Roger H. Bezdek Sur-Rebuttal OAH 80-2500-31888 MPUC E-999/CI-14-643

1	More basically, federal agencies' use of the SCC in benefit-cost analysis is not
2	even credible. As Jonathan Masur and Eric Posner found, "A close reading of the cost-
3	benefit analyses performed by agencies in connection with climate regulation reveals
4	much to worry about. There is a wide gap between the theory of cost-benefit analysis
5	and the performance of the agencies." ¹¹⁸ They found that the agencies' regulatory
6	efforts have been inadequate: "Simultaneously miscalculating the SCC and ignoring
7	their own numbers, agencies manage to do cost-benefit analysis poorly and then
8	disregard it." ¹¹⁹ They concluded that the SCC figures cannot be used in a conventional
9	cost-benefit analysis performed at the agency level because serious political issues
10	remain as a result of the global nature of climate change and the uncertainties that
11	continue to surround it.

12 Q: Dr. Gurney suggests that "The question should be centered on 13 assessing the total net impact on plants, particularly food crops, from 14 anthropogenic climate change." (Gurney Rebuttal 4:21-22.) Do you agree?

A: Yes. I agree with Dr. Gurney on one specific, limited point: "The question should be centered on assessing the total net impact on plants, particularly food crops, from *anthropogenic* climate change." (Gurney Rebuttal at 4:21-22 (emphasis added).) Until he and his colleagues can demonstrate attribution to humans – that the climate change they think they see is truly *anthropogenic* – then the SCC is defective on his own terms. As my testimony demonstrates, the gross benefits from humans generating carbon are hundreds of times greater than the gross harms represented by the SCC,

 ¹¹⁸ Jonathan S. Masur and Eric A. Posner Climate Regulation and the Limits of Cost-Benefit Analysis," *California Law Review*, Volume 99, Issue 6, (December 2011) pp. 1557-1599.
 ¹¹⁹ Ibid.

resulting in clear net benefits from unquestionably anthropogenic carbon use. He and
 his colleagues cannot come anywhere close to saying the same about the harms of
 climate change.

Q: Dr. Polasky (Rebuttal 46:18-19) contends that a uniform carbon tax across countries is required, but is highly unrealistic and "getting to such a policy does not appear likely any time soon." Do you agree with this statement?

7 A: I agree that getting to such a policy is virtually impossible. However, Dr. 8 Polasky either does not seem to realize or refuses to acknowledge that arbitrary 9 imposition of an SCC value is the equivalent to a carbon tax – and should thus also be 10 considered "unrealistic." For example, SCC values in the range of those recommended 11 by Dr. Polasky and some other witnesses have been shown by EIA – in one of the "side 12 cases" it has been running with the National Energy Modeling system (NEMS) as part of its Annual Energy Outlook – to be equivalent to a large carbon tax.¹²⁰ Thus, Dr. Polasky 13 and these witnesses are recommending imposition, by mandate, of a de facto, 14 unlegislated, clandestine carbon tax - a tax that both the U.S. Congress and the 15 16 Minnesota legislature refuse to enact. This proceeding should not be used to impose 17 stealth taxes that the legislature refuses to pass.

¹²⁰ For example, the "GHG25" EIA side case in *AEO 2014* "Applies a price for CO₂ emissions throughout the economy, starting at \$25/metric ton in 2015 and rising by 5 percent/year through 2040." U.S. Energy Information Administration, *Annual Energy Outlook 2014*, P. E-8. See also the discussion in Roger Bezdek, "Energy Costs: The Unseen Tax? A Case Study of Arizona," presented at the National Taxpayers Conference, Chandler, Arizona, October 2013.

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III. Flaws in IAMs

2 Q: In responding to Dr. Smith, Dr. Polasky argues that it is reasonable to 3 forecast both economic consequences and climate changes out to 2300. Do you 4 agree? 5 A: No. Imagine the differences in the world between 1715 and 2015. Is it likely 6 that anyone in 1715 would have accurately predicted the modern world? Projecting a 7 hypothetical scenario three centuries in the future places this squarely into the realm of science fiction. 8 9 It is virtually impossible to make accurate energy forecasts even one or two 10 decades into the future, much less centuries into the future. In a seminal analysis 11 published in a peer-reviewed journal, Bezdek and Wendling evaluated the major U.S. energy forecasts to the year 2000 made in the late 1970s and early 1980s - barely two 12 decades ahead.¹²¹ One of the major findings that emerged from this study is that 13 14 accurate long-range forecasting of even the most basic energy data is extremely difficult, and the track record of the studies reviewed was very poor. For example: 15 • Forecasts of even the most basic metric of interest, U.S. primary energy 16 consumption, were abysmal and the errors ranged between 25 and 50 17 percent. Further, "The gap between actual and forecast energy consumption 18 generally increased over time and, if we revisited this exercise in 5 or 10 19 years, the inaccuracies would be even more pronounced."¹²² That is. the 20 further out the forecast, the worse it became. 21

¹²¹ Roger Bezdek and Robert Wendling. "A Half Century of Long-Range Energy Forecasts: Errors Made, Lessons Learned, and Implications For Forecasting." Journal of Fusion Energy, Vol. 21. No. 3/4 (December 2003), pp. 155-172. ¹²² *Ibid*.

• The price of oil was mis-forecast by a factor of more than two, and the studies erred not only in the magnitude of the price change but also in the direction of the change.

• With respect to renewable energy (solar and wind) forecasts, the most "accurate" forecast was high by a factor of 14, the forecast made with the shortest time horizon was high by a factor of 18, and the average forecast of the five studies was high by a factor of more than 40. Thus, "[t]his gross inaccuracy is especially troubling because during the 1970s and early 1980s enormous time, effort, and resources were devoted to solar and wind energy technology specification, assessment, commercialization, and forecasting – probably more than for any other technology."¹²³

14 Even Mr. Martin (Rebuttal 8:6) acknowledges the virtual impossibility of credibly 15 forecasting over such a time frame: "All Parties appear to acknowledge the uncertainty 16 inherent in predicting population, economic growth, CO₂ emissions, temperature 17 change, and economic damages over almost 300 years. Even if economic growth were 18 known with certainty, predicting the CO_2 emissions resulting from this growth depends 19 on assumptions about how technology will evolve over a very long timeframe. Even if 20 CO₂ emissions were known with certainty, translating these into temperature change 21 depends on assumptions about highly complex processes including equilibrium climate 22 sensitivity, the global carbon cycle and radiative forcing. Even if temperature change 23 were known with certainty, translating this into economic damages depends on 24 assuming the shape and parameters of a damage function with very little empirical 25 evidence on which to base these assumptions. Finally, assigning a net present value to 26 damages depends on the highly contentious choice of discount rate." He further states 27 (Rebuttal 9:10, emphasis added): "IAMs are simplified, reduced-form models that -

¹²³ Ibid.

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while useful because they integrate in a single model emissions, temperature response, and economic damages – are imperfect. They are unable to adequately capture important dynamics such as adaptation and enhanced mitigation (causing them to overestimate damages) and catastrophic climate impacts (causing them to underestimate damages). Their predictions depend heavily on input assumptions, many of which represent policy judgments rather than objective scientific choices."

Q: Both Dr. Polasky and Dr. Hanemann point out that you rely on an article
by Robert Pindyck. Do you agree with Prof. Pindyck's analysis of the need for
IAMs?

10 A: In part. Both Drs. Hanemann and Polasky find it strange that I agree with Prof. 11 Pindyck's evidence of profound problems with IAMs, but disagree with his ultimate 12 policy recommendation. Prof. Pindyck is willing to overlook the fatal flaws in the IAMs 13 because he (incorrectly, in my expert opinion) holds other beliefs about climate science 14 and risk. This willingness to overlook the flawed nature of the SCC illustrates exactly 15 why it is problematic to attribute scientific levels of accuracy to a computation that is 16 essentially based on subjective, prejudged inputs. In my direct testimony (at 7-9, 26-28), report attached as Exhibit 2 to my direct testimony (at 93-115), and rebuttal 17 18 testimony (at 22-52) I have previously documented the flaws in the IWG and its reliance 19 on IAMs, and I will not repeat them here.

Q: Dr. Hanemann believes you quoted Prof. Pindyck as saying "IAM damage functions tend to place too much value ('willingness to pay') on abatement because they track absolute levels of GDP rather than growth rate,"

but those were really your words. Did you misquote or misattribute to Prof. Pindyck?

A: No. Dr. Hanemann attempts to manufacture a misquotation on my part of 3 Prof. Pindyck by comparing references to two different articles. The extended guotation 4 5 Dr. Hanemann (Rebuttal at 55:23-56:10) gives as "Pindyck (2013)" (beginning: "First, some effects of warming will be permanent") is not "the same Pindyck guotation" Dr. 6 7 Hanemann (Rebuttal at 56:11-22) finds in my Exhibit 3, which is actually a summary 8 (not a quotation) of a 2010 article by Prof. Pindyck in which he concludes, "[w]e have 9 seen that in most cases, a direct impact yields a higher WTP than a growth rate impact."¹²⁴ In his 2010 article Prof. Pindyck was focusing on a "willingness to pay" 10 (WTP) measure of damages, which is not the same as measuring the direct 11 consequences, as Dell, Jones, and Olken discuss.¹²⁵ The difference there is not 12 surprising, nor is there a misquotation involved: These are two different articles 13 discussing two different methods of measuring damages. I do not understand why Dr. 14 15 Hanemann characterized a citation to two different articles as a misquotation of one of 16 them.

17Q. Dr. Hanemann contends (Rebuttal 4:15) that the developers of DICE and18FUND acknowledge the existence of a CO2 fertilization effect and account for it in

- 19 some manner. Is this correct?
- 20 **A**. No, this is highly questionable.

 ¹²⁴ Robert S. Pindyck, "Modeling the Impact of Warming in Climate Change Economics," MIT Sloan School Working Paper No. 4769-10 (Jan. 11, 2010), *available at* http://ssrn.com/abstract=1539020.
 ¹²⁵ Melissa Dell, Benjamin F. Jones, and Benjamin A. Olken, "What Do We Learn from the Weather? The New Climate–Economy Literature." Journal of Economic Literature 2014, 52(3), 740–798.

Roger H. Bezdek Sur-Rebuttal OAH 80-2500-31888 MPUC E-999/CI-14-643

1 Numerous studies have questioned the degree to which the IAMs actually 2 incorporate the CO₂ benefits to plants and agriculture and the impact that including these benefits would have on the SCC estimates. For example: 3

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11 12 Patrick Michaels found that "only one of the three IAMs used by the IWG has any substantial impact from carbon dioxide fertilization, and the one -that does [FUND], underestimates the effect by approximately 2-3 times. The Integrated Assessment Models (IAMs) used to determine the social cost of carbon either significantly underplay (FUND) or largely ignore (PAGE, DICE) the large and positive impact that enhanced atmospheric carbon dioxide concentrations have of agricultural output."¹²⁶

- 13 • Stephanie Waldhoff, et al. found that the inclusion of the benefits of carbon 14 dioxide fertilization on agriculture and forestry in the FUND model substantially reduces the social cost of carbon dioxide.¹²⁷ They stated "Under 15 our base case assumptions, the social cost of carbon dioxide is \$6.6/t CO₂ 16 17 (1995\$) in 2010 with a pure rate of time preference of 1%. This is in line with previous estimates."¹²⁸ This can be compared to the \$37/ton SCC value the 18 19 IWG estimated. In other words, adding carbon fertilization to the SCC, which 20 is what the FUND analysis is supposed to do, can lower the SCC calculated by the Obama administration by around \$31 per ton – a reduction of more 21 than 80%. 22 23
- 24 • One of the leading papers used by those supporting a Social Cost of Carbon does not include carbon fertilization and calls it a "controversial benefit" -25 even though it is a proven scientific fact that plants require carbon dioxide for 26 survival, and are thriving with more CO₂.¹²⁹ This paper stated "FUND is the 27 only model of the three used by the Working Group to estimate a negative 28 29 SCC. This is a result of a controversial benefit included in FUND that predicts 30 CO₂ fertilization will significantly increase agricultural yields in the early stages of warming."130 31

¹²⁶ Written Statement of Patrick J. Michaels," Hearing on an Analysis of the Obama Administration's Social Cost of Carbon Before the U.S. House of Representatives Committee on Natural Resources, July 22, 2015.

¹²⁷ Stephanie Waldhoff, David Anthoff, Steven Rose, and Richard S. J. Tol (2014). The Marginal Damage Costs of Different Greenhouse Gases: An Application of FUND. Economics: The Open-Access, Open-Assessment E-Journal, 8 (2014-31): 1-33. ¹²⁸ *Ibid.*

¹²⁹ Laurie Johnson and Chris Hope, "The social cost of carbon in U.S. regulatory impact analyses: an introduction and critique," Journal of Environmental Studies and Sciences, September 2012, Volume 2, Issue 3, pp 205-221.

¹³⁰ *Ibid*.

- Kevin Dayaratna noted that the FUND model, in fact, allows for the SCC to be negative based on feedback mechanisms due to carbon dioxide emissions. In fact, he found that under a reasonable set of assumptions, the SCC is overwhelmingly likely to be negative.¹³¹ This would suggest that there are literally no costs, but benefits, to burning carbon dioxide
- Julian Morris conducted a detailed study that analyzed the costs and benefits of carbon dioxide emissions.¹³² He concluded that the weight of evidence suggests federal agencies should ignore carbon dioxide emissions when evaluating regulations, because on balance the "positive externalities" from enhanced agricultural output, reduced deaths from cold, and so forth balance out the "negative externalities" from climate change.
- Paul Knappenberger found that an important point largely ignored by the 14 Administration in developing SCC estimates is that there are "benefits" in 15 addition to the "costs" of carbon dioxide emissions. One of the key benefits is 16 17 enhanced global food production. Carbon dioxide is a fertilizer for plants, and 18 more carbon dioxide in the atmosphere means stronger, healthier, and more productive vegetation, including most crops – a fact established by literally 19 thousands of scientific studies. The handling of this large, significant and 20 proven benefit from carbon dioxide is grossly deficient in the Administration's 21 accounting of the social cost of carbon. He concluded that, had the new 22 23 science on the Earth's climate sensitivity to carbon dioxide, the science on carbon dioxide's role as a plant fertilizer, and other critical issues not been 24 largely ignored, the Administration's latest estimate of the social cost of 25 26 carbon would have dropped to near zero, or perhaps actually become negative.¹³³ 27
- 28 Q: Mr. Martin (Rebuttal 3:19) discusses the revisions made in the July 2015
- 29 TSD to the Federal SCC values in the November 2013 TSD. Do you agree that
- 30 such revisions are valid?

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 ¹³¹ Kevin D. Dayaratna, "An Analysis of the Obama Administration's Social Cost of Carbon," Testimony before Committee on Natural Resources, United States House of Representatives, July 23, 2015.
 ¹³² Julian Morris, "Assessing the Social Costs and Benefits of Regulating Carbon Emissions," Reason Foundation, Policy Study No. 445, August 2015.

¹³³ Paul C. Knappenberger, "Obama's 'Social Cost of Carbon' Is at Odds with Science," Cato, October 2013.

A: No, for three reasons. First, it is bad enough that the IWG revised the
estimated SCC values by 50% between 2010 and 2013 – a period of three years. Here
they are now making revisions within 20 months.

Second, and more important, the differences in the 2010 and 2013 SCC 4 5 estimates are so large and of such immense potential significance as to raise serious 6 questions as to their validity – especially since, prior to February 2010 the "official" 7 Federal government estimate of the value of SCC was zero. If any valid government 8 economic estimates, such as GDP or unemployment, were revised by 50 percent within 9 a three year period it would represent a scandal and a farce. For example, in 2010, U.S. GDP was estimated to be about \$14.6 trillion.¹³⁴ While the U.S. Bureau of 10 11 Economic Analysis (BEA) always makes slight revisions to its GDP estimates in 12 subsequent years, it is inconceivable that in 2013 it would have published a revised 13 estimate of 2010 U.S. GDP in the range of \$22 trillion.

Third, what would happen in 2017 when, for example, under a new Presidential Administration "non-minor" technical corrections are made that reduce the SCC by 50% or more? Are all decisions and regulations (in Minnesota and elsewhere) based on the 2013 (or 2015) SCC estimates supposed to be revisited? It is simply absurd to believe that meaningful government policies and regulatory decisions should be arbitrarily changed every year or so on the basis of "forecasting" models that depend on hypothesized effects hundreds of years in the future.

¹³⁴ Obtained from the U.S. Bureau of Economic Analysis web site www.bea.gov.

Q: Mr. Martin (Rebuttal 12) presents a figure (Figure 2) that illustrates the CO₂ values in the Parties' testimony in which he converted the proposed values to nominal dollars per short ton for emission year 2020. Do you find this figure to be instructive?

A. Yes. It shows such an incredibly wide variation in proposed CO_2 values –from 0.55 to 136.70 – as to be essentially meaningless. It is a very good illustration that potential CO_2 values are so highly variable and uncertain as to be totally inappropriate for use in Minnesota, or any other state. The average of the values in Figure 2 is 4.36. As I estimated in my rebuttal testimony of August 11, 2015 in this proceeding, this value of 4.36 is (in nominal dollars) at the high end of the value established by the Minnesota PUC in 1996.

Q: Mr. Martin's answer (Rebuttal 35:24), to the question "Does Peabody's testimony meet the company's proposed standard of review criteria?" is "Generally no. Because it includes five experts and a variety of conflicting recommendations, the Peabody testimony is difficult to assess against the Company's proposed criteria." Do you agree with his conclusion?

A: No. First, Peabody's witnesses all testify to the flaws in the SCC concept and recommend against using it as the basis for policy making in Minnesota. If anything, the differences prove the Peabody witnesses' independence, objectivity, and professionalism.

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IV. Peer Review, Consensus, and the IPCC

Q: Dr. Gurney criticizes you extensively for not relying on peer-reviewed 2 3 literature. Do you agree? 4 **A:** No. For a scholar who criticizes me for ignoring peer-reviewed sources, Dr. Gurney cites only one such source in the portions of his testimony germane to me and 5 6 completely ignores the ones I cite. He seems to demand a higher standard of proof 7 from people who disagree with him. 8 To illustrate my qualifications, I have published one or more pieces of peer-9 reviewed scholarship in the following sources: 10 1. Science 11 2. Nature 12 3. Energy Policy 13 4. Natural Resources Journal 14 5. Journal of Fusion Energy 6. Journal of the Royal Statistical Society 15 16 7. Energy Systems and Policy 17 8. Journal of Environmental Management 18 9. Journal of Economic Issues 19 10. Journal of Higher Education 20 11. Review of Income and Wealth. 21 12. Journal of the American Statistical Association 13. Review of Economics and Statistics 22

- 1 14. Quarterly Review of Economics and Business
- 2 15. Journal of Environmental Systems
- 3 16. The Computer Journal
- 4 17. Long-Range Planning
- 5 18. Public Utilities Fortnightly
- 6 19. International Journal of Global Warming
- 7 20. Issues in Science and Technology
- 8 21. Journal of the American Institute of Chemical Engineers
- 9 22. Environmental Science and Technology
- 10 23. Mineral and Energy Resources
- 11 24. Bulletin of the Atomic Scientists
- 12 25. Mechanical Engineering
- 13 26. International Journal of Global Energy Issues
- 14 **27**. *World Oil*
- 15 28. Energy Strategy Reviews
- 16 29. Journal of Economics and Business
- 17 **30**. Cornerstone
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- 20 32. Journal of Regional Science
- 21 33. Verlag für Architektur und technische Wissenschaften
- 22 34. Green Energy Economies
- 23 35. Australian Financial Review

- 1 36. *Modern Power Systems*
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- 12 44. International Journal of Nuclear Governance, Economy and Ecology
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- 14 46. Energy Futures and Urban Air Pollution: Challenges for China and the U.S.,
- 15 Washington, D.C.: National Academies Press, 2008.
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2	published jointly by the International Council for Capital Formation (Brussels
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4	Instituto Bruno Leoni (Turin, Italy), February 2005.
5	54. Journal of the American Academy of Business
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15	61. Space Power
16	62. Strategic Planning for Energy and the Environment
17	63. Technological Forecasting and Social Change
18	64. Government Accounts Journal
19	65. Public Budgeting and Finance
20	66. Ambio
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- 1 70. Electric Potential
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 16 Academy of Sciences, Washington, D.C., 1977
- 17 83. Solar Technology in the Seventies, International Solar Energy Society, 1978.
- 18 84. *Reconstruction of Macroeconomics*, Mason Gaffney, ed., Madison,
- 19 Wisconsin: University of Wisconsin Press, 1976.
- 20 85. Journal of Continuing Education and Training
- 21 86. Monthly Labor Review
- 22 87. Engineering Issues
- 23 88. College and University
- 89. The Systems Approach: Key to Successful Computer Applications, National
 Bureau of Standards and the Association for Computing Machinery,
- 3 Washington, D.C. 1974.
- 4 90. Urban and Social Change Review
- 5 91. The American Economist
- 6 My publications record speaks for itself.

7 Q: Have Drs. Abraham, Hanemann, Polasky, Kunkle, Martin, and Rumery

- 8 relied on any non-peer reviewed sources?
- 9 **A:** Yes. They cite the IWG, which is not peer-reviewed and is not transparent.
- 10 For example, the individuals involved and the details of the calculations have never
- 11 been fully disclosed. The opposing witnesses cite numerous other non-peer-reviewed
- 12 sources, including:
- 13 Abraham 1. Abraham, J.P., J. Cook, J. T. Fasullo, P. H. Jacobs, S. A. Mandia, and D. A. 14 Nuccitelli, Review of the Consensus and Asymmetric Quality of Research on 15 16 Human-Induced Climate Change, Cosmopolis, Vol. 2014-1, pp. 3-18, 2014b. 17 18 2. Arctic Report Card, accessed June 22, 2015, http://www.arctic.noaa.gov/ 19 reportcard/greenland ice sheet.html. 20 3. Bloomberg News, Mystery of the 'missing' global warming, October 23, 21 22 2013, http://www.bloomberg.com/news/2013-10-23/mystery-of-themissina-23 global- warming.html. 24 25 4. British Broadcasting Corporation (BBC), Journal editor resigns over 'problematic' climate paper, September 2, 2011, http://www.bbc.co.uk/ 26 27 news/science-environment-14768574. 28 29 5. G8 + 5 Academies, G8+5 Academies' joint statement: Climate change and the transformation of energy technologies for a low carbon future, 2009 30 31 http://www.nationalacademies.org/includes/G8+5energy-climate09.pdf

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- 10. Joint Science Academies' Statement, Global Response to Climate Change, 2005, *available at* http://www.academie-sciences.fr/actualites/textes/G8_gb.pdf#search=%22Joint%20Science%20Academies%E2%
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Hanemann

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- 26.AWEA, "U.S. Wind Industry Annual Market Report, Year Ending 2014", at 12 (2015).
- 27. AWEA, "U.S. Wind Industry Second Quarter Report 2015", (July 2015)
- 28. EPA, Alternative RE Approach Technical Support Document (June 2, 2014).
 - 29. MISO Informational Forum Presentation (January 22, 2013)
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 - 32. Minnesota Department of Employment and Economic Development, "Minnesota: Clean Energy Economy Profile, (October 2014)
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10 11 12	. Renewable Portfolio Standard Policies. June 2015.
13 14	. SB 350: Golden State Standards 50-50-50.
15 16 17	. New York State Energy Planning Board. 2015. The Energy to Lead; 2015. New York State Energy Plan.
17 18 19 20	 Overview of the Clean Power Plan: Cutting Carbon Pollution from Power Plants. Aug. 3, 2015. <u>http://www.epa.gov/airquality/cpp/fs-cpp-overview.pdf</u>.
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30 31 32 33	3.http://www.energy.ca.gov/renewables/tracking_progress/documents/renewabl e.pdf;
33 34 35	4.http://www.cpuc.ca.gov/PUC/energy/Renewables/.
36 37 38 39	5. Governor Brown Establishes Most Ambitious Greenhouse Gas Reduction Target In North America. April 29, 2015. http://gov.ca.gov/news.php?id=18938.
40 41 42	 Hawaii Passes Legislation to Go 100% Renewable. Greentech Media. May 12, 2015.
43 44	 Illinois Lawmakers Introduce Far-Reaching Clean Energy Bill With Bipartisan Support. Feb. 20, 2015. <i>Think Progress</i>.

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- 35 31. The Use of Solar and Wind as a Physical Hedge against Price Variability
 36 within a Generation Portfolio. Aug. 2013.
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- 38 Q: Dr. Gurney commends the standards of "impartiality" and "adherence to
- 39 strict scientific principles." Does the IPCC live up to those standards?
- 40 **A:** Not even marginally. Dr. Gurney gives "impartiality" and "adherence to strict
- 41 scientific principles" (Gurney Rebuttal at 25:3) as foundational principles of peer review

1	as "an essential component of higher education" (Gurney Rebuttal at 25:1). As some of
2	these "dissenters" and "skeptics" listed below allude to, the "peer-review" process in this
3	field is highly politicized, as the "ClimateGate" controversy of 2009 highlighted. The
4	emails released in that scandal showed IPCC scientists manipulating the peer review
5	process in order to ensure that they could cite supportive literature and obstruct the
6	publication of views that disagreed. A committee of the British Parliament investigated
7	for violations of freedom of information laws. ¹³⁵ If there is a consensus, it has bullied its
8	way into existence by exclusion rather than by virtue of the scientific evidence on which
9	it is based.
10	Q: How has the IPCC distorted the peer review process?
11	A: This tight network has distorted the peer-review process:
12 13 14 15 16	• In one extensively documented instance, ¹³⁶ an IPCC author who was also an editor at <i>International Journal of Climatology</i> agreed to expedite the review process for an article supporting his views (including accepting a list of potential reviewers furnished <i>by the authors</i>) and to delay the publication of an article disagreeing with those views. ¹³⁷
18 19 20 21	 Referring to two papers giving an alternate (non-anthropogenic) theory for recent warming, one of the IPCC authors stated: "I can't see either of these papers being in the next IPCC report. Kevin and I will keep them out somehow – even if we have to redefine what the peer-review literature is!"¹³⁸

¹³⁵ See Climate row unit 'broke data law,' Jan. 28, 2010 available at http://news.bbc.co.uk/2/hi/uk_ news/ 8484385.stm.

The "Kevin" in guestion is Kevin Trenberth and the author of the email is

¹³⁶ The full description from one of the authors of the delayed paper can be found at: David H. Douglass and John R. Christy, "A Climatology Conspiracy?," American Thinker (Dec. 20, 2009), available at http://www.americanthinker.com/articles/2009/12/a_climatology_conspiracy.html.

¹³⁷ CRU email 1196795844.txt (Dec. 4. 2007); CRU email 1196877845.txt (Dec. 5, 2007); CRU email 1196956362.txt (Dec. 6, 2007); CRU email 1196964260.txt (Dec. 6, 2007); CRU email 1197325034.txt (Dec. 10, 2007); CRU email 1197507092.txt (Dec. 12, 2007); CRU email 1199988028.txt (Jan. 10, 2008); CRU email 1199999668.txt (Jan. 10, 2008); CRU email 1200059003.txt (Jan. 11, 2008); CRU email 1200076878.txt (Jan. 11, 2008); CRU email 1209080077.txt (Apr. 24, 2008); CRU email 1215712600.txt (Jul. 10, 2008); CRU email 1216753979.txt (Jul. 22, 2008) ¹³⁸ CRU email 1089318616.txt (Jul. 8, 2004).

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1	Philip Jones, the Coordinating Lead Authors for Chapter 3 of the Working
2	Group I contribution to the Fourth Assessment Report, "Observations:
3	Surface and Atmosphere Climate Change. ²¹⁰⁰
4	
5	 IPCC authors also acted as peer reviewers for literature they wished to rely
6	on in their respective chapters. ¹⁴⁰
7	
8	 IPCC authors interfered with peer-review processes"
9	 as outsiders, by pressuring editors at refereed publications,
10	o as editors, by inappropriately revealing reviewers' identities to authors
11	they wanted to support, and
12	o as reviewers, soliciting arguments from authors of papers they were
13	reviewing to wield against disagreeing reviewers. ¹⁴¹
14	
15	• When one journal (Climate Research) published an article that could
16	undermine theories about the anthropogenic nature of climate change
17	(specifically, showing that the Medieval Warm Period was - for natural
18	reasons - even warmer than the present), lead IPCC authors with weight in
19	the community threatened to boycott the journal "until they rid themselves of
20	this troublesome editor." ¹⁴² A similar tactic worked at Geophysical Research
21	Letters, where after one editor left under pressure, an IPCC author wrote
22	"[t]he GRL leak may have been plugged up now w/ new editorial leadership
23	there." ¹⁴³
24	http://www.desmogblog.com/skeptics-prefer-pal-review-over-peer-review-chris-de-freitas-pat-
	michaels-and-their-pals-1997-2003
25	Q: Has the IPCC ever manipulated literature outside the normal peer review
-	· ····································

- processes? 26
- A: Yes. Not only does the IPCC rely on non-peer-reviewed literature, they 27
- manipulate it so it will be supportive to IPCC assessment reports.¹⁴⁴ Emails among 28
- 29 IPCC authors and editors revealed that one scientist used his contributions to the

¹³⁹ AR4 WG1 at 235-336.

¹⁴⁰ CRU email 1120593115.txt (Jul. 5, 2005); CRU email 1116017259.txt (May 13, 2005).

¹⁴¹ CRU email 1051156418.txt (Apr. 23, 2003); CRU email 1054748574.txt (Jun. 4, 2003); CRU email 1054756929.txt (Jun. 4, 2003); CRU email 1233249393.txt (Jan. 29, 2009); CRU email 1233245601.txt (Jan. 29, 2009). ¹⁴² CRU email 1047388489.txt (Mar. 11, 2003).

¹⁴³ CRU email 1132094873.txt (Nov. 15, 2005).

¹⁴⁴ See the discussion in Great Britain Parliament House of Commons Science and Technology Committee, The Disclosure of Climate Data from the Climatic Research Unit at the University of East Anglia, Volume 2, 2010.

RealClimate website to attack contrary viewpoints, then forwarded those indictments to
 the IPCC for consideration for AR4.¹⁴⁵ Phil Jones, one of the co-authors of the Working
 Group 1 contribution to AR4, candidly stated that he tried to "hide the decline" in data he
 was working on, referring in context to measurements of temperatures.¹⁴⁶
 Q: Dr. Abraham claims that "97 percent of the world's climate scientists

agree that humans are causing climate change." (Abraham Rebuttal 20:6-7.) Do
 you agree such a consensus exists?

- A: No. Such a consensus does not actually exist, and if it did, then it should be accorded no relevance: science is based on evidence, not agreement. I have previously documented the lack of existence of a "consensus" in my direct testimony (at 34-36) and in my rebuttal testimony (at 6-8), and I will not repeat those points here.
- 12

Q: Where does the claim about 97% of climate scientists comes from?

A: The claim is from an article by Cook, et al. (2013), "Quantifying the Consensus on Anthropogenic Global Warming in the Scientific Literature," *Envt'l Rsch Letters*, vol. 8.

16 **Q: Do**

Q: Do you agree with the conclusions of Cook, et al. (2013)?

A: No. The claim about 97% of climate scientists has been thoroughly debunked
by Richard Tol and Jose Duarte, who exposed the deeply flawed experimental design:
Activists with a predefined interest in a particular outcome rated abstracts selected
through overbroad search terms, with poor internal controls and high incidences of
Tol and Duarte are not exactly reliable sources on this topic.

¹⁴⁵ CRU email 1102956436.txt (Dec. 13, 2004).

¹⁴⁶ CRU email 942777075.txt (Nov. 16, 1999).

bias.¹⁴⁷ Indeed, "the fact that 97% of studies report positive results does not necessarily translate into a 97% consensus of the scientific community that climate change is human-made" and may in fact be evidence of publication bias.¹⁴⁸ Arbitrarily labeling and dismissing scientists as "dissenters" or "deniers" attempts to reinforce a consensus that does not truly exist. Such labels are just schoolyard bullying dressed up in a lab coat and should not be accorded actual weight.

Q: Dr. Abraham authored a study on the same subject. Do you agree with
its conclusions?

9 A: No. Dr. Abraham authored a study that he cites many times (as "Abraham 2014b") addressing the issue of consensus. His co-authors were John Cook (whose 10 "97%" claim was debunked) and two others directly affiliated with advocacy 11 organizations.¹⁴⁹ Although he gives Cook's work as strong evidence supporting a 12 consensus, he never addresses Richard Tol's well-publicized criticism of Cook's data.¹⁵⁰ 13 The journal "Abraham 2014b" is published in – Cosmopolis – is far afield from climate 14 science, and the original paper cannot be accessed there, raising questions about the 15 16 guality of the journal, even whether it is peer-reviewed. If "[i]t is also important not to

¹⁴⁷ Tol, R. S. J. (2014): "Quantifying the consensus on anthropogenic global warming in the literature: A reanalysis." *Energy Policy* 73: pp. 701–705; Tol, R.S.J., "Quantifying the Consensus on Anthropogeniuc Global Warming in the Literature: Rejoinder." *Energy Policy* 73: p.709; Jose Duarte, "Ignore Climate Consensus Studies Based on Random People Rating Journal Article Abstracts," *JoseDuarte.com* (July 22, 2014), *available at* http://www.joseduarte.com/blog/ignore-climate-consensus-studies-based-on-random-people-rating-journal-article-abstracts; Jose Duarts, "Cooking Stove Use, Housing Associations," White Males, and the 97%," *JoseDuarte.com* (Aug. 28, 2014), *available at* http://www.joseduarte.com/blog/ cooking-stove-use-housing-associations-white-males-and-the-97?; Jose

http://www.joseduarte.com/blog/ cooking-stove-use-nousing-associations-white-males-and-the-97?; Jose Duarte, "The Art of Evasion," *JoseDuarte.com* (Sep. 9, 2014), *available at*

http://www.joseduarte.com/blog/the-art-of-evasion.

¹⁴⁸ Havranek, *supra* n.27, at 3.

¹⁴⁹ J.P. Abraham, *et al.*, Review of the Consensus and Asymmetric Quality of Research on Human-Induced Climate Change, 2014-1 Cosmopolis 3 (2014).

¹⁵⁰ *Id.* at 3, 20.

rely upon non-reviewed information submitted by advocacy organizations" (Abraham 1 2 Rebuttal at 5:12-13), his central article entirely lacks credibility. As the prestigious journal Nature recently noted (September 2015), "Irreproducible research poses an 3 enormous burden."¹⁵¹ 4

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Q: Why do you disagree with the claims of Drs. Abraham and Polasky that 6 there is a scientific consensus of which you are not a part?

7 A: The critical question Abraham's study obscures – and why it cannot be accurate - is consensus as to what? If the question is whether humans have had some 8 9 impact on the environment, even I would be part of the consensus. However, there are 10 crucial, fundamental disagreements as to the degree of human attribution and the 11 magnitude of the effect, much less the proper policy response.

12 The studies Abraham lists here are seriously flawed and have been identified as 13 such by researchers. Examples are given below.

The study by Anderegg et al. (2010) Abraham cites was found to be highly 14 suspect in a rebuttal by Dr. Lawrence Bodenstein of Columbia University published by 15 the National Academy of Sciences.¹⁵² Dr. Bodenstein found that, for example, the 16 17 authors employed suspect methodology that treated publication metrics as a surrogate 18 for expertise, and they failed to address at all the data hoarding and publication 19 blockade imbroglio. The authors' framing of expertise was found to be especially 20 problematic: "In a casting pregnant with self-fulfillment, the authors defined number of

¹⁵¹ C. Glenn Begley, Alastair M. Buchan and Ulrich Dirnagl, "Institutions must do their part for reproducibility," Nature, September 3, 2015, Vol. 525, pp. 25-27.

Lawrence Bodenstein, "Regarding Anderegg et al. and Climate Change Credibility," Proceedings of the National Academy of Sciences, December 28, 2010, vol. 107, no. 52.

1 publications as expertise (italics). The italics were then dropped." Further, "In the 2 logical fallacy of an ad hominem argument, the characteristics, gualities, or failings of adversaries rather than the merits of their case are argued. 3 Here, the authors addressed the worth of CC critics (and agnostics) as scientists rather than the validity of 4 5 their science. Regarding purely scientific questions, it may be justified to discount 6 nonexperts. However, here, dissenters included established climate researchers. The 7 article undermined their expert standing and then, extrapolated expertise to the more 8 personal credibility. Using these methods to portray certain researchers as not credible 9 and, by implication, to be ignored is highly questionable. Tarring them as individuals by group metrics is unwarranted."153 10

The rebuttal concluded that "Publication of this article as an objective scientific study does a true disservice to scientific discourse. Prominent scientific journals must focus on scientific merit without sway from extracurricular forces. They must remain cautious about lending their imprimatur to works that seem more about agenda and less about science, more about promoting a certain dogma and less about using all of the evidence to better our understanding of the natural world."¹⁵⁴

The Zimmerman (2008) paper Abraham cites is by Maggie Kendall Zimmerman, a student then enrolled in a Master of Science program in the Department of Earth and Environmental Sciences at the University of Illinois at Chicago. She conducted an online survey designed to gauge the opinions of scientists on issues to do with climate change and global warming. Not only was the survey deeply flawed (see below), it was

¹⁵³ *Id.*

¹⁵⁴ *Id.*

not peer-reviewed, it was not published in a peer-reviewed journal, and it was not even
 published at all.

The paper that emerged from this study is the paper Abraham cites as Doran and Zimmerman (2009), written by Zimmerman and her master's thesis adviser Peter Doran.¹⁵⁵ It reported the results of a two-question online survey of selected scientists. Dr. Doran and Ms. Zimmerman claimed "97 percent of climate scientists agree" that global temperatures have risen and that humans are a significant contributing factor.¹⁵⁶

8 However, the survey's questions do not reveal much of interest. Most scientists 9 who are skeptical of catastrophic global warming would nevertheless answer "yes" to 10 both questions. The survey did not ask whether the human impact is large enough to 11 constitute a problem. Nor did it include solar scientists, space scientists, cosmologists, 12 physicists, meteorologists, or astronomers, who are the scientists most likely to be aware of natural causes of climate change.¹⁵⁷ The "97 percent" figure in the 13 Zimmerman/Doran survey represents the views of only 79 respondents who listed 14 15 climate science as an area of expertise and said they published more than half of their 16 recent peer-reviewed papers on climate change. Seventy-nine scientists – of the 3,146 who responded to the survey – does not constitute a "consensus." 17

18 The Cook et al. (2013) paper Abraham cites is a report by Professor John Cook 19 of the University of Queensland, et al., who claim to have reviewed over 11,000 climate

 ¹⁵⁵ Peter T. Doran and Maggie Kendall Zimmerman, "Examining the Scientific Consensus on Climate Change," *Eos, Transactions American Geophysical Union*, Volume 90, Issue 3, January 20, 2009, pp.22–23.
 ¹⁵⁶ Isid

¹⁵⁷ Joseph Bast and Roy Spencer, "The Myth of the Climate Change '97%," *Wall Street Journal*, May 26, 2014.

science articles.¹⁵⁸ Cook's paper contended that 97.1 percent of the reviewed abstracts 1 2 conclude humans are causing global warming. But, since most researchers agree that there is at least a very small effect, this statement means nothing. Cook also made the 3 mistake of including in his 97 percent papers by well-known skeptical scientists who do 4 5 not support the AGW theory. Accordingly, climate scientists included in the Cook 6 compilation, such as Craig Idso, Nicola Scafetta, Nir J. Shaviv, Nils-Axel Morner and 7 others, whose research questions the alleged consensus, protested that Cook ignored 8 or misrepresented their work. In 2013, Legates et. al. published a recount of Cook's 9 data that determined that only 64, or 0.5 percent, of 11,944 papers published since 10 1991 endorse the standard definition of consensus: That most warming since 1950 is anthropogenic.¹⁵⁹ 11

Duarte has noted that the Cook paper included numerous psychology studies, marketing papers, and surveys of the general public as scientific endorsement of anthropogenic climate change – which invalidates Cook's research.¹⁶⁰ Duarte found that Cook's paper is not credible as a scientific product, given that it included psychology papers, and also given that it twice misrepresented its method (claiming not to count social science papers, and claiming to use independent raters), and the admitted cheating by some of the raters. It was essentially voided by its invalid method

¹⁵⁸ J. Cook, D. Nuccitelli, S.A. Green, M. Richardson, B. Winkler, R. Painting, et al., "Quantifying the Consensus On Anthropogenic Global Warming In The Scientific Literature," *Environmental Research Letters*, *8*, 2013.

 ¹⁵⁹ David R. Legates, Willie Soon, William M. Briggs, and Christopher Monckton, "Climate Consensus and 'Misinformation': A Rejoinder to Agnotology, Scientific Consensus, and the Teaching and Learning of *Climate Change*," Science & Education, August 2013.
 ¹⁶⁰ Jose Duarte, "Cooking stove use, housing associations, white males, and the 97%," August 28, 2914,

¹⁶⁰ Jose Duarte, "Cooking stove use, housing associations, white males, and the 97%," August 28, 2914, www.joseduarte.com/blog/cooking-stove-use-housing-associations-white-males-and-the-97.

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1	of using partisan and unqualified political activists to subjectively rate climate science
2	abstracts on the issue on which their activism centers – which is inexcusable. Duarte
3	concluded that "This paper is vacated. It doesn't represent knowledge of the
4	consensus." ¹⁶¹
5	The Oreskes (2004) paper Abraham cites has also been discredited. For
6	example, researchers found that: ¹⁶²
7 8 9 10	 Oreskes' essay provides no sound basis for the assertion that a unanimous scientific "consensus" exists on climate change, for, although most climate scientists probably believe that humankind has caused 0.2C of the past half- century's 0.4C warming, there is no unanimity.
11 12 13 14	 Even in the limited sense defined by Oreskes, there were more scientific papers explicitly doubting or even rejecting the "consensus" than explicitly supporting it.
16 17 18	 Less than half of the papers which Oreskes said had implicitly endorsed the "consensus" had in fact done so.
19 20	 More than half of the papers which Oreskes considered had not mentioned anthropogenic climate change at all.
21 22 23 24 25 26 27 28	• The definition of "consensus" in Oreskes' essay is so limited, and her findings as published so greatly at variance with the content of the papers she reviewed, that the essay provides no justification for her "political" contention that "Our grandchildren will surely blame us when they find that we understood the reality of anthropogenic climate change and failed to do anything about it."
29	This phenomenon illustrates the deeper danger posed by Dr. Abraham's
30	unshared certainties: merely assuming there is a consensus can lead others to agree

simply for the sake of their own projects, which then creates a noticeable bias in the 31

 ¹⁶¹ *Ibid.* ¹⁶² Christopher Monckton, "Consensus"? What "Consensus"? Among Climate Scientists, the Debate Is Not Over, Science and Public Policy Institute, Washington, D.C., July 2007.

surveyed literature. That bias becomes self-reinforcing when people like Dr. Abraham
 point to this false consensus as a reason for disbelieving in an argument based on
 evidence.

As Dr. Judith Curry concluded, "The manufactured consensus of the IPCC has 4 5 had the unintended consequences of distorting the science, elevating the voices of 6 scientists that dispute the consensus, and motivating actions by the consensus 7 scientists and their supporters that have diminished the public's trust in the IPCC. 8 Research from the field of science and technology studies are finding that 9 manufacturing a consensus in the context of the IPCC has acted to hyper-politicize the 10 scientific and policy debates, to the detriment of both. Arguments are increasingly being 11 made to abandon the scientific consensus seeking approach in favor of open debate of 12 the arguments themselves and discussion of a broad range of policy options that 13 stimulate local and regional solutions to the multifaceted and interrelated issues of climate change, land use, resource management, cost effective clean energy solutions, 14 and developing technologies to expand energy access efficiently."¹⁶³ 15

Incidentally, a number of the opposition witnesses question Dr. Bezdek's
expertise and credentials, as well as those of some other Peabody witnesses such as
Dr. Happer. I just note here that, among the climate science "experts" that Dr. Abraham
cites:

20 21 • Oreskes is a radical historian who believes that scientists who do not endorse the AGW hypothesis are little more than paid shills deserving of criminal

¹⁶³ Judith Curry, Climate Change: No Consensus on Consensus," October 28, 2012, http://judithcurry.com/ 2012/10/28/climate-change-no-consensus-on-consensus/.

1 2 3 4 5 6 7	•	status, and she endorses having climate "deniers" arrested und act for thought collusion. Farnsworth and Lichter are political scientists. Zimmerman was a student working on a Masters thesis.	ler the RICO
8	Q:	: Assuming Drs. Abraham and Polasky were correct that the	re is such a

9 consensus, should it be given any weight?

- 10 A: Not at all. Science is not based on consensus, but on evidence empirical
- 11 fact. Even if there were a consensus, it would be irrelevant. Aside from obvious
- 12 examples such as Copernicus, Galileo, and Einstein:

13 There was no consensus on continental drift, but multiple competing hypotheses. Oreskes wrote book on this.

- 14 • Alfred Wegener was the first scientist to use the phrase "continental drift" and 15 formally publish the hypothesis that the continents had somehow "drifted" apart. Although he presented much evidence for continental drift, he was 16 17 unable to provide a convincing explanation for the physical processes which 18 might have caused this drift. Similar plant and animal fossils are found 19 around different continent shores, suggesting that they were once joined. Nevertheless, Wegener's hypothesis was rejected by the scientific 20 21 "consensus" and the theory of continental drift was not accepted for decades. Geological maps of the time showed huge land bridges spanning the Atlantic 22 23 and Indian oceans to account for the similarities of fauna and flora and the 24 divisions of the Asian continent in the Permian era, but failed to account for glaciation in India, Australia, and South Africa. The seismologic evidence 25 supporting plate tectonics which encompassed and superseded continental 26 27 drift was finally published in 1968, using data collected from seismologic stations. Evidence for the movement of continents on tectonic plates is now 28 29 extensive, but Wegener did not live long enough to be vindicated. 30
- 31 Mad cow disease (bovine spongiform encephalopathy) and the human • 32 equivalent, Creutzfeldt-Jakob disease, were degenerative brain diseases of 33 unknown cause. After 10 years of experiments, neurologist Stanley Prusiner 34 reported in 1982 that these diseases were caused by a virus-like protein which he named "prion" (derived from "protein" and "infectious"). 35 The 36 scientific establishment ridiculed Prusiner because viruses had been well 37 known to always be made of DNA or RNA. Nevertheless, Prusiner persisted and was convinced that the consensus was wrong. He proved to be correct 38 and was awarded the 1997 Nobel Prize for medicine or physiology for his 39

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novel discovery. Prions are now realized to affect tissues other than brain and, in fact, are found even in lower organisms such as yeast.

 For decades, peptic ulcer was believed to be caused by mental stress and excess stomach acid. Following many years of experiments, physicians Barry Marshall and Robin Warren found in the early 1980s that peptic ulcer was caused by Heliobacter pylori. This finding – which strongly contradicted the existing consensus – forever changed the field of ulcer research: Instead of treating ulcers with antacid medications and/or surgery, antibiotics could now kill the bacteria and cure the disease. Marshall and Warren were awarded the 2005 Nobel Prize for medicine or physiology for this breakthrough.

14 Steven Koonin, former Undersecretary for Science in the Department of Energy

15 during the first Obama Administration and Director of the Center for Urban Science and

16 Progress at New York University, has criticized an artificial rush to consensus:

17 The idea that "Climate science is settled" runs through today's 18 popular and policy discussion. Unfortunately, that claim is misguided. It 19 has not only distorted our public and policy debates on issues related to 20 energy, greenhouse-gas emission and the environment. But is has 21 inhibited the scientific and policy discussions that we need about our 22 climate future.¹⁶⁴

23 Professor Michael Kelly, a member of the Royal Society and the Prince Philip
24 Professor of Technology at Cambridge University, criticized climate models on March
25 14, 2015:

¹⁶⁴ Steven Koonin, *Climate Science is Not Settled*, WALL ST. J., (Sep. 19, 2014), *available at* http://online.wsj.com/articles/climate-science-is-not-settled-1411143565.

1 [T]here is even more uncertainty than previously thought. Carbon 2 dioxide levels in the atmosphere have continued to rise, but since 1998 there has been no statistically significant rise in global temperatures at all. 3

4 This flies in the face of the confident predictions made by nearly all 5 the climate computer models that the temperature would continue to rise 6 as it did from 1975 to 1998. More than 60 different explanations have 7 been proposed to explain why this 'pause' or 'hiatus' has happened, and 8 their sheer number is the clearest evidence that the system that climate 9 scientists are seeking to model is irreducibly complex. Human-sourced 10 carbon dioxide is at best one of many factors in causing climate change, and humility in front of this complexity is the appropriate stance.¹⁶⁵ 11

12 The labeling and marginalization of "dissenters" and "contrarians" inhibits real, 13 evidence-based science. Even Dr. Rajendra K. Pachauri, the former chairman of the 14 IPCC, said that "[p]eople have to guestion these things and science only thrives on the basis of questioning."166 15



Q: Dr. Polasky points out that you disagree with stated policy positions of prominent learned societies such as the Royal Society, the American 17

¹⁶⁵ Michael Kelly, *Why my own Royal Society is wrong on climate change: A devastating critique of* world's leading scientific organisation by one of its Fellows, The Mail On Sunday (Mar. 14, 2015), available at http://www.dailymail.co.uk/news/article-2995239/Why-Royal-Society-wrong-climate-changedevastating-critique-world-s-leading-scientific-organisation-one-Fellows.html.

¹⁶⁶ Graham Lloyd, "'Nothing Off-Limits' in Climate Debate," *The Australian* (Feb. 22, 2013), available at http://www.theaustralian.com.au/news/nothing-off-limits-in-climate-debate/story-e6frg6n6-1226583112134.

1 Geophysical Union, and the American Meteorological Association. Do you agree

- 2 that puts you outside the mainstream?
- 3 **A:** No. Those same learned societies have discovered, to their detriment, that
- 4 enforcing an artificial consensus and stepping into policy advocacy can have adverse
- 5 consequences. For example:

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- When the Royal Society (U.K.) made its grand pronouncements, it was 6 7 publicly embarrassed when 13 esteemed scientists (including the Assistant 8 Director of Programs, Science and Technology Policy at the United States 9 Department of the Interior) wrote a monograph explaining "What the Royal Society Left Out."¹⁶⁷ Professor Michael Kelly, a member of the Royal Society, 10 concluded that "[t]hose who fail to provide balance are not giving advice, but 11 lobbying. It is with the deepest regret that I must now state that this is the role 12 which has been adopted by the Royal Society."168 13
 - When the American Geophysical Union published its advocacy statement, it drew a strong dissenting report from one of the committee members (Roger Pielke Sr.) who drafted a more scientific version of the statement that acknowledged what was unknown and declined to venture into policy recommendations.¹⁶⁹
 - A similar reaction greeted the American Meteorological Society's statement, which was written on behalf of all of its members by a self-selected committee.¹⁷⁰
 - The American Physical Society (APS), a professional association for physicists, received a letter from 54 of its members in May 2009 objecting to the group's climate change advocacy. The letter said in part, "Measured or

¹⁶⁸ Michael Kelly, *Why my own Royal Society is wrong on climate change: A devastating critique of world's leading scientific organisation by one of its Fellows*, The Mail On Sunday (Mar. 14, 2015), *available at* http://www.dailymail.co.uk/news/article-2995239/Why-Royal-Society-wrong-climate-change-devastating-critique-world-s-leading-scientific-organisation-one-Fellows.html.

¹⁶⁷ 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" 1, 8 (Global Warming Policy Foundation March 2015) [hereafter, "What the Royal Society Left Out"].

¹⁶⁹ Judith Curry, "AGU Statement on Climate Change," *Climate Etc.* (Aug. 5, 2013), *available at* <u>http://judithcurry.com/2013/08/05/agu-statement-on-climate-change/.</u>

¹⁷⁰ Judith Curry, "(Ir)responsible Advocacy by Scientists," *Climate Etc.* (Aug. 6, 2013), *available at* http://judithcurry.com/2013/08/06/irresponsible-advocacy-by-scientists/.

http://www.desmogblog.com/another-silly-climate-petition-exposed I'm an APS member, Bezdek is not. This petition managed to get ><0.5% of the membership, skewed strongly towards older men.

1 reconstructed temperature records indicate that 20th - 21st century changes 2 are neither exceptional nor persistent, and the historical and geological 3 records show many periods warmer than today. There is a considerable 4 presence within the scientific community of people who do not agree with the 5 IPCC." The APS then agreed to review its current climate statement to 6 ensure it met the beliefs of its membership and of the best science available. The APS eventually appointed a balanced, six-person committee to review its 7 8 stance on climate change, and the committee included Judith Curry, John 9 Christy, and Richard Lindzen. 10

In 2011 Dr. Ivar Giaever, Nobel prize winner for physics, resigned as a Fellow
 from the APS in disgust over the group's promotion of man-made global
 warming fears. Dr. Giaever announced his resignation from APS was due to
 the group's belief in man-made global warming fears.

http://www.desmogblog.com/2016/01/04/ivar-giaever-nobel-icon-for-climate-deniers 15-year tobacco helper.

In July, 2009 editors of Chemical & Engineering News, a magazine published 16 17 by the American Chemical Society (ACS), confronted an uprising by its members after publishing an editorial attacking those who dare to guestion 18 19 man's effect on the climate. The editorial in the June 22nd issue of the 20 magazine said those that deny anthropogenic [manmade] global warming use 21 "the same tactics used by other purveyors of nonsense rejected by the mainstream scientific community" including the belief in creationism.¹⁷¹ One 22 23 week later, the July 27th issue of the magazine was filled with dozens of 24 letters rebuking the magazine and its parent society for being so dismissive of dissenting opinions on climate change. The letters bordered on a rebellion 25 26 within the society and called for Mr. Baum (the editor) to resign.

Any group has a small number of vocal rejectors of climate science. Baum did not resign.

- In 2010, Britain's premier scientific institution was forced to review its 28 • 29 statements on climate change after a rebellion by members who question mankind's contribution to rising temperatures. The Royal Society appointed a 30 panel to rewrite the 350-year-old institution's official position on global 31 warming and had to publish a new "guide to the science of climate change." 32 33 The society was accused by 43 of its Fellows of refusing to accept dissenting views on climate change and exaggerating the degree of certainty that man-34 made emissions are the main cause, and conceded the point. 35 36
 - In 2009, William Gray, Professor Emeritus of Colorado State University and head of the CSU Tropical Meteorology Project, who is best known for his renowned hurricane forecasts, asserted that the American Meteorological Society was being usurped by global warming alarmists. The AMS had announced it would award the Rossby Research Medal to Dr. James Hansen

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¹⁷¹ Rudy M. Baum, "Climate-Change News," *Chemical & Engineering News* (Jun. 22, 2009), *available at* http://cen.acs.org/articles/87/i25/Climate-Change-News.html.

of NASA's Goddard Institute of Space Studies. Gray objected saying that Hansen was not trained in earth sciences and that the climate change models Hansen uses to issue climate warnings are inaccurate. In a letter he titled "On the Hijacking of the American Meteorological Society," Gray stated "I am of the opinion that this is one of the greatest hoaxes ever perpetrated on the American people."¹⁷²

- 8 Q: Dr. Abraham contends that "contrarians" represent a "very small
- 9 minority of scientists." Do you agree?

10 A: No. Dr. Abraham understates the number of reputable scientists "outside" the current alleged consensus on global warming. In addition to the prominent learned 11 societies challenged by their own members, even climate scientists "on the other side" 12 of the question deny that there is a consensus. In 2010 – well after AR4 was published 13 - the former head of the United Kingdom's Climate Research Unit, Phil Jones, said that 14 15 he "[didn't] believe the vast majority of climate scientists think" "the debate on climate change is over."¹⁷³ Others have spoken out against an understanding that "climate 16 17 science is settled": 18 Former IPCC author John Christy of the University of Alabama has remarked:

- Former IPCC author John Christy of the University of Alabama has remarked: "Something needs to change as these reports are biased and out-of-date by the time they are released. The system now gives almost complete control of the text to authors who have been selected by their politically-aware governments to write it and who do not reflect the enormous ignorance we still have of the climate system."¹⁷⁴
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- Steve Rayner of Oxford University, a former IPCC author on three previous assessment reports, observed that "[a] look at the author lists over the years

¹⁷² Bill Gray, "On the Hijacking of the American Meterological Society (June 2011), *available at* <u>http://meteo.lcd.lu/globalwarming/Gray/AMS_Hijacking_paper_Gray_2011.pdf.</u>

 ¹⁷³ Roger Harrabin, "Q&A: Professor Phil Jones," *BBC* (Feb. 13, 2010), *available at* http://news.bbc.co.uk/
 ¹⁷⁴ Assoc. Press, "UN Climate Change Report: Do We Need Another One?," Christian Science Monitor

¹⁷⁴ Assoc. Press, "UN Climate Change Report: Do We Need Another One?," Christian Science Monitor (Nov. 3, 2014), online at http://www.csmonitor.com/Environment/Latest-News-Wires/2014/1103/UN-climate-change-report-Do-we-need-another-one-video.

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indicates that the working groups operate as self-perpetuating clubs. They are fairly tight networks of individuals who go on from one report to the next and cite each other's work. I decided to discontinue participation in the IPCC⁷¹⁷⁵

• John Coleman, a founder of the Weather Channel, explained that "governments pay scientists to study the issue and researchers reach expected conclusions in order to continue to receive funding" and suggested that the consensus seen in the IPCC report is a "manipulated figure."¹⁷⁶

11 • In July 2015, Nobel Laureate Dr. Iver Giaever in a speech to scientists from 90 countries attending the 65th annual Nobel Laureate Meeting in Lindau, 12 Germany stated that global warming is a non-problem.¹⁷⁷ "From 1880 to 13 2015, the temperature has increased from 288 K to 288.8 K - 0.3 percent. I 14 15 think the temperature has been amazingly stable. If I take where I live in Albany, New York, there is roughly an 80 K difference between summer and 16 17 winter at some time, so would you think that a 0.8 degree average on the Earth makes any difference to the climate in Albany? Is that sensible to you? 18 I would say that global warming basically is a non-problem. Just leave it 19 20 alone, it will take care of itself." Dr. Giaever rejected the notion that man-21 made global warming is an "incontrovertible" truth, telling his Lindau audience that "global warming really has become a new religion. Because you can't 22 23 discuss it - it's not proper. But the facts are that in the last 100 years we 24 have measured the temperature, it has gone up 0.8 degrees and everything in the world has gotten better ... We live better, we have better work, better 25 26 health, better everything – but if we go up another 0.8 degrees, we're gonna die, I quess," he said sarcastically. 27

http://www.desmogblog.com/2016/01/04/ivar-giaever-nobel-icon-for-climate-deniers

- Professor Lennart Bengtsson is a Swedish meteorologist who has conducted 29 30 extensive and prize-winning research on climate. He was previously the Head of Research at the European Centre for Medium-Range Weather 31 Forecasts from 1975 to 1981 and then Director until 1990, Director of the Max 32 33 Planck Institute for Meteorology in Hamburg, and he is now a Senior Research Fellow at the Environmental Systems Science Centre in the 34 University of Reading. He became a member of the Academic Advisory 35 Council of the Global Warming Policy Foundation ("GWPF"). 36 Quoted as stating that the "whole concept behind IPCC is basically wrong," Bengtsson 37
 - ¹⁷⁵ Id.

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¹⁷⁶ Steve Almasy, "Invest Now or Face 'Irreversible' Effects of Climate Change, U.N. Panel Warns,"

CNN.com (Nov. 2, 2014), online at http://www.cnn.com/2014/11/02/world/ipcc-climate-change-report/.

¹⁷⁷ Kathleen Brown, "Nobel Winner to Obama on Global Warming: 'Mr. President, You're Wrong,'" July 17, 2015, cnsnews.com.

objected to the premise that the science is settled on questions regarding global warming. Indeed, Bengtsson stated in an interview in May 2014 that

4 I have increasingly been disturbed by the strong tendencies to 5 politicization that has taken place in climate research in recent 6 years. I believe most serious scientists are sceptics and are 7 particularly frustrated that we are not able to properly validate 8 climate change simulations. I have always tried to follow the 9 philosophy of Karl Popper that I believe is particularly important when you are dealing with complex systems of which the 10 11 climate system is a primary example. For this reason empirical 12 evidence is absolutely essential. The warming of the climate system since the end of the 19th century has been very modest 13 14 by some 3/4 °C in spite of the simultaneous increase in greenhouse gas forcing by 2.5-3 W/m2. 15 16

- 17I am concerned that this as well as the lack of ocean surface18warming in some 17 years has not been properly recognized by19IPCC. Nor have the cooling and increase in sea ice around20Antarctica been properly recognized.
- 22 Bengtsson's affiliation with the GWPF created such discord within the
- 23 scientific community that he experienced pressure both professionally and
- 24 personally that he feared for his safety and was compelled to resign from his
- 25 membership on May 14, 2014, at which time he referenced "McCarthy"-like

2	6 persecution. ¹⁷⁹
	http://www.desmogblog.com/2014/05/20/did-lennart-bengtsson-know-gwpf-and-heartland
2	• In 2012, a group of 49 former NASA scientists and astronauts – including
2	seven Apollo astronauts and two former directors of NASA's Johnson Space
2	9 Center in Houston – sent a letter the NASA Administrator criticizing the agency

¹⁷⁸ See Hans von Storch, "Interview with Lennart Bengtsson," Die Klimazwiebel, May 3, 2014, *available at* http://klimazwiebel.blogspot.com.au/2014/05/interview-with-lennart-bengtsson.html?spref=tw.
 ¹⁷⁹ See GWPF Press Release, Lennart Bengtsson Resigns: GWPF Voices Shock and Concern at the Extent of Intolerance Within the Climate Science Community, May 14, 2014, *available at* http://www.thegwpf.org/ lennart-bengtsson-resigns-gwpf-voices-shock-and-concern-at-the-extent-of-intolerance-within-the-climate-science-community; *see also* Peter Foster, "Eminent Swedish Scientist Latest Victim of Climate McCarthyism," Fin. Post, May 15, 2014, *available at* http://business.financialpost.com/2014/05/15/eminent-swedish-scientist-latest-victim-of-climate-mccarthyism/

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1		for its role in advocating a high degree of certainty that man-made CO ₂ is a
2		major cause of climate change while neglecting empirical evidence that calls
3		the theory into question. ¹⁸⁰ The group was dismayed over the failure of NASA,
4		and specifically the Goddard Institute for Space Studies, to make an objective
5		assessment of all available scientific data on climate change. They stated
6		"With hundreds of well-known climate scientists and tens of thousands of other
7		scientists publicly declaring their disbelief in the catastrophic forecasts, coming
8		particularly from the GISS leadership, it is clear that the science is NOT
9		settled." ¹⁸¹
10	TRCS is no	ot a NASA group, but retired NASA engineers, not very competent at climate science. IMHO.
11	•	In 2014 the NASA group published an exhaustive report that concluded that
12		examination of the official U.S. Government method for establishing economic
13		justification for regulations to control CO ₂ and other GHG emissions reveals
14		their computational approach to be scientifically flawed. ¹⁸² It found that the
15		science on which these CO2 emissions regulations are based is very
16		immature, uncertain, and not clearly understood by federal regulatory
17		agencies. Further, "The speculative nature of the SCC process, without any
18		constraints easily imposed from scientific observations of physical data, is a
19		major flaw." ¹⁸³
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21	•	Claude Allegre is a French scientist who has worked on global warming issues
22		for decades. ¹⁸⁴ Dr. Allegre received a Ph.D. in physics in 1962 from the
23		University of Paris, became the Director of the geochemistry and
24		cosmochemistry program at the French National Scientific Research Centre in
25		1967, in 1971 was appointed Director of the University of Paris's Department
26		of Earth Sciences, in 1976 became Director of the Paris Institut de Physique
27		du Globe, has authored more than 100 scientific articles and 11 books, many
28		of them seminal studies on the evolution of the Earth using isotopic evidence,
29		and is a member of the U.S. National Academy of Sciences and the French
30		Academy of Science. ¹⁸⁵ Twenty years ago, he expressed his position that
31		human causes had raised global mean temperature by half a degree in the last
32		century, and fifteen years ago Dr. Allegre signed the "World Scientists'
33		Warning to Humanity" about global warming. ¹⁰⁰ As more data accumulated,
34		however, Dr. Allegre switched sides. In his view, climate models do not
35		establish man-made warming and significant evidence indicates that warming

¹⁸⁰ Letter to the the Honorable Charles Bolden, Jr., March 28, 2012.
¹⁸¹ *Ibid.*¹⁸² Harold H. Doiron, et al., *Bounding GHG Climate Sensitivity For Use in Regulatory Decisions,*" Houston, Texas, February 2014, www.therightclimatestuff.com.
¹⁸³ *Ibid.*¹⁸⁴ Octobergene "Alleggene" Second Thoughts "National Dect. Mar. 6, 2007, cupilable of the second throughts "National Dect. Mar. 6, 2007, cupilable of the second throughts and the second through the second the second through the second through the seco

 ¹⁸⁴ See Lawrence Solomon, "Allegre's Second Thoughts," National Post, Mar. 6, 2007, available at http://www.nationalpost.com/news/story.html?id=2f4cc62e-5b0d-4b59-8705-fc28f14da388
 ¹⁸⁵ Id.

¹⁸⁶ See id.

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is in fact a natural phenomenon.¹⁸⁷ Dr. Allegre points in part to evidence that Antarctica is gaining ice and that other, retreating snow caps are retreating naturally. In his more recent words, "[t]he cause of this climate change is unknown," and the science is not "settled."

• Fritz Vahrenholt is a German professor and environmental activist who was an early supporter of the German green movement.¹⁸⁹ He holds a Ph.D. in chemistry and is Honorary Professor at the Department of Chemistry at the University of Hamburg. From 1976 until 1997 he served in several public positions with environmental agencies such as the Federal Environment Agency, the Hessian Ministry of Environment, and as Deputy Environment Minister and Senator of the City of Hamburg. He then held top management positions in the renewable energy industry.¹⁹⁰ In 2013, he changed his views and published a book entitled *Die Kalte Sonne*, in which he argued that, in part, the sun rather than greenhouse gases driving climate change and that anthropomorphic impact was overstated.¹⁹¹

• Once a believer in man-made global warming, Hans Labohm, a professor at the Dutch Institute of International Relations Clingendael and the Netherlands Defense College, switched his view after conducting research and reviewing both an IPCC Summary for Policymakers and other research. He then coauthored a book skeptical of man-made global warming with chemical engineer Dick Thoenes, former chairman of the Royal Netherlands Chemical Society.¹⁹²

• A Canadian geologist, Bruno Wiskel reversed his view on man-made climate change and wrote a book debunking the AGW theory."¹⁹³

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¹⁸⁷ See id.

¹⁸⁸ See id.

¹⁸⁹ See GWPF Press Release, "Professor Fritz Vahrenholt Joins GWPF Academic Advisory Council, July 14, 2014, *available at* http://www.thegwpf.org/professor-fritz-vahrenholt-joins-gwpf-academic-advisorycouncil/.

¹⁹⁰ *Id.*

 ¹⁹¹ See James Delingpole, "Leading Climate Scientist Defects: No Longer Believes in the 'Consensus',"
 Breitbart, May 8, 2014, *available at* http://www.breitbart.com/Breitbart-London/2014/05/08/Leading-climate-scientist-defects-no-longer-believes-in-the-consensus.
 ¹⁹² See id. and Hans Labohm, Simon Rozendaal, and Dick Thoenes, Man-Made Global Warming:

 ¹⁹² See *id.* and Hans Labohm, Simon Rozendaal, and Dick Thoenes, Man-Made Global Warming: Unravelling a Dogma, UK: BetterWorldBooks, 2004.
 ¹⁹³ Bruno Wiskel, The Emperor's New Climate: Debunking the Myth of Global Warming, Evergreen

¹⁹³ Bruno Wiskel, *The Emperor's New Climate: Debunking the Myth of Global Warming*, Evergreen Environmental Company, 2006. Also see Marc Morano, "Climate Momentum Shifting: Prominent Scientists Reverse Belief in Man-made Global Warming—Now Skeptics," U.S. Senate Comm. on Env't & Public Works, May 15, 2007, available at

http://www.epw.senate.gov/public/index.cfm?FuseAction=Minority. Blogs&ContentRecord_id=927b9303-802a-23ad-494b-dccb00b51a12.

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V. <u>Renewable Energy Sources</u>

Q: Regarding renewable energy sources such as wind and solar, do you

believe they present the net benefits attested to by Messrs. Kunkle and Rumery?

4 **A:** Messrs. Rumery and Kunkle spend a great deal of time testifying to the 5 efficacy of renewable energy sources, supposedly in response to an assertion I made.

6 First, my understanding is that "[t]estimony regarding the efficacy of renewable 7 energy or renewable energy policy is presumed to be irrelevant" to the issues in this 8 case." (Third Prehearing Order, April 16, 2015.) I believe the sole purpose of their 9 testimony is not to introduce any useful expert testimony and is solely to promote their 10 respective power sources as advocates, not experts. This inference is strengthened by 11 the fact that their testimony begins with a disclaimer that is essentially verbatim 12 identical, save for a change for the proper energy source. (Rumery Rebuttal at 2:5-22; 13 Kunkle Rebuttal at 2:2-19.) Thus, I do not believe there is an obligation to respond.

Second, that said I stand by the arguments I gave before. While renewable energy sources have made many advances in recent years, they are not widespread enough to be able to support an electrical grid as a base load. Renewable energy is intermittent, unreliable, requires back-up, is non-dispatchable, and not available during emergencies. Moreover, in order to become a viable energy source, renewable energy requires government intervention in the form of mandates, subsidies, and tax credits.¹⁹⁴

¹⁹⁴ In the past five years alone, federal renewable energy subsidies totaled \$150 billion; see Taxpayers Protection Alliance, "Filling the Solar Sinkhole: Billions of Bucks Have Delivered Too Little Bang," Alexandria, Virginia, 2015. To make matters even worse, government subsidies for renewable energy are extremely regressive, and predominantly benefit higher-income persons. *See* Severin Borenstein and

1	If it is so cheap and effective, why are government intervention, subsidies, and
2	mandates required to force its adoption? This point is actually made by Mr. Kunkle
3	himself where he states (Rebuttal 17:16), in terms of a forecast of renewables growth:
4	"The UCS approach builds on and improves both of the EPA's renewable energy
5	estimates by incorporating the following core components:
6 7 8	 setting a national renewable energy growth rate benchmark based on demonstrated growth in the states from 2009 to 2013;
9 10 11	 assuming full compliance with current state renewable energy standard policies, as set by law, that require certain percentages of electricity to come from renewable sources; and
12 13 14 15	 accounting for actual and expected renewable energy growth between 2013 and 2017"
16	In other words, renewables growth is dependent upon government mandates, not
17	the "market factors" he references earlier (Kunkle Reubttal 5:7).
18	This becomes clear in Mr. Kunkle's rebuttal, where he has to fall back on the
19	"technical potential capacity" for wind energy." (Kunkle Rebuttal at 4:4-16.) Essentially,
20	his argument boils down to the unremarkable assertion that if every potential wind
21	generation unit were built and fully operational, there would be a lot of wind energy.
22	This argument is trivially true: Of course wind has potential, at some point and in some
23	manner. The question is whether it is practical, reliable, and affordable. While Mr.
24	Kunkle can give many examples of how much wind power can grow once a lot of
25	investments are made, that argument should be aimed toward investors, not this court.

Lucas Davis, "The Distributional Effects of U.S. Clean Energy Tax Credits," Energy Institute at the Haas Business School, University of California, Berkeley, July 2015.

1 It has nothing to do with the net benefits of wind energy in light of the question before us 2 in this proceeding: Whether the federal SCC is a proper regulatory tool for Minnesota to 3 use. The testimony of Messrs. Kunkle and Rumery is not relevant to answering that 4 question.

Q: On p. 21, In. 9, Mr. Kunkle states that "Today, operating wind farms located
in Minnesota provide over \$10 million in annual property tax payments to host
counties and townships. Cumulatively, 10 Minnesota communities have received
over \$50 million." Is this a valid argument for this proceeding?

9 **A.** No, it is not, for three reasons.

First, this proceeding concerns the social cost of carbon, not tax revenues fromany facility.

12 Second, if wind facility tax payments are to be considered, then the large federal, 13 state, and local government tax subsidies and the implications of mandates that force 14 wind facilities to be constructed must also be considered.

Third, if tax payments from wind facilities are considered, these must be compared to the large tax payments made to Minnesota by other types of fossil and nuclear energy production facilities in the state, which are orders of magnitude larger than wind facility tax payments. For example, Xcel Energy estimated that the continued operation of the Prairie Island nuclear power plant in Welch, Minnesota will result in increased state and federal income taxes being paid of \$380 million over the 20-year

1 continued operation of the plant.¹⁹⁵ "In addition, there will be a significant increase in 2 the local property tax payments due to the significant investment that will occur at the 3 plant due to the continued operation and the power uprate project."¹⁹⁶ More generally, 4 studies have found that the tax revenues from large nuclear power plant facilities are 5 significant and often provide 70%–90% of the local county and school district 6 budgets.¹⁹⁷

Q. Mr. Kunkle (Rebuttal 17:1) contends that you predict that the
 8 worldwide share of wind and other renewable sources of energy will not

9 measurably grow between now and 2040. Is this correct?

- 10 **A.** No, it is not, and Mr. Kunkle is not correct. That is not *my* prediction; rather, it
- 11 is the prediction of DOE's Energy Information Administration. For example:
 - For the world, EIA forecasts an energy consumption increase of 56 percent between 2010 and 2040.¹⁹⁸ EIA forecasts that in 2040, about 90% of this energy will be provided by fossil fuels or nuclear energy, roughly what they contribute at present.¹⁹⁹
- For the U.S. EIA forecasts an energy consumption increase of 13 percent between 2012 and 2040.²⁰⁰ EIA forecasts that in 2040, fossil fuels and nuclear power will provide about 95% of U.S. energy, about what they provide at present.²⁰¹
- 22 Overall, It should be noted that:

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¹⁹⁵ Xcel Energy, "Projects Benefit Society," Certificates of Need Application, Prairie Island Nuclear Generating Plant, Section 10, May 16, 2008.

¹⁹⁶ *Ibid*.

 ¹⁹⁷ Roger Bezdek and Robert Wendling. "The Impacts of Nuclear Facilities on Property Values and Other Factors in the Surrounding Communities" The *International Journal of Nuclear Governance, Economy and Ecology,* Vol.1 (2006), pp. 122-144.
 ¹⁹⁸ *Ibid.* U.S. Energy Information Administration, *International Energy Outlook 2013*, July 2013.

¹⁹⁸ *Ibid.* U.S. Energy Information Administration, *International Energy Outlook 2013*, July 2013. ¹⁹⁹ *Ibid.*

²⁰⁰ U.S. Energy Information Administration, *Annual Energy Outlook 2015*, April 2015.

²⁰¹ *Ibid*.

- Renewables like wind and solar were among the first sources of energy. They were discarded and were replaced by more efficient, reliable, and affordable fossil fuels.
- Wind and solar energy are not "new," as many advocates contend, but are • among the oldest world energy sources. The windmill dates back at least 3,000 years to ancient Persia, and the ancient Egyptians utilized solar energy to heat their homes – as did Native Americans in the U.S. Southwest.²⁰²
- The fossil fuel era is new, beginning in the 1800s with coal powering the ٠ Industrial Revolution and the first commercial oil well in 1859 in Pennsylvania.
- Wind and solar are less efficient because they only supply electricity 25-35% • and 10-25% of the time respectively, even on good days, compared to 85-95% for coal and natural gas.²⁰³ This point is especially relevant: Inefficient renewables, including wind, solar, and biofuels, are in violation of state and national goals of increased energy efficiency to reduce GHG emissions and lower energy consumption.²⁰⁴
- Wind and solar do not even displace significant amounts of fossil fuels. In • seminal research published in Nature Climate Change, Dr. Rich York studied 130 countries and found that that wind and solar displaced little fossil fuels.²⁰⁵ He thus concluded that "These results challenge conventional thinking in that they indicate that suppressing the use of fossil fuel will require changes other than simply technical ones such as expanding non-fossil-fuel energy production."206

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²⁰² Ali. B. Cambel and Roger H. Bezdek, "The Solar Energy/Utility Interface. *Energy – The International Journal.* Vol. 6 (1981), pp. 479-484. ²⁰³ Nicolas Boccard, "Capacity factor of wind power realized values vs. estimates," Energy Policy, Volume

^{37,} Issue 7, July 2009, Pages 2679–2688; Robert Wilson, "Low Capacity Factors: challenges for a low carbon energy transition." The Energy Collective, October 15, 2013; Mark Lynas, "Germany's 'Energiewende' - the story so far," 15 January 2013, www.marklynas.org/2013/01/germanysenergiewende-the-story-so-far/. Federal Association of Energy and Water Industries, BDEW veröffentlicht

Strom- und Gaszahlen 2012: Müller: 2013 ist ein wichtiges Jahr für die Energiepolitik in Deutschland. ²⁰⁴ For example, the final rule for EPA's Clean Power Plan requires early reductions from energy efficiency. See www2.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants.

²⁰⁵ Richard York, "Do alternative energy sources displace fossil fuels?" *Nature Climate Change,* Volume 2, (2012), Pages 441–443, doi:10.1038/nclimate1451.

1 The Clean Power Plan (CPP) assumes that wind and solar energy will provide 60% of incremental U.S. electricity by 2030.²⁰⁷ But, these two non-dispatchable power 2 sources have never produced even 5% of U.S. electricity, and thus the need for fossil 3 fuels is likely to be even higher than assumed. In any event, it is natural gas that backs 4 5 them up, as wind and solar are unavailable more often than not. For example, 6 California's Renewable Portfolio Standard began in 2003, and since then, natural gas 7 has increased its share of power generation from 47% to 61%. As Dr. Paulina Jaramillo 8 of Carnegie Mellon University notes, "I would say that without natural gas, the grid will 9 not be able to manage the variability and intermittency in power output from wind and solar plants."208 10

Most important, the addition of renewable energy resources in Minnesota will 11 12 increase the need for fossil fuel generated electricity because consumers require 13 reliable power that is available at all times, 24 x 7. Consumer requirements for 100 percent availability is accommodated by generating units supplying energy which 14 matches the load shape forecast over a 24 hour period. Generating units are 15 16 dispatched to match this 24 hour cycle, and additional operating (spinning) generation is 17 held in reserve to meet unanticipated and anticipated unit interruptions or changes to 18 the load forecast. The units supplying this energy are termed dispatchable and may be 19 further categorized as Base Load (called upon to operate 24 hours per day),

²⁰⁷ www2.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants; Roger Martella, Joel Visser, and Paul Ray, "EPA's Greenhouse Gas Rules," Sidley Austin LLP, August 5, 2015; Rebecca Smith, "Obama's New Climate-Change Regulations to Alter, Challenge Industry," *Wall Street Journal*, August 3, 2015.

²⁰⁸ Chris Varrone, June 2, 2011, "Natural Gas Complements Wind & Solar — Or Does It?" Clean Technica," http://cleantechnica.com/2011/06/02/natural-gas-compliments-wind-solar-or-does-it/
1 Intermediate Load (which typically operate 8-10 hours per day), Peaking (called upon to 2 operate a few hours per day, typically during peak periods), and Operating Reserve 3 (called upon either immediately or in a very short time frame to accommodate load which becomes un-served based on an operating unit coming off line very quickly or 4 5 based on an unusual unscheduled demand for supply). In order to operate, the system 6 must constantly be in balance, with the supply of energy equal to the load. If there is 7 too little supply, reserves are called on; if there is too much supply, generator output is 8 reduced or curtailed. After the bilateral contracts are scheduled into the daily dispatch, 9 the bids received from the generators are generally in a one-to-one correspondence 10 with the costs to supply the energy, with the supply cost curve typically moving up in 11 price from base load to peaking. Base and Intermediate Load generators are currently 12 fueled primarily by coal and nuclear, and, increasingly in recent years, by natural gas. 13 Peak power is typically fueled by natural gas.

Electric power from wind generators varies according to the cube of the wind speed impacting the turbine blades, but wind speeds vary dramatically over the course of a day, week, month, and year. Variations in wind power thus range from zero (no or very little wind blowing) to full nameplate capacity of the wind generators (during excessively high wind speeds generators are shut down to avoid damage). Such onagain, off-again cycling of wind generators, as well as solar generator outputs, is termed intermittent. Thus, the dispatching of wind turbines must accommodate intermittency,

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which is a significant system operational concern because consumers require power on-demand.²⁰⁹

One consequence of intermittency is that wind power requires near 100 percent 3 4 backup by fossil fuel power plants that are reliable and dispatchable. Such backup 5 plants must be capable of quickly ramping up or down to compensate for wind 6 variations so as to provide power-on-demand to the consumer. Further, the backup 7 plants must be maintained in a fully operational state at all times in order to be able to 8 quickly respond to wind variations. The reserve called on to operate immediately to 9 assure the changes to the supply/demand requirements are in balance is called "spinning reserve."²¹⁰ 10

Wind power is proposed to be a growing percentage of total generation in the 11 12 electric power sector of Minnesota, and wind's inherent nature-related variations must 13 be accommodated by adjustments in on-line generators. If wind power is planned to 14 grow significantly in Minnesota, the backup power burden can no longer come from minor adjustments to dispatchable power plants. On this basis, the cost of large-scale 15 16 wind generation must include not only the cost of the wind generators themselves but 17 also the cost of dedicated dispatchable backup generation of a size which 18 accommodates significant intermittent units operating on the system. The location of 19 backup generators for wind power must be relatively close to the wind generators,

 ²⁰⁹ James Schlesinger and Robert Hirsch, "Getting Real on Wind and Solar," *Washington Post*, April 24, 2009. Dr. Schlesinger was the first Secretary of Energy and Dr. Hirsch was the first director of the federal government's renewable energy research program.
 ²¹⁰ See the discussion in Roger Bezdek and Robert Wendling, Not-So-Green Superhighway:

²¹⁰ See the discussion in Roger Bezdek and Robert Wendling, Not-So-Green Superhighway: "Unforeseen Consequences of Dedicated Renewable Energy Transmission," *Public Utilities Fortnightly*, February 2012, pp. 34 - 42.

otherwise large blocks of backup electric power would have to be shuttled over long
 distances over routes that at times are constrained and thus cannot accommodate such
 shuttling.

To reiterate, wind turbines do not generate electricity when the wind does not blow. However, few understand the degree to which these resources fail to operate when electric power is most urgently required. Production data on the U.S. power industry clearly illustrate that wind's intermittency requires significant generation resources to be operating on the electric system to assure reliable continuous supply, which can only be accommodated by generation of sufficient size and operating capability to furnish such backup.

EIA's most recent estimates of average capacity factors are, for wind, 33 percent; 11 12 for solar thermal 19 percent; and for photovoltaics 27 percent – although in some months the capacity factors are only a fraction of these estimates.²¹¹ Other estimates of 13 actual validated wind capacity factors are in the range of 15 to 20 percent, and could be 14 even lower.²¹² Further, given the time frame during the course of the daily load cycle 15 16 during which peak loads occur, capacity factors for wind turbines are often much lower. 17 For example, during the California heat wave in July 2006, which resulted in significant 18 increases in electric demand, actual wind generation was at only about five percent of

²¹¹ U.S. Energy Information Administration, "Data for June 2015," *Electric Power Monthly*, August 26, 2015.
²¹² For example, Boccard notes, "For two decades, the capacity factor of wind power measuring the mean

²¹² For example, Boccard notes, "For two decades, the capacity factor of wind power measuring the mean energy delivered by wind turbines has been assumed at 35 percent of the nameplate capacity. Yet, the mean realized value for Europe over the last five years is closer to 21 percent thus making levelized cost 66 percent higher than previously thought." Nicolas Boccard, "Capacity Factor of Wind Power: Realized Values vs. Estimates," October 2008 and Boccard, "Capacity factor of wind power realized values vs. estimates," op. cit. The actual capacity factors for wind in Germany ranged between 14 and 21 percent over the period 2000 through 2007; see *Wind Energy Report Germany 2008*, ISET, Univ. Kassel, Germany, 2008.

available name plate capacity.²¹³ Thus, in this case, the capacity factor for wind was
 closer to five percent than 33.

3 Similar availability issues have been encountered in Texas, which has an aggressive wind power program. In 2008, the state installed nearly 2,700 MW of new 4 5 wind capacity, and if Texas were an independent country, it would rank sixth in the 6 world in terms of total wind power production capacity. However, the Electric Reliability Council of Texas (ERCOT) analyzed the capacity factor of wind and estimated it to be 7 8 less than nine percent. In a 2007 report, ERCOT determined that only "8.7 percent of 9 the installed wind capability can be counted on as dependable capacity during the peak demand period for the next year." It went on to say "Conventional generation must be 10 11 available to provide the remaining capacity needed to meet forecast load and reserve requirements." In 2009, ERCOT re-affirmed its decision to use the 8.7 percent capacity 12 factor.214 13

Wind power has been providing only about one percent of Texas's total reliable generation of energy, and ERCOT's projections show that wind will remain an insignificant player in terms of reliable capacity through at least 2015, when it expects wind to provide about 1 - 2 percent of its needed energy generation. Thus, Texas will continue to rely almost entirely on natural gas, coal, and nuclear power to generate electricity.

20 The experience of the Pacific Northwest, another region with an aggressive wind 21 program, is similar. Often when it is very hot or very cold and electric power demand is

²¹³ David Dixon, "Wind Generation's Performance during the July 2006 California Heat Storm," U.S. Department of Energy, 2007.

²¹⁴ Robert Bryce, "Texas Wind Power: The Numbers Versus the Hype," *Energy Tribune*, August 5, 2009.

1	greatest, wind generation is simply not available. For example, during the cold days of
2	January 5 to 28, 2009 wind generation in the region was virtually non-existent. ²¹⁵
3	Another example of wind generation variability took place on October 16, 2012 when
4	wind generation on the Bonneville Power Administration system was producing 4,300
5	MW, accounting for 85 percent of total generation in the pre-dawn hours. The next day,
6	wind generation was practically non-existent, falling to almost zero. ²¹⁶
7	Analysis of almost four years of generation data in ERCOT with over 10,000 MW
8	of wind capacity, the Midwest ISO (MISO) with almost 12,000 MW of wind capacity, and
9	the PJM Interconnection (PJM) with over 5,000 MW of wind capacity, found that: ²¹⁷
10 11	 In all three regions, over 84 percent of the installed wind generation failed to produce electricity when electric demand was greatest.
12 13 14 15	 In MISO, only between 1.8 percent and 7.6 percent of wind capacity was available and generating power during the peak hours on the highest demand days.
16 17 18	 In ERCOT, only between 6.0 percent and 15.9 percent of wind facilities generated power during peak summer periods.
19 20 21 22	 In PJM, the range was between 8.2 percent and 14.6 percent during peaks.
22 23 24 25	 These availability values are significantly lower than median availability for the entire period.
26	The July 2012 heat wave in Illinois, where temperatures reached 103 degrees in
27	Chicago, provides another example of wind generation's limitations to perform when

 ²¹⁵ http://www.transmission.bpa.gov/business/operations/wind/WindGen_VeryLow_Jan08Jan09x.xls.
 ²¹⁶ See "In a first, wind exceeds hydro in BPA region," Platt's *Megawatt Daily*, October 19, 2012, p. 9.
 ²¹⁷ Jonathan A. Lesser, "Wind Intermittency and the Production Tax Credit: A High Cost Subsidy For Low Value Power," Continental Economics, October 2012.

needed most. During this heat wave, Illinois wind units generated less than five percent
of name plate capacity, producing only an average of 120 MW of electricity from over
2,700 MW installed. On July 6, 2012, when the demand for electricity in northern Illinois
and Chicago averaged 22,000 MW, the average amount of wind power available during
the day was virtually nonexistent at 4 MW.²¹⁸

6 The New York State wind experience is similar to that of other regions, and 7 indicates the need for fossil fuel facilities to back-up renewable generation intermittency. 8 For example, an analysis of 16 wind projects in New York State between 2008 and 9 2011 found that, despite vendor promises prior to installation of capacity factors of 30 10 percent to 35 percent, average annual capacity factors ranged between 14.1 percent 11 and 22.7 percent.²¹⁹

12 All New York generating units, both renewable and non-renewable, have an 13 "unforced capacity value" (UCAP) for purposes of the capacity markets, which is used for reliability planning and which load serving entities such as the state's electric utilities 14 15 purchase to assure that installed generating reserve is available to serve customer load 16 during peak periods. This UCAP value is a percentage of a resource's nameplate MW value; for wind and solar this number is based on an initial NYISO designated rating for 17 18 Year 1 of operation and on actual historical energy output for every year thereafter. The 19 values are facility specific, but the UCAP for onshore wind in NY is 10 percent for the

 ²¹⁸ J. Lesser, "Wind Power in the Windy City: Not There When Needed" *Energy Tribune*, July 25, 2012.
 ²¹⁹ http://dailyenergyreport.com/wp-content/uploads/2011/06/NY_CF2008-2010_final.jpg. The data for estimates were obtained from the *2011 New York ISO Gold Book*.

summer peak (when electricity is needed the most and electricity prices are the highest)
 and 30 percent for winter peak.²²⁰

This unforced capacity value is not unique to New York State, or even to the U.S. Similar unforced capacity values are the case in the Netherlands, Denmark, England, Germany, Spain, Portugal, and Ireland, or anywhere that large scale wind generation is part of the installed generation mix.²²¹ An Australian study found that even wind farms spread over large, widely dispersed areas and interconnected into a single electric system cannot produce electricity with capacity factors close to name plate capacity.²²²

9 Further, there is evidence that the performance and capacity factors of wind 10 turbines deteriorate over time. The Renewable Energy Foundation, an organization that actually advocates in favor of renewable energy facilities, conducted a comprehensive 11 12 study of the available capacity factors over time for wind turbines in the UK. Using 13 monthly observations for 282 onshore installations in the UK with an age range of zero to 19 years, it found "the normalized load factor for UK onshore wind farms declines 14 from a peak of about 24 percent at age one to 15 percent at age 10."²²³ In other words. 15 16 the capacity factors for wind generators decline every year after installation.

²²¹ For example, due to Britain's increasing reliance on wind turbines to generate electricity, Steve Holliday, Chief Executive of the British National Grid, stated that, by 2020, the British people will have to change their behavior to use electricity "when it is available" rather than when it is needed; "Era of Constant Electricity at Home is Ending, Says Power Chief," the *Daily Telegraph*, March 2, 2011.
²²² Paul Miskelly, "Wind Farms in Eastern Australia – Recent Lessons," *Energy & Environment*, Vol. 23,

²²⁰ NYISO 2011 Installed Capacity Manual.

²²² Paul Miskelly, "Wind Farms in Eastern Australia – Recent Lessons," *Energy & Environment*, Vol. 23, No, 8 (December 2012) pp. 1233-1260.

²²³ Gordon Hughes, *The Performance of Wind Farms in the United Kingdom and Denmark*, prepared for the Renewable Energy Foundation, London, 2012. The load factor is determined by measuring the actual amount of electricity output over a time period against the total output expected had the turbine operated for 100 percent of the time period. The ratio is expressed as a percentage.

More generally, the greatest amounts of wind generation occur in the spring and fall, when the demand for electricity is lowest, and the smallest amounts of wind generation occur in summer, when the demand for electricity is the greatest. Wind generation data in PJM, the nation's largest independent system operator, show that the "load-wind gap" (the difference between summer electric demand and summer wind availability, relative to respective annual averages) was almost 70 percent in the summers of 2010 and 2011. In summer 2012, the load-wind gap was 59 percent.²²⁴

8 Thus, if renewable energy generation increases as a percentage of Minnesota's 9 generation capacity mix over the coming decade, the more necessary a source of non-10 intermittent generation from fossil fuel facilities will become. This necessity will increase 11 as more renewable energy facilities are installed and as these facilities age and become 12 less efficient and have lower capacity factors.

²²⁴ J. Lesser, "Wind Power in the Windy City: Not There When Needed," op. cit.