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November 21, 2006

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Re: In the Matter of Otter Tail Power Company on Behalf of Big Stone II Co-owners for an Energy Conversion Facility Permit for the Construction of the Big Stone II Project
Civ. No. 06-399 PUC Docket No. EL05-022

Dear Addressees:

Enclosed and served upon you, please find Brief of Minnesota Center for Environmental Advocacy, Fresh Energy, Izaak Walton League and Union of Concerned Scientists and an Affidavit of Service by mail.

If you have any questions, please do not hesitate to call me.

Sincerely,

John H. Davidson

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November 21, 2006

Hughes County Circuit Court Clerk
104 E. Capitol
Pierre, SD 57501-1112

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Civ. No. 06-399 **PUC Docket No. EL05-022**

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Enclosed for filing in the above-referenced matter, please find Brief of Minnesota Center for Environmental Advocacy, Fresh Energy, Izaak Walton League and Union of Concerned Scientists and Affidavit of Service by Mail.

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SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

STATE OF SOUTH DAKOTA
HUGHES COUNTY

CIRCUIT COURT
SIXTH JUDICIAL DISTRICT

In the Matter of Otter Tail Power Company on behalf of Big Stone II Co-owners for an Energy Conversion Facility Permit for the Construction Of the Big Stone II Project

BRIEF OF MINNESOTA CENTER FOR ENVIRONMENTAL ADVOCACY, FRESH ENERGY, IZAAK WALTON LEAGUE, AND UNION OF CONCERNED SCIENTISTS

Civ. No. 06-399
PUC Docket No. EL05-022

TABLE OF CONTENTS

TABLE OF AUTHORITIES

INTRODUCTION

This matter comes before the court upon the appeal of the Minnesota Center for Environmental Advocacy, Fresh Energy (f/k/a Minnesotans for an Energy Efficient Economy), Izaak Walton League of America – Midwest Office, and the Union of Concerned Scientists (collectively "Appellants") of the decision of the South Dakota Public Utilities Commission approving a permit to site the 600 megawatt ("MW") Big Stone II coal-fired power plant ("Big Stone II".) Appellants are non-profit science and environmental organizations, all of whom work on various environmental issues including clean energy and global warming.

STATEMENT OF ISSUE

Otter Tail Power Company and the Big Stone II Co-owners (collectively, the "The Coal Plant Owners") have failed to meet their burden under SDCL § 49-41B-22 (2006) of proving that Big Stone II will not cause serious harm to the environment. The decision of the South Dakota Public Utilities Commission (the "PUC") approving the permit is clearly erroneous, arbitrary and capricious, and contrary to law. The record as a whole shows that Big Stone II will pose a threat of serious injury to the environment, through its contribution to global warming and that any balancing of those harms against economic development benefits is improper under the law. Appellants request reversal of the permit approval by the PUC.

STATEMENT OF CASE

The Coal Plant Owners filed their application for a site permit on July 21, 2005. (R. 1-435.)[1] By order dated October 4, 2005, the PUC allowed Appellants to participate as intervenors. (R. 669-670.) After significant discovery, the permit came before the PUC for hearing on June 26 through 29, 2006. (R. 3800-8058.) After submission of post-hearing briefs, the PUC issued its findings and decision approving the Big Stone II permit on July 21, 2006. (R. 8286-8321.) One party, with the support of Appellants, requested rehearing and/or reconsideration. (R. 8326-8333; 8341-8348; 8358-8362.) On August 24, 2006, the PUC issued its final findings and order, denying rehearing and approving the Big Stone II Permit. (R. 8372-8373.) Appellants filed this appeal on September 21, 2006.

STATEMENT OF FACTS

The Coal Plant Owners seek permission to site a new 600 MW pulverized coal plant on the eastern border of South Dakota. (R. 1, et seq.) The Coal Plant Owners represent seven different utilities serving North Dakota, Minnesota, and Iowa as well as South Dakota. Two of the utilities, which together propose to own about forty percent of Big Stone II's output, are investor-owned utilities whose South Dakota retail sales are subject to rate regulation by the PUC. The others are a mix of cooperative and municipal utilities, some of which provide power in South Dakota but which are not rate-regulated. (R. 8288-8289.)

If built, Big Stone II will emit over 4.5 million tons of carbon dioxide (CO_2) into the atmosphere. *See,* Appellants' Direct Testimony of Dr. Ezra Hausman, (R. 7238; App. 94.)[2] This means that each year, Big Stone II will emit the equivalent global warming pollution of nearly

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[1] The Administrative Record in this matter was filed with this Court on October 26, 2006. Appellants will cite to the Record as "R" and the appropriate record document or page number.
[2] Copies of Dr. Ezra Hausman's and portions of David Schlissel and Anna Sommer's testimony are included with Appellants' Appendix and will be cited to as "App.")

670,000 cars, or roughly two-thirds more than the CO_2 emissions of all the cars registered in South Dakota combined. *Id.* CO_2 is a heat-trapping gas that is a major contributor to global warming. (R. 7216; App. 72.) The Coal Plant Owners propose to build Big Stone II with its substantial CO_2 emissions, at a time when scientists, policy-makers, and businesses are reaching agreement that global warming is an enormous negative fact, when there is growing apprehension about the impact of global warming, and when the federal government is debating various policy responses, all of which target CO_2 emissions from coal plants. (R. 7217-7222, 7093-7094, 7098; App. 73-78, 47-48, 52.) The Coal Plant Owners did not dispute the evidence of CO_2 negative environmental and economic impacts, nor did the Coal Plant Owners dispute the amount of CO_2 that Big Stone II would contribute to the global warming problem, waiving the right to cross examine Dr. Hausman. Rather, the Coal Plant Owner's position regarding global warming and CO_2 has primarily been a relative one—that Big Stone II's huge increased contribution of 4.5 million tons of CO_2 to the global warming problem annually, appears small when compared to all global sources. (R. 4660-4661.)

Based upon the evidence of the serious problem of global warming and Big Stone II's contribution to it, and based upon the record as a whole, the PUC's decision that Big Stone II does not pose a threat of serious injury to the environment is clearly erroneous, arbitrary and capricious, legal error, and clearly an unwarranted exercise of discretion. Further, taking the record as a whole, the PUC may have improperly "balanced" that serious environmental harm against economic gains for the immediately surrounding community, a legal error under the plain language of the applicable statute.

ARGUMENT

I. STANDARD OF REVIEW

Under South Dakota law, a reviewing court will reverse an administrative agency decision when the substantial rights of the appellant have been prejudiced because the administrative findings, inferences, conclusions or decisions are affected by error of law, clearly erroneous in light of the entire evidence in the record, or arbitrary and capricious, or characterized by abuse of discretion, or clearly unwarranted exercise of discretion. SDCL § 1-26-36 (2006); *In re One-time Special Underground Assessment by Northern States Power Company in Sioux Falls*, 628 N.W.2d 332, (S.D. 2001). *See also Wise v. Brooks Const. Services*, 721 N.W.2d 461, 466 (S.D. 2006); *Apland v. Butte County*, 716 N.W.2d 787, 791 (S.D. 2006). The South Dakota Supreme Court has clarified that the clearly erroneous standard is distinct from the substantial evidence standard (the old standard) in that a finding may be supported by substantial evidence, but still be set aside by a reviewing court if clearly erroneous. *Sopko v. C & R Transfer Co., Inc.*, 575 N.W.2d 225, 229 (S.D. 1998). "On the deference spectrum, clearly erroneous fits somewhere between de novo (no deference) review and substantial evidence (considerable deference) review." *Id.*, (*quoting* 1 S. Childress & M. Davis, *Federal Standards of Review*, § 15.03 at 15-17 (2d ed. 1991)). The administrative agency's factual findings will be reviewed under the clearly erroneous standard, although findings based on deposition testimony and documentary evidence are reviewed de novo. *Wise*, 721 N.W. 2d at 791. Questions of law are reviewed de novo. *Id.*

II. THE COAL PLANT OWNERS HAVE FAILED TO MEET THEIR BURDEN UNDER SDCL § 49-41B-22(2) (2006) OF PROVING THAT BIG STONE II WILL NOT POSE A THREAT OF SERIOUS INJURY TO THE ENVIRONMENT.

Under South Dakota's power plant siting statute, in order to obtain a permit, the Coal Plant Owners have the burden of proof to establish that:

> (1) The proposed facility will comply with all applicable laws and rules;
>
> (2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area;
>
> (3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and
>
> (4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government.

SDCL § 49-41B-22 (2006). The record as a whole demonstrates that Big Stone II will pose a serious threat to the environment.

A. The Record Establishes That Global Warming Poses A Threat of Serious Injury To The Environment, Globally And In South Dakota.

Almost all the evidence regarding global warming, the most significant environmental issue the world has been called upon to address, was presented by Appellants with little to no evidence form the Coal Plant Owners to the contrary. Appellants presented testimony and exhibits from Dr. Ezra Hausman, an expert on global warming. Dr. Hausman is with Synapse Energy Economics and holds a Ph.D. in Atmospheric Science from Harvard University as well as master's degrees in Applied Physics from Harvard University and in Water Resource Engineering from Tufts University. (R. 7212; App. 68.) Dr. Hausman's work makes him a highly valuable and highly credible expert on the issue of global warming and the magnitude of the threat generally and from Big Stone II. Among other things, Dr. Hausman has:

-built a dynamic computer model of the ocean-atmosphere system to explore how observed ocean changes at the end of the last ice-age can be used to explain certain aspects of the warming planet;

-worked with researchers at Columbia University to develop private sector application of climate forecast science, leading to an initiative called the Global Risk Prediction Network, Inc. for which he served as Vice President in 1997 and 1998;

-as part of the Global Risk Prediction Network, Inc., worked on projects including serving as principal investigator for a statistical assessment of grain yield predictability in several crop regions around the world based on global climate indicators;

-prepared a preliminary design of a climate an climate forecast information website tailored to the interests of the business community.

(R. 7213 and 7244-7248; App. 69 and 100-104.)

Dr. Hausman testified that early predicted effects of human-induced climate change are already observable, documented in the scientific literature and consistent with computer models. (R. 7214; App. 70.) Dr. Hausman testified that if climate trends continue, global warming is "likely to bring about a climate well outside the range of anything ever experienced by our species, with the potential for severe and irreversible changes that will forever alter our environment, our economies and our way of life." *Id.* "Human societies and ecosystems will find themselves poorly adapted to their local climate and this will result in disruption and dislocation of ecosystems…and disruptions in agriculture." (R. 7222; App. 78.)

Dr. Hausman's conclusion reflects the consensus among the world's preeminent scientists, who have concluded that global warming is a very serious threat meriting the immediate attention of the world's policymakers. (R. 7217-7222; App. 73-78.) He describes "unequivocal scientific consensus" on key aspects of global climate change. (R. 7221; App. 77.) For example, the scientific academies of 11 nations, including the National Academy of

Sciences in the U.S.,[3] recently issued a joint statement urging all nations "to acknowledge that the threat of climate change is clear and increasing" and to "take prompt action to reduce the causes of climate change." (R. 7286 et seq.; App. 142 et seq.)

The record in this case also includes conclusions of the Intergovernmental Panel on Climate Change (IPCC), representing the world's leading researchers in the field of climate science, which panel was brought together to assess the science and advise the world's policymakers. (R. 7217-7222; App. 73-78.) The IPCC finds the planet is currently experiencing unnatural warming, predicts much more serious warming ahead if current energy trends continue, and identifies a range of likely harmful consequences. (R. 7249 et seq.; App. 105 et seq.)(IPCC Working Group I Summary for Policymakers) and (R. 7269 et seq.; App. 125 et seq.)(IPCC Working Group II Summary for Policymakers.)

The cause of global warming is buildup in the atmosphere of heat trapping gases, known as "greenhouse gases," due to human activity. (R. 7215; App. 71.) Carbon dioxide (CO_2), a heat-trapping gas of particular concern, is emitted when we burn fossil fuels, especially coal because it has such a high carbon content. (R. 7216; App. 72.) Already, humans have increased background levels of CO_2 by roughly one-third above pre-industrial levels, which is considerably higher than it has been in 400,000 years (over four ice-age cycles), and probably higher than it has been in tens of millions of years. (R. 7224-7225; App. 80-81.) With "business as usual" fossil fuel use, CO_2 levels will continue rising steeply, increasing the likelihood that the earth will experience dangerous or even catastrophic warming. (R. 7225; App. 81.)

The global average surface temperature of the earth rose by 0.6°C over the twentieth century, with additional record-breaking warming in the first few years of the twenty-first

[3] The NAS has approximately 2000 members, and 350 foreign associates, of whom *more than 200 have won Nobel Prizes*. (R. 7220; App. 76.)

century; four of the five hottest years on record have occurred since 2000, with the ten hottest years since 1990. (R. 7226-7228; App. 82-84.) This warming is consistent with predictions by computer models of the climate response to today's elevated CO_2 concentrations. (R. 7228; App. 84.) The IPCC predicts that warming in the twenty-first century will be from 1.5 to 5.8° C – or 2.5 to 9.7 times greater than in the past century. *Id.* To put this in geo-historical context, the average surface temperature differential between the last ice age and today was only about 5°C. (R. 7229; App. 85.)

The impact of the increased CO2 in the atmosphere is not just measured in terms of a few warm days, "but in disruptions in the very characteristics of climate that define our lives and our livelihoods." (R. 7216; App. 72.) Dr. Hausman warns of an "extraordinary risk associated with pushing the climate system to where it has never gone in over 400,000 years, and probably tens of millions of years." (R. 7225; App. 81.) Among the serious negative impacts associated with this predicted warming are rising sea levels, damaged or lost ecosystems, greater species extinction, expansion of disease and pest vectors, greater heat waves, more intense precipitation causing more flooding, landslides and erosion, and in continental interiors like South Dakota, increased summer drying causing more droughts,[4] reduced crop yields, and reduced water availability and quality. *Id.* The more CO_2 emitted, the more severe the impacts are likely to be. *Id.* There is reason to worry that the warming ahead will not be gradual, given evidence that in

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[4] While this matter was pending before the PUC in the summer of 2006, South Dakota suffered its worst drought since the dust bowl era. Ironically, availability of water for Big Stone II's operations, especially during drought conditions, is of serious concern and a potential problem for the plant's operation. The PUC acknowledged this in its findings noting that the plant may have to reduce or cease operations during times of drought. (R. 8302, para. 101; App. 21.) This would obviously lead to serious consequences for customers. Conversely, if the plant did not diminish or cease operations during drought, it would then exceed the amount of water it is allowed to take from Big Stone Lake under agreement with the State of Minnesota. *Id.*

the past the earth has often made climate changes in "abrupt, lurching fashion," which would be even more disruptive than linear warming. (R. 7230; App. 86.)

In South Dakota, global warming is predicted to manifest itself in decreased soil moisture likely to harm both crops and natural vegetation; greater morbidity and mortality from heat stress; increased summer drought; displacement of today's plant and animal species; more agricultural pests and diseases; and increased storm intensity, causing greater flooding, water pollution, and erosion. (R. 7232-7233; App. 88-89.) Dr. Hausman describes likely harm to both agriculture and natural vegetation in the region, *Id.*, and that global warming from increased CO2 is likely to be economically and socially disruptive to South Dakota. (R. 7233; App. 89.) The Prairie Pothole Ecological Region covering the eastern Dakotas and western Minnesota, is particularly vulnerable to climate warming. Prairie pothole shallow wetlands in the region will be diminished or eliminated by drier conditions threatening the ducks and other migratory waterfowl for which the region is a critical breeding ground. (R. 7234-7235; App. 90-91.)

The evidence in the record establishing the gravely serious nature of the global warming threat and the role of human-caused increased CO_2 in the global warming threat, is overwhelming and *wholly unrebutted*. The Coal Plant Owners submitted no scientific evidence countering the testimony and studies submitted by Appellants, nor could they credibly do so. Not only does the evidence submitted by Appellants reflect the global scientific consensus, but it is the same evidence that is pushing the policy response on the global, national, state and local levels.[5] It was neither necessary nor appropriate for the PUC to put itself in the position of the global scientific community and predict, or minimize, the impacts of global warming. That work

[5] It is the same scientific evidence that has prompted the Western Governor's Association, now headed by Governor Rounds, to pass resolution 06-03 on June 13, 2006, urging action to reduce greenhouse gases. *See*, http://www.westgov.org/wga/policy/06/climate-change.pdf.

is already done by the global scientific community, and the PUC was duty-bound to recognize these scientific findings, which are wholly unrebutted in the record before it.

B. Big Stone II Will Be A Major Source Of Global Warming Pollution.

According to The Coal Plant Owners, Big Stone II will emit approximately 4.7 million tons of CO_2 per year, in turn, according to Dr. Hausman, "inexorably and significantly contributing to buildup of greenhouse gases in the atmosphere." (R. 4660(Rebuttal Testimony of Mr. Uggerud), 7237; App. 93).[6] Every year, Big Stone II will emit the equivalent global warming pollution of nearly 670,000 cars, roughly two-thirds more than the CO_2 emissions of all the cars registered in South Dakota combined. (R. 7238; App. 94.) This single project increases the CO_2 emissions of the entire state of South Dakota by 34%, and more than doubles the current emissions from the state's power sector (currently 3.79 million tons). *Id.* Dr. Hausman characterizes Big Stone II's impacts as an enormous increase in South Dakota's global warming emissions and states "Big Stone II will exacerbate a problem that is likely to cause dramatic environmental and economic harm to societies around the globe, including to the communities in South Dakota." (R.7214, 7238; App. 70, 94.) It is difficult to imagine anything the state of South Dakota could do to worsen global warming more in a single action than permitting Big Stone II, other than permitting an even bigger coal plant.

1. Big Stone II will cause irreversible changes to the environment that will remain beyond the operating lifetime of the facility.

South Dakota's power plant siting rules clearly demonstrate concern over an energy facility's long-term environmental impacts. The Coal Plant Owners are required to provide "estimates of changes in the existing environment which are anticipated to result from

[6] Appellants had calculated the emissions from the plant to be about 4.5 million tons per year, meaning that Appellants' testimony regarding the financial and environmental risks associated with the plant's CO_2 emissions are slightly *underestimated*.

construction and operation of the proposed facility, and identification of irreversible changes which are anticipated to remain beyond the operating lifetime of the facility." ARSD 20:10:22:13. The Coal Plant Owners ignored their obligation and failed to provide any such estimate. Appellants' testimony does provide and address the required information.

Large baseload coal plants are designed to operate for decades. (R. 7237; App. 93.) Some of today's coal plants have been operating for 70 years. *Id.* Assuming a conservative lifetime for Big Stone II of 50 years, the plant will emit over 225 million tons of CO_2 before it closes *Id.* The Coal Plant Owners left uncontroverted Dr. Hausman's statement that Big Stone II will cause irreversible damage to the environment, especially considering the plant's lifetime operation and the extremely slow recovery of the atmosphere. (R. 7239; App. 95.)

Moreover, the damage from Big Stone II's CO_2 pollution does not stop with the eventual shuttering of the facility. The CO_2 emitted from Big Stone II will continue warming the planet for centuries after the plant itself closes its doors. The IPCC states that "several centuries after CO_2 emissions occur, about a quarter of the increased CO_2 concentration caused by these emissions is still present in the atmosphere." (R. 7265; App. 121.) The PUC's decision in 2006 to allow Big Stone II to emit 4.7 million tons of CO_2 for every year of operation, will have implications for warming the Earth centuries from now.

While global warming is very much a long-term problem, it is also one that calls for immediate action. As Dr. Hausman notes, models demonstrate that we can still avoid the most dangerous impacts *by limiting the further buildup of CO_2 in the atmosphere.* (R. 7214; App. 70.) The recent statement from the U.S. National Academy of Sciences and its counterpart academies from 10 other nations calls it "vital" to take immediate steps to reduce CO_2 emissions now because "[f]ailure to implement significant reductions in net greenhouse gas emissions now, will make the job much harder in the future." (R. 7286 et seq.; App. 142 et seq.) That doesn't mean 'limit further buildup of all sources except ones of a certain size,' or 'limit further buildup from all sources except those in South Dakota'. The uncontested evidence in this case is that the scientific consensus it to stop increasing and start decreasing *all* CO_2 and to do it now. Action taken now to reduce greenhouse emissions will lessen the rate and magnitude of climate change ahead; the academies note that a lack of full scientific certainty about some aspects of climate change is "not a reason for delaying an immediate response that will, at a reasonable cost, prevent dangerous anthropogenic interference with the climate system." *Id.* Big Stone II is a threat to the environment now and the PUC erred in approving it.

2. The PUC failed to consider the cumulative and synergistic impact of Big Stone II's emissions along with those of other power plants, contributing to the clearly erroneous and arbitrary and capricious nature of this decision.

South Dakota's siting rules do not focus solely on the impact of the energy facility in question, but on the cumulative environmental impact of that facility with other energy facilities. Specifically, The Coal Plant Owners were required to calculate Big Stone II's environmental effects "to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction." ARSD 20:10:22:13. The Coal Plant Owners did not provide any such calculation, and generally ignored the global warming impact of Big Stone II, individually and cumulatively, in their application and testimony. (R. 4801-4802.)

Dr. Hausman directly states that he believes Big Stone II will have a cumulative effects. (R. 7239; App. 95.) The cumulative impact of America's coal plants on global warming is, as Dr. Hausman testified, "staggering." The United States is the source of more greenhouse gas emissions than any nation by far, on both a per capita and total basis. (R. 7236; App. 92.) The United States contributes 24% of world CO_2 emissions from fossil fuel consumption, and almost one-third of those emissions come from coal plants. *Id.*

The Coal Plant Owners have not attempted to rebut any of the evidence that global warming is a tremendous problem, that coal plants are a major cause of it, or that Big Stone II will greatly increase South Dakota's contribution to it for many decades to come (indeed centuries, considering the lingering impact of its emissions). Mr. Uggerud is the only witness for the Coal Plant Owners to even touch on any of the evidence of the harms of global warming and Big Stone II's role in it. He is an Otter Tail Power Senior Vice President with a 1971 Bachelor's Degree in electrical engineering, and with no expertise or professional experience or training in global warming, atmospherics, climate change, CO_2 feedback loops, impacts of CO_2 and global warming on natural or agricultural systems etc. (R. 3803-3805) The Coal Plant Owners are content to have Mr. Uggerud point out that Big Stone II will amount to just a fraction of global anthropogenic emissions, so apparently Big Stone II is 'no big deal'. (R. 4660-4661.) The Coal Plant Owners' cavalier dismissal of the biggest contribution South Dakota has ever made to this severe and urgent environmental threat runs counter to the plain language of the PUC's power plant siting rules that long-term and cumulative environmental impacts be considered. The plain statutory language requires Big Stone II not present a threat of serious injury to the environment.

Moreover, The Coal Plant Owners overlook the fact that a fractional share of a huge problem can be very significant indeed. Dr. Hausman addressed this issue directly. It is a cumulative problem. Therefore, adding even a fraction to the problem makes a difference. (R. 7564; App. 146.) More specifically, Dr. Hausman draws the opposite conclusion from Mr. Uggerud regarding the "smallness" of Big Stone II's share. Dr. Hausman notes that as a global problem, CO_2 pollution involves hundreds of thousands of points sources (smokestacks) and millions of nonpoint sources (e.g. cars and other activities). Given that, a single source in South Dakota that will increase an actual measurable share of the problem is huge. (R. 7564; App. 146.) If global warming were a small problem, then Big Stone II's share of it would indeed constitute a small amount of environmental harm. However, the record demonstrates global warming is a problem of overwhelming proportions, and even a fractional share of the damages associated with it represents an enormous amount of environmental damage. Just how enormous is indicated by the testimony of PUC Staff witness Dr. Olesya Denney, discussed further below.

C. PUC Staff Agreed That Big Stone II's Global Warming Emissions Will Cause Enormous Damage to the Environment, Measured Economically.

PUC Staff's analysis of the environmental damage caused by Big Stone II's CO_2 emissions shows that *Big Stone II will cause a range of environmental damage from tens of millions to billions of dollars*. (R. 7865.) In the absence of any calculation of Big Stone II's environmental impacts by the Coal Plant Owners, PUC Staff did its own calculation, beginning with a survey of existing environmental externality estimates per unit of air emissions. (R. 7849-7850.) Environmental externalities represent environmental impacts that are not reflected in the costs of the party that causes the impact. *Id.* For example, global warming damages and the costs that it may cause to the insurance industry are considered an externality. Or, costs associated with more frequent road maintenance due to changing climatic conditions may be considered an externality. Or, costs associated with water quality deterioration in a small town downstream of a city with increased paved surfaces would be an externality relative to the city causing the problem. All these are examples of costs borne by persons or governments that are not generating the pollution in question.[7]

The PUC Staff calculation relied mainly on a U.S. Environmental Protection Agency ("EPA") survey of externality studies showing that costs from the environmental impacts of CO_2 range from \$1.50 to \$51.00 per ton of CO_2 emitted. (R. 7852.) Using the low EPA value for annual CO_2 damages (\$1.50 per ton) associated with Big Stone II (at 4.36 million tons CO_2 per year), yields \$50,098,876 in CO_2 damages over 40 years of plant operation at a 10% discount rate.[8] (R. 7865.) (calculation derived from subtracting "Lower Boundary" Total Externalities Excluding CO_2 from Total Externalities Including CO_2). Applying a 3% discount rate, these minimum EPA-quantified damages increase to \$154,043,273. (R. 7868.) (calculation derived from subtracting "Lower Boundary" Total Externalities Excluding CO_2 from Total Externalities Including CO_2). The highest level of damages PUC Staff reviewed (EPA's \$51 value) represents five billion dollars worth of cumulative harm caused by the CO_2 emissions of this one plant. *Id.* (calculation derived from "Upper Boundary" totals for CO_2 externalities.)

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[7] Externalities are completely different from future CO_2 *regulatory* costs projected and also discussed by the parties. The future regulatory costs would be actual direct costs, imposed by a government entity, most likely Congress, that coal plant owners would be expected to pay in the future. (R. 7092; App. 46.) CO_2 regulatory costs are therefore costs directly borne by the entity emitting the pollutant--- not the same as an externality cost. Coal Plant Owners' efforts to suggest that environmental costs (borne by the world at large) and future regulatory costs (borne by Coal Plant Owners) are the same, *see, e.g.*, T. 37 and T. 340, suggest an effort to confuse the record. While regulatory costs are something that may happen in the future with action by a government entity, externalities costs will happen the very day that Big Stone II starts up.

[8] In addition, PUC Staff calculated the CO_2 damages using a 3% discount rate rather than the 10% discount rate used in PUC Staff's base case analyses. (R. 7867-7868.) Appellants agree with the position described by PUC Staff that it is inappropriate to discount the health and well-being of future generations as deeply as the 10% discount rate does. The 3% "social discount rate" which PUC Staff notes is used by EPA in its cost-benefit analyses, is far more appropriate when discussing long-term global damages. *Id.*

PUC Staff also calculated externalities costs using the average of EPA's high and low values. (R. 7852, 7856, 7860.) Using an average of high and low EPA values ($26.00 per ton) puts Big Stone II environmental damages from CO_2 pollution into the billions of dollars.

PUC Staff also introduced evidence regarding some states' development and use of externality values or figures. Using the Minnesota PUC externality value of $3.64 per ton of CO_2 would obviously more than double the low-end EPA damages to a figure in excess of $100 million. The California PUC value of $8.00 per ton of CO_2 would double again the Minnesota-based calculation of damages to far in excess of $200 million. (R. 7852, 7856, 7860.)

Although PUC Staff reviewed and applied a wide range of quantified CO_2 environmental damages to Big Stone II, any one of the valid calculations shows the environmental damages of Big Stone II are enormous.[9] Even using any of these low externalities values shows hundreds of millions of dollars of environmental damage from Big Stone II's CO_2 emissions. Such extensive damage clearly qualifies as "a threat of serious injury to the environment" under SDCL 49-41B-22(2)(2006). Appellants' request reversal of PUC's approval of the Big Stone II permit.

III. THE PUC'S DECISION IS CONTRARY TO THE CLEAR LANGUAGE OF THE POWER PLANT SITING STATUTE IN THAT IT WILL PERMIT MORE THAN JUST A THREAT OF SERIOUS INJURY TO THE ENVIRONMENT, SETTING A MINIMUM THRESHOLD OF ACTUAL HARM TO THE ENVIRONMENT THAT IS ALLOWED.

It is undisputed that the increase in CO_2 pollution that Big Stone II will contribute to the very serious environmental problem of global warming is more than just a threat. It is real, actual injury. Big Stone II agrees that it will contribute 4.5 million tons of CO_2 pollution to the

[9] Appellants note that in calculating Big Stone II's environmental damages, PUC Staff underestimate Big Stone II's CO_2 emissions, counting them as only 4,363,868 tons per year, (R. 7852), rather than at the approximately 4.7 million tons per year that Coal Plant Owners state it will emit. Appellants also note that PUC Staff's cumulative damages assume only forty years of operation, which would be a short lifetime judging by coal plants in operation today.

atmosphere every year for the life of the plant. Big Stone II offered no evidence to rebut this fact. Big Stone II offered only argument that the magnitude of the harm relative to the serious environmental problem appears small. The PUC adopted this argument in the face of the evidence to the contrary.

By so adopting this argument, the PUC disregarded the plain language of the statute and the decision approving Big Stone II should be reversed. The plain language of the statute prohibits the PUC from approving any plant where the plant will represent the *threat* of serious injury to the environment. The plain language of the statute does not require proof of actual injury to the environment, nor does it require particular thresholds of harm to the environment. The PUC reads a requirement for a particular level of actual injury that is not in the statute.

Where an administrative agency's decision is tainted by legal error—where the agency disregards the clear or plain language of the statute it is tasked to administer—courts will reverse the agency decision as clearly in error and prejudicial to the parties. In South Dakota, courts construe statutes according to their intent and that intent is determined from the statutes as a whole and in accordance with their language and its plain, ordinary and popular meaning. *Whalen v. Whalen*, 490 N.W.2d 276, 280 (S.D. 1992). *See also, In re West River Elec. Ass'n, Inc.*, 675 N.W.2d 222, 226 (S.D. 2004). Appellant's urge this Court to reverse the PUC's decision approving Big Stone II as contrary to the plain language of the siting statute requiring denial of a permit where the plant will pose a threat, not actual particularized amount, of serious injury to the environment.

IV. THE POWER PLANT SITING STATUTE DOES NOT ALLOW THE PERMITTING OF A PLANT THAT POSES A THREAT OF SERIOUS INJURY TO THE ENVIRONMENT, REGARDLESS OF ITS PURPORTED ECONOMIC BENEFITS.

A. The Plain Language Of South Dakota's Power Plant Siting Statute Provides No "Balancing Test" Of Environmental Harm Against Economic Gain.

The Coal Plant Owners' statutory burden to show that Big Stone II will not pose a threat of serious injury to the environment under is *unqualified*. Nonetheless, during the hearing, after showing how Big Stone II will cause potentially billions of dollars of damage to the environment, PUC Staff took the unwarranted and extra-legal step of comparing those damages to the economic benefits that Big Stone II would purportedly provide to the immediate area, and, on the basis of this "balance" ultimately recommended approval of this highly destructive project. (R. 7873-7874.) The PUC's Findings mention in detail these many economic benefits to the surrounding area, immediately following the PUC's findings that Big Stone II will emit CO_2 pollution, but "not that much" relative to world emissions. (R. 8306; App. 25.) While the PUC's findings do not expressly provide that the PUC is engaging in an improper balancing test, given the position urged by the PUC Staff and the detailed findings of the PUC as to economic benefit, this Court cannot be certain that the PUC decision to approve Big Stone II regardless of its obvious negative impact on the environment, did not involve an improper balancing consideration. To the extent that balancing entered into the PUC's decision, the PUC decision violated the plain language of the power plant siting statute. Where such "danger signals" exist as to an unwarranted exercise of discretion and/or error of law, it is proper for a reviewing court to overturn the agency decision, and, at a minimum remand the matter for a more specific decision that is more clearly in compliance with the plain language of the statute.

B. The Economic Benefits Justification For Big Stone II's Threat Of Serious Injury To The Environment Is Itself On Shaky Ground When Viewing The Evidence As A Whole.

Even if it were somehow proper for the PUC to consider the balance of environmental harms and economic considerations, the PUC's decision that the balance favors approving Big Stone II is clearly erroneous given the record as a whole. First, as set forth in detail above, the economics of externalities shows enormous cost burdens on a large scale for every ton of CO_2 emitted by Big Stone II. Those cost burdens alone erase much of any purported economic benefit and unfairly impose costs on a large number of people for the benefit of a few.

Second, policy responses to global warming are emerging throughout the U.S., as they have already in the rest of the developed world, which responses will increase costs to Big Stone II and its customers. Mainstream figures such as U.S. Senator John McCain, R-AZ, forecast the coming global warming policies, "the culmination of evidence is going to force us to act – the question is if we will act soon enough." T. 762.

Evidence submitted by Appellants demonstrates that CO_2 regulation will fully erase any economic gains that the PUC may have employed to "balance out" environmental harms. In June of 2005, the U.S. Senate passed a Sense of the Senate resolution calling for mandatory, market-based limits on emissions of greenhouse gases, and the House Appropriations Committee adopted similar language in 2006. (R. 7157.) Several bills that would impose such mandatory, market-based limits on CO_2 emissions have been proposed in Congress. (R. 7158.) These proposals employ a cap-and-trade regulatory technique requiring power plant operators to own an allowance for each ton of CO_2 emitted. (R. 7157-7158.) Allowances would be tradeable among emitters, and market forces would set the price of the allowances. Legislators are increasingly educating themselves on the impact of such proposals, laying the groundwork for a national regulatory program. (R. 7099; App. 53.)

A survey of electric generating companies conducted in 2004 showed that about half of the companies expected Congress to enact CO_2 limits within five years, while nearly 60% expected them within the next ten years. (R. 7168.) A 2005 survey of the North American electricity industry said that 93% of respondents expected increased pressure to take action on global climate change. *Id.* Both surveys were conducted before the Senate and the House Appropriations Committee even adopted language calling for mandatory CO_2 limits. Several utilities are already building future CO_2 regulatory costs into their planning, in some cases in response to state regulators who increasingly require these costs to be factored into resource decisions. (R. 7173-7175.) A growing number of power companies openly support some form of cap-and-trade regulation of CO_2, and have participated in hearings held by the Senate Energy and Natural Resources Committee to work out the details of such a proposal. (R. 7159.)

The federal Energy Information Administration and others have conducted computer modeling to project how much CO_2 allowances would cost under various federal regulatory proposals. After reviewing several such studies, and based on their larger review of climate science and policy and the risk-management practices of a growing number of utilities, Appellants' experts Synapse,[10] prepared low-, mid-, and high-case forecasts of likely future CO_2

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[10]Synapse Energy Economics, Inc. is a research and consulting firm specializing in energy and environmental issues, including electric generation, transmission and distribution system reliability, market power, electricity market prices, stranded costs, efficiency, renewable energy, environmental quality and nuclear power. Its clients are widely varied including consumer advocates, public utilities commission staff (including on occasion, South Dakota PUC staff), attorneys general, environmental organizations, federal government, and utilities. (R. 7089; App. 43.)

costs. (R. 7184-7187.) These forecasts not only reflect studies of existing federal proposals, but are in line with CO_2 cost projections used in planning by other utilities. (R. 7175.)

Clearly, the costs of future CO_2 allowances is subject to considerable regulatory uncertainty, but that uncertainty makes it more important to factor a reasonable range of them into planning, and certainly does not justify the now reckless assumption that such costs will remain at zero for the operating lifetime of a new coal plant. Synapse, an energy and atmospheric issues consulting firm, concluded that "[s]cientific developments, policy initiatives at the local, state, and federal level, and actions of corporate leaders, all indicate that climate change policy will affect the electric sector – the question is not "whether" but "when" and "in what magnitude." (R. 7146.) As Synapse notes, "the challenge, as with any unknown future cost, is to forecast a reasonable range of costs based on analysis of the information available." (R. 7189.) Synapse's forecasts of future CO_2 costs would add significantly to the cost of Big Stone II on a megawatt/hour (MWh) basis. The lowest cost trajectory would add $7.60 to the cost of energy from the plant, the mid-case costs would add $18.61 per MWh, and the high-case costs would add $29.72 per MWh. (R. 7111; App. 65.) In percentage terms, the mid-case costs, which Synapse considers most likely, would increase the plant's cost by 37-46% further eliminating economic benefits to be balanced against environmental harms. *Id.*

CONCLUSION

Global warming and its significant negative impacts on South Dakota, as well as the world, is the result of more CO_2 pollution in the earth's atmosphere than at any time in hundreds of thousands of years. That CO2 pollution is largely human-induced. Big Stone II will contribute a measurable share to that serious problem and as such was erroneously approved by the South Dakota PUC. Appellants respectfully request this Court to reverse the decision of the PUC as Big Stone II will pose a threat of serious injury to the environment.

Dated: 21 Nov, 2006

Respectfully submitted,

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STATE OF SOUTH DAKOTA
HUGHES COUNTY

CIRCUIT COURT
SIXTH JUDICIAL DISTRICT

In the Matter of Otter Tail Power Company on behalf of Big Stone II Co-owners for an Energy Conversion Facility Permit for the Construction Of the Big Stone II Project

APPENDIX OF MINNESOTA CENTER FOR ENVIRONMENTAL ADVOCACY, FRESH ENERGY, IZAAK WALTON LEAGUE, AND UNION OF CONCERNED SCIENTISTS

Civ. No. 06-399
PUC Docket No. EL05-022

TABLE OF CONTENTS

STATE OF SOUTH DAKOTA
HUGHES COUNTY

CIRCUIT COURT
SIXTH JUDICIAL DISTRICT

In the Matter of Otter Tail Power Company on behalf of Big Stone II Co-owners for an Energy Conversion Facility Permit for the Construction Of the Big Stone II Project

NOTICE OF APPEAL OF DECISION OF SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Civ. No.____________________
PUC Docket No. EL05-022
Decision date: 8/24/06

TO: Otter Tail Power Company on behalf of Big Stone II Co-Owners and its attorneys, Christopher W. Madsen, Boyce, Greenfield, Pashby & Welk, LLP, 101 N. Phillips Avenue, # 600, Sioux Falls, SD 57104 and other parties in interest.

Izaak Walton League of America – Midwest Office, Minnesota Center for Environmental Advocacy, Union of Concerned Scientists, and Fresh Energy (f/k/a Minnesotans for an Energy-Efficient Economy), (collectively, "Appellants") file this Notice of Appeal and petition for review of the South Dakota Public Utilities Commission ("SDPUC") decision to grant an Energy Conversion Facility Siting Permit for the construction of the Big Stone II Project to Otter Tail Power Company, on behalf of Big Stone II Co-owners, in SDPUC Docket No. EL05-022.

Appellants each intervened, and participated jointly, in the SDPUC administrative contested case proceeding below. The SDPUC issued its order granting the permit on July 21, 2006. A petition for rehearing the SDPUC decision was timely sought, and subsequently denied by SDPUC order issued August 24, 2006. This appeal is authorized by SDCL 49-41B-30. Copies of the July 21 and August 24, 2006 orders are enclosed with this Notice of Appeal.

The SDPUC's decision approving the Big Stone II Project and granting Big Stone II an Energy Conversion Facility Siting Permit is in error as it is not supported by substantial evidence and is arbitrary and capricious. Under SDCL 49-41B-22, an applicant has the burden of proof to establish that the proposed energy conversion facility "will not pose a threat of serious injury to the environment." The record before the SDPUC demonstrates through evidence unrefuted by the Big Stone Co-Owners, that the proposed Big Stone II Project poses a threat of serious injury to the environment due to its annual emissions of nearly five million tons of carbon dioxide, a greenhouse gas that causes global climate change with attendant adverse health and environmental impacts.

Dated: September 20, 2006

Respectfully submitted,

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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY OTTER TAIL POWER COMPANY ON BEHALF OF BIG STONE II CO-OWNERS FOR AN ENERGY CONVERSION FACILITY PERMIT FOR THE CONSTRUCTION OF THE BIG STONE II PROJECT	))))))))	ORDER DENYING APPLICATION FOR RECONSIDERATION; ORDER DENYING APPLICATION FOR RECONSIDERATION SECOND APPLICATION EL05-022

On July 21, 2005, Otter Tail Power Company (Otter Tail) on behalf of the Project Co-Owners, Central Minnesota Municipal Power Agency, Great River Energy, Heartland Consumers Power District, Montana-Dakota Utilities Co., a Division of MDU Resources Group, Inc., Otter Tail Corporation d/b/a Otter Tail Power Company, Southern Minnesota Municipal Power Agency and Western Minnesota Municipal Power Agency submitted to the Public Utilities Commission (Commission) an application for a permit for an energy conversion facility. The proposed energy conversion facility is a nominal 600 MW coal-fired electric generating facility and associated facilities, which the Project co-owners have named Big Stone II, to be located on an industrial site adjacent to the existing Big Stone Plant Unit I in Grant County, South Dakota. The proposed site is located East of Milbank and Northwest of Big Stone City, in Grant County, South Dakota.

On July 28, 2005, the Commission electronically transmitted notice of the filing to interested individuals and entities, however, it did not include an intervention date. On August 5, 2005, the Commission electronically transmitted an amended notice which included an intervention deadline of September 18, 2005. On August 18, 2005, the Commission electronically transmitted and posted to its web page an Errata Notice for Amended Weekly Filings setting forth the correct intervention deadline of September 19, 2005. On August 25, 2005, the Commission received a Petition to Intervene from Clean Water Action (Clean Water). On September 16, 2005, the Commission received Applications for Party Status from South Dakota Chapter Sierra Club (Sierra Club) and Union of Concerned Scientists (Union). On September 19, 2005, the Commission received Applications for Party Status from Mary Jo Stueve (Stueve), Minnesotans for an Energy-Efficient Economy (Minnesotans), Izaak Walton League of America - Midwest Office (Izaak Walton) and Minnesota Center for Environmental Advocacy (Minnesota Center). At its September 27, 2005, meeting, the Commission granted intervention to Clean Water, Sierra Club, Union, Stueve, Minnesotans, Izaak Walton and Minnesota Center. On February 16, 2006, the Commission received a letter from Clean Water Action requesting that its Petition to Intervene be withdrawn. At its regularly scheduled meeting of February 28, 2006, the Commission granted Clean Water Action's request to withdraw its Petition to Intervene.

On May 12, 2006, the Commission received a Joint Motion and Stipulation to Amend Second Scheduling and Procedural Order from Otter Tail. On May 19, 2006, the Commission received a Stipulation requesting withdrawal of its intervention from Sierra Club. At its regularly scheduled meeting of May 23, 2006, the Commission granted the Joint Motion and Stipulation to Amend Second Scheduling and Procedural Order. The Commission also granted Sierra Club's Stipulation requesting withdrawal of its intervention. On July 8, 2006, the Commission received a Notice of and Petition for Dismissal from Stueve. On July 21, 2006, the Commission issued its Final Decision and Order; Notice of Entry.

On July 28, 2006, the Commission received a Notice and Application for Reconsideration from Stueve. On August 3, 2006, the Commission received Applicants' Answer to Petition for Rehearing. On August 14, 2006, the Commission received a Notice and Application for Reconsideration Second Application from Stueve. On August 16, 2006, the Commission received Staff's Answer to Petitions for Reconsideration. On August 21, 2006, the Commission received a letter in support of Stueve's request for reconsideration from the Joint Intervenors and Applicants' Answer to Second Petition for Rehearing.

The Commission has jurisdiction over this matter pursuant to SDCL Chapter 49-41B, specifically 49-41B-1, 49-41B-2, 49-41B-2.1, 49-41B-4, 49-41B-6, 49-41B-7, 49-41B-8, 49-41B-9, 49-41B-10, 49-41B-11, 49-41B-12, 49-41B-13, 49-41B-14, 49-41B-15, 49-41B-16, 49-41B-17, 49-41B-17.1, 49-41B-19, 49-41B-20, 49-41B-21, 49-41B-22, 49-41B-24, 49-41B-26, 49-41B-33, 49-41B-35, 49-41B-36, 49-41B-38, and ARSD Chapter 20:10:22.

At its regularly scheduled meeting of August 23, 2006, the Commission considered this matter. The Commission found that the Notice and Application for Reconsideration and the Notice and Application for Reconsideration Second Application failed to demonstrate sufficient grounds for rehearing or reconsideration and should be denied (Chairman Sahr abstained). It is therefore

ORDERED, that the Notice and Application for Reconsideration and the Notice and Application for Reconsideration Second Application are denied.

Dated at Pierre, South Dakota, this 24th day of August, 2006.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 8/24/06

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

ROBERT K. SAHR, Chairman, abstaining

DUSTIN M. JOHNSON, Commissioner

GARY HANSON, Commissioner

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY OTTER TAIL POWER COMPANY ON BEHALF OF BIG STONE II CO-OWNERS FOR AN ENERGY CONVERSION FACILITY PERMIT FOR THE CONSTRUCTION OF THE BIG STONE II PROJECT	))))))	FINAL DECISION AND ORDER; NOTICE OF ENTRY EL05-022

PROCEDURAL HISTORY

On November 8, 2004, Otter Tail Corporation d/b/a Otter Tail Power Company ("OTP"), on behalf of Central Minnesota Municipal Power Agency ("CMMPA"), Great River Energy ("GRE"), Heartland Consumers Power District ("HCPD"), Montana-Dakota Utilities Co., a Division of MDU Resources Group, Inc. ("MDU"), Southern Minnesota Municipal Power Agency ("SMMPA"), and Western Minnesota Municipal Power Agency ("WMMPA") through Missouri River Energy Services ("MRES") (collectively, "Applicants") submitted to the South Dakota Public Utilities Commission ("Commission") a notice of intent to submit an application for permit to construct an energy conversion facility pursuant to SDCL 49-41B-5. The proposed energy conversion facility is a nominal 600 MW coal-fired electric generating facility and associated facilities, which the Project co-owners have named Big Stone II, to be located adjacent to the existing Big Stone Plant Unit I in Grant County, South Dakota ("Big Stone II" or the "Project"). The proposed site is located East of Milbank and Northwest of Big Stone City, in Grant County, South Dakota. On December 10, 2004, the Commission entered an Order Designating Affected Area and Local Review Committee in Docket EL04-034. On July 21, 2005, Applicants submitted to the Commission an application for a permit to construct an energy conversion facility for Big Stone Unit II.

On July 28, 2005, the Commission electronically transmitted notice of the filing to interested individuals and entities. The notice, however, inadvertently omitted mentioning the intervention date. On August 5, 2005, the Commission electronically transmitted an amended notice which included an intervention deadline of September 18, 2005. On August 18, 2005, the Commission electronically transmitted and posted to its web page an Errata Notice for Amended Weekly Filings setting forth the correct intervention deadline of September 19, 2005 in accordance with ARSD 20:10:22:40. On August 18, 2005, the Commission issued an Order Assessing Filing Fee establishing a fee amount pursuant to SDCL 49-41B-12 of not to exceed $700,000 with an initial deposit of $8,000, and issued a Notice of Application; Order for and Notice of Public Input Hearing; Notice of Opportunity to Apply for Party Status giving notice of a public input hearing to be held on the Project on September 13, 2005, in Milbank. Notice of the Public Input Hearing was published in the Milbank Valley Shopper, Sisseton Courier and Watertown Public Opinion. On September 13, 2005, the Public Input Hearing was held as scheduled in Milbank, South Dakota, and was attended by approximately 50 people.

On August 25, 2005, the Commission received a Petition to Intervene from Clean Water Action ("Clean Water"). On September 16, 2005, the Commission received Applications for Party Status from South Dakota Chapter Sierra Club ("Sierra Club") and the Union of Concerned Scientists ("UCS"). On September 19, 2005, the Commission received Applications for Party Status from Mary Jo Stueve ("Stueve"), Minnesotans for an Energy-Efficient Economy ("MEEE"), Izaak Walton League of America - Midwest Office ("Izaak Walton") and Minnesota Center for Environmental Advocacy ("MCEA") (MEEE, Izaak Walton, UCS and MCEA are referred to collectively as "Joint Intervenors"). At its September 27, 2005, meeting, the Commission granted intervention to Clean Water, Sierra Club, UCS, Stueve, MEEE, Izaak Walton and MCEA. On February 16, 2006, the Commission received a letter from Clean Water requesting that its Petition to Intervene be withdrawn. On March 16, 2006, the Commission granted an Order Granting Withdrawal of Intervention to Clean Water. On May 19, 2006, the Commission received a Stipulation requesting withdrawal of intervention from Sierra Club. On June 5, 2006, the Commission issued an Order Granting Stipulation for Withdrawal of Intervention to Sierra Club.

On September 20, 2005, the Commission received a letter and proposal from the Local Review Committee requesting funds to employ consultants to assist the Local Review Committee in carrying out the Committee's responsibilities, and on October 4, 2005, at its regularly scheduled meeting, the Commission voted unanimously to grant the Local Review Committee's request to hire consultants and to provide $47,950 for this purpose.

On November 28, 2005, the Commission received a Motion for Pre-Hearing Conference from Applicants. On December 2, 2005, a telephonic pre-hearing conference was held among counsel for the parties and the Commission's Counsel. On January 18, 2006, the Commission issued a Scheduling and Procedural Order. On February 23, 2006, Applicants filed a Motion to Clarify Scheduling and Procedural Order. On March 1, 2006, a second pre-hearing conference was held telephonically among counsel for the parties and Commission Counsel. On March 22, 2006, Applicants filed a letter suggesting changes to certain scheduling and procedural stipulations reached by the parties at the pre-hearing conference. On March 31, 2006, the Commission issued its Second Scheduling and Procedural Order, canceling the original procedural schedule, establishing a revised procedural schedule and making certain additional procedural rulings. On May 8, 2006, Joint Intervenors filed a Motion to Compel Discovery and to Extend Deadline for Intervenor Testimony. On May 12, 2006, Applicants and Joint Intervenors filed a Joint Motion and Stipulation to Amend Second Scheduling and Procedural Order, in which Joint Intervenors agreed to withdraw their Motion to Compel, Applicants agreed to respond to Joint Intervenors' discovery request IR 17, and Applicants and Joint Intervenors agreed to certain modifications of the procedural schedule in the Second Scheduling and Procedural Order to provide additional time for the filing of certain Joint Intervenor testimony responsive to the information provided by Applicants' response to IR 17. On May 19, 2006, the Commission issued a Third Scheduling and Procedural Order incorporating these stipulations.

In response to requests from the public, the Commission scheduled a second public comment hearing pursuant to ARSD 20:10:01:15.06 in conjunction with the formal evidentiary hearing and issued a Fourth Scheduling and Procedural Order on June 22, 2006, giving notice of the time, place and purpose of the public input hearing. The public comment hearing was held as scheduled on the evening of June 29, 2006, at the Capitol Building in Pierre and was attended by approximately 20 people.

In accordance with the Scheduling and Procedural Orders in this case, all parties filed pre-filed testimony. The formal evidentiary hearing was held as scheduled on June 26- 29, 2006, in Room 412 of the Capitol Building. On July 8, 2006, Stueve filed a Petition for Dismissal and accompanying Notice. Briefs were submitted by all parties on July 9, 2006, Proposed Findings of Fact, Conclusions of Law and Decision were submitted by Applicants and Joint Intervenors on July 9, 2006, and a Request for Specific Findings was submitted by Stueve on July 9, 2006. On July 10, 2006, Applicants submitted Amended Proposed Findings of Fact, Conclusions of Law and Decision. Oral argument was heard by the Commission on July 11, 2006.

On July 10, 2006, the Commission issued a Fifth Scheduling and Procedural Order to accommodate a Commissioner scheduling conflict, changing the time for Commission action on July 14, 2006, from 10:30 A.M. to 11:30 A.M.

The Commission rulings on Applicants' Amended Proposed Findings of Fact, Joint Intervenors Proposed Findings of Fact and Stueve's Proposed Findings of Fact are set forth on Attachment A, which is incorporated herein by reference.

Having considered the evidence of record and applicable law, the Commission makes the following Findings of Fact, Conclusions of Law and Decision:

FINDINGS OF FACT

1.0 APPLICANTS

1. The application is made by Otter Tail Corporation, d/b/a Otter Tail Power Company ("OTP") for itself and on behalf of the following: Central Minnesota Municipal Power Agency ("CMMPA"); Great River Energy ("GRE"); Heartland Consumers Power District ("HCPD"); Montana-Dakota Utilities Co, a Division of Montana-Dakota Resources Group, Inc. ("Montana-Dakota"); Southern Minnesota Municipal Power Agency ("SMMPA"); and Western Minnesota Municipal Power Agency ("WMMPA") through Missouri River Energy Services ("MRES"). (See Application, App. Ex 54; App. Ex. 8, pp. 3-4). (Hereinafter collectively referred to as the "Applicants"). The Applicants' proposed ownership and operation of the Big Stone Unit II is governed by participation and operating agreements. App. Ex. 8, p. 4.

2. CMMPA is a joint action agency that was created and incorporated as a municipal corporation and a political subdivision of the State of Minnesota. It is a municipal power agency that supplies wholesale electric service to its municipal utility members who are responsible for serving the retail needs of its customers. There are fourteen municipal members of CMMPA. App. Ex. 6, pp. 2-3; HTr 223-24. CMMPA has a five percent ownership interest in Big Stone Unit II. App. Ex. 6, p. 10; App. Ex. 8, pp. 3-4.

3. GRE is a non-profit generation and transmission cooperative which provides wholesale electric service to its 28 owner-members, serving approximately 666,000 retail member customers located primarily in Minnesota. App. Ex. 2, pp. 2-3. GRE has a 19.3% ownership interest in Big Stone Unit II. App. Ex. 8, pp. 3-4.

4. HCPD is a political subdivision and public corporation of South Dakota serving as a wholesale power supplier. App. Ex. 4, p. 2; App. Ex. 15, p. 6; HTr 237. HCPD is a consumer power district regulated by the statutory and administrative rules of the State of South Dakota. Id. HCPD has a statutory obligation to provide electric power and energy to the people of South Dakota, economically and reliably. SDCL 49-37-3.1. HCPD is required to forecast its needs and determine the best way to meet those needs. Id. HCPD serves municipalities in South Dakota, Minnesota, and Iowa, including three South Dakota state agencies, the University of South Dakota, South Dakota State University, and one South Dakota rural electric cooperative. HTr 171-172. HCPD has a 4.2% ownership interest in Big Stone Unit II. App. Ex. 8, pp. 3-4.

5. Montana-Dakota is an investor-owned electric utility company that operates an integrated electric system in portions of Montana, North Dakota and South Dakota. It is a division of Montana-Dakota Resources Group, Inc., a publicly traded corporation. App. Ex. 11, p. 11; App. Ex. 7, pp. 1, 3). Montana-Dakota has a 19.3% ownership interest in Big Stone Unit II. App. Ex. 7, p. 6; App. Ex. 8, pp. 3-4.

6. OTP is an investor-owned electric utility providing electric and energy services to more than 128,000 retail customers in Minnesota, North Dakota and South Dakota. Half of OTP's customers live in rural communities with populations of less than 200. App. Ex. 1, pp. 4, 7. OTP serves 423 communities, ranging in size from 200 to approximately 10,000 residents. HTr 29. It has a 19.33% ownership interest in Big Stone Unit II. App. Ex. 1, p. 10; App. Ex. 8, pp. 3-4.

7. SMMPA is a non-profit municipal corporation and political subdivision of the State of Minnesota. It provides wholesale electric service to its 18-member municipal utilities, and serves indirectly approximately 215,000 persons. App. Ex. 5, pp. 2-3. It has a 7.833% ownership interest in Big Stone Unit II. App. Ex. 5, p. 9; App. Ex. 8, pp. 3-4.

8. WMMPA is a municipal corporation and political subdivision of the State of Minnesota providing acquisition and ownership of power supply and transmission projects to 23 member municipal utilities, 22 of which are also members of MRES. App. Ex. 3, pp. 2-4. MRES is a not-for-profit joint action agency providing wholesale supplemental power service to its 60 member municipal electric utilities in South Dakota, Minnesota, North Dakota and Iowa. App. Ex. 3, pp. 4-5; App. Ex. 14, p. 12. The average population

of member communities is 4,100 persons. Id. The total number of members served is approximately 120,000. Id. WMMPA, through MRES, has a 25% ownership interest in Big Stone Unit II. App. Ex. 5, p. 9; App. Ex. 3, p. 11; App. Ex. 8, pp. 3-4.

9. The Commission has jurisdiction to regulate the retail rates of only two of the Applicants: OTP and Montana-Dakota. HTr 759. The remaining Applicants are not subject to rate regulation in any state. Instead, as a cooperative utility (GRE), or as municipal utilities (MRES, SMMPA, CMMPA and HCPD), each is self-regulating – i.e., each establishes its own rates. App. Ex. 29, pp. 4-6; App. Ex. 41, p. 8; App. Ex. 39, p. 2, HTr 760.

2.0 INTERVENORS/PARTICIPANTS

10. On October 4, 2005, the Commission granted the following parties intervenor status: MEEE; Isaak Walton; UCS; MCEA; Sierra Club; Clean Water, and Stueve.

11. The Commission's Staff ("Staff") is also a full-party participant in the case.

12. Clean Water withdrew as a party pursuant to a letter submitted to the Commission dated February 14, 2006. On May 18, 2006, Intervenor Sierra Club and the Applicants executed a written stipulation providing for the withdrawal of Intervenor Sierra Club in this matter. Notice of the Stipulation and Withdrawal was given to all the parties on May 19, 2006. The stipulation was approved at the Commission meeting held May 23, 2006, and the Order granting Sierra Club's request to withdraw was entered June 5, 2006.

3.0 PROCEDURAL FINDINGS

13. The Western Area Power Administration held Federal EIS scoping hearings in Milbank, South Dakota, and Morris, Granite Falls, and Benson, Minnesota, on June 13, 14, 15, and 16, 2005, respectively.

14. On July 21, 2005, Mark Rolfes of OTP, on behalf of the Applicants, signed and filed the Application with the Commission.

15. Pursuant to SDCL 49-41B-6, the Commission formed the Local Review Committee ("LRC"). LRC convened meetings during the fall of 2005. The LRC drafted a Report, which was filed with the Commission on or about December 20, 2005. Following a review of the LRC Report, the Applicants commissioned additional studies and hired a consultant pursuant to the Commission Order. The Report of the LRC was admitted into the record at the Hearing as App. Ex. 68.

16. A public input hearing was held on September 13, 2005, in Milbank, South Dakota. Fifteen persons provided testimony. Approximately fifty members of the public were in attendance. App. Ex. 73.

17. Substantial written discovery was exchanged. Applicants answered more than 500 discovery requests and made available more than 47,000 pages of documents. Applicants submitted more than 2,000 pages of testimony and exhibits. HTr 555.

18. The following testimony was pre-filed:

A. Applicants' March 15, 2006 Direct Testimony:

Larry Anderson, SMMPA, Senior Planner/Economist, App. Ex. 13
Dick Edenstrom, First District, Executive Director, App. Ex. 27
David Gaige, Burns & McDonnell, Senior Project Manager Environmental Studies and Permitting, App. Ex. 22
David Geschwind, SMMPA, Senior Planner/Economist, Director of Operations and Chief Operating Officer, App. Ex. 5

Stephen Gosoroski, Burns & McDonnell, Project Manager, App. Ex. 24
Terry Graumann, OTP, Manager of Environmental Services, App. Ex. 16
Jeffrey Greig, Burns & McDonnell, General Manager of the Business & Technology Services Division (corrected filing on June 16, 2006), App. Ex. 23
Kiah Harris, Burns & McDonnell, Project Manager Business & Technology Services Division, App. Ex. 25
Janelle Johnson, OTP, Senior Financial Planner, App. Ex. 28
Daniel Jones, Barr Engineering, App. Ex. 17
Anne Ketz, 106 Group, President and Technical Director, App. Ex. 21
John Knofczynski, HCPD, Manager of Engineering, App. Ex. 15
Peter Koegel, MAPPCOR, Project Manager, App. Ex. 9
Richard Lancaster, GRE, Vice President Generation, App. Ex. 2
John Lee, Barr Engineering, Vice President, App. Ex. 18
Mike McDowell, HCPD, General Manager and Chief Executive Officer, App. Ex. 4
Bryan Morlock, OTP, Manager of Resource Planning, App. Ex. 10
Hoa Nguyen, Montana-Dakota, Power Supply Coordinator, App. Ex. 11
Tina Pint, Barr Engineering, Geologist/Hydrogeologist, App. Ex. 19
Mark Rolfes, OTP, Project Manager for Big Stone Unit II, App. Ex. 8
Andrew J. Skoglund, Barr Engineering, Acoustical Engineer, App. Ex. 20
Andrea L. Stomberg, Montana-Dakota, Vice President Electric Supply, App. Ex. 7
Randall Stuefen, University of South Dakota, Professor Emeritus, App. Ex. 26
Stephen Thompson, Central Minnesota Municipal Company, Chief Operating Officer, App. Ex. 6
Gerald Tielke, MRES, Operations Manager, App. Ex. 14
Ward Uggerud, OTP, Senior Vice President, App. Ex. 1
Raymond Wahle, MRES, Director Power Supply and Operations, App. Ex. 3

B. Commission Staff's May 19, 2006 Direct Testimony:

Olesya Denney, Staff Ex. 1
Michael K. Madden, Staff Ex. 2

C. Joint Intervenors' May 19, 2006 Direct Testimony:

Marshall R. Goldberg, MRG & Associates, Joint Intervenors' Ex. 3
Eric Hausman, Synapse Energy Economics, Inc., Joint Intervenors' Ex. 2
David Schlissel and Anna Sommer, Synapse Energy Economics, Inc., Joint Intervenors' Ex. 1, (corrected testimony filed on May 26, 2006), Joint Intervenors' Ex. 4

D. May 19, 2006 Prefiled Testimony of Mary Jo Stueve:

Mary Jo Stueve, pro se, Intervenor Stueve Ex. 1

E. Applicants' June 9, 2006 Rebuttal Testimony:

Robert Brautovich, App. Ex. 35
Terry Graumann, App. Ex. 34
Thomas Hewson, Jr., App. Ex. 30
Daniel Jones, App. Ex. 37
Daniel E. Klein (corrected filing on June 19, 2006), App. Ex. 31
Richard R. Lancaster, App. Ex. 39
John Lee, App. Ex. 36
Bryan Morlock, App. Ex. 32
Mark Rolfes, App. Ex. 33
Andrew Skoglund, App. Ex. 38

Randall Stuefen, App. Ex. 40
Ward Uggerud, App. Ex. 29
Raymond Wahle, App. Ex. 41

F. Joint Intervenors' June 9, 2006 Rebuttal Testimony:

David Schlissel and Anna Sommer, Joint Intervenors' Ex. 5

G. Applicants' June 16, 2006 Rebuttal Testimony:

Robert Davis, App. Ex. 47
Jeffrey Greig, App. Ex. 51
Thomas Hewson, App. Ex. 52
Bryan Morlock, App. Ex. 42

H. Commission Staff's June 19, 2006 Surrebuttal Testimony:

Olesya Denney, Staff Ex. 3

I. Joint Intervenors' Sur-rebuttal Testimony:

Ezra Hausman (June 20, 2006), Joint Intervenors' Ex. 7
David Schlissel and Anna Sommer (June 22, 2006), Joint Intervenors' Ex. 6

19. Testimony at the June 26-30, 2006 hearing was given by the following individuals:

Ward Uggerud
Mark Rolfes
Terry Graumann
Raymond Wahle
Michael McDowell
Jerry Tielke
Steve Thompson
John Knofczynski
John Lee
Andrew Skoglund
Randall Stuefen
Robert Brautovich
Jeffrey Greig
Stephen Gosoroski
Kiah Harris
Peter Koegel
Bryan Morlock
Stan Selander
Larry Anderson
David Gaige
Hoa Nguyen
Robert Davis
Daniel Klein
Thomas Hewson
Mary Jo Stueve
Michael Madden
Olyesa Denney
Marshall Goldberg
David Schlissel
Anna Sommer

20. Pursuant to agreement of the parties, the testimony for the following witnesses was received into the record without cross-examination: Richard Lancaster, Andrea Stomberg, David Geschwind, Tina Pint, K. Anne Ketz, Janelle Johnson, Dick Edenstrom, Daniel Jones and Ezra Hausman.

21. Public input and comments were also heard by the Commission on Thursday, June 29, 2006, in Pierre, South Dakota, with approximately 20 members of the public in attendance and 12 persons appearing to personally provide comments. HTr 558.

4.0 APPLICABLE REGULATIONS AND STATUTES

22. The following Administrative Rules of South Dakota ("ARSD") are applicable: ARSD 20:10:22:01 through ARSD 20:10:22:33, ARSD 20:10:22:36, ARSD 20:10:22:39 and ARSD 20:10:22:40.

23. The following South Dakota Codified Laws ("SDCL") are applicable: SDCL 49-41B-1, 49-41B-2, 49-41B-4 through 49-41B-17, 49-41B-17.1, 49-41B-19 through 49-41B-22, and 49-41B-24.

5.0 NAME OF OWNER AND MANAGER

24. CMMPA, GRE, HCPD, Montana-Dakota, OTP, SMMPA, and WMMPA will own Big Stone Unit II as tenants-in-common. App. Ex. 8, pp. 3-4. Management of the facility will be by OTP. App. Ex. 8, p. 4.

25. Each of the Applicants will be responsible for financing its respective ownership interest in the unit in a manner unique to each owner. App. Ex. 1-7.

6.0 PURPOSE OF FACILITY

26. Big Stone Unit II is a proposed coal-fired electric generating facility and associated facilities intended to provide approximately 600 MW of baseload energy for the seven participating owners in a low-cost, environmentally responsible manner. App. Ex. 8, p. 4. The energy from the facility is intended to serve the Applicants' retail and wholesale native load customers. App. Ex. 8, p. 4. The majority of the consumers live in South Dakota, North Dakota, Minnesota, Iowa, Montana, and Wisconsin. App. Ex. 5, p. 2; App. Ex. 15, pp. 7, 12; App. Ex. 9, pp. 2-3; App. Ex. 2, pp. 2, 18; App. Ex. 4, pp. 6, 16; App. Ex. 6, pp. 3-4; App. Ex. 1, pp. 4, 7. The facility is expected to produce 4.6 million MW hrs of electricity per year. App. Ex. 8, p. 11.

27. As a baseload plant, Big Stone Unit II is expected to be dispatchable, available for generation 24 hours a day, seven days a week. As a dispatchable resource, Big Stone Unit II can be controlled to match the Applicants' customers' energy needs. App. Ex. 8, p. 8.

7.0 ESTIMATED COST

28. The estimated construction cost for Big Stone Unit II is in excess of $1 billion in 2011 dollars. As Applicants approach a more defined design stage, refined cost estimates will be prepared. App. Ex. 8, p. 6. It is anticipated that construction costs for Big Stone Unit II will be subject to overall trends for steel, concrete, and other construction commodities. HTr. p. 89.

8.0 DEMAND FOR FACILITY

Regional Needs

29. MAPP is a voluntary association of electric utilities and other electric industry participants in the Upper Midwest and others that was organized in 1972 for the purpose of pooling generation and transmission to promote efficiency and reliability. App. Ex. 9, pp. 2-3. MAPP can meet its Reserve Capability Obligation for the next five years. However, by the summer of 2011, the MAPP-US region is projected to have a capacity deficit of approximately 219 MW even if Big Stone Unit II is constructed. Without Big Stone Unit II, the MAPP-US region will have a capacity deficit of approximately 819 MW by 2011, and 2400 MW by 2014. In order to meet its forecasted Reserve Capacity Obligation, MAPP members will need to build generation, purchase additional capacity, and/or reduce their demand growth. App. Ex. 9, p. 5.

30. MAPP-US has 7,900 MW of generation fueled by oil and natural gas. Such units have relatively high production costs, and are among the last in the power pool to be called upon to run. App. Ex. 50, p. 2.

31. MAPP-US had significant installed capacity margins during the 1980s. These margins have been declining since then, due to ongoing load growth in the region. Reserve margins were maintained at adequate levels during the 1990s, primarily through the addition of new, natural gas-fired capacity. Continuing load growth will result in inadequate generation capacity by 2011, unless additional resources are added. App. Ex. 50, p. 3.

32. MAPP-Canada projects a 1,383 MW surplus in the summer season of 2011. Of that amount, Manitoba Hydro Electric Board (MHEB) represents the lion's share at 1,350 MW. Saskatchewan Power (SP) represents the balance of 33 MW. App. Ex. 50, p. 4.

33. MAPP-Canada projects a 1,200 MW surplus in the 2011/2012 winter season. Of that amount, MHEB represents 1380 MW. SP represents the balance: a net capacity deficit of 180 MW in that season. App. Ex. 50, p. 4.

34. Similar to the situation of MAPP-US, a portion of the capacity surpluses in MAPP-Canada is fired by high-cost oil and natural gas generation resources. The availability of such surpluses is limited by transmission constraints, the energy-based rather than capacity-based makeup of the MHEB system, and the unwillingness or inability of utilities in Canada to sell any surpluses to utilities in the United States. App. Ex. 50, p. 5.

Applicants' Needs

35. Each of the Applicants presented evidence of a forecasted need for the additional baseload capacity and energy that Big Stone Unit II is designed to provide. Each Applicant has performed detailed resource planning studies that demonstrate such need. Based on these studies, the Applicants have projected that they need the following baseload energy and capacity by the 2011 timeframe:

Applicant	Baseload Need in 2001 (MW)	Proposed Share in Big Stone II (MW)
CMMPA	60	30
GRE	150	116
HCPD	30	25
Montana-Dakota	126	116
MRES[1]	200	150
OTP	120	116
SMMPA	100	47
Totals	786	600

Note:
[1] Includes Hutchinson, Minnesota.

OTP

36. OTP's energy requirements are forecast to steadily increase from the present through 2014 and beyond. Over the 10-year period shown from 2005-2014, OTP's energy needs are projected to grow at an average annual rate of 1.6%. OTP experiences summer season capacity deficits beginning in 2006 with the expiration of a 50 MW capacity and energy contract coupled with the expiration of a seasonal "diversity" agreement under which OTP was providing 75 MW of summer capacity to another regional utility. The net effect of these two transactions ending is a deficit of 5 MW in 2006. This deficit increases each year due to system load growth, and then takes another increase in 2010 to 116 MW with the expiration of a second 50 MW contract. Continued forecast load growth results in a projected capacity deficit of 173 MW by 2014. App. Ex. 10, p. 7; App. Ex. 54.

37. OTP conducts extensive integrated resource planning. OTP uses capacity expansion software to develop a series of optimized resource plans. The utility's entire system (i.e., Minnesota, North Dakota, and South Dakota) is modeled within the program, including the load forecast, existing generating and capacity transaction resources, all existing assets of the utility, and its financial structure. The model contains a detailed financial sub-model that calculates all financial parameters, tracks cash flow, and can issue new financings based on the need for capital to finance operations and construction. Available supply-side

(including renewables) and demand-side alternatives are input to the model and the model is executed to select the optimized resource plan for the given scenario. App. Ex. 10, p. 4.

38. Based on OTP's resource planning, Big Stone Unit II is shown to be a least cost baseload resource for the OTP system. OTP's planning efforts also identified optimal levels of conservation (e.g., specific demand-side management programs) and renewable generation resources that should also be added to the OTP resource portfolio, in addition to its proposed share of Big Stone Unit II. App. Ex. 10, p. 11.

MRES

39. The 2006 summer peak demand for the MRES member cities is forecasted at 818 MW, of which MRES will be responsible for 418 MW plus 15% planning reserves, or 480 MW. The MRES forecasts estimate that member total demand will grow annually by an average of 1.8% between 2006 and 2010, and by an average of 1.5% between 2010 and 2020. By 2011, MRES will have an expected shortfall of 8 MW of generation capacity, increasing to 230 MW by 2020. App. Ex. 44, p. 3.

40. MRES has a Power Purchase Agreement with its municipal utility member Hutchinson, Minnesota (HUC) under which MRES has an obligation to sell, and HUC to purchase, 40 MW of capacity and related energy from the Big Stone Unit II. App. Ex. 44, p. 2.

41. MRES performs integrated resource planning, including the use of a sophisticated capacity expansion software tool which performs a combined analysis of forecasted energy requirements, demand-side management programs, and supply-side generation capability (including renewables) to determine how projected energy requirements are going to be best met in the future. The results of MRES' capacity expansion integrated resource planning confirms that 150 MW of the Big Stone Unit II project is a least-cost alternative for MRES, including the 40 MW needed to serve the HUC PPA. App. Ex. 44, pp. 10-12.

GRE

42. GRE forecasts that from 2004-2023 its demand will increase an average of approximately 96 MW per year. During the same period, GRE forecasts its energy requirements will increase by an average of approximately 337,500 MWh per year. App. Ex. 2, p. 12-13, including App. Ex. 2-D and 2-E; App. Ex. 54, Tables 3-3 and 3-4.

43. Based on GRE's continued strong load growth and the expiration of several purchase contracts, GRE will experience a capacity deficit of approximately 680 MW in 2011. App. Ex. 2, p. 11.

44. GRE conducts extensive integrated resource planning, including the use of sophisticated computer models to determine the correct, cost-effective combinations of DSM, renewables and other resources to be used to meet its customers' needs. Those resource-planning techniques have recently been expanded to include a capacity expansion optimization model as another planning tool used to confirm the need for Big Stone Unit II. The results of that analyses determined that a baseload resource such as Big Stone Unit II is projected to be needed in 2011 and to be least cost. App. Ex. 14, p. 13; App. Ex. 44.

MDU

45. Montana-Dakota's forecasts show that its energy use is growing at an average annual rate of 1.3% over the next ten years. Montana-Dakota's energy requirements are forecast to be approximately 2,440 gigawatt hours (GWh) in 2006, 2,650 GWh in 2011 and 2,744 GWh in 2016. The compounded average rate for energy requirements is 1.0 percent per year. Montana-Dakota's most recent forecast shows capacity deficits beginning in 2011 (101 MW) and increasing steadily through 2021 (164 MW). App. Ex. 11, p. 8; App. Ex. 11-C.

46. Montana-Dakota experiences a capacity deficit in 2011 of 101 MW, and the capacity deficits increase to 134 MW in 2016 and 164 MW by the summer of 2021. The deficits are largely caused by the 2006 expiration of a 66.4 MW baseload purchase agreement with Basin Electric Power Cooperative and increases in annual peak demand that grows at a rate of 1.1% per year. App. Ex. 11, p. 9.

47. Montana-Dakota undertakes extensive integrated resource planning efforts, including the use of sophisticated capacity expansion analysis that compares supply-side resources (including renewable resources) on a comparative basis with demand-side resources. The result of this analysis, along with Montana-Dakota's exercise of prudent management decisions regarding the high cost of natural gas, shows that Montana-Dakota's proposed share in Big Stone Unit II is projected to be its least-cost alternative. App. Ex. 11, pp. 10-11.

48. While Montana-Dakota's resource planning shows that its proposed 116 MW share of Big Stone Unit II in 2011 meets its needs, the evidence also shows that Montana-Dakota could justify another 10 MW. First, additional capacity would provide an incremental level of risk management to cover load forecast uncertainty, future resource uncertainty, and the potential for extreme weather conditions, thereby improving system reliability. In addition, ten additional megawatts would satisfy its customers' demand for capacity and energy requirements through 2015, thereby delaying the need for its next resource addition for another two years. App. Ex. 48, p.7.

SMMPA

49. SMMPA forecasts energy growth of 2.4% of its members over the next decade. The evidence shows that energy use in 2004 was 2,943,972 MWhr, and increases to 3,637,903 MWhr by 2014 and 4,037,580 MWhr by 2020. SMMPA forecasts annual demand growth of approximately 1.2% over the next decade. SMMPA's forecasted demand was 536 MW in 2005 and increases steadily to 640 MW by 2020. App. Ex. 13, p. 4.

50. SMMPA engages in sophisticated integrated resource planning, including the use of capacity expansion software modeling tools to forecast and plan the future power and energy resources necessary to meet its members' obligations. The modeling tools used by SMMPA are designed to evaluate integrated resource plans, independent power producers, avoided costs, and plant life management programs. These tools also have modules developed to specifically accommodate the integration of demand-side-management options and to facilitate the development of environmental compliance plans. App. Ex. 13, p. 3.

51. Because natural gas prices continue to climb, SMMPA's most recent analyses showed that a 100 MW share of a pulverized coal plant in 2011 is its least-cost alternative. A 50 MW share of a pulverized coal plant would be its second-best plan followed by a 50 MW, gas-fired alternative. Thus, SMMPA's proposed 47 MW participation in Big Stone Unit II is a least-cost option for its customers, combined with its plans for certain defined amounts of conservation and renewables. App. Ex. 45, p. 8.

CMMPA

52. Net energy for load and peak demands for CMMPA members participating in the project are projected to grow at annual growth rates of approximately 1.5 percent over the twenty year period from 2006 through 2025. Primarily following the forecast trends for major economic indicators used to develop the forecast, load growth rates for the CMMPA members are projected to decline over time, with growth rates of approximately 1.6 percent over the first decade of the forecast period (2006 through 2015), declining to approximately 1.4 percent over the second decade of the forecast period (2016 through 2025). The annual coincident peak demand of the CMMPA members is projected to be 177 MW by the summer of 2011 (the summer immediately following the anticipated commercial operating date for the Big Stone Unit II). App. Ex. 47, p. 4.

53. Assuming a 15 percent MAPP planning reserve margin is applied to the forecast of coincident peak demands for the CMMPA members, CMMPA is first in need of capacity additions in 2008. Capacity deficiencies in 2008 are projected to be rather small (less than 2 MW), and capacity needs are projected to increase only slightly in 2009 as certain purchase power contracts are set to expire and other planned resources are scheduled to come online. However by 2011, without the addition of the CMMPA members' share of Big Stone Unit II, the reserve margin for CMMPA is projected to fall below 10 percent. Capacity needs are projected to grow by an average of 3.5 MW per year thereafter. By 2025, if no capacity other than currently planned amounts are added, CMMPA would need approximately 58 MW of capacity additions.

54. CMMPA employed a sophisticated capacity expansion analysis as part of its resource planning efforts. The resource expansion analysis was performed using a generation and demand-side planning optimization analysis software package, which employs a dynamic programming optimization technique combined with a convolution generation dispatch process to approximate the operation of generating resources and power purchases and sales for electric utilities. Through this dynamic optimization process, the software tool explores all potential generation expansion plans that can be produced from a given set of resource alternatives and identifies the best candidate plans based on the planning objectives identified by CMMPA. Based on that analysis, a resource expansion plan consisting of the planned 30 MW of the Big Stone Unit II in 2011, plus an additional 10 MW of installed wind capacity in 2011, followed by 10 MW of supercritical pulverized coal capacity installed every two to three years beginning in 2019, was found to be the least-cost potential resource expansion plan. App. Ex. 47, p. 7-8.

HCPD

55. HCPD is projecting peak demand in 2006 of 118 MW. This forecast grows to 157 MW in 2008 (or 39 MW higher than as originally indicated in the Application), and 152 MW by 2021 (45 MW higher than as originally indicated in the Application). HCPD forecasts energy growth of 725,443 MWhr in 2006, growing to 876,257 MWhr by 2021. App. Ex. 49, p. 8; App. Ex. 49-B.

56. HCPD's proposed 25 MW share of Big Stone Unit II in 2011 is a least cost option for HCPD. The evidence also shows that HCPD's needs could justify another five MW. First, the additional capacity would provide an additional, incremental level of risk management to cover forecast uncertainty, future resource uncertainty, and the potential for extreme weather conditions. Second, HCPD revised forecast shows total growth at approximately four to five 5 MW per year in the 2001-to-2013 time period. As a result, a larger share in Big Stone Unit II would satisfy its customers' demand for baseload capacity and energy requirements for an additional one or two years, and thereby help HCPD delay the need for its next baseload resource addition. App. Ex. 15, p. 6; App. 49, p. 11.

Conservation/Demand-Side Management

57. The Applicants have extensive plans for conservation and demand-side management (DSM) programs and renewables, in addition to the resource additions related to their respective shares of the Big Stone Unit II. Each has performed detailed, system-level studies of these resources, and as a result each is proposing a combination of DSM and renewables and Big Stone Unit II to round out its resource portfolios. App. Ex. 42, p. 2.

58. The Applicants have enacted significant DSM measures. Their plans include accomplishment of significantly more DSM in future years, in addition to Big Stone Unit II. Taken together, as of 2005 the Applicants have collectively reduced peak demand by approximately 560 MW, or the equivalent of a large-size generating plant, and reduced energy consumption by about 370 GWh per year. Together, over the next few years, the Applicants plan to reduce peak demand by an additional 240 MW, and reduce energy consumption by an additional 780 GWh per year, compared to 2005 levels. App. Ex. 42, p. 12.

OTP

59. OTP is committed to DSM and conservation. Approximately 13% or more of its capacity needs are expected to come from conservation and DSM measures. App. Ex. 10, p. 10. The projected incremental annual DSM energy savings in OTP's preferred resource plan over the 2006-2019 planning period, which also includes its share of Big Stone Unit II, are typically in the 8,000,000 kWh to 9,000,000 kWh range. As a comparison, OTP expects to receive approximately 900,000,000 kWh annually from its 116 MW share of Big Stone Unit II. Achieving the level of energy and demand savings necessary to replace the annual energy and capacity the company expects to receive from Big Stone Unit II is not practical or economically viable. App. Ex. 10, pp. 10-11.

MRES

60. MRES and its members have enacted significant DSM measures. The MRES resource plan includes the accomplishment of a significant amount of new DSM in future years, in addition to Big Stone Unit II. DSM and conservation efforts among MRES members have reduced generation capacity requirements by approximately 57 MW as of 2005. App. Ex. 44, p. 4.

61. MRES has modeled potential DSM additions to allow the capacity expansion software to analyze the direct impact of various levels of additional DSM on supply-side choices, in order to allow DSM to compete directly against supply-side (including renewables) resources in developing the optimal resource mix. According to the results of recent DSM studies undertaken by MRES, up to 82 MW of additional cost-effective DSM appears to be least cost, in addition to its participation in Big Stone Unit II. MRES' analysis also shows that HUC will benefit from additional DSM programs, though it does not offset its need for its share of Big Stone Unit II through its PPA with MRES. App. Ex. 44, pp. 10-13.

GRE

62. Conservation is an active part of GRE's planning efforts. Taken together, GRE's DSM efforts have reduced peak demand by approximately 369 MW, and reduced energy consumption by 169 GWh as of 2005. App. Ex. 43, p. 2. GRE plans to reduce demand by an additional 35 MW and to reduce energy consumption by an additional 59 GWh by 2007. App. Ex. 43, p. 3. GRE's DSM effort, along with its members, while significant, does not offset its need for its share of Big Stone Unit II.

MDU

63. As a tool to evaluate and determine the available and most cost-effective demand-side management programs applicable to MDU's system, demand-side analysis is an integral part of MDU's integrated resource planning process. Using the ratepayer impact and societal tests, DSM evaluation is performed for MDU's residential and commercial sectors. App. Ex. 48, p. 3.

64. MDU has implemented additional DSM measures that will result in 8.1 MW of demand savings by 2010, resulting in energy savings of 0.13% of energy requirements. MDU plans to implement an additional 6.5 MW of demand-side management and conservation measures during the 2006-2010 time period. These programs will result in approximately 38,000 MWh savings. Despite these demand and energy reduction goals, MDU's resource planning analysis nevertheless indicates that its share of Big Stone Unit II is reasonable. App. Ex. 48, p. 2, 8-9.

SMMPA

65. SMMPA and its members have made significant investment in load management and conservation programs. The DSM program budget for SMMPA and its members is typically between $3 million and $3.5 million annually, which represents 2% of its members' aggregate gross operating revenue. The total DSM savings achieved from SMMPA's members in 2003, and 2004 alone was approximately 28 MW

and 13,416 MWhr, and 32 MW and 19,407 MWhr, respectively. SMMPA continues to look for, evaluate and add new conservation initiatives. Such DSM efforts will be effective in reducing the size and/or delaying the timing of additional SMMPA resources. SMMPA's DSM resources are important in deferring the investment in new generation facilities, including Big Stone Unit II, but they are not a replacement. App. Ex. 13, pp. 7-8.

CMMPA

66. In the past, CMMPA has had no direct control over the development and implementation of the DSM and energy conservation programs of its members as the members are individually responsible for demand-side management and conservation programs. Nonetheless, CMMPA has assisted and encouraged its members to establish the reporting of the effects of the various DSM and conservation programs. CMMPA is currently developing an integrated load management system for its members. App. Ex. 46, p. 3.

67. CMMPA did evaluate incremental demand-side programs against the lowest cost of the generating resource expansion cases (the addition of 30 MW of Big Stone Unit II capacity in 2011 along with 10 MW of wind capacity 2011 and future additions of coal capacity). The results of this analysis reveal, however, that the average cost per demand and energy reduction resulting from the CMMPA member DSM programs is higher than the marginal avoided costs of generation production and capacity. These results indicate that the existing demand-side programs of the CMMPA members cause higher total and average operating costs for the members than would otherwise occur if the members implemented no demand-side programs and that any increase in funding and implementation of the current demand-side programs of the members would not be cost-effective. App. Ex. 47, pp. 10-11.

HCPD

68. HCPD, as a supplemental wholesale power supplier, works with its wholesale customers to promote demand-side management programs and conservation. It assists its municipal customers in the evaluation and development of many conservation and load management programs. Each of HCPD's municipal customers is responsible for monitoring the effectiveness and accomplishments of its individual energy conservation efficiency programs and reporting those efforts to HCPD. App. Ex. 15, p. 6. In 2005, HCPD estimates that it reduced its peak demand by 7 MW, and reduced its energy consumption by 90 MWh. HCPD will continue to work with its customers to encourage more efficient use of their electric supply through load management efforts. App. Ex. 49, p. 3.

Renewables

69. Collectively, the Applicants are pursuing a significant amount of renewable energy projects in addition to the Big Stone Unit II Project. Taken together, as of 2005 the Applicants are already producing or purchasing more than 740 GWh per year from a variety of renewable resources. In addition, the Applicants plan to install or purchase an additional 2,170 GWh per year of renewable energy over the next few years. Putting the total 2,910 GWh per year of existing and planned renewables efforts of the Applicants in perspective, although it will come from a variety of renewable sources, it is equivalent to more than 950 MW of wind machines operating at a 35% annual capacity factor. App. Ex. 42, p. 20. The Applicants have shown, however, that additional renewable generation is not a replacement for the baseload need to be provided by Big Stone Unit II. The Applicants will be pursuing Big Stone Unit II and additional renewable generation projects. E.g. App. Ex. 42, Ex. 48, p. 4 Ex. 41, p. 7.

OTP

70. Over the past few years, Otter Tail's resource mix has varied from 9% to 11% renewable resources on an energy basis. On March 31, 2006, OTP issued a Request-for-Proposals (RFP) for 75 MW of additional renewable resources. OTP's resource plan calls for adding the equivalent of 110.5 MW of new wind generation by 2015. App. Ex. 42, p. 21.

MRES

71. MRES has existing renewable energy resources, and is planning significant renewable resource additions, including approximately 40 MW of new wind energy by 2020. App. Ex. 14, p. 10, 13-17.

GRE

72. GRE has made a significant commitment to renewable energy, particularly wind energy. GRE's 2005 renewable energy generation was 248,816 MWh, more than two times its Minnesota Renewable Energy Obligation goal for 2005.. GRE expects to have approximately 1.6 million MWh of renewable energy in its portfolio by 2020. App. Ex. 2, pp. 8, 14-15; App. Ex. 43, p. 4.

SMMPA

73. SMMPA already has under commitment approximately 8.5 MW of wind energy that is used to serve its customers. App. Ex. 13, p. 5. It has plans to add approximately 60 MW of wind energy by 2015. App. Ex. 45, p. 5.

CMMPA

74. CMMPA also is pursuing renewable energy projects. In 2005, CMMPA entered into three wind energy purchase agreements, which provide for the purchase of 6 MW beginning in 2005 and 16.25 MW beginning in 2006, for a total of 22.25 MW. In addition, the City of Blue Earth, a CMMPA member, has recently entered into an agreement for the purchase of 2.5 MW of wind energy from a project developed by a local farmer. CMMPA is also active in the research of the potential use of landfill methane gas in the generation of electrical energy. It has been investigating a possible project at an operating landfill site. The project involves harnessing the potential energy benefits from the methane gas at the site, currently being flared to the atmosphere. The total output of the project would be between 2500 kW and 3000 kW. App. Ex. 46, p. 5.

HCPD

75. In 2005, the wind turbines at various customer sites produced 1,616 MWhr. HCPD is currently investigating the potential for additional wind energy developments. HCPD is negotiating for the output of a proposed wind development in central South Dakota in the minimum amount of 5MW. HCPD is also evaluating, in conjunction with several of its customers, the addition of wind turbines adjacent to the customers' communities. HCPD is also evaluating a landfill gas generator with one of its customers. App. Ex. 49, p. 4.

Consequences of Delay

76. Any delay in construction of Big Stone Unit II could have significant negative consequences for the Applicants, the region, and ultimately the consuming public. App. Ex. 5, p. 8; App. Ex. 25, p. 2; App. Ex. 15, p. 7; App. Ex. 2, p. 18; App. Ex. 4, p. 8; App. Ex. 10, p. 17; App. Ex. 11, pp. 9, 11; App. Ex. 3, p. 13. It increases the probability of inadequate regional generation capability and causes a reduction in the reliability of the Applicants' systems and the regional electrical supply system. Id.

77. If Big Stone Unit II does not become operational, the owners have scarce alternative resources from which to obtain energy, they are faced with increased risk and cost, and there is no single next best resource alternative or other baseload project from which to obtain the needed energy. App. Ex. 5, p. 8; App. Ex. 25, p. 2; App. Ex. 15, p. 7; App. Ex. 2, p. 18; App. Ex. 4, p. 8; App. Ex. 10, p. 17; App. Ex. 11, pp. 9, 11; App. Ex. 3, p. 13. Intervenors have not proposed an alternative to provide baseload capacity through natural gas or oil instead of coal. HTr 534. Intervenors have not suggested any specific alternative to Big

Stone Unit II, and are not specifically recommending any wind/gas combination as an alternative to Big Stone Unit II. HTr 747-48.

78. If Big Stone Unit II is not built, and a higher-cost alternative power source used instead, there would be higher costs for electricity to the consumers, and this in turn would lead to less disposable income for those consumers to meet other household needs and cause adverse impacts on South Dakota residents in terms of health, safety, welfare, and employment. App. Ex. 31, pp. 34-36. Applicants have a demand for Big Stone Unit II, despite current reserves, conservation and DSM programs and renewables.

9.0 GENERAL SITE DESCRIPTION

79. Big Stone Unit II will be constructed adjacent to the existing Big Stone Unit I, on approximately 3,200 acres located in Grant County, South Dakota, east of Milbank, South Dakota, approximately two miles west-northwest of Big Stone City, South Dakota, and two miles from the Minnesota border. MR 6. The facility will be accessible from U.S. Highway 12 at Big Stone City via State Highway 109 and County Road 34 (144th Street) and from U.S. Highway 12 via County Road 4 and 484th Avenue. App. Ex. 54, p. 2 and Ex. 1-3; App. Ex. 8, p. 6.

80. The site is situated in a relatively flat to gently rolling landscape comprising agricultural fields interspersed with small emergent wetlands. App. Ex. 17, p. 11. There are no large metropolitan areas nearby. App. Ex. 53, Table ES-4, p. ES-21.

81. Big Stone I sits on 2,200 acres. App. Ex. 8, p. 9. 1,200 acres are available for Big Stone Unit II, with an existing option to purchase an additional 625 acres. App. Ex. 27, p. 20. For Big Stone Unit II, an additional 530 acres of land will be taken permanently, with an additional 90 acres to be taken out for the construction phase; the land to be taken is primarily agricultural land. Current and future agricultural land use issues arising from the proposed construction and operation of Big Stone Unit II is remote. App. Ex. 29, p. 20.

10.0 ALTERNATIVE SITES

82. Criteria used for site selection included location (e.g., presence in North Dakota, South Dakota or Minnesota, away from residents, recreation and parks, etc.); available infrastructure (e.g., rail, transmission lines, water); and environmental impact. App. Ex. 8, pp. 6 -7.

83. Thirty-eight (38) initial alternative sites were considered; these sites were located in South Dakota, North Dakota and Minnesota, which is consistent with the Applicants' service territories. App. Ex. 8, pp. 6-7; HTr 86. Thirty of these sites were eliminated due to lack of available water supply or nearby residential development, leaving eight sites that were evaluated in more detail. Id. Of these eight sites, two were further eliminated due to nearby residences and development. App. Ex. 8, p. 7.

84. Weighted criteria were used to rank the remaining six sites. App. Ex. 8, p. 8. The criteria included air impacts, water supply, environmental considerations, fuel supply, transmission availability, highway access, land availability and staff. App. Ex. 8, p. 8; App. Ex. 54, Application, Table 3-5. Generally, water supply, fuel lines, and transmission were each given a weight of 20%; environmental issues and air quality specifically were each given 15%; and other factors, such as highway access were given 10%. App. Ex. 8, p. 8.

85. The Big Stone site ranked highest. App. Ex. 8, p. 8. The Big Stone site received the highest weighted score, due primarily to the availability of existing infrastructure, such as water structures, rail spur, staff and waste disposal. App. Ex. 2, pp. 6-7; App. Ex. 7, pp. 8-9; App. Ex. 26, p. 8. In addition, area residents are already familiar with the construction and operation of a power plant, having lived with Big Stone Unit I for more than 30 years. App. Ex. 8, p. 8. Location at this site allows for a common wet scrubber to be used by Big Stone Units I and II. App. Ex. 8, pp. 8, 11.

86. The other five sites were rejected due to considerations, such as location to wildlife refuges, insufficient existing transmission lines or water supply, higher population density and location to lignite fields. App. Ex. 54, Application, pp. 63-65.

87. The process by which the site was selected was reasonable, and Applicants' determination that the Big Stone site is the best site for them on which to locate the proposed facility is reasonable.

11.0 ENVIRONMENTAL INFORMATION

88. The Applicants have described the existing environment and the potential environmental effects of Big Stone Unit II in detail in the Application and in their testimony. The Applicants hired Barr Engineering to assist in the preparation of the Application. Barr conducted site surveys and reviewed available information and work product of other consultants hired by the Applicants. App. Exs. 17, 18, 19, 20, 21, 26, 27 and 54. In addition, the potential environmental effects have been identified and considered in an Environmental Impact Statement being prepared by the Western Area Power Administration for the federal government, which was required due to the request to interconnect to two Western Area Power Administration substations which thereby involves a major federal action significantly affecting the quality of human environment. App. Ex. 16, pp. 4-5; App. Ex. 53. The U.S. Department of Agriculture, Rural Utilities Service ("RUS") and the U.S. Department of Defense, Army Corps of Engineers ("USACE") are both cooperating agencies for preparation of the EIS. On May 27, 2005, notice of intent to develop an EIS was published. Id. On May 6, 2006, the draft EIS was sent to the parties. App. Ex. 34, pp. 6-7. The draft EIS was published and made available to the public beginning on May 6, 2006. Id. Notices of the hearing were published in 12 papers two times, and 6,000 mailings regarding notices were sent. Id. The draft federal EIS is a part of this administrative record, App. Ex. 53. Public hearings were held on the draft EIS on June 13-16, 2006, in Big Stone City, South Dakota, and Morris, Minnesota, Granite Falls, Minnesota, and Benson, Minnesota, respectively. A Record of Decision is expected from the Western Area Power Administration in December 2006. App. Ex. 34, p. 6.

89. The Applicants calculated through a narrative description the potential environmental effects from Big Stone Unit II consistent with past Commission practice. ARSD 20:10:22:13; App. Ex. 54, Section 4; App. Ex. 16-22, 27, 30, 34, 36-38, 52.

90. Assuming the Applicants comply with the environmental conditions of this decision and permit and the air quality, water quality, solid waste and water appropriation permits which Applicants must obtain in order to construct and operate the facility, no serious long-term effects to the environment or to health have been demonstrated as probable of occurrence from operation of Big Stone Unit II.

12.0 EFFECT ON PHYSICAL ENVIRONMENT

91. The Big Stone II Project area is situated in a relatively flat to gently rolling landscape comprising agricultural fields interspersed with small emergent wetlands. The existing Big Stone Plant Unit I is situated on an area developed for industrial use, and includes one large artificial cooling pond, an evaporation pond, a holding pond, and several smaller impoundments. Southeast of the plant, the Whetstone River meanders eastward to the Minnesota River. Immediately adjacent to the Whetstone River, the topography changes abruptly to steep 50 to 60-foot embankments. App. Ex. 54, at Section 4.1.1.

92. The Applicants provided a topographical map of the local area at 1.0 foot contours. App. Ex. 54.

93. Construction of the Big Stone II facility will result in the conversion of additional land into active industrial use. Approximately 500 acres, mostly in existing cropland, will be converted to an open makeup storage pond. Another 30 acres will be converted to a cooling tower blowdown pond. Grading for the new plant structure and cooling tower within the existing Big Stone Plant Unit I site will not appreciably alter the existing topography. App. Ex. 54, at Section 4.1.1.

94. The overall indirect or cumulative geological characteristics do not require any constraints on the construction and operation of Big Stone Unit II. App. Ex. 19, p. 4. Big Stone Unit II will not have an adverse impact relating to the geology in the region. App. Ex. 19, p. 2.

95. There are no economically valuable mineral deposits within the project boundaries. App. Ex. 54, p. 82.

96. Sixteen land use types exist in the project area. Crop and grassland consist of over 80% of the area. The remaining uses include industrial, woodland and wetlands. Construction of the plant will take place primarily on grassland. Ponds and the construction laydown area and parking will be constructed mainly in row crop and pasture lands. Some of the soils on the project site are classified as farmland soil; excavation will occur in areas that are primarily farmland soil. Big Stone Unit II will not have a detrimental effect on the soil. App. Ex. 22, p. 13.

97. An erosion and sedimentation analysis regarding construction and operation was done. A moderate-to-low erosion factor was determined. After construction, stabilization methods will be employed to prevent erosion from wind and water. App. Ex. 17, p. 7.

98. No seismic risks, subsidence potential, or slope instability exists in the siting area. Some grading will be done, but it will not appreciably alter the existing topography or create instability. App. Ex. 54, p. 83.

13.0 HYDROLOGY

99. Water for Big Stone Unit II will come from Big Stone Lake. App. Ex. 18, p. 8. Pumps will deliver water through an existing underground pipeline to ponds on the Big Stone property. Storage ponds will be created that have sufficient capacity to operate both Big Stone Units I and II during most drought conditions without recharging onsite storage from Big Stone Lake. Over a 70-year period, Big Stone Lake is expected to be impacted, on average, 2.5 inches. App. Ex. 18, pp. 8-9; App. Ex. 36, pp. 3-7; HTr 286-87.

100. Changes in drainage patterns due to the project will primarily be related to the construction of the makeup storage pond. The makeup storage pond will alter local surface water drainage patterns because of its size and configuration. However, this alteration is not expected to have deleterious impacts on local surface drainage. The makeup storage pond simply alters the route of the drainage. App. Ex. 17, p. 3.

101. Makeup water will be withdrawn from Big Stone Lake in compliance with permits and when the lake is at acceptable levels. App. Ex. 16, p. 14; App. Ex. 18, pp. 8-9. The additional makeup water will come from extended operation time of the existing pumps with no increase in the withdrawal rate. The impact on Big Stone Lake will be infrequent, and adverse affects on the lake are not expected to be significant. App. Ex. 18, pp. 10-11. The Applicants may rely on the use of groundwater during construction of Big Stone Unit II and may consider groundwater sources for water supply during periods of extended drought. HTr 273. In the absence of an alternative water supply in periods of extended drought, it is possible the plant could not be operated. HTr 273.

102. Three wetlands will be directly impacted during project construction. App. Ex. 17, p. 11. Alternatives to completely avoiding the wetlands are not feasible. App. Ex. 17, p. 11. The proposed construction reflects the most practicable alternative to minimize the impacts to wetlands. App. Ex. 17, p. 11. Indirect impacts to wetlands will also occur, however, the risk of harm is low, cumulative impacts on wetlands is minimal, and management and monitoring will be undertaken. Mitigation efforts as directed by governmental agencies will be complied with. App. Ex. 17, p. 11-12. In addition, measures to contribute to mitigation will be undertaken such as restoration and/or enhancement of unaffected wetlands, establishment of new wetlands, and enhancement of existing wetlands. App. Ex. 17, p. 12.

103. Big Stone Unit II will be required to comply with all hydrologic governmental standards. App. Ex. 17, p. 5.

104. On or about March 16, 2006, the Applicants filed a permit with the South Dakota Water Management Board to increase the appropriation of water under the existing permit. App. Ex. 36, p. 4. A hearing will be held on such application before the Water Board on or about July 12 and 13, 2006. App. Ex. 34, pp. 7-8; Ex. 34-B; HTr 100, 118.

14.0 LAND USE

105. The existing Big Stone II Project area comprises sixteen land use types. The Application contains a map showing the various land use types, Application, Exhibit 4-1-1, and lists the types in Table 4-7. Existing land use is dominated by row crops, which account for over half of the total Project area. Grass-dominated land uses, including industrial grasslands, pastured areas and hayfields account for another third of the Project area.

106. The Application also contains maps showing the cities, lakes, rivers, water supplies, cemeteries, historical places, housing, transportation/public, noise sensitive land use, adjacent facilities, major industries, surface water drainage, pastureland/rangeland/hayland, crops, grassland, and nonrenewable resources.

107. The construction of Big Stone II will take place primarily in existing industrial grassland areas. The cooling tower blowdown pond and the makeup storage pond will be constructed mainly in row crops and pasture lands, as will the construction laydown area and parking. App. Ex. 54, at Section 4.5.1.

108. There are no significant impacts to land use associated with the Big Stone Unit II Project.

15.0 EFFECT ON TERRESTRIAL ECOSYSTEMS

109. Big Stone Unit II will not have a detrimental effect on wildlife. App. Ex. 22, p. 13. Wildlife in the area consists primarily of game animals, songbirds, waterfowl and fur-bearers. App. Ex. 37, pp. 1-3. Three federally listed species that may occur in the project area include the Bald eagle, the Topeka shiner, and the western prairie fringed-orchid. App. Ex. 37, pp. 1-3. No adverse impact to these species is expected. App. Ex. 37, pp. 1-3.

110. On the Big Stone Unit II property, 24 vegetation cover types comprising 120 plant communities exist. 87% of the total vegetative cover is rated as low ecological quality. Most of the direct impacts to vegetation will affect the low ecological quality vegetation. Indirect impacts to vegetation may occur due to alteration of surface water drainage patterns and introduction of non-native invasive plant species to the area. Mitigation efforts will be undertaken to minimize vegetative impacts. App. Ex. 17, pp. 14-15. Construction and operation of Big Stone Unit II will have a minimal cumulative impact on vegetation in the area. App. Ex. 22, p. 13; App. Ex. 18, p. 11.

16.0 EFFECT ON AQUATIC ECOSYSTEMS

111. Big Stone Unit II will not result in either direct or indirect significant impacts to fish populations. App. Ex. 22, p. 13; App. Ex. 17, p. 12; App. Ex. 18, p. 15. Some impingement and entrainment may occur associated with water intake for cooling, however, a water intake structure and systems will be in place to reduce these occurrences to a minimum. App. Ex. 17, p. 12.

112. In part because Big Stone Lake is now regulated and will continue to be regulated at a fixed elevation, no significant adverse effects on water bodies are expected due to the water needs for the operation of the Big Stone Plant after Big Stone Unit II goes on line. App. Ex. 18, p. 10.

17.0 LOCAL LAND USE CONTROLS

113. A portion of the plant site in the vicinity of the makeup water storage pond will require rezoning from agricultural to industrial use. The Grant County Planning and Zoning Board and the Grant County Commission will review and consider the request for rezoning. The project will need a building permit from Grant County. App. Ex. 16, p. 21.

114. Other than the one rezoning issue described above, Big Stone Unit II will be required to comply with existing zoning, building rules, regulations, and ordinances pursuant to the conditions of this order.

18.0 WATER QUALITY

115. The facility will be a zero liquid discharge facility so that no process water will discharge to the surface drainage network. Consequently, plant operations will have minor impact on the existing water quality of watersheds and/or streams. App. Ex. 17, p. 7.

116. Big Stone Unit II includes a wet cooling system that involves a closed-loop circulating water system. Circulating water is used to condense steam, and the condensate is collected and returned to the boiler feed-water system. The warm water is then circulated through a cooling tower, which dissipates heat through evaporation. App. Ex. 16, p. 11. Small droplets of circulating water (drift) will be entrained within the cooling tower plume. App. Ex. 16, p. 11. Once cooled, the circulating water is returned to the condenser to complete the cooling circuit. Water for the cooling system will be supplied from the existing Big Stone I cooling pond. Makeup water for the cooling pond will be supplied from Big Stone Lake and the Minnesota River. App. Ex. 18, p. 9. To conserve fresh water, cooling pond water will be reused as makeup to the facility-cooling tower. App. Ex. 54, p. 30.

117. Construction-related water quality impact will be limited and controlled by the implementation of best management practices ("BMPs") for soil erosion. The specific BMPs for the Big Stone II project will be detailed in the Stormwater Pollution Prevention Plan that is part of the National Pollutant Discharge Elimination System Permit that is required prior to beginning construction. App. Ex. 18, p. 7.

118. All applicable water quality standards and regulations will be complied with, and necessary permits obtained. App. Ex. 17, pp. 5, 10; App. Ex. 18, p. 9. No significant adverse environmental impacts are expected relating to water, wetlands, aquifers or reservoirs. App. Ex. 17, pp. 3, 7, 8; App. Ex. 17, p. 9.

19.0 AIR QUALITY

119. The pollutants of concern that will be emitted by Big Stone Unit II include the following: sulfur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM10), sulfuric acid mist (SAM), fluorides, mercury (Hg), volatile organic compounds (VOCs), lead, and carbon dioxide (CO_2). See, e.g., App. Ex. 16.

120. SO2, NOx, and PM10 are criteria pollutants, for which national ambient air quality standards have been established by the U.S. Environmental Protection Agency. There will be no violations of any national ambient air quality standards resulting from operation of Big Stone Unit II. See e.g. App. Ex. 22.

121. The Applicants are required to obtain a permit from the South Dakota Department of Environmental and Natural Resources ("DENR") for operation of Big Stone Unit II. On or about July 21, 2005, the Applicants filed an application for a Prevention of Significant Deterioration ("PSD") air quality construction permit. As part of that process, the DENR will ensure that Big Stone Unit II will comply with all applicable requirements, including Best Available Control Technology ("BACT"), New Source Performance Standards ("NSPS"), acid rain, mercury, and Prevention of Significant Deterioration ("PSD") requirements. The DENR issued a draft permit on April 26, 2006, and the public comment period ended on June 26, 2006. HTr 118.

The Applicants have committed to comply with all applicable requirements established by the DENR, including the emission limits established for the various pollutants that will be emitted and all record keeping and reporting requirements. App. Ex. 16, 22, 34.

122. The Applicants intend to install highly effective pollution control equipment to control emissions of pollutants into the atmosphere. One piece of control equipment is a wet flue gas desulfurization system (wet scrubber) that will capture sulfur dioxide emissions from both Unit I and Unit II. In addition, a pulse-jet fabric filter will be installed to control particulate matter, including small particles less than 10 microns in size. The wet scrubber and the fabric filter will also remove some of the mercury in the exhaust gases. The Applicants will use fabric filters or passive dust control methods to control emissions of fugitive dust from material handling processes. App. Ex. 16, p. 10.

123. The supercritical boiler that is planned for Unit II will use burners that produce low levels of nitrogen oxides and will employ a selective catalytic reduction ("SCR") emission control technology to further control emissions of nitrogen oxides from Unit II. App. Ex. 16, pp. 10-11.

Sulfur Dioxide and Nitrogen Oxides

124. The emissions of sulfur dioxide from Unit I and Unit II will be only 1/7 of what they are presently from Unit I because of the installation of the wet scrubber to control emissions from both units and the use of the SCR system on Unit II. HTr p. 118.

125. Nitrogen oxide emissions from Unit I will be reduced through more aggressive operation of Unit I's over-fire air system so that the sum total of nitrogen oxide emissions from Unit I and Unit II will be equal to or less than Unit I's historical emissions. App. Ex. 16, p. 11.

126. Due to the control equipment and technology that will be installed to control sulfur dioxide and nitrogen oxides, the net change in emission of these pollutants is below the level required for PSD review. App. Ex. 22, p. 4.

Mercury

127. Because mercury is a trace element in coal, there will be emissions of mercury from combustion of the coal. Elemental mercury that is emitted out the stack will travel great distances before being deposited. Mercury accumulates in fish, and various state governments have issued advisories regarding the eating of fish from lakes where mercury has been found. App. Ex. 53, EIS, pp. 4-8-4-10, 4-26.

128. The U.S. Environmental Protection Agency promulgated the Clean Air Mercury Rule in May 2005. EPA established a New Source Performance Standard of 42 x 10-6 pounds of mercury per megawatt hour for new sub-bituminous coal-fired power plants. That standard was changed to 66 x 10-6 pounds per megawatt hour in June 2006. This standard would allow Big Stone Unit II to emit 330 pounds per year at its anticipated capacity. App. Ex. 16, p. 12 and 22, p. 14.

129. In the year 2004, Big Stone Unit I emitted 189 pounds of mercury into the atmosphere. In May 2006, the Applicants made a commitment to hold mercury emissions from both Unit I and Unit II combined to no more than 189 pounds per year, beginning three years after commercial operation of Unit II. Three years is a reasonable period of time to allow the Applicants to test and implement commercially available, technically feasible mercury control equipment. Even though electrical output from the Plant will increase by 130% over its current capacity, mercury emissions will not increase beyond the amount emitted during 2004 after the three-year testing and implementation period. App. Ex. 34, pp. 1-4 and Ex. 34A.

130. The Clean Air Mercury Rule ("CAMR") also establishes an allocation of mercury emissions for each state in the country for the years 2010 and 2018. South Dakota's allocation is 144 pounds of mercury per year beginning in the year 2010. Utilities may comply with the allocation requirements by reducing

emissions or by purchasing allowances. The Big Stone Applicants may be able to comply with the CAMR allowance limitation for South Dakota through installation of controls but, if necessary, it is expected that the Applicants will comply by purchasing allowances. The cost of obtaining these allowances cannot be determined at this time but will likely be in the millions of dollars per year. App. Ex. 34, pp. 1-4.

131. The Applicants have a financial incentive to select the most environmentally economical Hg emission control in existence. Possible future technology will be created to further reduce Hg emissions; such technology is anticipated to have a low cost. HTr 108, 582-83.

132. After the three year testing and implementation period, no additional impacts on the environment are expected from mercury emissions as a result of operation of Unit II because emissions of mercury will not exceed what is presently emitted from Unit I.

Carbon Dioxide

133. The combustion of fossil fuels including coal results in the formation of carbon dioxide. Carbon dioxide is a greenhouse gas. Big Stone Unit II is projected to emit 4.7 million tons of CO_2 per year. App. Ex. 53, p. 4-10- 4-11. Assuming an operating lifetime for Big Stone II of 50 years and no installation of CO_2 capture system, the plant will emit over 225 million tons of CO_2 before it closes. Ex. JI-2 at 26.

134. The Energy Information Administration reports that anthropogenic carbon dioxide emissions in 2010 are project to be 6,365 million metric tons in the United States alone. Worldwide, the projected 2010 CO_2 emissions figure is 30,005 million metric tons. App. Ex. 29, p. 6.

135. Based on projected annual emissions of 4.7 million tons, Big Stone Unit II would increase U.S. emissions of carbon dioxide by approximately 0.0007, or seven-hundredths of one percent. As a result, the proposed Big Stone Unit II plant will not contribute materially to increases in the production of anthropogenic carbon dioxide. App. Ex. 29, p. 6.

136. Big Stone Unit II will produce about 18% less CO_2 than other existing coal-fired plants because the super-critical boiler proposed here is more efficient than other forms of coal-fired technologies. App. Ex. 2, p. 7.

20.0 RISK OF REGULATION/ENVIRONMENTAL COSTS

137. Issues arose at the hearing as to whether costs should be imputed to the project for possible future regulation of CO_2 emissions. Neither federal government regulations nor South Dakota regulations have been established for CO_2 emissions. Minnesota has established environmental cost values for CO_2 emissions from electric generation, but these values do not apply to generation located outside of Minnesota. App. Ex. 30, p. 7, 5; App. Ex. 34, p. 2; HTr 737-39. It is speculative whether Congress or South Dakota will regulate CO_2, and, if either does so, what the timing and stringency of those regulations will be. App. Ex. 30, p. 9; 19-20; HTr 89-90, 523, 737-43. Quantifying the cost of future CO_2 regulations is therefore a speculative undertaking, and the evidence shows that only a small minority of states utilize quantified values to approximate the cost of future regulation. App. Ex. 30, p. 12.

138. Evidence adduced at the hearing shows that only a few states have required CO_2 emission reductions from electric generators. A group of Northeastern states is currently examining such regulations; however, the cost of the program (projected CO_2 allowance prices of $1-$3) is expected to be relatively modest. States either implementing or considering CO_2 reduction programs generally utilize far less coal generation than South Dakota (and the United States) as a percentage of their total electric generation portfolios. Such states also have higher electric rates than South Dakota. Hence, these states do not furnish a model for South Dakota for purposes of examining the CO_2 issue. App. Ex. 30, pp. 10-28.

139. Evidence was also adduced at the hearing concerning various bills introduced in Congress that would regulate CO_2 emissions. These bills do not furnish support for Intervenors' contention that there should be a cost imputed to Big Stone Unit II for future CO_2 regulation in an amount equal to $7.80-$30.50, with a mid-case range of $19.10 per ton. None of these bills passed either branch of Congress. One proposal that appeared to have the best chance of passing the Senate last year, but was never voted on, had a maximum "safety valve" allowance price cap of less than $6.36 per ton. Various planning numbers were discussed at the hearing in the $5-$6 range, and Minnesota has a CO_2 environmental cost value for use in electric generation resource planning of between $.35 and $3.64 for in-state generation. In any event, all reasonable planning numbers for possible future CO_2 regulation were substantially less than the Intervenors' $19.10 mid-case number, and none appeared to affect the cost-effectiveness of the Big Stone Unit II project as compared to alternatives. App. Ex. 30, pp. 4-28.

21.0 TIME SCHEDULE

140. At the present time, construction is scheduled to begin in the spring of 2007 after all necessary permits and approvals are obtained, with commercial operation targeted for the spring of 2011. In mid-spring 2007, mobilization is scheduled to begin with support equipment being moved to the site. During the summer of 2007, site preparation and foundation installment will occur. Steel work will commence in early 2008, followed by erection of the boiler and turbine in late 2008. In early 2009, construction of the balance of the plant equipment will commence. Installation of the boiler and turbine will be completed by early 2010. Checkout procedures will next occur, with the unit being operated first in mid-2010. Commission and checkout will be complete in late 2010, for commercial operation in spring 2011. App. Ex. 8, pp. 9-10.

22.0 COMMUNITY IMPACT

141. No material adverse effects on cultural resources will occur from the construction and operation of Big Stone Unit II. App. Ex. 29, pp. 8, 18; HTr 268. Big Stone Unit II will not impact areas of high archeological potential nor materially impact the adjacent area in terms of historical purposes. App. Ex. 21, pp. 9-10. While two nearby properties have architectural significance, no adverse effect as to these properties exists with the construction and operation of Big Stone Unit II. App. Ex. 21, pp. 14-15. Two nearby residences may be affected, but one resident is retiring and moving and the Applicants are in discussion with the other resident to purchase the land for a storage pond. HTr 101.

142. No material adverse effect in terms of noise from Big Stone Unit II will occur. App. Ex. 21, p. 14; App. Ex. 20, p. 3; App. Ex. 38, p. 2; HTr 293-94. Big Stone Unit II is not expected to create a discernable increase in noise. App. Ex. 38, p. 2. Moreover, due to the construction of Big Stone Unit II, noise from operation of snow machines that have been the subject of complaints related to Big Stone I will be eliminated. App. Ex. 20, p. 3.

143. The construction, operation and maintenance of Big Stone Unit II is not anticipated to have a significant adverse impact on land use or the community. App. Ex. 27, pp. 3, 9-21; App. Ex. 21, pp. 14, 14. It will not detract from the energy needs in the area nor on sanitary sewer systems. App. Ex. 27, p. 17; App. Ex. 18, p. 15. Solid waste disposal will be managed during the construction and operation phase to not adversely affect the community or existing landfills. App. Ex. 27, p. 20. An increase in roadway and rail traffic will occur, which can be accommodated without adverse impact. App. Ex. 27, pp. 11-12; App. Ex. 18, p. 16. Parking needs are not a significant concern. Sufficient health and educational services and facilities exist to accommodate such needs during the construction and operation phases of Big Stone Unit II. App. Ex. 27, pp. 10-11; App. Ex. 18, pp. 17-18. Neither phase will create a drain on cultural or public safety resources. App. Ex. 27, pp. 14-16; JL 18. The influx of employees required can be absorbed by the surrounding communities. App. Ex. 17, p. 16. Housing needs can be met. App. Ex. 18, pp. 14-15. No significant adverse effect for any cultural resource, recreation, population or income of the primary communities will occur. App. Ex. 27, p. 20; App. Ex. 18, p. 18. The existing railway system is sufficient to mitigate any railway transportation concerns. App. Ex. 18, p. 17.

144. The community and social impacts of Big Stone Unit II are expected to be positive and potential adverse effects to the community will be ameliorated through planned measures. App. Ex. 27, pp. 3, 21; App. Ex. 18, p. 18.

145. The Big Stone Unit II project has strong community support. App. Ex. 27, p. 21. Resolutions of Support have been passed by the City of Big Stone, County of Grant, City of Milbank, Milbank School District School Board, and the Upper Minnesota River Watershed District. App. Ex. 27, p. 21.

146. Assuming the contingency construction housing plan is implemented as required in this decision, no significant adverse economic impacts are expected related to Big Stone Unit II. Taxes assessed on Big Stone Unit II will significantly increase the tax revenue base of the State of South Dakota and the communities surrounding the facility, both during the construction phase and the operational phase of Big Stone Unit II. App. Ex. 21, p. 19; App. Ex. 28, p. 6. It is anticipated an additional $11 million in sales tax, use tax and contractor's excise tax will be realized by the State of South Dakota during the construction of Big Stone Unit II. App. Ex. 28, pp. 5, 6. The local economic impact is estimated, in 2008 dollars, at $672.8 million during construction; the State level is at $745.1 million. Long-term local economic impact is $3.6 million per year of new income in the four county area not including on-going contractor support for plant activities. App. Ex. 26, p. 8. Once operational, Big Stone Unit II will be paying around $4.7 million in annual property taxes, App. Ex. 28, p. 3, which may reduce the state aid required by the Milbank school district by about $1.4 million. $300 million of assessed value to the mill levy calculation is anticipated once Big Stone Unit II is operational. Local property taxes should decrease as a result of Big Stone Unit II. App. Ex. 28, p. 6.

147. No adverse impact on agriculture land use is expected, and any impact on such land is expected to be insignificant. App. Ex. 27, p. 20. The construction and operation are not expected to have material adverse effects on construction and operations of other industries. App. Ex. 22, p. 12.

148. There are no other major industrial facilities under regulation that may have an adverse affect on the environment as a result of the facility construction or operation.

23.0 EMPLOYMENT ESTIMATES

149. During peak construction in 2008, the project is projected to employ 1,400 workers; this peak could last up to, but probably not exceed, one year. App. Ex. 27, pp. 9, 16; App. Ex. 26, pp. 5, 10; HTr 301. Anticipated construction labor hours approximate to 5.1 million hours, at a $211 million value. Local job growth is estimated at 2,550 positions for the construction phase, and 1,844 jobs in the surrounding communities; the average for each of the four construction years is 1,098. Id. The State benefit for job growth is estimated at 2,550 jobs during construction and 2,291 jobs in the communities, with the average being 1,210. Id. Job classifications include unskilled labor, skilled labor, technical and advanced technical. App. Ex. 27, p. 16. Numerous sectors will benefit from the construction, such as food, service, real estate, auto repair, and motor vehicle. App. Ex. 26, p. 11. It is expected that the local labor pool would supply a portion of the semi-skilled and skilled project labor personnel, utilizing unemployed, underemployed, and farmers in need of additional seasonal income. Big Stone Unit II will share operational staff with existing staff from Big Stone I. App. Ex. 8, pp. 8-9. Once operational, it is anticipated that an additional 35 full time employees will be added. App. Ex. 26, p. 10; App. Ex. 18, pp. 14-15. The added 35 employees are at a cost of $2.5 million per year, at 2004 wage levels. App. Ex. 54, p. 115-116.

24.0 FUTURE ADDITIONS AND MODIFICATIONS

150. There are no future expansion plans for the proposed Big Stone Unit II or for construction of additional facilities. In the design of Big Stone Unit II, consideration is being given to allow for enough space between Unit I and Unit II to accommodate any future modifications that may be required because of changing regulations. At this time, there is no plan to make any modifications to Big Stone Unit I, other than to re-route exhaust gases from Unit I to the common scrubber. App. Ex. 8, p. 10; App. Ex. 33.

25.0 NATURE OF PROPOSED ENERGY CONVERSION SYSTEM

151. The Big Stone Unit II project involves construction of a single pulverized coal-fired steam generator (boiler) with balanced-draft combustion and a single, reheat steam turbine. App. Ex. 54, p. 2. The unit will burn Powder River Basin sub-bituminous coal, the type of fuel currently used at Big Stone Unit I. App. Ex. 8, p. 5; App. Ex. 8, p. 2. Number two fuel oil will be used for igniting the fuel on initial startup and for flame stabilization. "Opportunity fuels" such as wood or agricultural waste may also be burned, though in relatively small percentages to the overall fuel mix. App. Ex. 8, p. 12. The steam boiler will provide steam to a single steam turbine generator that converts mechanical energy of the steam turbine to electrical energy. A water-cooled steam condenser will accept the steam exhausted from the turbine. A circulating water system will supply cooling water from a wet cooling tower to the water-cooled steam condenser to dissipate the energy in the condensing steam. App. Ex. 54, p. 9.

152. Electricity produced by the generator will be supplied to the 230 kV transmission system through a new generator step-up transformer and switching equipment. App. Ex. 54, p. 9. To accommodate power and energy from Big Stone Unit II, the Applicants are proposing to construct and operate two new high voltage transmission lines and associated facilities: a line from the Big Stone Plant to Morris, Minnesota, to be designed and operated at 230 kV; and a line from the Big Stone Plant to Granite Falls, Minnesota, to be designed at 345 kV, but initially operated at 230 kV. When connected with other planned upgrades to the bulk transmission system, the Big Stone – Granite Falls line will increase transfer capability by approximately 1000 MW beyond what is required for Big Stone Unit II, which will facilitate wind and other generation resources. TR p. 32; App. Ex. 1, p. 14; App. Ex. 2, p. 7; App. Ex. 53, pp. 2-44 through 2-53.

153. Maintenance will consist of routine periodic, unscheduled and scheduled maintenance, primarily to occur on site. Annual outages for inspection of major equipment as well as major maintenance (i.e., every five years) is also expected. Onsite maintenance support will be supplied. App. Ex. 54, p. 38-39.

26.0 PRODUCTS TO BE PRODUCED

154. The burning of solid fuel will produce ash, a combustion by-product. The unit is being designed and the fuel is being selected with the expectation that the fly ash produced will be sold into the cement replacement market, thus yielding a valuable by-product. The waste from the wet scrubber will be a gypsum material. If a market can be found, this product may be sold into the wallboard manufacturing area. The remaining ash is expected to be land filled. App. Ex. 8, p. 11.

27.0 FUEL TYPE USED

155. The proposed fuel for Big Stone Unit II is sub-bituminous coal from the Powder River Basin in Wyoming and Montana. It is the same coal that is burned in Unit I. Analysis of the Unit I coal over the last five years shows a heat content of a minimum of 7,980 BTU per pound and a maximum of 9,500 BTU per pound. The Applicants have provided in the Application the expected chemical analysis of the coal. App. Ex. 8, p. 11; App. Ex. 54, pp. 16-17.

28.0 PROPOSED PRIMARY AND SECONDARY FUEL SOURCES AND TRANSPORTATION

156. Coal will be transported from the Powder River Basin to the site by unit trains by the Burlington Northern Santa Fe Railway ("BNSF"), which is the delivery system for Big Stone I. App. Ex. 8, pp. 2, 8. Combined, the two units will require six-to-eight train deliveries weekly (approximately 115 coal cars per delivery). App. Ex. 18, p. 17.

157. The existing Big Stone I rail spur provides site access. App. Ex. 18, p. 17. The existing access spur begins at a turnout ¾ mile southwest of Big Stone City; an overpass exists where the spur crosses 484th Avenue. No changes are anticipated to the rail spur. Construction to the loop on plant site will

occur to provide space for the Big Stone Unit II turbine building and to accommodate deliveries and car storage. App. Ex. 8, p. 8; App. Ex. 18, p. 17; App. Ex. 54, pp. 17-19.

158. BNSF recently experienced a shortage in railroad delivery service capability for coal transportation to Big Stone I and other plants in the Midwest. This was the first shortage because of fuel shortages experienced since Big Stone I became operational. App. Ex. 29, pp. 1-2; App. Ex. 35, p. 6. The BNSF has undertaken a significant capital expansion program to increase coal deliveries and improve reliability. App. Ex. 35, pp. 4-5; HTr 43, 314-15. HTr 316-17. In addition, the Big Stone I co-owners have leased a third train, which will increase reliability for the existing plant by 50%, and has increased stockpiling for the summer months. HTr 76-77, 96. No future coal delivery shortages are likely. Id.

159. Changing the site location because of the recent coal delivery shortage would not create any significant benefit in terms of reliability of future coal delivery. App. Ex. 29, p. 3.

160. No significant impact on the surrounding communities is anticipated on account of rail traffic. App. Ex. 18, p. 17; App. Ex. 54, p. 125.

29.0 ALTERNATE ENERGY RESOURCES

161. The decision to pursue construction of a 600 MW coal-fired second unit at the Big Stone plant is one that resulted from extensive analysis by the Applicants. Each of the Applicants, through their individual resource planning efforts, considered various different types of generation, both fossil fuel-fired and renewable energy sources, before selecting Big Stone Unit II to meet their baseload needs. App. Ex. 8, p. 8.

162. In considering all the different ways in which electricity can be generated, the Applicants made a qualitative assessment of each alternative's capability to meet the underlying objective of providing approximately 600 megawatts of baseload capacity by 2011, at a reasonable cost to their customers. The Applicants also took into account potential environmental and community impacts associated with any project. App. Ex. 8, p. 13.

163. The Applicants conducted an initial screening of various alternatives to determine whether any of the alternatives have the potential to address the need to be served by the proposed project, and then examined in more detail only those options that appeared feasible. The Applicants wanted to make sure that any generation alternative be able to satisfy three basic objectives for a baseload generation unit – the technology must be applicable; the facility must be available for service when needed; and the facility should enhance the overall reliability of the bulk electric system. While costs, economic effects, and environmental impacts are legitimate project objectives, if an alternative is not feasible, these other factors are of little significance. App. Ex. 8, p. 14.

164. Applicants' review and analysis showed that there are no renewable generation options available to address the need for 600 MW of baseload power within the timeframe required, and that other fossil fuel sources are more expensive and less desirable. App. Ex. 8, p. 14.

165. As a part of its overall analytic process, the Applicants retained the Burns & McDonnell Engineering Co. to examine alternative baseload generation technologies that could be developed at the Big Stone site. Burns & McDonnell completed this report, termed the "Phase I Report," in July 2005. App. Ex. 24-A.

166. The Phase I Report examined the following generation technologies: (1) 600 MW supercritical PC unit; (2) 450 MW supercritical PC unit; (3) 300 MW subcritical PC unit; (4) 600 MW subcritical circulating fluidized bed (CFB) unit; (5) 450 MW subcritical CFB unit; (6) 300 MW subcritical CFB unit; and (7) 500 MW Combined Cycle Gas Turbine (CCGT) unit. The Phase I Report concluded that a 600 MW supercritical pulverized coal plant represented the lowest cost generation alternative of the technologies evaluated for the

Big Stone station site on a life-cycle basis considering capital and operating costs. App. Ex. 24-A; App. Ex. 8, p. 14.

167. The Applicants further asked Burns & McDonnell to examine alternative generation technologies regardless of where these technologies might be constructed. That analysis is contained in the September 2005 Report entitled "Analysis of Baseload Generation Alternatives." App. Ex. 23-A. The report shows that a super-critical pulverized coal plant is the least-cost most appropriate way of meeting the base load power needs of the Applicants. App. Ex. 23-A.

168. The Applicants considered the following technologies:

Wind

169. While wind will continue to play a significant part in meeting the regional energy needs of the Applicants in the future, there are several reasons why wind energy cannot replace the Big Stone Unit II project. The major reason is that wind cannot be relied on to satisfy a baseload demand for 600 MW. Electricity produced from wind is an intermittent resource. Wind turbines typically are only capable of achieving capacity factors in the range of 30-to-40 percent if properly sited in an area with adequate wind resources. This means that wind turbines only generate 30-to-40 percent of the megawatt hours that would have been generated if the units had run at full load continuously for the year. Baseload generation is typically required to achieve capacity factors closer to 90%, and provide reliable energy on an around the clock basis. As a result, wind generation is not suitable to meet baseload capacity and energy needs. Baseload resources are also required to be dispatchable, meaning that they can be scheduled to run at a specified load for a given duration. Since wind power is intermittent based on wind velocities, it is not dispatchable and not suitable as a baseload capacity and energy resource. App. Ex. 8, pp. 15-17.

170. Before considering wind for baseload power, a backup source of firm generation to rely on when the wind is not blowing at the necessary speed is required. The Burns & McDonnell's Analysis of Baseload Generation Alternatives Report, App. Ex. 23-A, evaluated a combination of 600 MW of wind, backed-up by a 600 MW combined cycle gas turbine (CCGT). Under this scenario, wind energy would be utilized when it was available and the combined cycle unit would operate as necessary to back-up the wind's intermittency. Based on the report, the Applicants found that the busbar cost (the cost of electricity at the point of delivery from the generation source without any transmission or distribution costs) for wind plus CCGT of $72.89/MWh for investor owned utilities (such as OTP and Montana-Dakota) and $70.57/MWh for public power companies (such as MRES, CMMPA, SMMPA, HCPD, and GRE). This is significantly more expensive than Big Stone Unit II. App. Ex. 23, p. 10-11; App. Ex. 23-A; App. Ex. 8, p. 21.

Biomass

171. The Burns & McDonnell Analysis of Baseload Generation Alternatives Report, App. Ex. 23-A, demonstrated that biomass is not a feasible alternative. It also demonstrated that it would take approximately 600,000 acres of land to support such a plant if it were to burn whole trees, a land size nearly double the size of Big Stone County, Minnesota. The report found that biomass is not economically viable for base load energy production compared to Big Stone Unit II. App. Ex. 23-A.

Hydropower

172. Hydropower was another generation option that was considered and rejected by the Applicants because there was not enough hydropower to satisfy the projected need. App. Ex. 8, p. 17.

173. Recent analysis showed that neither Minnesota (with undeveloped capacity of 137 MW of hydropower) nor North Dakota (with only 50 MW of availability) would be able to satisfy the Applicants' need. The analysis also showed that South Dakota had the potential for 695 MW of hydropower at 33 different sites, three of which are on the Missouri River that had a potential capacity greater than 50 MW. It would take nearly

every watt of hydropower potential in South Dakota to satisfy the 600 MW demand and the Missouri River Basin is presently suffering through a long-term drought. Id. As a result, hydropower is not a realistic option. App. Ex. 8, p. 18.

Solar

174. Solar power is not a viable option to the proposed Big Stone Unit II. The Applicants need base load energy – which means electricity that is capable of running at very high capacity factors – e.g., better than 90%. Solar has been recognized not to be an option in this region because it is an intermittent resource that customers cannot count on to be dispatched. App. Ex. 8, p. 18.

Landfill gas

175. Landfill gas is not a viable option because no sources are available that would satisfy the need for additional base load generation. App. Ex. 8, p. 18.

Geothermal energy

176. Geothermal energy is also not a viable option because there are no such resources available to meet the demand in the Applicants' service areas. App. Ex. 8, p. 18.

Distributed Generation

177. Fuel cells and microturbines are two methods of distributed or dispersed generation. Neither option passed the screening analysis because the technology is not compatible with baseload energy. App. Ex. 8, p. 18.

Atmospheric Circulating Fluidized Bed ("ACFB")

178. A fluidized bed unit uses a different type of technology to burn the coal. The combustion process occurs in a suspended bed of solid particles in the lower section of the boiler. Combustion occurs at a slower rate and at lower temperatures than a conventional pulverized coal boiler. This technology allows a wide variation in fuel size and type and heat content. The coal normally burns cleaner than in a pulverized boiler but state-of-the-art control equipment is still required. A fluidized bed unit costs about 5% more than a pulverized coal unit. Also, the largest atmospheric fluidized bed boilers in operation are approximately 300 MW in size, and all ACFB boilers built to date are of sub-critical design; thus their efficiency is considerably less than the super-critical pulverized coal design of Big Stone Unit II. App. Ex. 8, p. 19.

Combined Cycle Natural Gas Turbine

179. The basic principle of the combined cycle gas turbine is to utilize gaseous fuels, such as natural gas, to produce power in a gas turbine, which is used to generate electricity, and to use the hot exhaust gases from the gas turbine to produce steam in a heat recovery steam generator to produce more electricity from the steam. Combined cycle operations can obtain efficiencies in the 50 to 58% range. A natural gas combined cycle plant is less expensive to construct than a pulverized coal plant. However, the busbar cost of the electricity is significantly higher. The Burns & McDonnell Analysis of Baseload Generation Alternatives Report, Exhibit 23-A, confirms this. That report shows a busbar cost of $77.94/MWh for investor owned utilities and $75.61/MWh for public power companies. In addition, the availability and price volatility of natural gas is a concern to the Applicants and the Commission. A combined cycle natural gas plant is not a good alternative for a 600 MW baseload unit. App. Ex. 8, p. 19-20.

Integrated Coal Gasification Combined Cycle

180. Integrated Gasification Combined Cycle ("IGCC") technology is a system that produces a syngas from a fossil fuel such as coal and utilizes the gas to generate electricity in a conventional combined cycle plant. The Applicants asked Burns & McDonnell in its Analysis of Baseload Generation Alternatives Report to determine the performance and costs and other features of an IGCC system. The proposal as examined called for a 535 MW IGCC generating station comprised of two coal gasifiers, two "F" class gas turbines, each coupled with a heat recovery steam generator and a single, reheat steam turbine. Because there are no IGCC facilities in the United States that have ever used sub-bituminous western coal, as proposed for Big Stone Unit II, Burns & McDonnell assumed that bituminous Illinois coal would be used. Also, because an IGCC unit would require natural gas as backup, Burns & McDonnell assumed that an IGCC facility would not be located at the Big Stone Plant, because there is no natural gas supply at that location. The Burns & McDonnell report found that an IGCC plant had higher construction costs than a coal plant. Burns & McDonnell calculated a busbar cost (the cost of electricity at the point of delivery from the generation source without any transmission or distribution costs) of $58.81/MWh for a super-critical pulverized coal plant and $83.84/MWh for an IGCC facility for investor owned utilities, and $47.37/MWh and $71.05/MWh respectively, for public utilities. An IGCC plant would cost 43% and 50% more than a coal plant for the two types of utilities. In addition, historically, IGCC plants have not achieved high capacity factor operations. App. Ex. 8, pp. 21-22; App. Ex. 23-A.

30.0 SOLID OR RADIOACTIVE WASTE

181. By-products produced from coal combustion primarily consist of bottom ash, fly ash and gypsum. App. Ex. 16, p. 14; App. Ex. 8, p. 11. Additional wastes include construction debris, plastic, cardboard, wood, metal, food and office and laboratory waste. App. Ex. 16, p. 16; App. Ex. 8, p. 11. The applicable standards and regulations will be complied with for the treatment and storage of the by-products and waste. Ash by-product is environmentally safe. HTr 95.

182. Bottom ash and gypsum will be removed by conveyor, and transferred to a temporary storage area for loading, transport and disposal in the onsite landfill. App. Ex. 16, p. 3. The gypsum may be sold and shipped for use in sheetrock or wallboard manufacturing. App. Ex. 16, p. 16.

183. Fly ash will be conveyed to the fly ash storage silo with controls of vent filters, and from there it will be unloaded onto trucks for potential sale and shipment offsite for use in concrete, soil stabilization or fill. App. Ex. 16, p. 16. Excess fly ash will be disposed of in the onsite landfill. App. Ex. 16, p. 16. Exposed (uncontained) ash will be wetted prior to open handling. Fly ash from the economizer and selective catalytic reduction section will be conveyed to the bottom ash hopper and mixed with bottom ash. App. Ex. 54, pp. 22-23.

184. At the landfill, the by-products will be distributed in layers and compacted. Water will be applied to assist in compaction and dust control. App. Ex. 33, p. 19. The existing Big Stone I landfill will accommodate approximately 10 years of disposal before it will need to be expanded. App. Ex. 33, p. 19. When the site is exhausted, the necessary permit will be obtained and regulations complied with. App. Ex. 33, p. 19.

185. Construction debris will be transported offsite to an approved solid waste landfill. App. Ex. 16, p. 16. Normal operation waste will be properly disposed of at a landfill or treatment facility. App. Ex. 16, p. 3. Combustion by-products will be disposed of at the Big Stone I landfill. App. Ex. 16, p. 17.

186. All wastes generated during construction and operation of Big Stone Unit II will be evaluated to determine whether any are classified as hazardous wastes. Small quantities of hazardous wastes may be generated. App. Ex. 16, p. 19. All hazardous wastes generated will be reported to the proper authorities and properly disposed of in accordance with all requirements. App. Ex. 33, p. 19.

187. It is likely that Big Stone Unit II will use sealed radioactive sources to monitor certain process conditions such as coal flow and the wet scrubber slurry density. Existing power plants have used these types of devices for years. They were included in the original design of the Big Stone Plant. The U. S. Nuclear Regulatory Commission regulates the installation and operation of such sources. No radioactive wastes will be disposed of on site, but will be monitored and disposal will be to an approved facility. App. Ex. 16, p. 3, 20; App. Ex. 33, p. 20.

31.0 ESTIMATE OF EXPECTED EFFICIENCY

188. The exact efficiency of Big Stone Unit II depends on final design determinations that are yet to be made. However, the super-critical steam cycle that is to be used here delivers a higher efficiency than a sub-critical unit. Assuming that it will take 9,392 BTUs of energy to produce one kilowatt hour of electricity translates into an overall efficiency of greater than 36%. App. Ex. 8, p. 23.

32.0 DECOMMISSIONING

189. Because the life of Big Stone Unit II is expected to be quite long, it is difficult to predict what decommissioning requirements will be at the time necessary to decommission the Unit. However, the Applicants intend to fully comply with all applicable laws and rules and intend to set aside an appropriate amount of reserve funds to cover decommissioning costs. App. Ex. 8, p. 23.

33.0 GENERAL

190. Pursuant to SDCL 49-41B-12, on August 9, 2005, the Commission voted to assess Applicants a filing fee not to exceed $700,000.00 with an initial deposit of $8,000.00, the minimum amount of the fee. Receipt of the deposit of $8,000.00 from OTP on behalf of Applicants was acknowledged. Applicants have paid all fees and additional deposits required by the Commission in this matter. App. Ex. 55.

191. Dr. Olesya Denney is an economist with a PhD from Oregon State University. She was retained by the Commission Staff to assists its evaluation of the Application, testimony, discovery and all other facts submitted in support of and in opposition to the permit Application. Dr. Denney recommended approval of the Application for an Energy Conversion Facility Permit, subject to certain conditions. Among other conditions, Dr. Denney recommended – to which the Applicants agreed – the following: (1) that the Applicants shall submit quarterly progress reports to the Commission that summarize the status of the construction, the status of the land acquisition, the status of environmental control activities, and the overall percent of physical completion of the project and design changes of a substantive nature. Each report shall include a summary of consultations with DENR (the South Dakota Department of Environment and Natural Resources), and other agencies concerning the issuance of permits. The reports shall list dates, names, and the results of each contact and the company's progress implementing prescribed environmental protection or control standards. The first report shall be due for the quarter ending September 30, 2006. The reports shall be filed within 31 days after the end of each quarter and shall continue until the project is fully operational; (2) that Applicants prepare a contingency housing plan for construction housing; (3) that Applicants fund an additional officer to the Grant County Sheriff's office for three years, have drug testing on potential workers, and advise law enforcement of peak employment months; (4) that Applicants purchase a high angle rescue kit and provide training in its use to a number of members of the local fire department; and (5) that Applicants provide a public affairs employee, implement a web site, and schedule periodic meetings to update the public. App. Ex. 68; Ex. 8, p. 116.

192. In addition to the above conditions recommended by Dr. Denney, the Commission finds that the evidence justifies the imposition of certain other conditions as set forth below in findings 193 through 199.

193. Applicants have applied for various federal, state and local permits in connection with Big Stone Unit II and will require additional zoning and other permits as the project progresses. These permits include but are not limited to the Water Appropriation Permit, PSD Air Quality Construction Permit, Solid

Waste Permit and Section 404 Permit. The Commission finds that in order to comply with SDCL 49-41B-22(1), the permit must be conditioned on the receipt of and compliance with all applicable federal, state and local permits.

194. Applicants have made commitments to both this Commission and DENR regarding meeting or exceeding a mercury emissions limit equal to the mercury emissions from Big Stone Unit I in 2004 of 189 pounds. See Finding 129. A condition reflecting this commitment is appropriate.

195. As discussed in finding 101, under extended drought conditions, it is possible that operation of Big Stone II might have to be diminished or shut down. Although Applicants discussed the potential for use of groundwater or other alternative water source in that contingency, no evidence relative to the specifics of such alternative supply was produced. The Commission believes that Applicants should undertake an evaluation of alternatives during the development phase of the project to enable timely response to this contingency should it occur.

196. Applicants also committed at the hearing to complying with all mitigation measures recommended as part of the Final EIS Record of Decision. A condition reflecting this commitment is appropriate.

197. Applicants OTP and MDU are subject to rate regulation by the Commission. Both of these utilities have made statements of commitment in this proceeding about increasing the contribution of DSM and renewables to their portfolio mix. The Commission accordingly finds that to keep the Commission informed concerning these efforts, beginning on July 1, 2007, OTP and MDU shall file annually a detailed report of their ongoing DSM and renewable programs and a forecast of their near- and long-term initiatives to optimize benefits related to demand-side management and renewable energy programs.

198. In her evidence, comments and argument presented to the Commission, Mary Jo Stueve expressed concern with mercury emissions despite tightened regulation of mercury under EPA's new mercury rule and Applicants' commitments in this proceeding. Although the Commission does not find that evidence peculiar to Big Stone Unit II was presented in this case that would justify denial of the permit or imposition of permanent mercury standards that are more stringent than those imposed by EPA and DENR in its air quality permitting process, the Commission does share Stueve's concern that mercury emissions be brought down to the control level as rapidly as practicable. To advise the Commission and the public of Applicants' efforts in this regard, the Commission finds that the permit shall be subject to the condition that on or before the date Big Stone Unit II starts operation and every six months thereafter, the operating partner shall provide the Commission with an update on the mercury control efforts being undertaken by the partners, until such time as the combined plants meet the agreed level of mercury emissions set forth in Findings 129 and 194.

199. Because there does not yet exist any federal or state regulation of CO_2 emissions, and because we do not yet know what effect such regulation may have on ratepayers in the future, the Commission finds that it is important for Applicants to keep the Commission informed of developments relative to the project involving CO_2 and that a condition so requiring is appropriate. The Applicants shall submit an annual report to the Commission on CO_2 with the first such report to be filed on or before July 1, 2008. Such report shall review any federal or state action taken to regulate carbon dioxide, how the operator plans to act to come into compliance with those regulations, the expected costs of those compliance efforts and the estimated effect of such compliance on rate-payers. The report should also evaluate operational techniques and commercially-available equipment being used to control CO_2 emissions at pulverized coal plants, the cost of those techniques or equipment, and whether or not the operator has evaluated the prudence of implementing those techniques or equipment.

200. Applicants have provided all information required by ARSD 20:10:22 and SDCL 49-41B.

201. SDCL Chapter 49-41B is not a certificate of convenience and necessity proceeding, and the Findings of Fact that the Commission has made in this proceeding regarding Applicants' description of need

for the baseload generation to be provided by Big Stone Unit II pursuant to ARSD 20:10:22:08 are not intended to be nor have the effect of prospective findings of prudency that may arise in any future rate proceeding involving such investments.

202. On July 8, 2006, Stueve filed and served a Petition to Dismiss Application and Notice. The Commission finds that Stueve's Petition to Dismiss should be denied. The Petition was filed less than a week before the scheduled Commission decision date and involved the type of factual determinations that consumed 52 pre-filed testimony exhibits and four full days of testimony. The Commission considered the arguments made by Stueve in her Petition in connection with its decision on the merits as it did the evidence and arguments of all parties and commenters in this proceeding and finds that the evidentiary deficiencies cited by Stueve are not material and do not warrant dismissal of the Application.

203. To the extent that any of the below conclusions are more appropriately a finding of fact, that conclusion of law is incorporated by reference as a finding of fact.

Based on the above Findings of Fact, the Commission hereby makes the following:

CONCLUSIONS OF LAW

1. The Commission has jurisdiction over the subject matter and parties to this proceeding pursuant to SDCL Chapter 49-41B and ARSD 20:10:22. Subject to the findings made on the four elements of proof under SDCL 49-41B-22, the Commission has authority to grant, deny or grant upon reasonable terms, conditions or modifications, a permit for the construction, operation and maintenance of Big Stone Unit II.

2. The Big Stone Unit II Project is an energy conversion facility as defined in SDCL 49-41B-2.1(2).

3. The Applicants' Permit Application, as amended, complies with the applicable requirements of SDL Chapter 49-41B and ARSD 20:10:22.

4. The Big Stone Unit II Project as defined herein will comply with all applicable laws and rules, including all requirements of SDCL Chapter 49-41B and ARSD 20:10:22.

5. The Big Stone Unit II Project, if constructed in accordance with the terms and conditions of this Decision, will not pose a threat of serious injury to the environment or to the social and economic conditions of inhabitants or expected inhabitants in the siting area.

6. The Big Stone Unit II Project, if constructed in accordance with the terms and conditions of this Decision, will not substantially impair the health, safety or welfare of the inhabitants of the siting area.

7. The Big Stone Unit II Project, if constructed in accordance with the terms and conditions of this Decision, will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government.

8. The Commission has the authority to revoke or suspend any permit granted under the South Dakota Energy Facility Permit Act for failure to comply with the terms and conditions of the permit pursuant to SDCL 49-41B-33.

9. To the extent that any of the above made findings of fact are determined to be conclusions of law or mixed findings of fact and conclusions of law the same are incorporated herein by this reference as a conclusion as if set forth in full.

10. Administrative rules have the force of law and are presumed valid. Feltrop v. Department of Social Svcs,. 559 NW2d 883, 884 (SD 1997). An administrative agency is bound by its own rules. Mulder v. Department of Social Svcs., 675 NW2d 212, 216 (SD 2004).

11. The Applicants have met their burden of proof pursuant to SDCL 49-41B-22 and are entitled to a permit as provided in SDCL 49-41B-25.

12. Because a federal EIS is required in this project and because the federal EIS complies with the requirements of SDCL Ch. 34A-9, neither the Commission nor any other agency of the State of South Dakota is required to prepare a separate environmental impact statement. SDCL 34A-9-11. It is appropriate for the Commission to use the federal EIS. The requirements of SDCL 49-41B-21 have been met.

13. The burden of proof on the parties on which they have the burden is by the preponderance of the evidence.

14. The Commission concludes that it needs no other information to assess the impact of the proposed facility or to determine if Applicants or any Intervenor has met its burden of proof.

15. The Commission concludes that the Application and all required filings have been filed with the Commission in conformity with South Dakota law. All procedural requirements required under South Dakota law have been met. All data, exhibits, and related testimony have been filed.

16. The Commission concludes that the Application is supported by the testimony of the witnesses and documentary evidence.

17. The Commission concludes that the Application is legally and procedurally appropriate and complete. All formatting and timing requirements have been complied with. All public hearing requirements have been met.

18. A full and fair opportunity to litigate the issues involved in the Application was given to all parties and those in privity with the parties prior to the Commission's decision.

19. The Commission concludes that Stueve's Petition to Dismiss should be denied.

20. The Commission concludes that the conditions referenced in Findings 191 through 199 are appropriate and necessary.

21. The Commission concludes based on the evidence and findings of fact that all applicable fees and deposits have been paid; the Applicant has sustained its burden of proving the proposed facility will comply with all applicable laws and rules; the facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area; the facility will not substantially impair the health, safety or welfare of the inhabitants; and the facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government.

22. The Commission concludes that the permit to construct Big Stone Unit II should be granted subject to the conditions set forth in Findings 191 through 199.

DECISION AND ORDER

Based on the above Findings of Fact and Conclusions of Law, it is therefore:

ORDERED, that Stueve's Petition to Dismiss is denied; and it is further

ORDERED, that an Energy Conversion Facility Siting Permit is issued to OTP, for itself and on behalf of the Applicants, and construction of the Big Stone Unit II Project is authorized, subject to the following conditions:

1. The Applicants shall comply with the recommendations made by the Local Review Committee in its report dated December 14, 2005, as modified by the Commission in these conditions, including but not limited to the following:

A. Applicants shall prepare a contingency housing plan for construction housing;

B. Applicants shall fund an additional officer to the Grant County Sheriff's office for three years, implement a program of drug testing of potential workers and advise law enforcement of peak employment months;

C. Applicants shall purchase for the Big Stone City Fire Department a high angle rescue kit and provide for the training of several of the Big Stone City Fire Department members in the use of the equipment; and

D. Applicants shall provide a public liaison officer to facilitate the exchange of information between the project owners, contractors and the local communities and residents and to promptly resolve problems that may develop for local communities and residents as a result of the project. Applicants shall also implement a web site and conduct periodic meetings to update the public. The public liaison officer shall be afforded immediate access to the Applicants' project manager and to contractors' on-site managers.

2. The Applicants shall comply with the following conditions recommended by Staff:

A. The Applicants shall obtain and shall thereafter comply with all applicable federal, state and local permits, including but not limited to the Water Appropriation Permit, PSD Air Quality Construction Permit, Solid Waste Permit and Section 404 Permit.

B. In the PSD Air Quality Construction Permit proceeding and at the hearing in this case, Applicants have agreed to limit mercury emissions from the combined Big Stone Unit I and Big Stone Unit II plants to no more than the emissions from Big Stone Unit I in 2004 which is 189 pounds per year, beginning three years after commercial operation commences of Unit 2. Applicants shall meet or exceed this standard.

C. The Applicants shall submit semi-annual progress reports to the Commission that summarize the status of the construction, the status of the land acquisition, the status of environmental control activities, the implementation of the other measures required by these conditions, and the overall percent of physical completion of the project and design changes of a substantive nature. Each report shall include a summary of consultations with DENR (the South Dakota Department of Environment and Natural Resources), and other agencies concerning the issuance of permits. The reports shall list dates, names, and the results of each contact and the company's progress implementing prescribed environmental protection or control standards. The first report shall be due for the period ending December 31, 2006. The reports shall be filed within 31 days after the end of each semi-annual period and shall continue until the project is fully operational;

D. The Applicants shall comply with all mitigation measures recommended as part of the Final EIS Record of Decision.

3. Applicants shall conduct an evaluation of alternative water supply options to provide water to the plant in the event that withdrawals from Big Stone Lake are curtailed for an extended period of time. Applicants shall file a report with the Commission detailing the findings of such study on or before September

1, 2007. Such study shall include (i) identification of particular potential source options, (ii) an assessment of the facilities which would be required to effectuate water delivery to the plant from such alternative sources, institutional and other impediments to contingent development of one or more of these options and the timing and logistics of implementing such options, (iii) a preliminary cost analysis of alternative supply options and (iv) a comparison of financial effects of development of one or more alternative supply options with the no-run option.

4. Beginning on July 1, 2007, Otter Tail Power and Montana-Dakota Utilities shall file annually a detailed report of their ongoing DSM and renewable programs and a forecast of their near- and long-term initiatives to optimize benefits related to demand-side management and renewable energy programs.

5. On or before the date Big Stone Unit II starts operation and every six months thereafter, the operating partner shall provide the Commission with an update on the mercury control efforts being undertaken by the partners, until such time as the combined plants meet the agreed level of mercury emissions set forth in Condition 2.B.

6. Because there does not yet exist any federal or state regulation of CO_2 emissions, and because we do not yet know what effect such regulation may have on ratepayers in the future, the Applicants shall submit an annual report to the Commission on CO_2 with the first such report to be filed on or before July 1, 2008. Such report shall review any federal or state action taken to regulate carbon dioxide, how the operator plans to act to come into compliance with those regulations, the expected costs of those compliance efforts and the estimated effect of such compliance on rate-payers. The report should also evaluate operational techniques and commercially-available equipment being used to control CO_2 emissions at pulverized coal plants, the cost of those techniques or equipment, and whether or not the operator has evaluated the prudence of implementing those techniques or equipment.

NOTICE OF ENTRY AND OF RIGHT TO APPEAL

PLEASE TAKE NOTICE that this Final Decision and Order was duly entered on the 21st day of July, 2006. Pursuant to SDCL 1-26-32, this Final Decision and Order will take effect 10 days after the date of receipt or failure to accept delivery of the decision by the parties. Pursuant to ARSD 20:10:01:30.01, an application for a rehearing or reconsideration may be made by filing a written petition therefor and ten copies with the Commission within 30 days from the date of issuance of this Final Decision and Order. Pursuant to SDCL 1-26-31, the parties have the right to appeal this Final Decision and Order to the appropriate Circuit Court by serving notice of appeal of this decision to the circuit court within thirty (30) days after the date of service of this Notice of Decision.

Dated at Pierre, South Dakota, this 21st day of July, 2006.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 7/21/06

BY ORDER OF THE COMMISSION:

Robert K. Sahr
ROBERT K. SAHR, Chairman

Dustin M. Johnson
DUSTIN M. JOHNSON, Commissioner

Gary Hanson
GARY HANSON, Commissioner

ATTACHMENT A

RULINGS ON PROPOSED FINDINGS OF FACT

Rulings on Applicants' Amended Proposed Findings of Fact

Applicants' Amended Proposed Findings of Fact are accepted essentially as proposed and incorporated in the Decision's Findings of Fact with the exception of Finding 117, which appeared to be an inadvertent and misplaced repetition of Finding 76. Applicants' Amended Proposed Findings 118 – 192 have been renumbered as Findings 117 – 191. Applicants' Amended Proposed Findings 193 and 194 have been renumbered as Findings 200 and 203. Certain of Applicants' Amended Proposed Findings of Fact have been modified to some extent to reflect the Commission's understanding of the record and to add citations to the record where these were omitted.

Rulings on Joint Intervenors Proposed Findings of Fact

Proposed Findings 1 and 2 - Accepted and incorporated in substance in Decision Findings 1-9.

Proposed Finding 5 (Findings 3 and 4 were omitted from Joint Intervenors Proposed Findings) – Accepted and incorporated in Finding 133 with a modification to the second sentence to reflect a further necessary assumption that no CO_2 capture system is installed.

Proposed Findings 6 through 16 – Rejected. In Finding 135, the Commission finds that even though the emissions of CO_2 seem significant on a tonnage basis, they will represent only a minute fraction of total U.S. anthropogenic emissions and a much more minute fraction of global emissions. The Commission is only called upon to determine whether this particular facility will have a serious adverse impact on the environment, and there is insufficient evidence in this record on which to base a finding that Big Stone Unit II will have any appreciable effect on the global climate. It is clear from this record that if a consensus is ever reached at the national level concerning global warming and the contribution of CO_2 to the problem, regulation of carbon emissions will have to occur in a national or even global context. In Findings 139 and 199, the Commission notes that there is no federal or state regulation of CO_2, and thus far the debate at the Federal level over such regulation has yet to result in a bill that passed either house. EPA at the Federal level and DENR at the state level are charged with regulation of air pollutants, and neither agency has yet seen fit to implement regulations. The Commission acknowledges the concerns about CO_2 in Finding 199, and believes that the approach it has taken in that Finding and in Condition 6 is a proper approach given the current record and absence of regulations or standards.

Proposed Findings 17 and 18 – Rejected. Finding 123 acknowledges that the agreed mercury emissions limit of 189 pounds per year will not take effect until three years after the plant goes on line. The evidence in the record demonstrated that this period of time will be needed by plant operators to test and adjust their mercury control systems. Further, mercury emissions standards are regulated by DENR through its permitting process, and the Commission has subjected the permit to Conditions 2.A. and B. To the extent DENR determines that the emissions during the three-year shake down period or other mercury emissions from the plant will not meet state air quality standards, Applicants will be required to adjust their implementation time table and operations accordingly. Finally, the Commission has acknowledged the concerns with mercury during the three-year shakedown period in Finding 198 and has subjected the permit to Condition 5 in order to encourage the Applicants to bring mercury levels down to the agreed level as soon as practicable.

Proposed Findings 19 through 21 – Rejected. While the Commission agrees that South Dakota has an excellent wind resource and has itself been active in encouraging wind generation development in South Dakota, the Commission is called upon in this proceeding to consider whether to approve the construction of a particular coal fired base load generation facility. The evidence in the record demonstrated both a projected probable need for a true base load facility such as Big Stone Unit II and the plans by Applicants to bring significant amounts of wind energy into their resource mixes. Furthermore, the record demonstrates that the transmission constructed to accommodate Big Stone Unit II will provide surplus transmission capacity for up to

1000 MW of wind generation. The record demonstrated that the project may actually encourage wind development, not impede it.

Stueve's Proposed Findings of Fact

Proposed Finding 1 – Rejected. In Conclusion of Law 12, the Commission concluded that because a federal EIS has been prepared in this case and was entered into the record as evidence, any requirement that may exist regarding the preparation of an EIS has been substantially satisfied. SDCL 34A-9-11. The Commission is required to act on the Application within one year, and the Commission does not believe that it is justifiable to deny the permit and subject the Applicants and the other parties to the very substantial cost of another proceeding merely on the basis that the federal EIS process has not yet resulted in adoption of the final EIS document. The Commission expects changes to the Draft EIS to be minimal. Furthermore, the permit issued by this Decision is subject to Condition 2.D. which will require Applicants to comply with any mitigation measures which are included in the Final EIS.

Proposed Finding 2 – Rejected. The evidence introduced by Applicants, including the federal Draft EIS, thoroughly addressed the environmental impacts of the Big Stone Unit II facility, and the Decision contains numerous Findings of Fact reflecting the evidence regarding environmental impacts.

Proposed Finding 3 – Rejected. The Decision includes Findings of Fact on mercury emissions and required conditions in Findings 127-132 and 198 and Conditions 2.A., 2.B. and 5. requiring compliance with the mercury emissions standards and the required emissions limit and reporting on progress toward attainment of the mercury emissions limit during the three year implementations period.

BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

In the Matter of the Application by Otter Tail Power Company on behalf of the Big Stone II Co-owners for an Energy Conversion Facility Siting Permit for the Construction of the Big Stone II Project	))))	Case No EL05-022

Direct Testimony of

David A. Schlissel and Anna Sommer
Synapse Energy Economics, Inc.

On Behalf of

Minnesotans for an Energy-Efficient Economy
Izaak Walton League of America – Midwest Office
Union of Concerned Scientists
Minnesota Center for Environmental Advocacy

May 19, 2006

List of Joint Intervenors Exhibits

JI-1-A	Resume of David Schlissel
JI-1-B	Resume of Anna Sommer
JI-1-C	EIA Natural Gas Price Forecasts 1990-2006
JI-1-D	Interrogatory 18 of Joint Intervenors' First Set and First Amended Set of Interrogatories
JI-1-E	Descriptive Slide Submitted to Commission by Co-owners on 10.5.2005
JI-1-F	Climate Change and Power: Carbon Dioxide Emissions Costs and Electricity Resource Planning
JI-1-G	Minnesota PUC Order Establishing Environmental Cost Values
JI-1-H	Joint Intervenors' First Set of Requests for Admission

Q. Mr. Schlissel, please state your name, position and business address.

A. My name is David A. Schlissel. I am a Senior Consultant at Synapse Energy Economics, Inc, 22 Pearl Street, Cambridge, MA 02139.

Q. Ms. Sommer, please state your name position and business address.

A. My name is Anna Sommer. I am a Research Associate at Synapse Energy Economics, Inc., 22 Pearl Street, Cambridge, MA 02139.

Q. On whose behalf are you testifying in this case?

A. We are testifying on behalf of Minnesotans for an Energy-Efficient Economy, Izaak Walton League of America – Midwest Office, Union of Concerned Scientists, and Minnesota Center for Environmental Advocacy ("Joint Intervenors").

Q. Please describe Synapse Energy Economics.

A. Synapse Energy Economics ("Synapse") is a research and consulting firm specializing in energy and environmental issues, including electric generation, transmission and distribution system reliability, market power, electricity market prices, stranded costs, efficiency, renewable energy, environmental quality, and nuclear power.

Synapse's clients include state consumer advocates, public utilities commission staff (and have included the Staff of the South Dakota Public Utilities Commission), attorneys general, environmental organizations, federal government and utilities.

Q. Mr. Schlissel, please summarize your educational background and recent work experience.

A. I graduated from the Massachusetts Institute of Technology in 1968 with a Bachelor of Science Degree in Engineering. In 1969, I received a Master of Science Degree in Engineering from Stanford University. In 1973, I received a Law Degree from Stanford University. In addition, I studied nuclear engineering at the Massachusetts Institute of Technology during the years 1983-1986.

Since 1983 I have been retained by governmental bodies, publicly-owned utilities, and private organizations in 28 states to prepare expert testimony and analyses on engineering and economic issues related to electric utilities. My clients have included the Staff of the Arizona Corporation Commission, the General Staff of the Arkansas Public Service Commission, the Staff of the Kansas State Corporation Commission, municipal utility systems in Massachusetts, New York, Texas, and North Carolina, and the Attorney General of the Commonwealth of Massachusetts.

I have testified before state regulatory commissions in Arizona, New Jersey, Connecticut, Kansas, Texas, New Mexico, New York, Vermont, North Carolina, South Carolina, Maine, Illinois, Indiana, Ohio, Massachusetts, Missouri, and Wisconsin and before an Atomic Safety & Licensing Board of the U.S. Nuclear Regulatory Commission.

A copy of my current resume is attached as Exhibit JI-1-A.

Q. Have you previously submitted testimony before this Commission?

A. No.

Q. Ms. Sommer, please summarize your educational background and work experience.

A. I am a Research Associate with Synapse Energy Economics. I provide research and assist in writing testimony and reports on a wide range of issues from renewable energy policy to integrated resource planning. My recent work includes aiding a Florida utility in its integrated resource planning, evaluating the feasibility of carbon sequestration and reviewing the analyses of the air emissions compliance plans of two Indiana utilities and one Nova Scotia utility.

I also have participated in studies of proposed renewable portfolio standards in the United States and Canada. In addition, I have evaluated the equity of utility renewable energy solicitations in Nova Scotia and the feasibility and prudence of the sale and purchase of existing gas and nuclear capacity in Arkansas and Iowa.

Prior to joining Synapse, I worked at EFI and XENERGY (now KEMA Consulting) and Zilkha Renewable Energy (now Horizon Wind Energy). At XENERGY and Zilkha I focused on policy and economic aspects of renewable energy. While at Zilkha, I authored a strategy and information plan for the development of wind farms in the western United States.

I hold a BS in Economics and Environmental Studies from Tufts University. A copy of my current resume is attached as Exhibit JI-1-B.

Q. Ms. Sommer, have you previously submitted testimony before this Commission?

A. No.

Q. What is the purpose of your testimony?

A. Synapse was asked by Joint Intervenors to investigate the following four issues regarding the proposed Big Stone II coal-fired generating facility:

A. The need and timing for new supply options in the utilities' service territories.

B. Whether there are alternatives to the proposed facility that are technically feasible and economically cost-effective.

C. Whether the applicants have included appropriate emissions control technologies in the design of the proposed facility.

D. Whether the applicants have appropriately reflected the potential for the regulation of greenhouse gases in the design of the proposed facility and in their analyses of the alternatives.

This testimony and the testimony of our colleague Dr. Ezra Hausman presents the results of our investigations of Issue D. Our testimony regarding Issues A, B and C will be submitted on May 26, 2006.

Q. Please summarize your conclusions on the issue of whether the Big Stone II Co-owners have appropriately reflected the potential for the regulation of greenhouse gases in the design of the proposed facility and in their analyses of the alternatives.

A. Our conclusions on this issue are as follows:

1. Climate change is causing and can be expected in the future to cause "significant" environmental harm, as explained in detail in the Testimony of Dr. Ezra Hausman.

2. There is scientific consensus that emissions of carbon dioxide cause climate change.

3. Big Stone Unit II would emit significant amounts of additional carbon dioxide.

4. As a result, the Big Stone Unit II will pose a serious threat to the environment.

5. The potential for the regulation of carbon dioxide must be considered as part of any prudent cost estimates of Big Stone Unit II and alternatives.

6. However, the Big Stone II Co-owners have not adequately analyzed the potential for future carbon regulation.

7. The externality values for carbon dioxide established by the Minnesota Public Utilities Commission and used in resource planning by some of the Co-owners are meant to recognize "external" costs, or, in other words, costs that are not directly paid by utilities or their customers. The Minnesota Commission's externality values are not reflective of any concerns about the real costs of complying with future carbon dioxide regulation.

8. Synapse Energy Economics has developed a greenhouse gas allowance price forecast that reflects a range of prices that could reasonably be expected through 2030.

9. Adopting Synapse's range of prices would increase Big Stone Unit II's annual projected costs by $35,152,128 to $137,463,322 on a levelized basis.

Q. In the process of your investigation did you keep in mind the interests of the Big Stone Co-owners' customers?

A. Absolutely. Synapse regularly works for consumer advocates and has worked for over half of the members of the National Association of State Utility Consumer Advocates. Fundamentally, we believe that greenhouse gas regulation not only is an environmental issue. It also is a consumer issue in that it will have direct and tangible impacts on future rates.

Q. You have mentioned the terms "carbon dioxide regulation" and "greenhouse gas regulation." What is the difference between these two?

A. As we use these terms throughout our testimony, there is no difference. While we believe that the future regulation we discuss here will govern emissions of all types of greenhouse gases, not just carbon dioxide ("CO_2"), for the purposes of our discussion we are chiefly concerned with emissions of carbon dioxide. Therefore, we use the terms "carbon dioxide regulation" and "greenhouse gas regulation" interchangeably. Similarly, the terms "carbon dioxide price," "greenhouse gas price" and "carbon price" are interchangeable.

Q. Is it prudent to expect that a policy to address climate change will be implemented in the U.S. in a way that should be of concern to coal-dependent utilities in the Midwest?

A. Yes. The prospect of global warming and the resultant widespread climate changes has spurred international efforts to work towards a sustainable level of greenhouse gas emissions. These international efforts are embodied in the United Nations Framework Convention on Climate Change ("UNFCCC"), a treaty that the U.S. ratified in 1992, along with almost every other country in the world. The Kyoto Protocol, a supplement to the UNFCCC, establishes legally binding limits on the greenhouse gas emissions of industrialized nations and economies in transition.

Despite being the single largest contributor to global emissions of greenhouse gases, the United States remains one of a very few industrialized nations that have not signed the Kyoto Protocol. Nevertheless, individual states, regional groups of states, shareholders and corporations are making serious efforts and taking significant steps towards reducing greenhouse gas emissions in the United States. Efforts to pass federal legislation addressing carbon, though not yet successful, have gained ground in recent years. These developments, combined with the growing scientific understanding of, and evidence of, climate change as outlined in Dr. Hausman's testimony, mean that establishing federal policy requiring greenhouse gas emission reductions is just a matter of time. The question is not whether the United States will develop a national policy addressing climate change, but when and how. The electric sector will be a key component of any regulatory or legislative approach to reducing greenhouse gas emissions both because of this sector's contribution to national emissions and the comparative ease of regulating large point sources.

There are, of course, important uncertainties with regard to the timing, the emission limits, and many other details of what a carbon policy in the United States will look like.

Q. **If there are uncertainties with regard to such important details as timing, emission limits and other details, why should a utility engage in the exercise of forecasting greenhouse gas prices?**

A. First of all, utilities are implicitly assuming a value for carbon allowance prices whether they go to the effort of collecting all the relevant information and create a price forecast or whether they simply ignore future carbon regulation. In other words, a utility that ignores future carbon regulations is implicitly assuming that the allowance value will be zero. The question is whether it's appropriate to assume zero or some other number. There is uncertainty in any type of utility forecasting and to write off the need to forecast carbon allowance prices because of the uncertainties is not prudent.

For example, there are myriad uncertainties that utility planners have learned to address in planning. These include randomly occurring generating unit outages, load forecast error and demand fluctuations, and fuel price volatility and uncertainty. These various uncertainties can be addressed through techniques such as sensitivity and scenario analyses.

To illustrate that there is significant uncertainty in other types of forecasts, we think it is informative to examine historical gas price forecasts by the Energy Information Administration (EIA). Exhibit JI-1-C compares EIA forecasts from the period 1990 - 2006 with actual price data through 2005. The data, over more than a decade, shows considerable volatility, even on an annual time scale.[1] But the truly striking thing that jumps out of the figure is how wrong the forecasts have sometimes been. For example, the 1996 forecast predicted gas prices would start at $2.61/MMBtu and remain under $3/MMBTU through 2010, but by the year 2000 actual prices had already jumped to $4.82/MMBTu and by 2005 they were up to $8.09/MMBtu.

In view of the forecasting track record for gas prices one might be tempted to give up, and either throw darts or abandon planning altogether. But thankfully modelers, forecasters, and planners have taken on the challenge – and have improved the models over time, thereby producing more reliable (although still quite uncertain) price forecasts, and system planners have refined and applied techniques for addressing fuel price uncertainty in a rational and proactive way.

It is, therefore, troubling and wrong to claim that forecasting carbon allowance prices should not be undertaken as a part of utility resource decision-making because it is "speculative."

Q. Do the Co-owners have any opinions or thoughts as to when carbon regulation will happen?

A. No. Interrogatory 18 of Joint Intervenors' First Set and First Amended Set of Interrogatories[2] asked each of the Co-owners to state whether it:

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1 Gas prices also show terrific volatility on shorter time scales (e.g., monthly or weekly prices).

2 The Co-owners' response to Interrogatory 18 is attached as Exhibit JI-1-D.

> believes it is likely that greenhouse gas regulation (ghg) will be implemented in the U.S. (a) in the next five years, (b) in the next ten years, and (c) in the next twenty years.

None of the co-owners had any thoughts as to when or even if greenhouse gas regulation would occur. Two of the Co-owners (GRE and HCPD) claim to closely follow discussion of GHG regulation at the federal and State levels, but apparently had no opinions about what might result from such discussions.

Q. If the siting permit for Big Stone Unit II were to be approved and the unit were built, is carbon regulation an issue that could be reasonably dealt with in the future, once the timing and stringency of the regulation is known?

A. Unfortunately, no. Unlike for other power plant air emissions like sulfur dioxide and oxides of nitrogen, there currently is no commercial or economical method for post-combustion removal of carbon dioxide from supercritical pulverized coal plants. The Big Stone II Co-owners agree on that point. During the public hearing in Milbank held on September 13, 20005, the Co-owners presented several slides on the expected combined emissions from Big Stone Units I & II. The descriptive slide for the CO_2 emissions chart submitted to the South Dakota PUC states there is "no commercially available capture and sequestration technology." This slide is attached as Exhibit JI-1-E. Regardless of the uncertainty, this is an issue that needs to be dealt with before new resource decisions are made.

Q. Do other utilities have opinions about whether and when greenhouse gas regulation will come?

A. Yes. For example, James Rogers, CEO of Duke Energy, has publicly said "[I]n private, 80-85% of my peers think carbon regulation is coming within ten years, but most sure don't want it now."[3] Not wanting carbon regulation from a utility perspective is understandable because carbon price forecasting is not simple and easy, it makes resource planning more difficult and is likely to change "business

3 "The Greening of General Electric: A Lean, Clean Electric Machine," *The Economist*, December 10, 2005, at page 79.

as usual." For many utilities, including the Big Stone II Co-owners, that means that it is much more difficult to justify building a pulverized coal plant. Regardless, it is imprudent to ignore the risk.

Duke is not alone in believing that carbon regulation is inevitable and, indeed, some utilities are advocating for mandatory greenhouse gas reductions. In a May 6, 2005, statement to the Climate Leaders Partners (a voluntary EPA-industry partnership), John Rowe, Chair and CEO of Exelon stated, "At Exelon, we accept that the science of global warming is overwhelming. We accept that limitations on greenhouse gases emissions [sic] will prove necessary. Until those limitations are adopted, we believe that business should take voluntary action to begin the transition to a lower carbon future."

In fact, several electric utilities and electric generation companies have incorporated assumptions about carbon regulation and costs into their long term planning, and have set specific agendas to mitigate shareholder risks associated with future U.S. carbon regulation policy. These utilities cite a variety of reasons for incorporating risk of future carbon regulation as a risk factor in their resource planning and evaluation, including scientific evidence of human-induced climate change, the U.S. electric sector's contribution to emissions, and the magnitude of the financial risk of future greenhouse gas regulation.

Some of the companies believe that there is a high likelihood of federal regulation of greenhouse gas emissions within their planning period. For example, Pacificorp states a 50% probability of a CO_2 limit starting in 2010 and a 75% probability starting in 2011. The Northwest Power and Conservation Council models a 67% probability of federal regulation in the twenty-year planning period ending 2025 in its resource plan. Northwest Energy states that CO_2 taxes "are no longer a remote possibility."[4]

4 Northwest Energy 2005 Electric Default Supply Resource Procurement Plan, December 20, 2005; Volume 1, p. 4.

Even those in the electric industry who oppose mandatory limits on greenhouse gas regulation believe that regulation is inevitable. David Ratcliffe, CEO of Southern Company, a predominantly coal-fired utility that opposes mandatory limits, said at a March 29, 2006, press briefing that "There certainly is enough public pressure and enough Congressional discussion that it is likely we will see some form of regulation, some sort of legislation around carbon."[5]

Q. Do companies outside of electric utilities support greenhouse gas regulation?

Support for the passage of greenhouse gas regulation has been expressed by senior executives in companies such as Wal-Mart, General Electric, BP, Shell, and Goldman Sachs. For example, on April 4, 2006, during a Senate hearing on the design of a CO_2 cap-and-trade system, a representative of GE Energy said the following:

"GE supports development of market-based programs to slow, eventually stop, and ultimately reverse the growth of greenhouse gases (GHG)."

--David Slump, GE Energy, General Manager, Global Marketing, executive summary of comments to Senate Energy and Natural Resources Committee

Q. Why would so many electric utilities, in particular, be concerned about future carbon regulation?

A. Electricity generation is very carbon-intensive. Electric utilities are likely to be one of the first, if not the first, industries subject to carbon regulation because of the relative ease in regulating stationary sources as opposed to mobile sources (automobiles) and because electricity generation represents a significant portion of total U.S. greenhouse gas emissions. A new generating facility may have a book life of twenty to forty years, but in practice, the utility may expect that that asset will have an operating life of 50 years or more. By adding new plants, especially new coal plants, a utility is essentially locking-in a large quantity of

5 Quoted in "U.S. Utilities Urge Congress to Establish CO2 Limits," Bloomberg.com, http://www.bloomberg.com/apps/news?pid=10000103&sid=a75A1ADJv8cs&refer=us

carbon dioxide emissions for decades to come. In general, electric utilities are increasingly aware that the fact that we do not currently have federal greenhouse gas regulation is irrelevant to the issue of whether we will in the future, and that new plant investment decisions are extremely sensitive to the expected cost of greenhouse gas regulation throughout the life of the facility.

Q. Have mandatory greenhouse gas emissions reductions programs begun to be examined and debated in the U.S. federal government?

A. To date, the U.S. government has not required greenhouse gas emission reductions. However, legislative initiatives for a mandatory market-based greenhouse gas cap and trade program are under consideration.[6]

Several mandatory emissions reduction proposals have been introduced in Congress. These proposals establish carbon dioxide emission trajectories below the projected business-as-usual emission trajectories, and they generally rely on market-based mechanisms (such as cap and trade programs) for achieving the targets. The proposals also include various provisions to spur technology innovation, as well as details pertaining to offsets, allowance allocation, restrictions on allowance prices and other issues. Through their consideration of these proposals, legislators are increasingly educated on the complex details of different policy approaches, and they are laying the groundwork for a national mandatory program. Federal proposals that would require greenhouse gas emission reductions are summarized in Table 5.1 in Exhibit JI-1-F.

It is significant that the U.S. Congress is examining and debating these emissions reduction proposals. However, as shown in Figure 5.2 in Exhibit JI-1-F, the emissions trajectories contained in the proposed federal legislation are in fact quite modest compared with the emissions reductions that are anticipated to be necessary to achieve stabilization of atmospheric concentrations of greenhouse gases. Figure 5.2 in Exhibit JI-1-F compares various emission reduction trajectories and goals in relation to a 1990 baseline. U.S. federal proposals, and

[6] Exhibit JI-1-F, at pages 11- 16.

even Kyoto Protocol reduction targets, are small compared with the current E.U. emissions reduction target for 2020, and the emissions reductions that most scientists claim will ultimately be necessary to avoid the most dangerous impacts of global warming.

Q. Are any states developing and implementing climate change policies that will have a bearing on resource choices in the electric sector?

A. Yes. A growing number of states are developing and implementing the following types of policies that will affect greenhouse gas emissions in the electric sector: (1) direct policies that require specific emissions reductions from electric generation sources; (2) indirect policies that affect electric sector resource mix such as through promoting low-emission electric sources; (3) legal proceedings; or (4) voluntary programs including educational efforts and energy planning.[7]

Direct policies include the New Hampshire and Massachusetts laws imposing caps on carbon dioxide emissions from power plants in those states.

Indirect policies include the requirements by various states to either consider future carbon dioxide regulation or use specific "adders" for carbon dioxide in resource planning. It also includes policies and incentives to increase energy efficiency and renewable energy use, such as renewable portfolio standards. Some of these requirements are at the direction of state public utilities commissions, others are statutory requirements.

Lawsuits make up the majority of the third category. For example, several states are suing the U.S. Environmental Protection Agency (EPA) to have carbon dioxide regulated as a pollutant under the Clean Air Act.

Among the voluntary programs undertaken at the state level are the climate change action plans developed by 28 states.

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7 Exhibit JL-1-F, at pages 16 through 20.

But states are not just acting individually; there are a number of examples of innovative regional policy initiatives that range from agreeing to coordinate information (e.g., Southwest governors and Midwestern legislators) to development of a regional cap and trade program through the Regional Greenhouse Gas Initiative in the Northeast ("RGGI"). The objective of the RGGI is the stabilization of CO_2 emissions from power plants at current levels for the period 2009-2015, followed by a 10 percent reduction below current levels by 2019. These regional activities are summarized in Table 5.5 in Exhibit JI-1-F.

Q. Have any states adopted direct policies that require specific emissions reductions from electric sources?

A. Yes. The states of Massachusetts, New Hampshire, Oregon and California have adopted policies requiring greenhouse gas emission reductions from power plants.[8]

Q. Do any states require that utilities or default service suppliers evaluate costs or risks associated with greenhouse gas emissions in long-range planning or resource procurement?

A. Yes. As shown in Table 1 below, several states require companies under their jurisdiction to account for the emission of greenhouse gases in resource planning.

8 Exhibit JI-1-F, Table 5.3 on page 18.

Table 1. Requirements for Consideration of Greenhouse Gas Emissions in Electric Resource Decisions

Program type	State	Description	Date	Source
GHG value in resource planning	CA	PUC requires that regulated utility IRPs include carbon adder of $8/ton CO_2, escalating at 5% per year.	April 1, 2005	CPUC Decision 05-04-024
GHG value in resource planning	WA	Law requiring that cost of risks associated with carbon emissions be included in Integrated Resource Planning for electric and gas utilities	January, 2006	WAC 480-100-238 and 480-90-238
GHG value in resource planning	OR	PUC requires that regulated utility IRPs include analysis of a range of carbon costs	Year 1993	Order 93-695
GHG value in resource planning	NWPCC	Inclusion of carbon tax scenarios in Fifth Power Plan	May, 2006	NWPCC Fifth Energy Plan
GHG value in resource planning	MN	Law requires utilities to use PUC established environmental externalities values in resource planning	January 3, 1997	Order in Docket No. E-999/CI-93-583
GHG in resource planning	MT	IRP statute includes an "Environmental Externality Adjustment Factor" which includes risk due to greenhouse gases. PSC required Northwestern to account for financial risk of carbon dioxide emissions in 2005 IRP.	August 17, 2004	Written Comments Identifying Concerns with NWE's Compliance with A.R.M. 38.5.8209-8229; Sec. 38.5.8219, A.R.M.
GHG in resource planning	KY	KY staff reports on IRP require IRPs to demonstrate that planning adequately reflects impact of future CO_2 restrictions	2003 and 2006	Staff Report On the 2005 Integrated Resource Plan Report of Louisville Gas and Electric Company and Kentucky Utilities Company - Case 2005-00162, February 2006
GHG in resource planning	UT	Commission directs Pacificorp to consider financial risk associated with potential future regulations, including carbon regulation	June 18, 1992	Docket 90-2035-01, and subsequent IRP reviews
GHG in resource planning	MN	Commission directs Xcel to "provide an expansion of CO2 contingency planning to check the extent to which resource mix changes can lower the cost of meeting customer demand under different forms of regulation."	August 29, 2001	Order in Docket No. RP00-787
GHG in CON	MN	Law requires that proposed non-renewable generating facilities consider the risk of environmental regulation over expected useful life of the facility	2005	Minn. Stat. §216B.243 subd. 3(12) (2005)

Q. What carbon dioxide values are being used by utilities in electric resource planning?

A. Table 2 below presents the carbon dioxide costs, in $/ton CO_2, that are presently being used in the industry for both resource planning and modeling of carbon regulation policies.

Table 2. Carbon Dioxide Costs Used by Utilities

Company	CO2 emissions trading assumptions for various years ($2005)
PG&E*	$0-9/ton (start year 2006)
Avista 2003*	$3/ton (start year 2004)
Avista 2005	$7 and $25/ton (2010) $15 and $62/ton (2026 and 2023)
Portland General Electric*	$0-55/ton (start year 2003)
Xcel-PSCCo	$9/ton (start year 2010) escalating at 2.5%/year
Idaho Power*	$0-61/ton (start year 2008)
Pacificorp 2004	$0-55/ton
Northwest Energy 2005	$15 and $41/ton
Northwest Power and Conservation Council	$0-15/ton between 2008 and 2016 $0-31/ton after 2016

**Values for these utilities from Wiser, Ryan, and Bolinger, Mark. "Balancing Cost and Risk: The Treatment of Renewable Energy in Western Utility Resource Plans." Lawrence Berkeley National Laboratories. August 2005. LBNL-58450. Table 7.*
Other values: PacifiCorp, Integrated Resource Plan 2003, pages 45-46; and Idaho Power Company, 2004 Integrated Resource Plan Draft, July 2004, page 59; Avista Integrated Resource Plan 2005, Section 6.3; Northwestern Energy Integrated Resource Plan 2005, Volume 1 p. 62; Northwest Power and Conservation Council, Fifth Power Plan pp. 6-7. Xcel-PSCCo, Comprehensive Settlement submitted to the CO PUC in dockets 04A-214E, 215E and 216E, December 3, 2004. Converted to $2005 using GDP implicit price deflator.

Q. How should utilities plan for and mitigate the risk of greenhouse gas regulation?

A. The key part of that question is "plan for the risk of greenhouse gas regulation." Mitigating risk begins with the resource planning process and the decision as to the demand-side and supply-side options that should be pursued. A utility that chooses to go forward with a new, carbon intensive energy resource without proper consideration of carbon regulation is imprudent. To give an analogy it would be like choosing to build a gas-fired power plant without consideration of the cost of gas because one believes that building the plant is "worth it" regardless of what gas might cost.

A utility that desires to be prudent about the risk of carbon regulation would, at a minimum, consider carbon regulation by developing an expected carbon price forecast as well as reasonable sensitivities around that case.

Q. Please explain how Synapse developed its carbon price forecast.

A. Our forecast is described in more detail in Exhibit JI-1-F starting on page 39.

During the decade from 2010 to 2020, we anticipate that a reasonable range of carbon emissions prices will reflect the effects of increasing public concern over climate change (this public concern is likely to support increasingly stringent emission reduction requirements) and the reluctance of policymakers to take steps that would increase the cost of compliance (this reluctance could lead to increased emphasis on energy efficiency, modest emission reduction targets, or increased use of offsets). We expect that the widest uncertainty in our forecasts will begin at the end of this decade, that is, from $10 to $40 per ton of CO_2 in 2020, depending on the relative strength of these factors.

After 2020, we expect the price of carbon emissions allowances to trend upward toward a marginal mitigation cost. This number will depend on currently uncertain factors such as technological innovation and the stringency of carbon caps, but it is likely that, by this time, the least expensive mitigation options (such as simple energy efficiency and fuel switching) will have been exhausted. Our projection for greenhouse gas emissions costs at the end of this decade ranges from $20 to $50 per ton of CO_2 emissions.

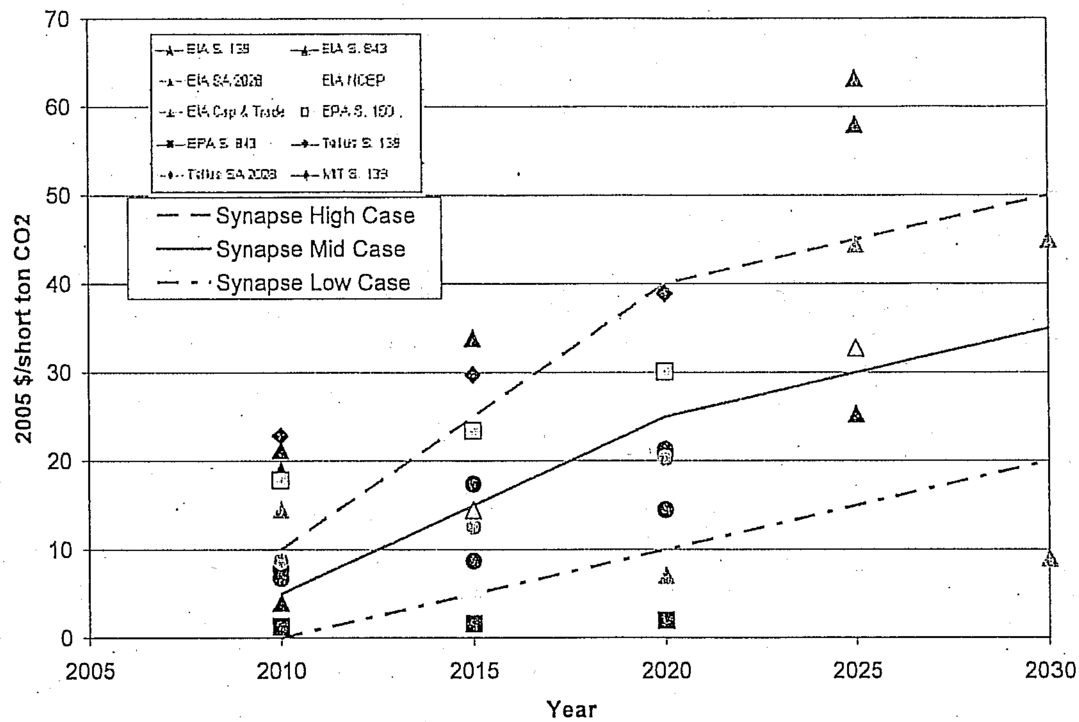
We currently believe that the most likely scenario is that as policymakers commit to taking serious action to reduce carbon emissions, they will choose to enact both cap and trade regimes and a range of complementary energy policies that lead to lower cost scenarios, and that technology innovation will reduce the price of low-carbon technologies, making the most likely scenario closer to (though not equal to) low case scenarios than the high case scenario. We expect that the probability of taking this path will increase over time, as society learns more about optimal carbon reduction policies.

After 2030, and possibly even earlier, the uncertainty surrounding a forecast of carbon emission prices will increase due to the interplay of factors such as the level of carbon constraints required and technological innovation. As discussed in Exhibit JI-1-F, scientists anticipate that very significant emission reductions will be necessary, in the range of 80 percent below 1990 emission levels, to achieve stabilization targets that will keep global temperature increases to a somewhat manageable level. As such, we believe there is a substantial likelihood that response to climate change impacts will require much more aggressive emission reductions than those contained in U.S. policy proposals, and in the Kyoto Protocol, to date. If the severity and certainty of climate change are such that emissions levels 70-80% below current rates are mandated, this could result in very high marginal emissions reduction costs, though we have not quantified the cost of such deeper cuts on a per ton basis.

Q. What is Synapse's forecast of carbon dioxide emissions prices?

A. Synapse's forecast of future carbon dioxide emissions prices are presented in Figure 1 below. This figure superimposes Synapse's forecast on the results of other cost analyses of proposed federal policies:

Figure 1. Synapse Carbon Dioxide Prices



Q. What is Synapse's levelized carbon price forecast?

A. Synapse's forecast, levelized[9] over 20 years, 2011 – 2030, is provided in Table 3 below.

Table 3. Synapse's Levelized Carbon Price Forecast (2005$/ton)

Low Case	Mid Case	High Case
$7.8	$19.1	$30.5

[9] A value that is "levelized" is the present value of the total cost converted to equal annual payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

Q. The Minnesota Public Utilities Commission has established environmental externality values for a number of pollutants including CO_2. Wouldn't it be sufficient and more efficient to simply use the CO_2 externality values? The effect is the same, to bias resource selection towards non-CO_2 emitting resources.

A. That would appear to be an easy solution, but the MN PUC values are meant to reflect external costs arising from damage to the environment caused by climate change (as a percentage of GDP). The Commission's order of January 3, 1997 explained:[10]

> The environmental values for CO_2 quantified in this Order follow MPCA witness Ciborowski's general methodology. First, Ciborowski estimated **long-term global costs** based on the existing economic literature and **discounted** them to current values. Then, he divided that amount by the amount of long-term CO_2 emissions to arrive at an average cost per ton. Ciborowski essentially converted published damage estimates made by economists from percentages of gross domestic product (GDP) into costs per ton of CO_2.

The full order is attached as Exhibit JI-1-G. Clearly this order shows that the Minnesota environmental externality values contain no consideration of future carbon regulation and the *actual* costs that regulation would impose on utilities. Indeed, the range of CO_2 values adopted by the Minnesota PUC is much smaller than the range of Synapse's price forecasts, \$0.35 – 3.64 per ton of CO_2 (2004\$).

Q. Have the Big Stone II co-owners adequately considered the risk of greenhouse gas regulation?

A. No. The Co-owners' approach is what might be called keeping their heads in the sand and hoping that the problem of global warming goes away. For example, the Co-owners could not answer basic questions about the United Nations Framework Convention on Climate Change. Request for Admission No. 22 in the Joint Intervenors' First Set of Requests for Admission asked the Co-owners to:

[10] Page 27 of the Order Establishing Environmental Cost Values in Docket No. E-99/CI-93-583 issued January 3, 1997.

> Admit that in 1992 the United Nations Framework Convention on Climate Change was adopted [IPCC 2005, p 5].

The Co-owners responded by saying that:

> Applicant has made reasonable inquiry and the information known to it is insufficient to enable Applicant to admit or deny this statement.

Similarly, Request for Admission No. 25 asked the Co-owners to:

> Admit that the most recent Assessment Report released by the IPCC is the Third Assessment Report (TAR), released in 2001, and that part of the TAR is the report of the Working Group I of the IPCC, entitled "Climate Change 2001: The Scientific Basis."

Again, the Co-owners responded, in part:

> Applicant has made reasonable inquiry and the information known to it is insufficient to enable Applicant to admit or deny this statement.

In *twenty* separate instances, the Co-owners could not answer requests for admission requiring them to do nothing more than admit facts that could easily be verified by an internet search (starting with the internet addresses that Joint Intervenors in many cases provided in the questions) or by referring to the document(s) attached to the request. Attached as Exhibit JI-1-H, is the Joint Intervenors' First Set of Requests for Admission with these twenty responses highlighted.

Q. How are such responses relevant to the issue of considering carbon regulation in resource planning?

A. If a utility does not rely upon outside expertise to, at a basic level, advise the utility on future carbon regulation and second to forecast carbon allowance prices, it must rely upon its own knowledge and information gathering to do so. A major step in that process is to understand the various parties involved and what their recommendations mean to policymakers. Organizations such as the Intergovernmental Panel on Climate Change are well recognized and regarded and their thoughts on topics such as climate change do not go by the wayside. The inability to answer these basic questions, let alone put in the small effort that would be necessary to answer such questions, bodes poorly for the Co-owners' decision-making.

Q. Did the Co-owners reflect any potential greenhouse gas regulations in their resource planning for Big Stone II?

A. No. In certain instances they used the Minnesota PUC environmental externality value for carbon dioxide, which as we discussed above is not adequate consideration of regulatory risk and uncertainty.

Q. Are the Big Stone II Co-owners already heavily dependent upon coal-fired generation?

A. Yes. The testimony in this proceeding reveals that each of the Co-owners already is heavily dependent upon coal-fired generation. Although some Co-owners are making some efforts to add wind, participation in Big Stone II will further increase the Co-owners' dependence upon coal-fired generation and, consequently, their exposure to future greenhouse gas regulations.

For example, Otter Tail Power's testimony in this proceeding reveals that as of 2004, 60.3 percent (winter) to 65.3 percent (summer) of the Company's generating capacity was coal-fired.[11] When oil and natural gas fired capacity is included, more than 75 percent of Otter Tail's current generating capacity is fossil-fired.

GRE's 2006 generation mix is 76 percent from coal, not including additional coal-fired generation that might be the sources for the other purchased power listed in the Company's testimony.[12]

CMMPA's listing of its existing and planned capacity resources includes 43 MW of coal-fired capacity (75 percent of the total) and 13.5 MW of wind.[13]

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11 Applicants' Exhibits 10-D and 10-E.

12 Applicants' Exhibit 2, page 14, lines 19-23.

13 Applicants' Exhibit 6, page 10, lines 1-2.

Seventy-six percent of Montana-Dakota Utilities existing owned-generation is coal-fired.[14] However, despite this reliance on coal, Montana-Dakota Utilities 2005 Integrated Resource Plan reveals that, other than possible purchases from other utilities or the energy market, the only new baseload options that the company was considering were coal-fired units.[15]

Approximately 50 percent of MRES' existing capacity, and all of its baseload capacity, is coal-fired.[16]

Approximately 59 percent of SMMPA's existing generating capacity is coal-fired.[17]

Finally, Heartland's existing resources appear to be a mix of coal-fired generation and purchased power contracts.[18] Heartland has indicated that from 2013 to 2020, i.e., after the end of its purchased power agreement with Nebraska Public Power District, it plans to have the following resources available for its customers: Laramie River Station (50 MW); Customer-owned peaking generation (24 MW); Big Stone Unit II (25 MW); and Whelan Energy Center Unit 2 (80 MW).[19] This means that all of the resources that Heartland plans to have available for its customers during these years will be fossil-fired, and approximately 86 percent will be coal-fired.

Q. How much additional CO_2 will Big Stone II emit into the atmosphere?

A. At its projected 88 percent capacity factor (i.e., 4625 GWH), Big Stone II will emit approximately 4,506,000 tons of CO_2 annually.

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14 Applicants' Exhibit 11, page 8, lines 9-17.

15 *Montana-Dakota Utilities Co. 2005 Integrated Resource Plan submitted to the Montana Public Service Commission*, dated September 15, 2005, at pages (iii) and (iv).

16 Applicants' Exhibit 14, at page 9, line 6, to page 10, line 3.

17 Applicants' Exhibit 13, page 4, line 14, to page 5, line 8.

18 Applicants' Exhibit 15, page 16, lines 16-23.

19 Co-owners' Response to Interrogatory 62 of the Intervenors' Sixth Set of Interrogatories in this Docket.

Q. Would incorporating Synapse's carbon price forecast have a material effect on the economics of building and operating the proposed Big Stone II Project?

A. Yes. For illustrative purposes, we have calculated the CO_2 cost of a new fossil-fuel fired generating unit built in 2011 using each case of our carbon price forecast levelized over the 20-year period from 2011 to 2030.

Table 4. CO_2 Cost of New Fossil-Fuel Resources

For a new plant online in 2011

	Supercritical PC	Combined Cycle	IGCC	Source Notes
Size (MW)	600	600	535	1
CO_2 (lb/MMBtu)	208	110	200	1
Heat Rate (Btu/KWh)	9,369	7,400	9,612	1
CO_2 Low Price (2005$/ton)	7.80	7.80	7.80	2
CO_2 Mid Price (2005$/ton)	19.10	19.10	19.10	2
CO_2 High Price (2005$/ton)	30.50	30.50	30.50	2
CO_2 Low Cost per MWh	$7.60	$3.17	$7.50	
CO_2 Mid Cost per MWh	$18.61	$7.77	$18.36	
CO_2 High Cost per MWh	$29.72	$12.41	$29.32	

1 - From Applicants' Exhibit 23-A
2 - Synapse's carbon allowance price forecast levelized over 20 years at 7.32% real discount rate

As demonstrated in Table 4, the cost per MWh attributable to a supercritical coal plant like Big Stone II from greenhouse gas regulation is quite significant. From a purely qualitative standpoint, it is very difficult to imagine that other resources would not be more cost-effective than Big Stone II with the addition of *$18.61/MWh* in operating costs from our mid-case CO_2 price forecast.

According to Applicants' Exhibit 23-A, Burns & McDonnell's *Analysis of Baseload Generation Alternatives*, the busbar cost of Big Stone II is $50.71/MWh (2005$) for investor-owned utilities (IOUs) and $40.85/MWh (2005$) for public power. An $18.61/MWh increase in operating costs would represent a 37% increase in cost per MWh of Big Stone II generation to the Big Stone II investor owned utilities and a 46% increase to the public power Co-owners.

Q. What would be the annual CO_2 cost to the Big Stone II Co-owners?

A. Assuming the *Analysis of Baseload Generation Alternatives* will accurately reflect the operating parameters of Big Stone Unit II including an 88% capacity factor, the range of annual, levelized cost to the Big Stone II Co-owners of CO_2 regulation would be:

Low Case - 4,625,280 MWh · $7.74/MWh = $35,152,128

Mid Case - 4,625,280 MWh · $19.60/MWh = $86,076,461

High Case - 4,625,280 MWh · $30.39/MWh = $137,463,322

Q. Does this conclude your testimony?

A. No. The remainder of our testimony will be filed on May 26, 2006.

BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

In the Matter of the Application by Otter Tail Power Company on behalf of the Big Stone II Co-owners for an Energy Conversion Facility Siting Permit for the Construction of the Big Stone II Project	))))	Case No EL05-022

Direct Testimony of
Ezra D. Hausman, Ph.D.
Synapse Energy Economics, Inc.

On Behalf of
Minnesotans for An Energy-Efficient Economy
Izaak Walton League of America – Midwest Office
Union of Concerned Scientists
Minnesota Center for Environmental Advocacy

May 19, 2006

I. PROFESSIONAL QUALIFICATIONS AND SUMMARY

Q. Please state your name for the record.

A. My name is Ezra D. Hausman

Q. Where are you employed?

A. I am a Senior Associate with Synapse Energy Economics of Cambridge, Massachusetts

Q. Please describe your formal education.

A. I hold a PhD. in Atmospheric Science from Harvard University, a master's degree in applied physics from Harvard University, a master's degree in water resource engineering from Tufts University, and a Bachelor of Arts degree from Wesleyan University.

Q. Please describe "atmospheric science."

A. Briefly, atmospheric science is the study of the chemistry, circulation and heat transfer processes of the atmosphere. It encompasses the study of how the atmosphere interacts with the ocean and land surface through processes of chemistry, moisture exchange, and energy transfers. These processes are central to what we think of as the "climate" of the Earth and, in concert with oceanic processes, they control the distribution of surface temperature and patterns of precipitation on the planet.

Another way to look at this is as follows: A certain amount of energy reaches the surface of the Earth, as sunlight, every day. At equilibrium, the same amount of energy must be vented back to space, on average. Atmospheric science is the science of all of those chemical, physical and dynamical processes which work together to move that energy to the top of the atmosphere and release it back into space.

Q. Please describe your experience in the field of atmospheric science.

A. For my doctoral research at Harvard University, I built a dynamic computer model of the ocean-atmosphere system to explore how a number of observed changes in atmospheric chemistry, ocean circulation and ocean surface temperature at the end of the last glaciation ("ice age") can be used to explain certain aspects of the warming of the planet at that time. I demonstrated, among other things, that the increase in atmospheric Carbon Dioxide (CO_2) at that time was both a result of and a strong positive feedback for the concurrent warming of the planet.

After graduation, I worked with researchers at Columbia University to develop private sector applications of climate forecast science. This led to an initiative called the Global Risk Prediction Network, Inc. for which I served as Vice President in 1997-1998. Specific projects included serving as Principal Investigator for a statistical assessment of grain yield predictability in several crop regions around the world based on global climate indicators and for a statistical assessment of road salt demand predictability in the United States based on global climate indicators. I also prepared a preliminary design of a climate and climate forecast information website tailored to the interests of the business community.

Q. Please describe your work since 1998.

A. Since 1998 I have been primarily focused on electricity market issues, turning my numerical modeling and analysis skills to issues of electricity market structure, electric industry restructuring, asset valuation and price forecasting, and environmental regulations in the electric industry. In July of 2005, I joined Synapse Energy Economics of Cambridge, Massachusetts, to continue this work but with more of a focus on the environmental, long-term planning and consumer protection aspects of the industry. This has given me an opportunity to apply my combined expertise, in atmospheric science and in the electric industry, to some of the most important issues facing the industry and, indeed, our society.

Q. Have you attached a copy of your current resume to this testimony?

A. Yes, I have, as Exhibit JI-2-A

Q. Please provide a summary of the main points of your testimony.

A. Human induced climate change is a grave and increasing threat to the environment and to human societies around the globe. Its early effects, which are already observable and documented in the scientific literature, are consistent with those predicted by computer models of the global climate, and these same models predict much more severe effects to come. Indeed, we are on a path that, if unchanged, is likely to bring about a climate well outside the range of anything ever experienced by our species, with the potential for severe and irreversible changes that will forever alter our environment, our economies and our way of life.

While some level of climate change is already a fact, computer models tell us that we can still avoid the most dangerous impacts by limiting the further buildup of CO_2 in the atmosphere. Perhaps the most important way to achieve this is by limiting the burning of fossil fuels in the decades ahead. In contrast, if the Big Stone Unit II is built, it would inject enormous amounts of CO_2 into the atmosphere for decades to come and would contribute to the dangerous atmospheric buildup of this gas. Thus, the proposed unit would exacerbate a problem that is likely to cause dramatic environmental and economic harm to societies around the globe, including to the communities in South Dakota.

Q. What issues in particular will your testimony cover?

A. My testimony will:

- discuss the scientific basics of global climate change (Part II)
- describe some of the authoritative scientific literature on the subject, including that which is written specifically for the use of policymakers, and the state of the scientific consensus on the subject (Part III)

- describe the rise of atmospheric CO_2 globally and in the context of the long-term history of atmospheric CO_2 (Part IV)
- discuss climate changes that have occurred already (Part V)
- describe what is predicted for the future (Part VI)
- discuss some of the global impacts of climate change (Part VII)
- discuss some likely impacts of climate change on South Dakota (Part VIII)
- put Big Stone II's CO_2 emissions in the context of overall emissions (Part IX)
- express my scientific conclusions as they relate to legal standards applicable to this proceeding (Part X)

II. THE SCIENTIFIC BASICS OF GLOBAL CLIMATE CHANGE

Q. Would you explain the "greenhouse effect"?

A. The planet's climate is a function of how much energy it receives from the sun, how much of that energy it retains, and how that energy is distributed throughout the planet (by wind and ocean currents, evaporation, condensation, and other mechanisms). Solar radiation arrives on earth, mainly in the form of visible light. That radiation is absorbed by the surface of the planet, which in turn radiates heat energy upward. Some of that heat is trapped in the lower atmosphere by naturally-occurring gases, analogous to how heat is trapped in a greenhouse by the glass. This is the natural "greenhouse effect" and the heat trapping gases are commonly called "greenhouse gases."

Without the greenhouse effect, the earth would be far too cold to support liquid water, or probably any kind of life. Similarly with too strong of a greenhouse effect, the earth would be considerably warmer and might have no polar ice caps, as has happened in the geologic past. With an even stronger greenhouse effect the earth could become extremely hot and uninhabitable, like the planet Venus. For all of recorded human history, the greenhouse effect has remained within a fairly narrow range that we know today, allowing complex human civilizations to form and develop. During periods of geologic history that had different abundances of greenhouse gases such as CO_2, the earth had a very different climate.

Q. **How have humans enhanced the natural greenhouse effect?**

A. Human activities have increased the atmospheric concentration of many greenhouse gases, most notably the concentration of CO_2. This increase has come primarily from the burning of fossil fuels (coal, oil, and natural gas), and also from changes in land use such as deforestation. Of the fossil fuels, coal emits the most CO_2 per unit of energy obtained. Today the primary reason for burning coal is for generation of electricity.

Because of the continuous and accelerating recovery and combustion of fossil fuels, the background level of CO_2 in the air has increased by roughly one third since preindustrial times. This means that the planet as a whole does not lose heat to space as efficiently as it otherwise would, so the system as a whole is warming up. This is the phenomenon commonly referred to as "global warming."

Global warming will affect different areas differently, changing the distribution of rainfall, warming many areas but cooling some others, changing the length of growing seasons, and so forth. To emphasize the planet's complex *response* to global warming, scientists have coined the term "global climate change." I personally prefer to use the term "global climate change" in contexts such as this one to emphasize that the impact of the increased atmospheric CO_2 burden will not just be measured in a few warm days, but in disruptions in the very characteristics of climate that define our lives and our livelihoods.

III. SCIENTIFIC LITERATURE ON GLOBAL CLIMATE CHANGE

Q. In your opinion, what is the most comprehensive, reliable, authoritative, and scientifically credible account, relied upon by you and other experts in your field of climate science, regarding global warming, including the causes of global warming and the potential impacts on people and on the natural world?

A. There are a great number of studies published in distinguished, peer-reviewed scientific journals that are relied upon by scientists in developing a full understanding of the many aspects of climate science and climate change. However, perhaps unique to this area of science, there is a single source that has been carefully assembled by the leading researchers in the field to provide a comprehensive, reliable, authoritative, and scientifically credible digest of this body of research. This source is the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC).

Q. What is the IPCC?

A. The IPCC was formed in 1988 by the World Meteorological Organization and the U.N. Environment Programme in response to rising concerns about global climate change. It provides an organizational structure for the work of hundreds of the world's leading researchers in climate science and related sciences. The IPCC does not do scientific research as an organization; rather, it assesses the scientific literature in an extremely methodical and transparent way, publishing consensus reports that reflect the work of scientists from around the world.

Q. Does the IPCC have any official role in advising policymakers?

A. Yes. In 1988 the United Nations General Assembly formally requested that the IPCC provide a comprehensive review and recommendations with respect to "the state of knowledge of the science of climate and climatic change."[1] In 1992, after receiving the IPCC's first assessment of the science, nearly every nation in the world, including the U.S., entered into the United Nations Framework Convention on Climate Change. The signers of the Framework Convention have asked the IPCC to provide full assessments of the state of climate science every 4 to 5 years, and to prepare various technical papers related to specific aspects of climate science, technology, and the social and economic impacts of climate change. The IPCC's assessments are therefore written with policy making in mind; they do not advocate for particular policies, but they do strive to provide policy-relevant information.

Q. Do the periodic assessments by the IPPC address the science of climate change?

A. Yes. The most recent Assessment Report released by the IPCC is the Third Assessment Report (TAR), released in 2001. The Report of Working Group I of the IPCC, entitled "Climate Change 2001: The Scientific Basis," is the part of the TAR that addresses the science of climate change. (Hereinafter "Working Group I Report".)

Q. How and by whom was the Working Group I Report prepared?

A. The Working Group I report describes in its preface how it was prepared, stating: "This report was compiled between July 1998 and January 2001, by 122 Lead Authors. In addition, 515 Contributing Authors submitted draft text and information to the Lead Authors. The draft report was circulated for review by experts, with 420 reviewers submitting valuable suggestions for improvement. This was followed by review by governments and experts, through which several hundred more reviewers participated. All the comments received were carefully analyzed and assimilated into a revised document for consideration at the session of Working Group I held in Shanghai, 17 to 20 January 2001. There the

[1] IPCC 2004 document, "Sixteen Years of Scientific Assessment in Support of the Climate Convention."

Summary for Policymakers was approved in detail and the underlying report accepted."

The lead and contributing authors of this report were, like the IPCC itself, drawn from the ranks of the world's leading researchers. It is my opinion that the IPCC Working Group I report represents a thorough, fully informed, and authoritative assessment of scientific knowledge related to climate change as of the time it was written.

Q. Is there a summary of the report?

A. Yes. The Summary for Policymakers was adopted as part of the Working Group I Report. A copy of the Working Group I Summary for Policymakers is attached as Exhibit JI-2-B to my testimony.

Q. Does the IPCC Third Assessment Report include an analysis of the potential impacts of global warming?

A. Yes. The IPCC Third Assessment Report (TAR) includes the report of Working Group II of the IPCC, entitled "Climate Change 2001: Impacts, Adaptation, and Vulnerability," hereinafter referred to as "Working Group II Report".

Q. How was the Working Group II Report prepared?

A. The preface of the Working Group II Report describes how it was prepared, stating: "The WGII report was compiled by 183 Lead Authors between July 1998 and February 2001. In addition, 243 Contributing Authors submitted draft text and information to the Lead Author teams. Drafts of the report were circulated twice for review, first to experts and a second time to both experts and governments. Comments received from 440 reviewers were carefully analyzed and assimilated to revise the document with guidance provided by 33 Review Editors. The revised report was presented for consideration at a session of the Working Group II panel held in Geneva from 13 to 16 February 2001, in which delegates from 100 countries participated. There, the Summary for Policymakers was approved in detail and the full report accepted."

As with Working Group I, the authors of the Working Group II report were among the leading researchers in their fields, and their findings are based on a thorough consideration of the science. The Working Group II's Summary for Policymakers is attached as Exhibit JI-2-C.

Q. Can you identify any other documents for a nontechnical, policymaking audience which you consider to be authoritative on the subject of global warming?

A. Yes. A good example is a statement issued in 2005 by the U.S. National Academy of Sciences along with national science academies of Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, and the United Kingdom entitled "Joint Science Academies' Statement: Global Response to Climate Change," which I will refer to as the "Joint Science Academies Statement". The Joint Science Academies Statement is attached to my testimony as Exhibit JI-2-D.

Q. What is the US National Academy of Sciences?

A. The National Academy of Sciences (NAS) was formed by legislation signed in 1863, and as mandated in its Act of Incorporation it has since then served to "investigate, examine, experiment, and report upon any subject of science or art" whenever called upon to do so by any department of the government. The National Academy of Sciences is comprised of approximately 2,000 members and 350 foreign associates, of whom more than 200 have won Nobel Prizes. Although chartered by the federal government, the NAS is a private, non-profit and independent scientific organization. It is currently headed by Dr. Ralph J. Cicerone, himself an atmospheric scientist with research interests in atmospheric chemistry and climate change. Election to the NAS is considered by many to be one of the highest honors an American scientist can receive.

Q. In addition to expressing its views in the Joint Science Academies Statement, has the NAS released any reports on climate change?

A. The NAS has issued a number of publications and reports on this subject, reflecting the importance with which the scientific community views this issue. In 2001, at the request of the Bush Administration, it released a study entitled "Climate Change Science: An Analysis of Some Key Questions," which endorsed the essential findings and predictions of the IPCC.

Q. In your opinion is the National Academy of Sciences qualified to assess and report on the scientific data related to the increased concentration of CO_2 and the effects of that increase on air, water, and natural resources?

A. Yes. The National Academy of Sciences is eminently qualified to address and produce authoritative reports on these issues.

Q. Would you say that there is a scientific consensus on the issue of global climate change?

A. There is an unequivocal scientific consensus on many aspects of the issue of global climate change. These aspects include:

- The fact that the CO_2 content of the atmosphere is increasing rapidly;
- The fact that this rate of increase, and the resulting abundance of CO_2 in the atmosphere, is unprecedented in at least the past 200,000 years, and probably much longer;
- The fact that the primary source of the increase is combustion of fossil fuels by human industrialized societies, i.e., that it is anthropogenic CO_2;
- The fact that the increased abundance of atmospheric CO_2 has a direct radiative forcing effect on climate by altering the heat transfer characteristics of the atmosphere;
- The fact that this change in the heat transfer properties of the atmosphere will have an impact on the climate of the planet;
- The fact that the climate of the earth is currently changing in ways that are consistent with model predictions based on the increased radiative forcing due to the anthropogenic increase in atmospheric

CO_2, and that these changes include increased sea surface temperatures, increased sea level, loss of arctic permafrost, loss of mountain and polar glacier mass, and destruction of arctic habitat;

- The fact that these observed changes cannot be ascribed to any known natural phenomenon;
- The fact that the magnitude of climate impacts will increase with increasing atmospheric CO_2 content; and
- The fact that once the atmospheric abundance of CO_2 has been increased, it will only return to equilibrium levels through natural processes on a timescale of several centuries.

In addition, there is a strong scientific consensus that natural feedbacks in the climate system would, on balance, tend to reinforce warming rather than mitigate it; that one effect of global warming will be migration of climate zones so that human societies and natural ecosystems will find themselves poorly adapted to their local climate; and that this will result in disruption and dislocation of ecosystems, migration of pest species and disease vectors, and disruptions in agriculture. There is general agreement, if not yet consensus, that global climate change will lead to generally more extreme weather patterns across most of the globe, including more intense storms and rainfall events and more extreme dry spells.

Q. Do the documents identified in this testimony, including the IPCC Working Group reports and the Joint Science Academies Statement, support these conclusions regarding scientific consensus?

A. Yes.

IV. THE RISE OF ATMOSPHERIC CO_2 LEVELS

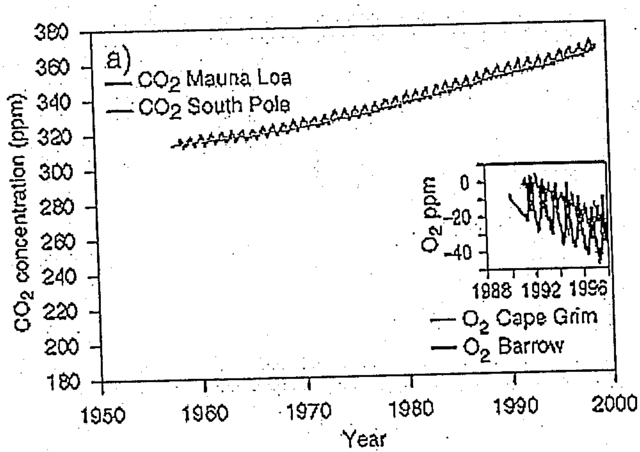
Q. Since the last IPCC report in 2001, what has been observed by climate scientists about global levels of CO_2?

A. The level of CO_2 is still increasing. For example, the U.S. National Oceanic and Atmospheric Administration (NOAA) reported on May 1, 2006, that the average atmospheric carbon dioxide level increased from an average of 376.8 parts per million in 2004 to 378.9 parts per million last year.[2]

Q. Could you put this increase in CO_2 levels in perspective?

A. Yes. I will put this in context with reference to a few figures from the Working Group I Report, which will show some of the key evidence demonstrating the nature of the modern rise in atmospheric CO_2.

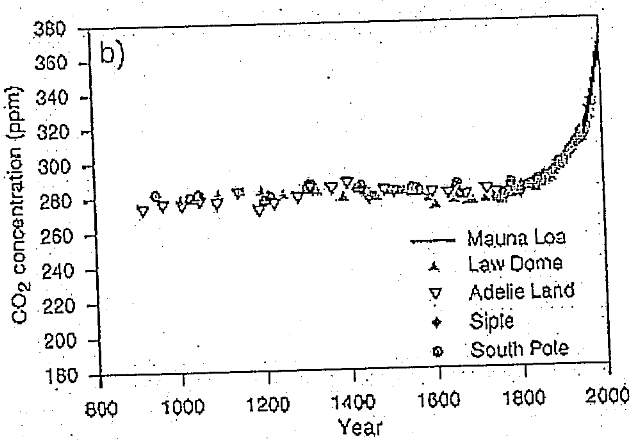
The first graph shows the direct, instrumental measurements of CO_2 from Mauna Loa, in Hawaii, taken since the late 1950s. This graph shows both the seasonal variations in CO_2 associated with the growing season in the northern hemisphere, and the year-to-year increase in atmospheric CO_2 during this period:



In this period alone, essentially my lifetime, atmospheric CO_2 has risen from under 320 parts per million to almost 380 parts per million, and the rate of increase itself is also increasing.

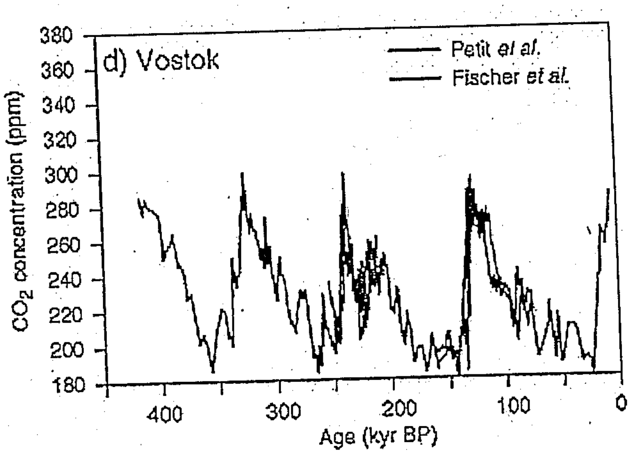
This next graph shows the history of atmospheric CO_2 for the last thousand years or so. This is measured in ancient air samples recovered from bubbles trapped in polar ice, in this case from various sites in Antarctica. The vertical scale is the same as in the previous graph, and in fact it also shows the Mauna Loa data for comparison:

[2] *http://www.cmdl.noaa.gov/aggi*



These data demonstrate that CO_2 levels have been relatively steady in the atmosphere for over 1,000 years, a time of remarkably quiescent climate by geological standards, during which modern human civilization and culture have flourished around the world.

Finally, this last graph shows the variations in atmospheric CO_2 over the last four glacial cycles, also recovered from Antarctic ice cores. The vertical scale is the same as for the two previous graphs, while the horizontal scale is in thousand years before the present:



Remember that the Mauna Loa data begin just below 320 ppm, and increase rapidly from there. This is already higher than has been measured for any time in the last 400,000 years, although the variations during this period were considerable. These variations were accompanied by enormous changes in climate, including the enormous advances of glaciers to cover much of the North American continent and Eurasia.

We have excellent computer models to predict some of the effects of elevated CO_2 levels, and some of these are the topic of my testimony. In addition to this, however, is the extraordinary risk associated with pushing the climate system to where it has never gone in over 400,000 years, and probably in tens of millions of years. This is, in my opinion, a dangerous game to play with the only planet we have.

Q. How high are CO_2 levels projected to go in the century ahead?

A. The IPCC predicts that CO_2 levels in the coming century will continue to steadily rise if the earth follows the "business as usual" path of fossil fuel consumption. These projections, based on various scenarios covering a range of assumptions regarding population growth, economic growth, globalization, etc., suggest that atmospheric CO_2 concentrations could reach from 490 to 1260 parts per million (an increase of 75% to 350% above 1750 concentrations). The higher the concentration, the more likely it is the earth will face dangerous or even catastrophic warming. Even concentrations above 550 or even 500 parts per million have the potential to cause dramatic and irreversible changes to our planet.

Q. How long will these increased CO_2 levels persist in the atmosphere?

A. The IPCC Working Group I Summary for Policymakers states that "several centuries after CO_2 emissions occur, about a quarter of the increase in CO_2 concentration caused by these emissions is still present in the atmosphere." [p. 17]. Thus, CO_2 that we put in the atmosphere today will affect the climate of the planet for many centuries to come.

V. CLIMATE CHANGE TO DATE

Q. Please describe, in general, changes in global temperatures in the last century, and the likely causes of those changes.

A. The IPCC Working Group I Summary for Policymakers states that "[t]he global average surface temperature has increased over the 20th century by about 0.6 °C." [p.2] This is the conclusion drawn both from the more recent instrumental record, and from a number of so-called paleothermometers—the collected evidence from a large number of temperature proxies that all point the same direction.

We know that there is a causal relationship between atmospheric CO_2 levels and rising average surface temperatures. This relationship was originally postulated by the great mathematician and scientist Joseph Fourier as early as 1824, and was first quantified by Svante Arrhenius in 1896. As the quality of both measurement technology and numerical analysis have improved, these ideas have been strengthened and refined, and shown to be observable and measurable.

Q. How do we know that this warming is not part of a natural trend?

A. The IPCC Working Group I Summary for Policymakers concludes that "[t]here is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities….There is a longer and more closely scrutinized temperature record and new model estimates of variability. The warming over the past 100 years is very unlikely to be due to internal variability alone, as estimated by current models." [p.10]. [footnote omitted]

It goes on to state that "[i]n the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations." [p.10]

Based on what I have seen in the scientific literature in the last few years I would expect the fourth annual report, due next year, to express even more certainty on this point in particular.

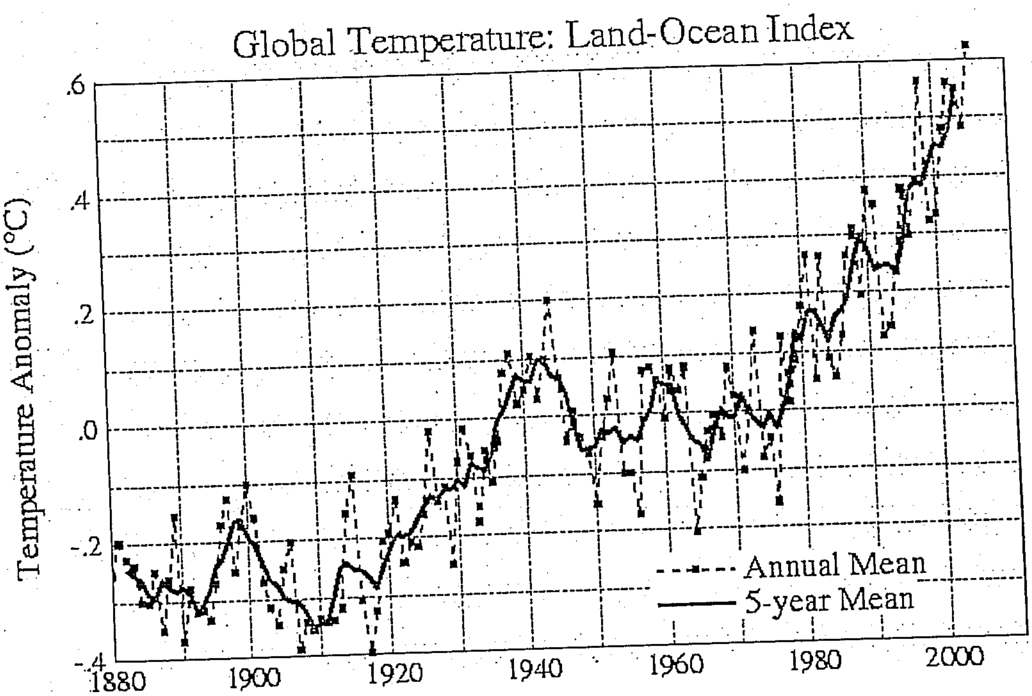
Q. Since the IPCC report was issued in 2001, what has been observed by climate scientists about global temperatures?

A. The highest annual average global surface temperature ever measured occurred during the 2005 calendar year, based upon an ongoing NASA analysis. The NASA scientific team noted that 2005 was slightly warmer than 1998, the warmest previous year known. However, in 1998, there was an "El Niño" event,[3] which was not the case in 2005. This event has a strong effect on the equatorial Pacific surface ocean and would have affected the temperature record in that year.[4]

Below I have reproduced one of the graphs from this study, showing the mean surface temperature "anomaly" from 1880 through the present. By anomaly the authors mean the difference between the annual average surface temperature for a given year and the long-term average surface temperature, which they define as the overall average for the period 1951 through 1980. If a year is exactly average in terms of temperature, the anomaly would be zero. The graph also shows the "smoothed" 5-year mean temperature anomaly over this period:

[3] El Niño is an occasional disruption of the ocean-atmosphere system in the tropical Pacific, in which the trade winds weaken and warm water from the western boundary floods much of the surface equatorial Pacific. Thus this large warm anomaly would tend to elevate average global surface temperatures, independent of any other effects.

[4] The GISS Surface Temperature Analysis is produced by Dr. James Hansen, director of NASA's Goddard Institute for Space Studies (GISS) at Columbia University in New York, along with Dr. Reto Ruedy and Dr. Ken Lo, also with the Goddard Institute, and Dr. Makiko Sato of the Columbia University Center for Climate Systems Research.



There are a number of ways to look at this. Four of the five warmest years on record have occurred since 2000. The ten hottest years on record have all occurred since 1990. Nineteen of the twenty warmest years on record have occurred since 1980, and so on. The evidence is consistent, statistically significant, and convincing. In addition, it is consistent with what is and has been predicted by computer models of the climate in response to today's elevated concentrations of atmospheric CO_2.

VI. PROJECTED WARMING

Q. What additional warming is predicted for the century ahead?

A. The IPCC predicts that the average surface temperature of the earth will increase by 1.5 to 5.8 degrees Celsius by 2100. The range reflects uncertainty about future emission levels and about precisely how the earth will respond to those emissions.

Q. Can you provide any perspective on the significance of the projected changes in global temperatures in this century?

A. These may sound like small figures, but the average surface temperature differential between the last ice age and the present was only about 5 degrees Celsius. During the last ice age, earth was a profoundly different place, with much of North America covered by an ice sheet a mile or more thick. At the upper range of the IPCC's 2001 warming prediction, earth would experience a warming equivalent to the one that melted that ice sheet. The recovery from the last major glacial period took 5,000 to 10,000 years. The warming we are discussing here will occur within a single century.

VII. IMPACTS OF CLIMATE CHANGE GLOBALLY

Q. What kinds of impacts are associated with warming projections in this range?

A. The IPCC Working Groups I and II Reports predict a large number of very serious negative impacts associated with this warming, including:

- rising sea levels, exposing coastal areas to increased risk of inundation and storm damage;
- Damage to or loss of natural ecosystems, such as prairie wetlands and alpine;
- Migration of habitats, leading to species extinctions and expansion of disease vectors and pests;
- heat waves leading to higher morbidity and mortality from heat stress;
- more intense precipitation events resulting in increased floods, mudslides, and soil erosion; and
- increased summer drying in most continental interiors resulting in more droughts; reduced crop yields, reduced water availability and quality.

The higher the atmospheric abundance of CO_2 rises, the more severe we can expect these impacts to be; to some extent they are expected even at the lower warming projections. Indeed, there is evidence that the 0.6 °C warming we have experienced to date has already initiated some of these impacts.

Q. Are the impacts of future warming likely to unfold gradually?

A. Many scientists believe that this is unlikely. While the computer models are unable to predict specific abrupt climate changes, we know from the geologic history that when the planet is changing from one type of climate to another, such as from an ice age to an interglacial, it often makes those changes in an abrupt, lurching fashion. The well-dated ice core records, in particular, show several abrupt and sudden climate swings of a magnitude that would be extremely disruptive were they to occur today. Unfortunately, we cannot predict with certainty at what level of atmospheric CO_2 such abrupt climate events would be likely to occur.

VIII. IMPACTS OF CLIMATE CHANGE ON SOUTH DAKOTA

Q. Turning now to the regional impacts of climate change, can you identify any credible sources that forecast the impacts of increased atmospheric CO_2 on the geographic region around South Dakota?

A. First let me note that it is much more difficult to predict climate change impacts for specific areas than it is for the planet as a whole, because of the significant complexities associated with changes in atmospheric circulation and cycling of moisture. Further, even the most highly resolved climate models still treat the Earth in large chunks compared to human scales—the most recent GISS model,[5] for example, has a grid size of 4° longitude by 3° latitude—an area about 2/3 the size of South Dakota in a single grid square.

Nonetheless, certain forecasts can be made for mid-continental areas such as South Dakota, which appear to be a robust feature of climate models. Furthermore, a team of leading university and government scientists in the Great Lakes region conducted an extensive study in 2003 of the likely

[5] A climate model produced by NASA's Goddard Institute for Space Studies at Columbia University in New York.

impacts of climate change in the Great Lakes area, including Minnesota, which provides valuable guidance. The report, entitled "Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems" ("Great Lakes Study"), was co-sponsored by the Ecological Society of America and the Union of Concerned Scientists. I consider this report to present scientifically sound, credible projections of the likely impacts of climate change in the nearby region.

Q. What approach did the Great Lakes Study use in forecasting local impacts of increased atmospheric CO_2?

A. The Great Lakes Study based its analysis upon global climate simulations using two of the world's leading climate models. In addition, they analyzed historical climate and weather data to establish relationships between climate trends (predictable by the models) and local temperature and weather characteristics.

Q. What did the Great Lakes Study team conclude about the likely impacts of climate change on the region?

A. I will quote from the subreport, which deals specifically with impacts on Minnesota, which is likely to be the closest proxy in this study for impacts in Eastern South Dakota:

> **Climate Projections**
> In general, Minnesota's climate will grow considerably warmer and probably drier during this century, especially in summer.
>
> • *Temperature:* By the end of the 21st century, temperatures are projected to rise 6–10 °F in winter and 7–16 °F in summer. This dramatic warming is roughly the same as the warming since the last ice age. Overall, extreme heat will be more common and the growing season could be 3–6 weeks longer.
>
> • *Precipitation:* While annual average precipitation may not change much, the state may grow drier overall because rainfall cannot compensate for the drying effects of a warmer climate, especially in the summer. Seasonal precipitation in the state is likely to change, increasing in winter by 15–40% and decreasing in summer by up to 15%. Minnesota, then, may well see drier soils and perhaps more

droughts.

• *Extreme events:* The frequency of heavy rainstorms, both 24-hour and multiday, will continue to increase, and could be 50–100% higher than today.

• *Ice cover:* Declines in ice cover on the Great Lakes and inland lakes have been recorded during the past 100–150 years and are expected to continue.

How the Climate Will Feel
These changes will dramatically affect how the climate feels to us. By the end of the century, the Minnesota summer climate will generally resemble that of current-day Kansas, and winters may be like those in current-day Wisconsin.

The report goes on to project specific impacts on the region, including impacts on water resources, agriculture, human health, wetlands and shorebirds, recreation and tourism, and forests and terrestrial wildlife. Some of these impacts will be similar in South Dakota and some will not. What is a consistent theme for all regions studied in this manner, however, is that the seasonal temperatures, seasonal pattern of rainfall, growing season, and other climate variables will be affected.

Q. **Understanding that you cannot predict impacts on South Dakota itself with great specificity, what can you predict in more general terms?**

A. I can make a number of general predictions with fairly high level of confidence. South Dakota is likely to experience increased heating for more of the year, which will lead to increased evaporation and transpiration and ultimately to decreased soil moisture. This is likely to harm both agriculture and natural vegetation. There will be an increase in heat stress as the number of extremely hot days increases, and an increase of heat-related morbidity and mortality. Although total rainfall may not change appreciably or may even increase, the region can expect an increased probability of severe drying and drought in the summer months and resulting ecological and economic damage.

As a result, plant and animal species that reside in South Dakota today will be displaced, and others will encroach the state's habitats as conditions change within the state and in the surrounding regions. Many species of plants and animals will not be able to adapt to change and will become extinct. Agricultural pests and diseases are likely to spread as a result of the disruption of ecosystems. As a result of increased storm intensity, flooding and pollution of streams from soil erosion can be expected to increase.

In addition, a large percentage of prairie wetlands will be damaged or dry up, particularly the ephemeral seasonal wetlands that are so important to waterfowl production, likely resulting in a loss of waterfowl population. The impact on Prairie Pothole Region, wetlands and waterfowl will be discussed more fully below.

Q. **Is it likely that most of the changes in the South Dakota climate will be detrimental?**

A. Yes. It is an unfortunate fact that most of the climate changes described in the Great Lakes Study are likely to be detrimental to the environment of South Dakota. In fact, *any* rapid change in hydrology, temperature, seasonality, and habitat is likely to be economically and socially disruptive. The ecosystem and agriculture of the state exist in a balance, which is adapted to a certain set of climatic conditions, including a long-term range of variability. Once this system is changed that balance is disturbed, invariably resulting in damage to the natural system as it exists and is valued today.

Q. **Is your testimony on these climate change trends supported by specific findings and conclusions in the IPCC report, Working Group I?**

A. Yes.

Q. What are the key findings and conclusions from that Report on which you rely?

A. The IPCC Working Group I Summary for Policymakers contains the following statements and forecasts which support the conclusions I have presented:

1. "Increase of heat index over land areas" is projected to be "very likely, over most areas" during the 21st century. [p. 15, Table 1] [footnotes omitted].

2. "More intense precipitation events" are projected to be "very likely, over many areas" during the 21st century. [p. 15, Table 1] [footnotes omitted].

3. "Increased summer continental drying and associated risk of drought" is projected to be "likely, over most mid-latitude continental interiors" in the 21st century. [p. 15, Table 1] [footnote omitted].

Q. Are you familiar with and have you reviewed a recent publication by W. Carter Johnson and coauthors, entitled "Vulnerability of Northern Prairie Wetlands to Climate Change", appearing in the October, 2005 issue of the journal Bioscience?[6]

A. Yes.

Q. Can you summarize the approach taken by the researchers as reported in this article?

A. The researchers base their analysis on global circulation models predictions of future climate, with increased atmospheric CO_2, in the Prairie Pothole Region (PPR). The PPR extends from northern Iowa and Nebraska, across most of the eastern Dakotas and up into Canada.

The authors then apply these climate conditions to a calibrated model of the PPR wetlands to determine how the wetlands will respond and what the

[6] Johnson, W.C., B.V. Millett, T. Gilmanov, R.A. Voldseth, G.R. Guntenspergen and D.E. Naugle, "Vulnerability of Northern Prairie Wetlands to Climate Change", *Bioscience 55(10)*, pp.863-872, October, 2005.

implications will be for migrating waterfowl, in what they refer to as the "heart of the PPR's 'duck factory' during the 20th century." [p. 869]

Q. What do the authors conclude regarding expected future changes in climate in this region?

A. Johnson and coauthors summarize the climate model results as follows:

> Increased drought conditions in the PPR are forecast to occur under nearly all global circulation model scenarios. Regional climate assessments suggest that the central and northern Great Plains of the United States may experience a 3.6 °C to 6.1 °C increase in mean air temperature over the next 100 years. Longer growing seasons, milder winters in the north, hotter summers in the south, and extreme drought are projected to be a more common occurrence over the PPR. Trends in mean annual precipitation are more difficult to predict, and range from no change to an increase of 10% to 20% concentrated in the fall, winter, and spring, accompanied by decreased summer precipitation and a higher frequency of extreme spring and fall precipitation events. [pp. 864-865. References removed.]

Q. Can you comment on the conclusions reached in that article regarding the impact of these changes on the ecology of the Prairie Pothole Region?

A. The authors find that global climate change is likely to have a significant negative effect on this region, and ultimately on the population of waterfowl that use this region as a breeding ground:

> The observed sensitivity of the model to climate variability suggests that wetlands in the drier portions of the PPR, such as the US and Canadian High Plains, would be especially vulnerable to climate warming, even if precipitation were to continue at historic levels. Only a substantial increase in precipitation would counterbalance the effects of a warmer climate. Additionally, the most productive wetlands, currently centrally located in the PPR, may become marginally productive in a warmer, drier future climate. Historically a mainstay for waterfowl, the region including the Dakotas and southeastern Saskatchewan would become a more episodic and less reliable region for waterfowl production, much as areas farther west have been during the past century. [p. 871]

Interestingly, the authors find this to be the case even though some regions will become wetter and others will become dryer:

> A logical question is whether the favorable water and cover conditions in the eastern PPR that we simulated can compensate for habitat losses in the western and central PPR. Historically, the eastern PPR and northern parklands served as a safe haven for waterfowl during periodic droughts. Today, however, options are limited, because more than 90% of eastern PPR wetlands have been drained for agricultural production. Although wetland restoration programs have been under way since the mid-1980s, less than 1% of basins drained in Minnesota and Iowa have been restored. Restoration efforts in the east have developed slowly, largely because of the high cost of farmland easements. [pp.871-872, references removed]

Q. Does this finding support your assertion, stated earlier, that "*any* rapid change in hydrology, temperature, seasonality, and habitat is likely to be economically and socially disruptive"?

A. Yes.

IX. BIG STONE UNIT II's CO_2 EMISSIONS

Q. Are fossil-fired electric generation plants in the United States, such as the proposed Big Stone Project. a significant contributor to the production and build-up of these gases?

A. Yes. The United States contributes more than any other nation, by far, to global greenhouse gas emissions on both a total and a per capita basis, contributing 24 percent of the world CO_2 emissions from fossil fuel consumption.

Coal-fired power plants in the United States already emit almost one-third of U.S. emissions, or 8% of all the world's anthropogenic CO_2 into the atmosphere, a staggering contribution to the global buildup of greenhouse gases. Further, recent analysis has shown that in 2004, power plant CO_2

emissions were 27 percent higher than they were in 1990.[7] Coal fired power plants are unquestionably a major and growing source of greenhouse gases, and thus a significant cause of global climate change.

Q. Other than their relative contribution to increasing atmospheric CO_2 each year, are there any other characteristics of coal-fired power plants like the proposed Big Stone Unit II that raise particular concerns regarding climate change?

A. Yes. Large, base load coal plants in the United States are built to produce electricity for decades, as long as 70 years in the case of some of the older plants still operating today. The evidence I have presented and discussed in my testimony shows that climate change is a serious threat to the environment and to human societies, including that of South Dakota, and that that threat is becoming increasingly obvious and severe. Today, the United States is almost alone among industrialized nations in failing to impose any cost on our electric sector or our industries for producing the greenhouse gases that cause this problem. As a result, utilities around the nation are making plans to invest in infrastructure that will emit CO_2 by the millions of tons into the indefinite future. The Big Stone II proposal is a good example of this shortsighted and distorted investment strategy.

Q. What would the lifetime emissions of CO_2 from the Big Stone II Unit be?

A. If built and operated as proposed, the Big Stone II Unit would add over 4.5 million tons of CO_2 to the atmosphere every year of its operational life, inexorably and significantly contributing to the buildup of greenhouse gases in the atmosphere. Assuming it operates for fifty years, that amounts to lifetime emissions of over 225 million tons of CO_2. For perspective, this lifetime production is roughly equal to the total amount of CO_2 produced by the entire country of Spain in one year.

[7] EIA, "Emissions of Greenhouse Gases in the United Sates, 2004;" Energy Information Administration; December 2005, xiii

Q. Could you compare the projected CO_2 emissions from the Big Stone II Unit to South Dakota emissions today?

A. The Big Stone II Unit's annual emissions would represent an enormous increase in South Dakota's emission levels. According to the EPA,[8] South Dakota's CO_2 emissions in 2001 (the last year for which these figures are available) was 13.23 million tons. The Big Stone II Unit's emissions of over 4.5 million tons per year of CO_2 would therefore represent approximately a 34% increase in the state's 2001 CO_2 emissions. It would more than double the current rate of emissions from the state's electric sector (3.79 million tons).

The EPA states that the average annual CO_2 emissions for an American automobile is about 6.75 tons.[9] At 4.5 million tons per year, emissions from the Big Stone Unit II would be equivalent to emissions from almost 670,000 cars. According to the federal Department of Transportation, there were fewer than 400,000 cars registered in South Dakota in 2004.[10] This means that the Big Stone Unit II is very likely to emit over two-thirds more CO_2 than all of the cars currently registered in South Dakota, combined.

Q. What is the significance of the Midwestern United States to the Global Warming phenomenon?

A. The Midwest is America's heartland and responsible for 20% of the CO_2 emissions in the United States, and 5% of the world's total emissions. The Midwest alone is responsible for more global warming gas pollutants than any country in the world other than the U.S. itself, China, the former Soviet Union, India and Japan.

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[8] U.S. EPA, "Carbon Dioxide Emissions from Fossil Fuel Combustion (Million Metric Tons CO2)," Prepared by the U.S. EPA using DOE/EIA State Energy Consumption Data (2001) and EIIP emission factors.

[9] U.S. EPA, "EPA's Personal Greenhouse Gas Calculator," states that 13,500 lbs/year of CO2 emissions is "about average per vehicle."

[10] Federal Highway Administration (Department of Transportation), "State Motor-Vehicle Registrations – 2004."

X. SCIENTIFIC CONCLUSIONS RELATED TO LEGAL STANDARDS

Q. Based upon your background, education, training and experience, your reading of the Governmental and non-governmental documents and treatises, including those that you have described, and assuming that the emissions from the proposed plant will operate as described in the record, including emissions of over 4.5 million tons of CO_2 annually, do you have an opinion to a reasonable level of scientific certainty, as to whether the proposed Big Stone II facility will cause irreversible changes anticipated to remain beyond the life of the facility?

A. Yes. My opinion is that the emissions of over 4.5 million tons of CO_2 per year from this proposed facility would cause irreversible damage to the environment, especially considering its expected lifetime of 50 years or more and the slow recovery time for atmospheric CO_2. These emissions will contribute to elevated levels of CO_2 in the atmosphere, to increased radiative forcing of climate and to accelerated global climate change for several centuries to come. I consider this to be a significant and irreversible impact on the environment, both globally and in South Dakota.

Q. Based upon your background, education, training and experience, your reading of the Governmental and non-governmental documents and treatises, including those that you have described, do you have an opinion, to a reasonable level of scientific certainty, as to whether the proposed Big Stone II facility will have cumulative or synergistic adverse consequences in combination with other operating energy conversion facilities, existing or under construction?

A. Yes. My opinion is that this facility will have a cumulative effect, in combination with other operating energy conversion facilities, both existing and under construction, of causing the level of atmospheric carbon dioxide to be significantly elevated relative to what it would be without this plant. The cumulative impact of coal-fired electrical generation plants in the

United States alone contributes about 8% of all anthropogenic CO_2 emissions today. This represents a substantial and growing contribution to global warming and global climate change, and a considerable threat to the environment globally and in South Dakota.

In dealing with a global problem such as warming, it is appropriate to look at the cumulative impact of like facilities. This is particularly true of coal fired electrical plants, since the number of plants is relatively small, but the cumulative impact is great.

Q. Are you aware that the Administrative Rules of South Dakota provide the following guidance in identifying the environmental, health and welfare effects of a proposed electrical generation facility:

> **The environmental effects shall be calculated to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction. ASDR 20:10:22:13.**

A. Yes.

Q. Considering that definition of environmental effects, and based upon those same assumptions and factors as in the previous two questions, do you have an opinion as to whether this facility, considering the cumulative effect which you have described in your previous answer, will or will not pose a threat of serious injury to the environment or to the social and economic condition of inhabitants or expected inhabitants in the siting area?

A. Yes. In my opinion, the environmental effects of this facility will pose a threat of serious injury to the environment in South Dakota and in the broader region.

As noted in my earlier testimony, the continued growth of carbon dioxide emissions from coal fired power plants as well as from other sources is extremely likely to trigger dangerous and irreversible global climate change. Any increase in emissions will increase the ultimate environmental damage and social costs, as well as the likelihood of abrupt and potentially catastrophic climate shifts. South Dakota, specifically, would expect severe drying and droughts in the summer months, disruptive changes in precipitation patterns in the winter, more intense storms, and adverse impacts on local ecosystems and on agriculture. We can expect harmful migration of pests, loss of a number of species of plants and animals due to habitat destruction and migration and invasive species, and a severe impact on the prairie pothole resource and its breeding waterfowl populations.

Q, Based upon your background, education, training and experience, your reading of the Governmental and non-governmental documents and treatises, including those that you have described do you have opinion as to whether the facility will or will not substantially impair the health, safety or welfare of the inhabitants in South Dakota?

A. Yes. My opinion is that the environmental effects of the facility as discussed above will substantially impair the health and welfare of the inhabitants of South Dakota, along with those of the rest of the world.

Q. Please explain your opinion.

A. The expected health impacts of climate change include morbidity and mortality due to increased heat in the region, and expanded habitat for disease vectors. Welfare impacts include the economic impacts expected to agriculture, as well as the loss of recreational hunting grounds and loss of the economic benefits of hunting, tourism and recreation in the region.

Q. Based upon your background, education, training and experience, your reading of the Governmental and non-governmental documents and treatises, including those that you have described, do you have an opinion as to whether the facility will result in any pollution, impairment, or destruction of the air, water, or other natural resources or the public trust therein?

A. Yes. My opinion is that this facility will result in impairment of the air, by increasing the carbon dioxide levels in the atmosphere. I state this based both on the volume of carbon dioxide emissions that it will cause over its lifetime, over 225 million tons, and on the fact that this will elevate the carbon dioxide load of the atmosphere for several centuries. This facility, by itself and cumulatively with other electrical generation plants, will exacerbate the effects of global warming and global climate change. The levels of carbon dioxide in the atmosphere will determine how much global warming, and hence how much environmental damage, ultimately occurs. Reducing carbon emissions now will have a definite impact on the ultimate severity of climate impacts and on the ultimate costs of remediation. Likewise, investments in infrastructure which materially increase those emissions, will surely increase the severity of future impacts and costs.

This plant's emissions of carbon dioxide, by itself and cumulatively with other electrical coal fired generation plants, will also impair the water resources of South Dakota. This is because the adverse environmental impacts of global warming, including changes in the patterns of precipitation to which our ecosystems, our society and our agriculture are adapted, will be made more severe than they would be without this plant or without the cumulative effect of this and other electrical generation plants. As noted elsewhere in my testimony, such water impairment will likely include increasingly severe summer droughts, more intense storms and extreme rainfall events, increased soil erosion and silting, and the loss of much of the prairie pothole wetland resource and its associated waterfowl populations.

Q. In summary, what would you say is the significance of the Big Stone II plant to the problem of Global Warming, assuming that it will emit over 4.5 million tons of CO_2 each year for approximately the next 50 years, or longer?

A. The significance of the proposed plant is this: This plant, alone and in combination with other energy conversion facilities, will contribute materially and significantly to the environmental, social and economic destruction associated with global climate change. We cannot pretend to be protecting the environment of either South Dakota or the world at large from this overwhelming threat while we continue to build long-lived infrastructure that has exactly the opposite effect. In this respect, I conclude that Big Stone Unit II will have a significant, long-term, and costly adverse impact on the environment both in South Dakota and throughout the region, the continent and the planet.

Q. Does this conclude your testimony?

A. Yes.

Ezra D. Hausman, Ph.D.

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SUMMARY

I have worked since 1998 as an electricity market analyst with a focus on market design and market restructuring, as well as pricing of energy, capacity, transmission, losses and other electricity-related services. I have recently performed market analysis, prepared testimony and/or provided other expert support to clients in a number of areas, including:

- Electricity and capacity price forcasting and asset valuation
- Efficient and cost-effective pricing of generating capacity
- The impact of environmental and other regulations, including future CO_2 regulations, on electricity markets
- The role of the electric sector in addressing global climate change
- The impact of increased Liquefied Natural Gas (LNG) imports in the U.S. natural gas and electricity markets.

I hold a Ph.D. in atmospheric science from Harvard University, a Master's degree in applied physics from Harvard University, a Master's degree in water resource engineering from Tufts University, and a Bachelor of Arts degree from Wesleyan University.

PROFESSIONAL EXPERIENCE

Synapse Energy Economics Inc., Cambridge, MA. Research Associate, 2005-present. Conducting research, writing reports, and presenting expert testimony pertaining to consumer, environmental, and public policy implications of electricity industry regulation. Focus of work includes:

- Electricity industry regulation and restructuring
- Efficient and cost-effective pricing of generating and transmission capacity
- Long-term electric power system planning and market design
- Electricity market analysis and price forecasting
- Impact of air quality and environmental regulations on electricity markets and pricing
- Natural gas and Liquified Natural Gas (LNG) market dynamics
- Energy efficiency and renewable energy programs and policies, and their role in the electricity market
- Power plant performance and economics
- Market power and market concentration analysis in electricity markets
- Consumer and environmental protection.

Charles River Associates (CRA). Cambridge, MA. Senior Associate, 2004-2005.
CRA acquired Tabors Caramanis & Associates in October, 2004.

Tabors Caramanis & Associates. Cambridge, MA. Senior Associate, 1998-2004.
Modeling and analysis of electricity markets, generation and transmission systems. Projects included:

- Several market transition cost-benefit studies for development of Locational Marginal Price (LMP) based markets in US electricity markets
- Long-term market forecasting studies for valuation of generation and transmission assets,
- Valuation of financial instruments relating to transmission system congestion and losses
- Natural gas market analysis and price forecasting studies
- Co-developed an innovative approach to hedging financial risk associated with transmission system losses of electricity
- Designed, developed and ran training seminars using a computer-based electricity market simulation game, to help familiarize market participants and students in the operation of LMP-based electricity markets.
- Developed and implemented analytical tools for assessment of market concentration in interconnected electricity markets, based on the "delivered price test" for assessing market accessibility in such a network
- Performed regional market power and market power mitigation studies
- Performed transmission feasibility studies for proposed new generation and transmission projects in various locations in the US
- Provided analytical support for expert testimony in a variety of regulatory and litigation proceedings, including breach of contract, bankruptcy, and antitrust cases, among others.

Global Risk Prediction Network, Inc. Greenland, NH. Vice President, 1997-1998.
Developed private sector applications of climate forecast science in partnership with researchers at Columbia University. Specific projects included a statistical assessment of grain yield predictability in several crop regions around the world based on global climate indicators (Principal Investigator); a statistical assessment of road salt demand predictability in the United States based on global climate indicators (Principal Investigator); a preliminary design of a climate and climate forecast information website tailored to the interests of the business community; and the development of client base.

Hub Data, Inc. Cambridge, MA. Financial Software Consultant, 1986-1987, 1993-1997.
Responsible for design, implementation and support of analytic and communications modules for bond portfolio management software; and developed software tools such as dynamic data compression technique to facilitate product delivery, Windows interface for securities data products.

Abt Associates, Inc., Cambridge, MA. Environmental Policy Analyst, 1990-1991.
Quantitative risk analysis to support federal environmental policy-making. Specific areas of research included risk assessment for federal regulations concerning sewage sludge disposal and pesticide use; statistical alternatives to Most-Exposed-Individual risk assessment paradigm; and research on non-point sources of water pollution.

Massachusetts Water Resources Authority, Charlestown, MA. Analyst, 1988-1990.
Applied and evaluated demand forecasting techniques for the Eastern Massachusetts service area. Assessed applicability of various techniques to the system and to regional planning needs; and assessed yield/reliability relationship for the eastern Massachusetts water supply system, based on Monte-Carlo analysis of historical hydrology.

Somerville High School. Somerville, MA. Math Teacher, 1986-1987.
Courses included trigonometry, computer programming, and basic math courses.

EDUCATION

Ph.D., Earth and Planetary Sciences. Harvard University, Cambridge, MA, 1997.

S.M., Applied Physics. Harvard University, Cambridge, MA, 1993.

M.S., Civil Engineering. Tufts University, Medford, MA, 1990.

B.A., Wesleyan University, Psychology. Middletown, MA, 1985.

FELLOWSHIPS AND AWARDS

UCAR Visiting Scientist Postdoctoral Fellowship, 1997.

Postdoctoral Research Fellowship, Harvard University, 1997.

Certificate of Distinction in Teaching, Harvard University, 1997.

Graduate Research Fellowship, Harvard University, 1991-1997.

Invited Participant, UCAR Global Change Institute, 1993.

House Tutor, Leverett House, Harvard University, 1991-1993.

Graduate Research Fellowship, Massachusetts Water Resources Authority, 1989-1990.

Teaching Fellowships:

> **Harvard University:** *Principles of Measurement and Modeling in Atmospheric Chemistry; Hydrology; Introduction to Environmental Science and Public Policy; The Atmosphere.*
>
> **Wesleyan University:** *Introduction to Computer Programming; Psychological Statistics; Playwriting and Production.*

PUBLICATIONS AND REPORTS

Hausman, E.D., K. Takahashi, D. Schlissel and B. Biewald, "The Proposed Broadwater LNG Import Terminal: An Analysis and Assessment of Alternatives" Synapse Energy report on behalf of the Connecticut Fund for the Environment and Save The Sound, March 2, 2006.

Hausman, E.D., P. Peterson, D. White and B. Biewald, "RPM 2006: Windfall Profits for Existing Base Load Units in PJM: An Update of Two Case Studies" Synapse Energy report prepared on behalf of Pennsylvania Office of Consumer Advocate and the Illinois Citizens Utility Board, February, 2006.

Hausman, E.D., K. Takahashi, and B. Biewald, "The Glebe Mountain Wind Energy Project: Assessment of Project Benefits for Vermont and the New England Region" Report prepared on behalf of Glebe Mountain Wind Energy, LLC., February, 2006.

Hausman, E.D., K. Takahashi, and B. Biewald, "The Deerfield Wind Project: Assessment of the Need for Power and the Economic and Environmental Attributes of the Project" Report prepared on behalf of Deerfield Wind, LLC., January, 2006.

Hausman, E.D., P. Peterson, D. White and B. Biewald, "An RPM Case Study: Higher Costs for Consumers, Windfall Profits for Exelon" Synapse Energy report to the Illinois Citizens Utility Board, October, 2005.

Hausman, E.D. and G. Keith, "Calculating Displaced Emissions from Energy Efficiency and Renewable Energy Initiatives" Content for EPA website, 2005 (in prep.)

Rudkevich, A., E.D. Hausman, R.D. Tabors, J. Bagnal and C Kopel, "Loss Hedging Rights: A Final Piece in the LMP Puzzle" *Hawaii International Conference on System Sciences, Hawaii,* January, 2005 *(accepted).*

Hausman, E.D. and R.D. Tabors, "The Role of Demand Underscheduling in the California Energy Crisis" *Hawaii International Conference on System Sciences, Hawaii,* January, 2004.

Hausman, E.D. and M.B. McElroy, The reorganization of the global carbon cycle at the last glacial termination, *Global Biogeochemical Cycles, 13*(2), 371-381, 1999.

Norton, F.L., E.D. Hausman and M.B. McElroy, "Hydrospheric transports, the oxygen isotope record, and tropical sea surface temperatures during the last glacial maximum" *Paleoceanography, 12,* 15-22, 1997.

Hausman, E.D. and M.B. McElroy, "Variations in the oceanic carbon cycle over glacial transitions: a time-dependent box model simulation" presented at the spring meeting of the American Geophysical Union, San Francisco, 1996.

PRESENTATIONS AND WORKSHOPS

Energy Modeling Forum: Participant in coordinated academic exercise focused on modeling US and world natural gas markets, December, 2004.

Massachusetts Institute of Technology (MIT): Guest lecturer in Technology and Policy Program on electricity market structure, the LMP pricing system and risk hedging with FTRs, 2002-2005.

LMP: The Ultimate Hands-On Seminar. Two-day seminar held at various sites to explore concepts of LMP pricing and congestion risk hedging, including lecture and market simulation exercises, July-December, 2003.

Learning to Live with Locational Marginal Pricing: Fundamentals and Hands-On Simulation. Day-long seminar including on-line mock electricity market and congestion rights auction, December 2002.

LMP in California. Series of seminars on the introduction of LMP in the California electricity market, including on-line market simulation exercise. 2002.

EXPERT TESTIMONY

Illinois Pollution Control Board (Docket No. R2006-025) – April 2006
Prefile testimony on behalf of the Illinois EPA regarding the costs and benefits of proposed mercury emissions rule for Illinois power plants.

Federal Energy Regulatory Commission (Docket Nos. ER055-1410-000 and EL05-148-000) - February 2006
Affidavit filed on setting of model parameters for PJM's proposed RPM capacity market model.

State of Vermont Public Service Board – February 2006
Prefile testimony in support of Certificate of Public Good pursuant to 30 V.S.A. §248 for proposed Catamount Wind Project.

State of Vermont Public Service Board – February 2006
Prefile testimony in support of Certificate of Public Good pursuant to 30 V.S.A. §248 for proposed Deerfield Wind Project.

Long Island Sound LNG Task Force – January 2006
Presentation of study on the need for and alternatives to the proposed Broadwater LNG storage and regasification facility in Long Island Sound.

Iowa Utilities Board (Docket No. SPU-05-15) – November 2005
Whether Interstate Power and Light's should be permitted to sell the Duane Arnold Energy Center nuclear facility to FPLE Duane Arnold, Inc., a subsidiary of Florida Power and Light.

Summary for Policymakers

A Report of Working Group I of the Intergovernmental Panel on Climate Change

Based on a draft prepared by:
Daniel L. Albritton, Myles R. Allen, Alfons P. M. Baede, John A. Church, Ulrich Cubasch, Dai Xiaosu, Ding Yihui, Dieter H. Ehhalt, Christopher K. Folland, Filippo Giorgi, Jonathan M. Gregory, David J. Griggs, Jim M. Haywood, Bruce Hewitson, John T. Houghton, Joanna I. House, Michael Hulme, Ivar Isaksen, Victor J. Jaramillo, Achuthan Jayaraman, Catherine A. Johnson, Fortunat Joos, Sylvie Joussaume, Thomas Karl, David J. Karoly, Haroon S. Kheshgi, Corrine Le Quéré, Kathy Maskell, Luis J. Mata, Bryant J. McAvaney, Mack McFarland, Linda O. Mearns, Gerald A. Meehl, L. Gylvan Meira-Filho, Valentin P. Meleshko, John F. B. Mitchell, Berrien Moore, Richard K. Mugara, Maria Noguer, Buruhani S. Nyenzi, Michael Oppenheimer, Joyce E. Penner, Steven Pollonais, Michael Prather, I. Colin Prentice, Venkatchalam Ramaswamy, Armando Ramirez-Rojas, Sarah C. B. Raper, M. Jim Salinger, Robert J. Scholes, Susan Solomon, Thomas F. Stocker, John M. R. Stone, Ronald J. Stouffer, Kevin E. Trenberth, Ming-Xing Wang, Robert T. Watson, Kok S. Yap, John Zillman

with contributions from many authors and reviewers.

Summary for Policymakers

The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change[1]. Many hundreds of scientists[2] from many countries participated in its preparation and review.

This Summary for Policymakers (SPM), which was approved by IPCC member governments in Shanghai in January 2001[3], describes the current state of understanding of the climate system and provides estimates of its projected future evolution and their uncertainties. Further details can be found in the underlying report, and the appended Source Information provides cross references to the report's chapters.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

Since the release of the Second Assessment Report (SAR[4]), additional data from new studies of current and palaeoclimates, improved analysis of data sets, more rigorous evaluation of their quality, and comparisons among data from different sources have led to greater understanding of climate change.

The global average surface temperature has increased over the 20th century by about 0.6°C.

- The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2°C[5,6] (Figure 1a). This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects. The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.
- Globally, it is very likely[7] that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861 (see Figure 1a).
- New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely[7] to have been the largest of any century during the past 1,000 years. It is also likely[7] that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year (Figure 1b). Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.
- On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures (0.1°C per decade). This has lengthened the freeze-free season in many mid- and high latitude regions. The increase in sea surface temperature over this period is about half that of the mean land surface air temperature.

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1 *Climate change* in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where *climate change* refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

2 In total 122 Co-ordinating Lead Authors and Lead Authors, 515 Contributing Authors, 21 Review Editors and 420 Expert Reviewers.

3 Delegations of 99 IPCC member countries participated in the Eighth Session of Working Group I in Shanghai on 17 to 20 January 2001.

4 The IPCC Second Assessment Report is referred to in this Summary for Policymakers as the SAR.

5 Generally temperature trends are rounded to the nearest 0.05°C per unit time, the periods often being limited by data availability.

6 In general, a 5% statistical significance level is used, and a 95% confidence level.

7 In this Summary for Policymakers and in the Technical Summary, the following words have been used where appropriate to indicate judgmental estimates of confidence: *virtually certain* (greater than 99% chance that a result is true); *very likely* (90–99% chance); *likely* (66–90% chance); *medium likelihood* (33–66% chance); *unlikely* (10–33% chance); *very unlikely* (1–10% chance); *exceptionally unlikely* (less than 1% chance). The reader is referred to individual chapters for more details.

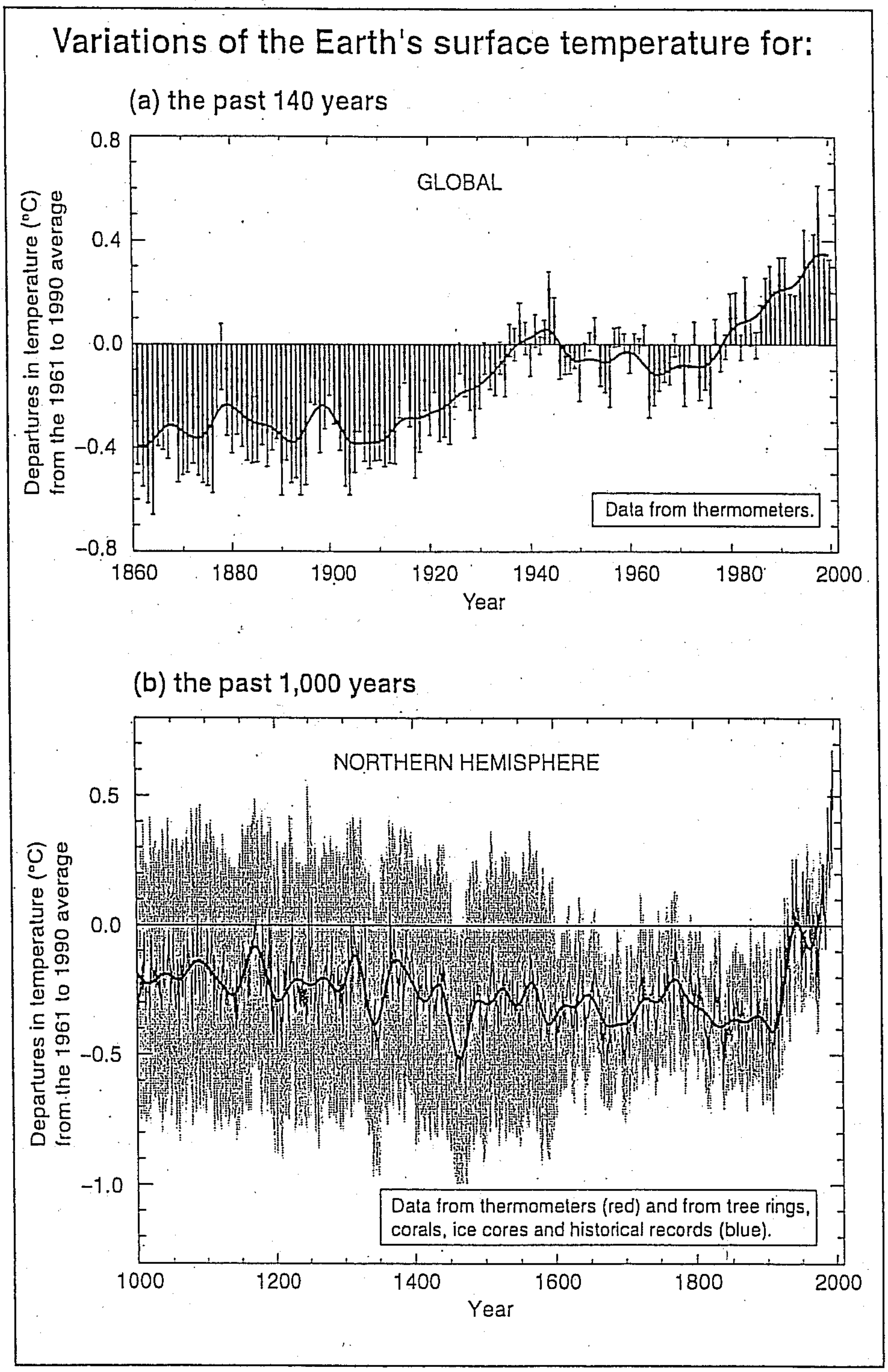

Figure 1: Variations of the Earth's surface temperature over the last 140 years and the last millennium.

(a) The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line, a filtered annual curve suppressing fluctuations below near decadal time-scales). There are uncertainties in the annual data (thin black whisker bars represent the 95% confidence range) due to data gaps, random instrumental errors and uncertainties, uncertainties in bias corrections in the ocean surface temperature data and also in adjustments for urbanisation over the land. Over both the last 140 years and 100 years, the best estimate is that the global average surface temperature has increased by 0.6 ± 0.2°C.

(b) Additionally, the year by year (blue curve) and 50 year average (black curve) variations of the average surface temperature of the Northern Hemisphere for the past 1000 years have been reconstructed from "proxy" data calibrated against thermometer data (see list of the main proxy data in the diagram). The 95% confidence range in the annual data is represented by the grey region. These uncertainties increase in more distant times and are always much larger than in the instrumental record due to the use of relatively sparse proxy data. Nevertheless the rate and duration of warming of the 20th century has been much greater than in any of the previous nine centuries. Similarly, it is likely[7] that the 1990s have been the warmest decade and 1998 the warmest year of the millennium.

[Based upon (a) Chapter 2, Figure 2.7c and (b) Chapter 2, Figure 2.20]

Temperatures have risen during the past four decades in the lowest 8 kilometres of the atmosphere.

- Since the late 1950s (the period of adequate observations from weather balloons), the overall global temperature increases in the lowest 8 kilometres of the atmosphere and in surface temperature have been similar at 0.1°C per decade.
- Since the start of the satellite record in 1979, both satellite and weather balloon measurements show that the global average temperature of the lowest 8 kilometres of the atmosphere has changed by +0.05 ± 0.10°C per decade, but the global average surface temperature has increased significantly by +0.15 ± 0.05°C per decade. The difference in the warming rates is statistically significant. This difference occurs primarily over the tropical and sub-tropical regions.
- The lowest 8 kilometres of the atmosphere and the surface are influenced differently by factors such as stratospheric ozone depletion, atmospheric aerosols, and the El Niño phenomenon. Hence, it is physically plausible to expect that over a short time period (e.g., 20 years) there may be differences in temperature trends. In addition, spatial sampling techniques can also explain some of the differences in trends, but these differences are not fully resolved.

Snow cover and ice extent have decreased.

- Satellite data show that there are very likely[7] to have been decreases of about 10% in the extent of snow cover since the late 1960s, and ground-based observations show that there is very likely[7] to have been a reduction of about two weeks in the annual duration of lake and river ice cover in the mid- and high latitudes of the Northern Hemisphere, over the 20th century.
- There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century.
- Northern Hemisphere spring and summer sea-ice extent has decreased by about 10 to 15% since the 1950s. It is likely[7] that there has been about a 40% decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness.

Global average sea level has risen and ocean heat content has increased.

- Tide gauge data show that global average sea level rose between 0.1 and 0.2 metres during the 20th century.
- Global ocean heat content has increased since the late 1950s, the period for which adequate observations of sub-surface ocean temperatures have been available.

Changes have also occurred in other important aspects of climate.

- It is very likely[7] that precipitation has increased by 0.5 to 1% per decade in the 20th century over most mid- and high latitudes of the Northern Hemisphere continents, and it is likely[7] that rainfall has increased by 0.2 to 0.3% per decade over the tropical (10°N to 10°S) land areas. Increases in the tropics are not evident over the past few decades. It is also likely[7] that rainfall has decreased over much of the Northern Hemisphere sub-tropical (10°N to 30°N) land areas during the 20th century by about 0.3% per decade. In contrast to the Northern Hemisphere, no comparable systematic changes have been detected in broad latitudinal averages over the Southern Hemisphere. There are insufficient data to establish trends in precipitation over the oceans.
- In the mid- and high latitudes of the Northern Hemisphere over the latter half of the 20th century, it is likely[7] that there has been a 2 to 4% increase in the frequency of heavy precipitation events. Increases in heavy precipitation events can arise from a number of causes, e.g., changes in atmospheric moisture, thunderstorm activity and large-scale storm activity.
- It is likely[7] that there has been a 2% increase in cloud cover over mid- to high latitude land areas during the 20th century. In most areas the trends relate well to the observed decrease in daily temperature range.
- Since 1950 it is very likely[7] that there has been a reduction in the frequency of extreme low temperatures, with a smaller increase in the frequency of extreme high temperatures.

- Warm episodes of the El Niño-Southern Oscillation (ENSO) phenomenon (which consistently affects regional variations of precipitation and temperature over much of the tropics, sub-tropics and some mid-latitude areas) have been more frequent, persistent and intense since the mid-1970s, compared with the previous 100 years.
- Over the 20th century (1900 to 1995), there were relatively small increases in global land areas experiencing severe drought or severe wetness. In many regions, these changes are dominated by inter-decadal and multi-decadal climate variability, such as the shift in ENSO towards more warm events.
- In some regions, such as parts of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades.

Some important aspects of climate appear not to have changed.

- A few areas of the globe have not warmed in recent decades, mainly over some parts of the Southern Hemisphere oceans and parts of Antarctica.
- No significant trends of Antarctic sea-ice extent are apparent since 1978, the period of reliable satellite measurements.
- Changes globally in tropical and extra-tropical storm intensity and frequency are dominated by inter-decadal to multi-decadal variations, with no significant trends evident over the 20th century. Conflicting analyses make it difficult to draw definitive conclusions about changes in storm activity, especially in the extra-tropics.
- No systematic changes in the frequency of tornadoes, thunder days, or hail events are evident in the limited areas analysed.

Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.

Changes in climate occur as a result of both internal variability within the climate system and external factors (both natural and anthropogenic). The influence of external factors on climate can be broadly compared using the concept of radiative forcing[8]. A positive radiative forcing, such as that produced by increasing concentrations of greenhouse gases, tends to warm the surface. A negative radiative forcing, which can arise from an increase in some types of aerosols (microscopic airborne particles) tends to cool the surface. Natural factors, such as changes in solar output or explosive volcanic activity, can also cause radiative forcing. Characterisation of these climate forcing agents and their changes over time (see Figure 2) is required to understand past climate changes in the context of natural variations and to project what climate changes could lie ahead. Figure 3 shows current estimates of the radiative forcing due to increased concentrations of atmospheric constituents and other mechanisms.

[8] *Radiative forcing* is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, and is an index of the importance of the factor as a potential climate change mechanism. It is expressed in Watts per square metre (Wm^{-2}).

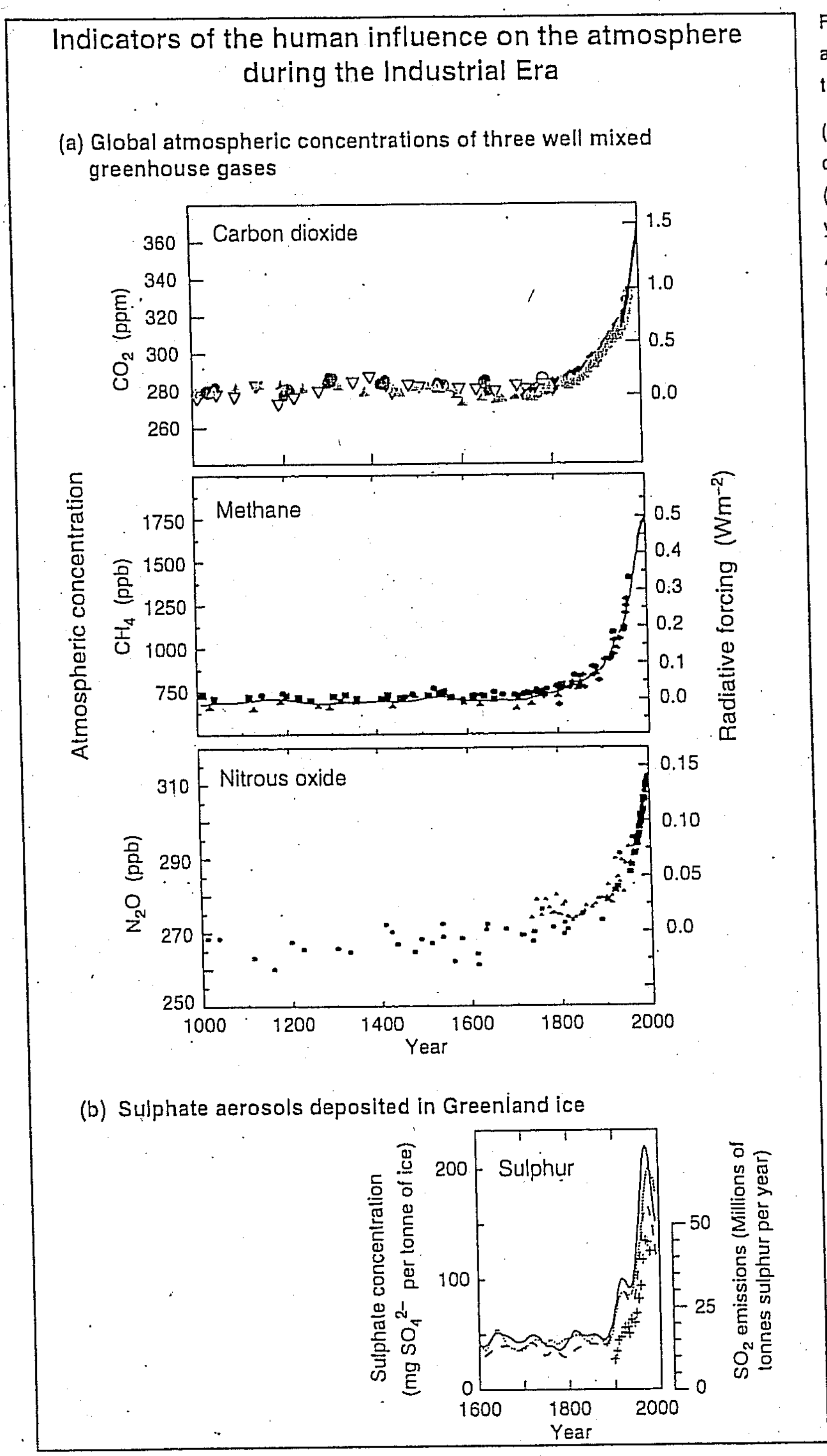

Figure 2: Long records of past changes in atmospheric composition provide the context for the influence of anthropogenic emissions.

(a) shows changes in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) over the past 1000 years. The ice core and firn data for several sites in Antarctica and Greenland (shown by different symbols) are supplemented with the data from direct atmospheric samples over the past few decades (shown by the line for CO_2 and incorporated in the curve representing the global average of CH_4). The estimated positive radiative forcing of the climate system from these gases is indicated on the right-hand scale. Since these gases have atmospheric lifetimes of a decade or more, they are well mixed, and their concentrations reflect emissions from sources throughout the globe. All three records show effects of the large and increasing growth in anthropogenic emissions during the Industrial Era.

(b) illustrates the influence of industrial emissions on atmospheric sulphate concentrations, which produce negative radiative forcing. Shown is the time history of the concentrations of sulphate, not in the atmosphere but in ice cores in Greenland (shown by lines; from which the episodic effects of volcanic eruptions have been removed). Such data indicate the local deposition of sulphate aerosols at the site, reflecting sulphur dioxide (SO_2) emissions at mid-latitudes in the Northern Hemisphere. This record, albeit more regional than that of the globally-mixed greenhouse gases, demonstrates the large growth in anthropogenic SO_2 emissions during the Industrial Era. The pluses denote the relevant regional estimated SO_2 emissions (right-hand scale).

[Based upon (a) Chapter 3, Figure 3.2b (CO_2); Chapter 4, Figure 4.1a and b (CH_4) and Chapter 4, Figure 4.2 (N_2O) and (b) Chapter 5, Figure 5.4a]

Concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities.

- The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750. The present CO_2 concentration has not been exceeded during the past 420,000 years and likely[7] not during the past 20 million years. The current rate of increase is unprecedented during at least the past 20,000 years.
- About three-quarters of the anthropogenic emissions of CO_2 to the atmosphere during the past 20 years is due to fossil fuel burning. The rest is predominantly due to land-use change, especially deforestation.
- Currently the ocean and the land together are taking up about half of the anthropogenic CO_2 emissions. On land, the uptake of anthropogenic CO_2 very likely[7] exceeded the release of CO_2 by deforestation during the 1990s.
- The rate of increase of atmospheric CO_2 concentration has been about 1.5 ppm[9] (0.4%) per year over the past two decades. During the 1990s the year to year increase varied from 0.9 ppm (0.2%) to 2.8 ppm (0.8%). A large part of this variability is due to the effect of climate variability (e.g., El Niño events) on CO_2 uptake and release by land and oceans.
- The atmospheric concentration of methane (CH_4) has increased by 1060 ppb[9] (151%) since 1750 and continues to increase. The present CH_4 concentration has not been exceeded during the past 420,000 years. The annual growth in CH_4 concentration slowed and became more variable in the 1990s, compared with the 1980s. Slightly more than half of current CH_4 emissions are anthropogenic (e.g., use of fossil fuels, cattle, rice agriculture and landfills). In addition, carbon monoxide (CO) emissions have recently been identified as a cause of increasing CH_4 concentration.
- The atmospheric concentration of nitrous oxide (N_2O) has increased by 46 ppb (17%) since 1750 and continues to increase. The present N_2O concentration has not been exceeded during at least the past thousand years. About a third of current N_2O emissions are anthropogenic (e.g., agricultural soils, cattle feed lots and chemical industry).
- Since 1995, the atmospheric concentrations of many of those halocarbon gases that are both ozone-depleting and greenhouse gases (e.g., $CFCl_3$ and CF_2Cl_2), are either increasing more slowly or decreasing, both in response to reduced emissions under the regulations of the Montreal Protocol and its Amendments. Their substitute compounds (e.g., CHF_2Cl and CF_3CH_2F) and some other synthetic compounds (e.g., perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6)) are also greenhouse gases, and their concentrations are currently increasing.
- The radiative forcing due to increases of the well-mixed greenhouse gases from 1750 to 2000 is estimated to be 2.43 Wm^{-2}: 1.46 Wm^{-2} from CO_2; 0.48 Wm^{-2} from CH_4; 0.34 Wm^{-2} from the halocarbons; and 0.15 Wm^{-2} from N_2O. (See Figure 3, where the uncertainties are also illustrated.)
- The observed depletion of the stratospheric ozone (O_3) layer from 1979 to 2000 is estimated to have caused a negative radiative forcing (–0.15 Wm^{-2}). Assuming full compliance with current halocarbon regulations, the positive forcing of the halocarbons will be reduced as will the magnitude of the negative forcing from stratospheric ozone depletion as the ozone layer recovers over the 21st century.
- The total amount of O_3 in the troposphere is estimated to have increased by 36% since 1750, due primarily to anthropogenic emissions of several O_3-forming gases. This corresponds to a positive radiative forcing of 0.35 Wm^{-2}. O_3 forcing varies considerably by region and responds much more quickly to changes in emissions than the long-lived greenhouse gases, such as CO_2.

[9] ppm (parts per million) or ppb (parts per billion, 1 billion = 1,000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example: 300 ppm means 300 molecules of a greenhouse gas per million molecules of dry air.

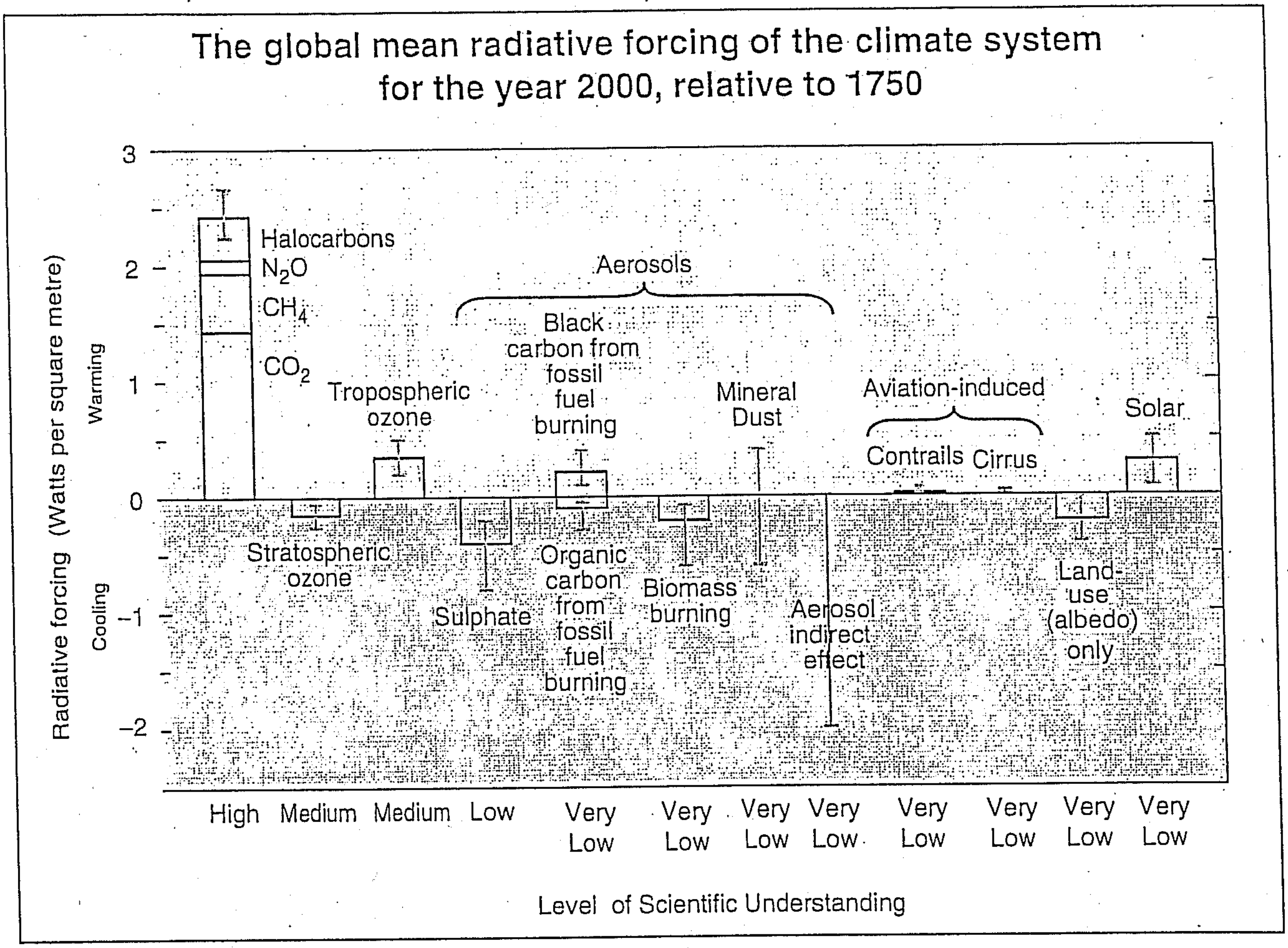

Figure 3: Many external factors force climate change.

These radiative forcings arise from changes in the atmospheric composition, alteration of surface reflectance by land use, and variation in the output of the sun. Except for solar variation, some form of human activity is linked to each. The rectangular bars represent estimates of the contributions of these forcings – some of which yield warming, and some cooling. Forcing due to episodic volcanic events, which lead to a negative forcing lasting only for a few years, is not shown. The indirect effect of aerosols shown is their effect on the size and number of cloud droplets. A second indirect effect of aerosols on clouds, namely their effect on cloud lifetime, which would also lead to a negative forcing, is not shown. Effects of aviation on greenhouse gases are included in the individual bars. The vertical line about the rectangular bars indicates a range of estimates, guided by the spread in the published values of the forcings and physical understanding. Some of the forcings possess a much greater degree of certainty than others. A vertical line without a rectangular bar denotes a forcing for which no best estimate can be given owing to large uncertainties. The overall level of scientific understanding for each forcing varies considerably, as noted. Some of the radiative forcing agents are well mixed over the globe, such as CO_2, thereby perturbing the global heat balance. Others represent perturbations with stronger regional signatures because of their spatial distribution, such as aerosols. For this and other reasons, a simple sum of the positive and negative bars cannot be expected to yield the net effect on the climate system. The simulations of this assessment report (for example, Figure 5) indicate that the estimated net effect of these perturbations is to have warmed the global climate since 1750. [Based upon Chapter 6, Figure 6.6]

Anthropogenic aerosols are short-lived and mostly produce negative radiative forcing.

- The major sources of anthropogenic aerosols are fossil fuel and biomass burning. These sources are also linked to degradation of air quality and acid deposition.
- Since the SAR, significant progress has been achieved in better characterising the direct radiative roles of different types of aerosols. Direct radiative forcing is estimated to be -0.4 Wm^{-2} for sulphate, -0.2 Wm^{-2} for biomass burning aerosols, -0.1 Wm^{-2} for fossil fuel organic carbon and $+0.2$ Wm^{-2} for fossil fuel black carbon aerosols. There is much less confidence in the ability to quantify the total aerosol direct effect, and its evolution over time, than that for the gases listed above. Aerosols also vary considerably by region and respond quickly to changes in emissions.
- In addition to their direct radiative forcing, aerosols have an indirect radiative forcing through their effects on clouds. There is now more evidence for this indirect effect, which is negative, although of very uncertain magnitude.

Natural factors have made small contributions to radiative forcing over the past century.

- The radiative forcing due to changes in solar irradiance for the period since 1750 is estimated to be about $+0.3$ Wm^{-2}, most of which occurred during the first half of the 20th century. Since the late 1970s, satellite instruments have observed small oscillations due to the 11-year solar cycle. Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical or observational basis.
- Stratospheric aerosols from explosive volcanic eruptions lead to negative forcing, which lasts a few years. Several major eruptions occurred in the periods 1880 to 1920 and 1960 to 1991.
- The combined change in radiative forcing of the two major natural factors (solar variation and volcanic aerosols) is estimated to be negative for the past two, and possibly the past four, decades.

Confidence in the ability of models to project future climate has increased.

Complex physically-based climate models are required to provide detailed estimates of feedbacks and of regional features. Such models cannot yet simulate all aspects of climate (e.g., they still cannot account fully for the observed trend in the surface-troposphere temperature difference since 1979) and there are particular uncertainties associated with clouds and their interaction with radiation and aerosols. Nevertheless, confidence in the ability of these models to provide useful projections of future climate has improved due to their demonstrated performance on a range of space and time-scales.

- Understanding of climate processes and their incorporation in climate models have improved, including water vapour, sea-ice dynamics, and ocean heat transport.
- Some recent models produce satisfactory simulations of current climate without the need for non-physical adjustments of heat and water fluxes at the ocean-atmosphere interface used in earlier models.
- Simulations that include estimates of natural and anthropogenic forcing reproduce the observed large-scale changes in surface temperature over the 20th century (Figure 4). However, contributions from some additional processes and forcings may not have been included in the models. Nevertheless, the large-scale consistency between models and observations can be used to provide an independent check on projected warming rates over the next few decades under a given emissions scenario.
- Some aspects of model simulations of ENSO, monsoons and the North Atlantic Oscillation, as well as selected periods of past climate, have improved.

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

The SAR concluded: "The balance of evidence suggests a discernible human influence on global climate". That report also noted that the anthropogenic signal was still emerging from the background of natural climate variability. Since the SAR, progress has been made in reducing uncertainty, particularly with respect to distinguishing and quantifying the magnitude of responses to different external influences. Although many of the sources of uncertainty identified in the SAR still remain to some degree, new evidence and improved understanding support an updated conclusion.

- There is a longer and more closely scrutinised temperature record and new model estimates of variability. The warming over the past 100 years is very unlikely[7] to be due to internal variability alone, as estimated by current models. Reconstructions of climate data for the past 1,000 years (Figure 1b) also indicate that this warming was unusual and is unlikely[7] to be entirely natural in origin.
- There are new estimates of the climate response to natural and anthropogenic forcing, and new detection techniques have been applied. Detection and attribution studies consistently find evidence for an anthropogenic signal in the climate record of the last 35 to 50 years.
- Simulations of the response to natural forcings alone (i.e., the response to variability in solar irradiance and volcanic eruptions) do not explain the warming in the second half of the 20th century (see for example Figure 4a). However, they indicate that natural forcings may have contributed to the observed warming in the first half of the 20th century.
- The warming over the last 50 years due to anthropogenic greenhouse gases can be identified despite uncertainties in forcing due to anthropogenic sulphate aerosol and natural factors (volcanoes and solar irradiance). The anthropogenic sulphate aerosol forcing, while uncertain, is negative over this period and therefore cannot explain the warming. Changes in natural forcing during most of this period are also estimated to be negative and are unlikely[7] to explain the warming.
- Detection and attribution studies comparing model simulated changes with the observed record can now take into account uncertainty in the magnitude of modelled response to external forcing, in particular that due to uncertainty in climate sensitivity.
- Most of these studies find that, over the last 50 years, the estimated rate and magnitude of warming due to increasing concentrations of greenhouse gases alone are comparable with, or larger than, the observed warming. Furthermore, most model estimates that take into account both greenhouse gases and sulphate aerosols are consistent with observations over this period.
- The best agreement between model simulations and observations over the last 140 years has been found when all the above anthropogenic and natural forcing factors are combined, as shown in Figure 4c. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed.

In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely[7] to have been due to the increase in greenhouse gas concentrations.

Furthermore, it is very likely[7] that the 20th century warming has contributed significantly to the observed sea level rise, through thermal expansion of sea water and widespread loss of land ice. Within present uncertainties, observations and models are both consistent with a lack of significant acceleration of sea level rise during the 20th century.

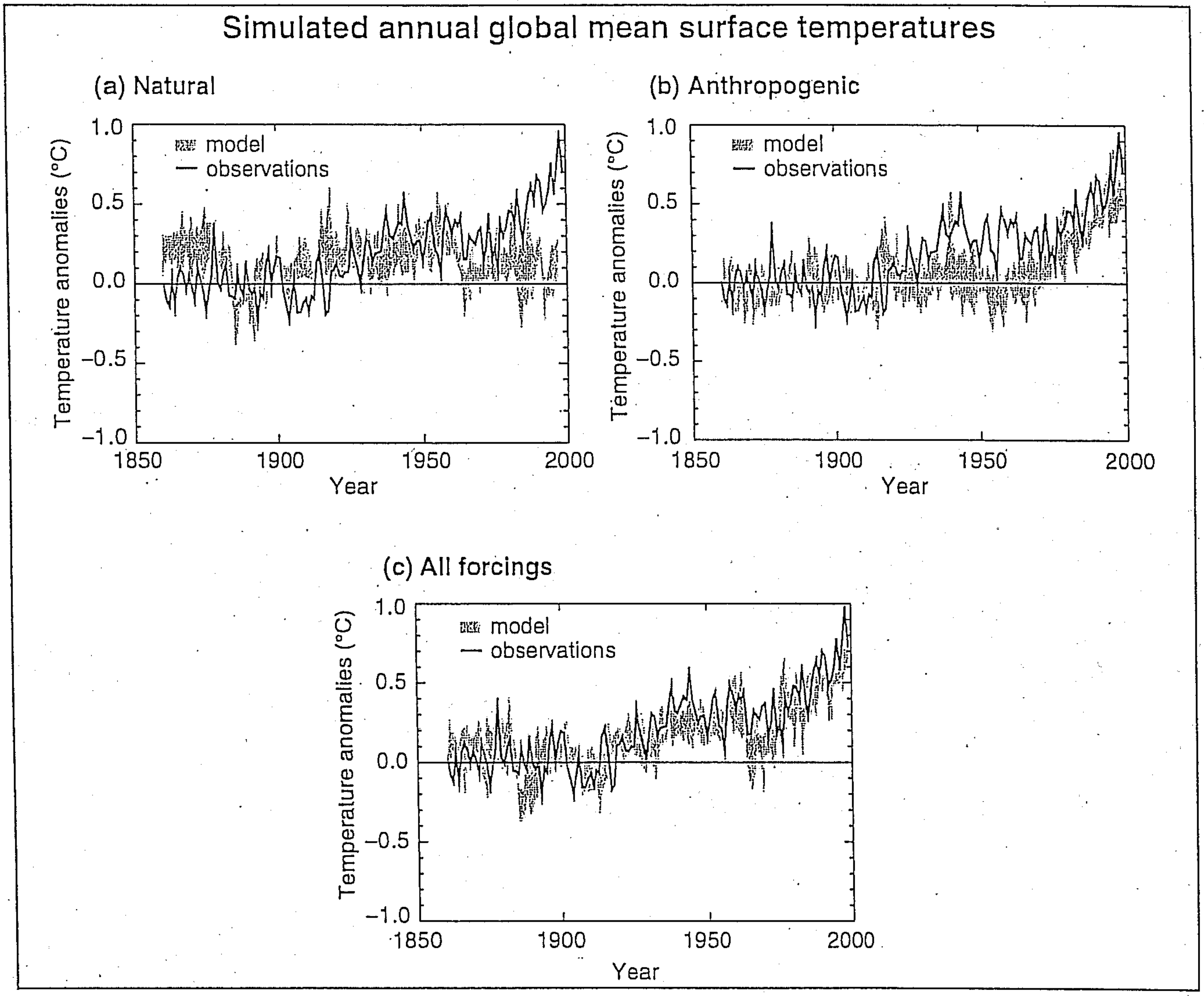

Figure 4: Simulating the Earth's temperature variations, and comparing the results to measured changes, can provide insight into the underlying causes of the major changes.

A climate model can be used to simulate the temperature changes that occur both from natural and anthropogenic causes. The simulations represented by the band in (a) were done with only natural forcings: solar variation and volcanic activity. Those encompassed by the band in (b) were done with anthropogenic forcings: greenhouse gases and an estimate of sulphate aerosols, and those encompassed by the band in (c) were done with both natural and anthropogenic forcings included. From (b), it can be seen that inclusion of anthropogenic forcings provides a plausible explanation for a substantial part of the observed temperature changes over the past century, but the best match with observations is obtained in (c) when both natural and anthropogenic factors are included. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed. The bands of model results presented here are for four runs from the same model. Similar results to those in (b) are obtained with other models with anthropogenic forcing. [Based upon Chapter 12, Figure 12.7]

Human influences will continue to change atmospheric composition throughout the 21st century.

Models have been used to make projections of atmospheric concentrations of greenhouse gases and aerosols, and hence of future climate, based upon emissions scenarios from the IPCC Special Report on Emission Scenarios (SRES) (Figure 5). These scenarios were developed to update the IS92 series, which were used in the SAR and are shown for comparison here in some cases.

Greenhouse gases

- Emissions of CO_2 due to fossil fuel burning are virtually certain[7] to be the dominant influence on the trends in atmospheric CO_2 concentration during the 21st century.
- As the CO_2 concentration of the atmosphere increases, ocean and land will take up a decreasing fraction of anthropogenic CO_2 emissions. The net effect of land and ocean climate feedbacks as indicated by models is to further increase projected atmospheric CO_2 concentrations, by reducing both the ocean and land uptake of CO_2.
- By 2100, carbon cycle models project atmospheric CO_2 concentrations of 540 to 970 ppm for the illustrative SRES scenarios (90 to 250% above the concentration of 280 ppm in the year 1750), Figure 5b. These projections include the land and ocean climate feedbacks. Uncertainties, especially about the magnitude of the climate feedback from the terrestrial biosphere, cause a variation of about −10 to +30% around each scenario. The total range is 490 to 1260 ppm (75 to 350% above the 1750 concentration).
- Changing land use could influence atmospheric CO_2 concentration. Hypothetically, if all of the carbon released by historical land-use changes could be restored to the terrestrial biosphere over the course of the century (e.g., by reforestation), CO_2 concentration would be reduced by 40 to 70 ppm.
- Model calculations of the concentrations of the non-CO_2 greenhouse gases by 2100 vary considerably across the SRES illustrative scenarios, with CH_4 changing by −190 to +1,970 ppb (present concentration 1,760 ppb), N_2O changing by +38 to +144 ppb (present concentration 316 ppb), total tropospheric O_3 changing by −12 to +62%, and a wide range of changes in concentrations of HFCs, PFCs and SF_6, all relative to the year 2000. In some scenarios, total tropospheric O_3 would become as important a radiative forcing agent as CH_4 and, over much of the Northern Hemisphere, would threaten the attainment of current air quality targets.
- Reductions in greenhouse gas emissions and the gases that control their concentration would be necessary to stabilise radiative forcing. For example, for the most important anthropogenic greenhouse gas, carbon cycle models indicate that stabilisation of atmospheric CO_2 concentrations at 450, 650 or 1,000 ppm would require global anthropogenic CO_2 emissions to drop below 1990 levels, within a few decades, about a century, or about two centuries, respectively, and continue to decrease steadily thereafter. Eventually CO_2 emissions would need to decline to a very small fraction of current emissions.

Aerosols

- The SRES scenarios include the possibility of either increases or decreases in anthropogenic aerosols (e.g., sulphate aerosols (Figure 5c), biomass aerosols, black and organic carbon aerosols) depending on the extent of fossil fuel use and policies to abate polluting emissions. In addition, natural aerosols (e.g., sea salt, dust and emissions leading to the production of sulphate and carbon aerosols) are projected to increase as a result of changes in climate.

Radiative forcing over the 21st century

- For the SRES illustrative scenarios, relative to the year 2000, the global mean radiative forcing due to greenhouse gases continues to increase through the 21st century, with the fraction due to CO_2 projected to increase from slightly more than half to about three quarters. The change in the direct plus indirect aerosol radiative forcing is projected to be smaller in magnitude than that of CO_2.

Global average temperature and sea level are projected to rise under all IPCC SRES scenarios.

In order to make projections of future climate, models incorporate past, as well as future emissions of greenhouse gases and aerosols. Hence, they include estimates of warming to date and the commitment to future warming from past emissions.

Temperature

- The globally averaged surface temperature is projected to increase by 1.4 to 5.8°C (Figure 5d) over the period 1990 to 2100. These results are for the full range of 35 SRES scenarios, based on a number of climate models[10,11].
- Temperature increases are projected to be greater than those in the SAR, which were about 1.0 to 3.5°C based on the six IS92 scenarios. The higher projected temperatures and the wider range are due primarily to the lower projected sulphur dioxide emissions in the SRES scenarios relative to the IS92 scenarios.
- The projected rate of warming is much larger than the observed changes during the 20th century and is very likely[7] to be without precedent during at least the last 10,000 years, based on palaeoclimate data.
- By 2100, the range in the surface temperature response across the group of climate models run with a given scenario is comparable to the range obtained from a single model run with the different SRES scenarios.
- On timescales of a few decades, the current observed rate of warming can be used to constrain the projected response to a given emissions scenario despite uncertainty in climate sensitivity. This approach suggests that anthropogenic warming is likely[7] to lie in the range of 0.1 to 0.2°C per decade over the next few decades under the IS92a scenario, similar to the corresponding range of projections of the simple model used in Figure 5d.
- Based on recent global model simulations, it is very likely[7] that nearly all land areas will warm more rapidly than the global average, particularly those at northern high latitudes in the cold season. Most notable of these is the warming in the northern regions of North America, and northern and central Asia, which exceeds global mean warming in each model by more than 40%. In contrast, the warming is less than the global mean change in south and southeast Asia in summer and in southern South America in winter.
- Recent trends for surface temperature to become more El Niño-like in the tropical Pacific, with the eastern tropical Pacific warming more than the western tropical Pacific, with a corresponding eastward shift of precipitation, are projected to continue in many models.

Precipitation

- Based on global model simulations and for a wide range of scenarios, global average water vapour concentration and precipitation are projected to increase during the 21st century. By the second half of the 21st century, it is likely[7] that precipitation will have increased over northern mid- to high latitudes and Antarctica in winter. At low latitudes there are both regional increases and decreases over land areas. Larger year to year variations in precipitation are very likely[7] over most areas where an increase in mean precipitation is projected.

[10] Complex physically based climate models are the main tool for projecting future climate change. In order to explore the full range of scenarios, these are complemented by simple climate models calibrated to yield an equivalent response in temperature and sea level to complex climate models. These projections are obtained using a simple climate model whose climate sensitivity and ocean heat uptake are calibrated to each of seven complex climate models. The climate sensitivity used in the simple model ranges from 1.7 to 4.2°C, which is comparable to the commonly accepted range of 1.5 to 4.5°C.

[11] This range does not include uncertainties in the modelling of radiative forcing, e.g. aerosol forcing uncertainties. A small carbon-cycle climate feedback is included.

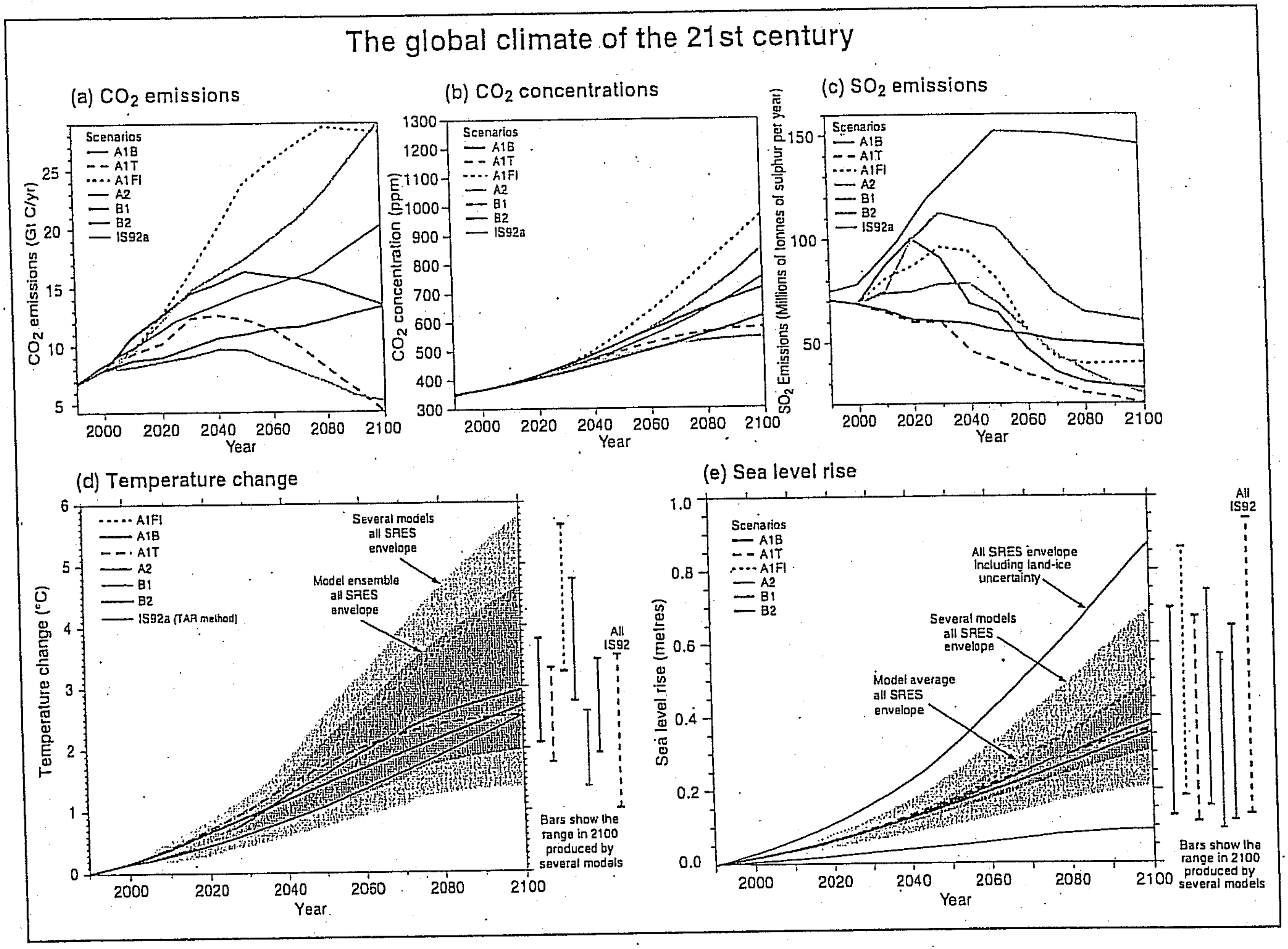

Figure 5: The global climate of the 21st century will depend on natural changes and the response of the climate system to human activities.

Climate models project the response of many climate variables – such as increases in global surface temperature and sea level – to various scenarios of greenhouse gas and other human-related emissions. (a) shows the CO_2 emissions of the six illustrative SRES scenarios, which are summarised in the box on page 18, along with IS92a for comparison purposes with the SAR. (b) shows projected CO_2 concentrations. (c) shows anthropogenic SO_2 emissions. Emissions of other gases and other aerosols were included in the model but are not shown in the figure. (d) and (e) show the projected temperature and sea level responses, respectively. The "several models all SRES envelope" in (d) and (e) shows the temperature and sea level rise, respectively, for the simple model when tuned to a number of complex models with a range of climate sensitivities. All SRES envelopes refer to the full range of 35 SRES scenarios. The "model average all SRES envelope" shows the average from these models for the range of scenarios. Note that the warming and sea level rise from these emissions would continue well beyond 2100. Also note that this range does not allow for uncertainty relating to ice dynamical changes in the West Antarctic ice sheet, nor does it account for uncertainties in projecting non-sulphate aerosols and greenhouse gas concentrations. [Based upon (a) Chapter 3, Figure 3.12, (b) Chapter 3, Figure 3.12, (c) Chapter 5, Figure 5.13, (d) Chapter 9, Figure 9.14, (e) Chapter 11, Figure 11.12, Appendix II]

Extreme Events

Table 1 depicts an assessment of confidence in observed changes in extremes of weather and climate during the latter half of the 20th century (left column) and in projected changes during the 21st century (right column)[a]. This assessment relies on observational and modelling studies, as well as the physical plausibility of future projections across all commonly-used scenarios and is based on expert judgement[7].

- For some other extreme phenomena, many of which may have important impacts on the environment and society, there is currently insufficient information to assess recent trends, and climate models currently lack the spatial detail required to make confident projections. For example, very small-scale phenomena, such as thunderstorms, tornadoes, hail and lightning, are not simulated in climate models.

Table 1: Estimates of confidence in observed and projected changes in extreme weather and climate events.

Confidence in observed changes (latter half of the 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely[7]	Higher maximum temperatures and more hot days over nearly all land areas	Very likely[7]
Very likely[7]	Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely[7]
Very likely[7]	Reduced diurnal temperature range over most land areas	Very likely[7]
Likely[7], over many areas.	Increase of heat index[12] over land areas	Very likely[7], over most areas
Likely[7], over many Northern Hemisphere mid- to high latitude land areas	More intense precipitation events[b]	Very likely[7], over many areas
Likely[7], in a few areas	Increased summer continental drying and associated risk of drought	Likely[7], over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	Increase in tropical cyclone peak wind intensities[c]	Likely[7], over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities[c]	Likely[7], over some areas

[a] For more details see Chapter 2 (observations) and Chapter 9, 10 (projections).

[b] For other areas, there are either insufficient data or conflicting analyses.

[c] Past and future changes in tropical cyclone location and frequency are uncertain.

[12] Heat index: A combination of temperature and humidity that measures effects on human comfort.

El Niño

- Confidence in projections of changes in future frequency, amplitude, and spatial pattern of El Niño events in the tropical Pacific is tempered by some shortcomings in how well El Niño is simulated in complex models. Current projections show little change or a small increase in amplitude for El Niño events over the next 100 years.

- Even with little or no change in El Niño amplitude, global warming is likely[7] to lead to greater extremes of drying and heavy rainfall and increase the risk of droughts and floods that occur with El Niño events in many different regions.

Monsoons

- It is likely[7] that warming associated with increasing greenhouse gas concentrations will cause an increase of Asian summer monsoon precipitation variability. Changes in monsoon mean duration and strength depend on the details of the emission scenario. The confidence in such projections is also limited by how well the climate models simulate the detailed seasonal evolution of the monsoons.

Thermohaline circulation

- Most models show weakening of the ocean thermohaline circulation which leads to a reduction of the heat transport into high latitudes of the Northern Hemisphere. However, even in models where the thermohaline circulation weakens, there is still a warming over Europe due to increased greenhouse gases. The current projections using climate models do not exhibit a complete shut-down of the thermohaline circulation by 2100. Beyond 2100, the thermohaline circulation could completely, and possibly irreversibly, shut-down in either hemisphere if the change in radiative forcing is large enough and applied long enough.

Snow and ice

- Northern Hemisphere snow cover and sea-ice extent are projected to decrease further.

- Glaciers and ice caps are projected to continue their widespread retreat during the 21st century.

- The Antarctic ice sheet is likely[7] to gain mass because of greater precipitation, while the Greenland ice sheet is likely[7] to lose mass because the increase in runoff will exceed the precipitation increase.

- Concerns have been expressed about the stability of the West Antarctic ice sheet because it is grounded below sea level. However, loss of grounded ice leading to substantial sea level rise from this source is now widely agreed to be very unlikely[7] during the 21st century, although its dynamics are still inadequately understood, especially for projections on longer time-scales.

Sea level

- Global mean sea level is projected to rise by 0.09 to 0.88 metres between 1990 and 2100, for the full range of SRES scenarios. This is due primarily to thermal expansion and loss of mass from glaciers and ice caps (Figure 5e). The range of sea level rise presented in the SAR was 0.13 to 0.94 metres based on the IS92 scenarios. Despite the higher temperature change projections in this assessment, the sea level projections are slightly lower, primarily due to the use of improved models, which give a smaller contribution from glaciers and ice sheets.

Anthropogenic climate change will persist for many centuries.

- Emissions of long-lived greenhouse gases (i.e., CO_2, N_2O, PFCs, SF_6) have a lasting effect on atmospheric composition, radiative forcing and climate. For example, several centuries after CO_2 emissions occur, about a quarter of the increase in CO_2 concentration caused by these emissions is still present in the atmosphere.
- After greenhouse gas concentrations have stabilised, global average surface temperatures would rise at a rate of only a few tenths of a degree per century rather than several degrees per century as projected for the 21st century without stabilisation. The lower the level at which concentrations are stabilised, the smaller the total temperature change.
- Global mean surface temperature increases and rising sea level from thermal expansion of the ocean are projected to continue for hundreds of years after stabilisation of greenhouse gas concentrations (even at present levels), owing to the long timescales on which the deep ocean adjusts to climate change.
- Ice sheets will continue to react to climate warming and contribute to sea level rise for thousands of years after climate has been stabilised. Climate models indicate that the local warming over Greenland is likely[7] to be one to three times the global average. Ice sheet models project that a local warming of larger than 3°C, if sustained for millennia, would lead to virtually a complete melting of the Greenland ice sheet with a resulting sea level rise of about 7 metres. A local warming of 5.5°C, if sustained for 1,000 years, would be likely[7] to result in a contribution from Greenland of about 3 metres to sea level rise.
- Current ice dynamic models suggest that the West Antarctic ice sheet could contribute up to 3 metres to sea level rise over the next 1,000 years, but such results are strongly dependent on model assumptions regarding climate change scenarios, ice dynamics and other factors.

Further action is required to address remaining gaps in information and understanding.

Further research is required to improve the ability to detect, attribute and understand climate change, to reduce uncertainties and to project future climate changes. In particular, there is a need for additional systematic and sustained observations, modelling and process studies. A serious concern is the decline of observational networks. The following are high priority areas for action.

- Systematic observations and reconstructions:
  - Reverse the decline of observational networks in many parts of the world.
  - Sustain and expand the observational foundation for climate studies by providing accurate, long-term, consistent data including implementation of a strategy for integrated global observations.
  - Enhance the development of reconstructions of past climate periods.
  - Improve the observations of the spatial distribution of greenhouse gases and aerosols.
- Modelling and process studies:
  - Improve understanding of the mechanisms and factors leading to changes in radiative forcing.
  - Understand and characterise the important unresolved processes and feedbacks, both physical and biogeochemical, in the climate system.
  - Improve methods to quantify uncertainties of climate projections and scenarios, including long-term ensemble simulations using complex models.
  - Improve the integrated hierarchy of global and regional climate models with a focus on the simulation of climate variability, regional climate changes and extreme events.
  - Link more effectively models of the physical climate and the biogeochemical system, and in turn improve coupling with descriptions of human activities.

Cutting across these foci are crucial needs associated with strengthening international co-operation and co-ordination in order to better utilise scientific, computational and observational resources. This should also promote the free exchange of data among scientists. A special need is to increase the observational and research capacities in many regions, particularly in developing countries. Finally, as is the goal of this assessment, there is a continuing imperative to communicate research advances in terms that are relevant to decision making.

The Emissions Scenarios of the Special Report on Emissions Scenarios (SRES)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

Source Information: Summary for Policymakers

This appendix provides the cross-reference of the topics in the Summary for Policymakers (page and bullet point topic) to the sections of the chapters of the full report that contain expanded information about the topic.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
2	*The global average surface temperature has increased over the 20th century by about 0.6°C.* ● Chapter 2.2.2 ● Chapter 2.2.2 ● Chapter 2.3 ● Chapter 2.2.2
4	*Temperatures have risen during the past four decades in the lowest 8 kilometres of the atmosphere.* ● Chapter 2.2.3 and 2.2.4 ● Chapter 2.2.3 and 2.2.4 ● Chapter 2.2.3, 2.2.4 and Chapter 12.3.2
4	*Snow cover and ice extent have decreased.* All three bullet points: Chapter 2.2.5 and 2.2.6
4	*Global average sea level has risen and ocean heat content has increased.* ● Chapter 11.3.2 ● Chapter 2.2.2 and Chapter 11.2.1
4 – 5	*Changes have also occurred in other important aspects of climate.* ● Chapter 2.5.2 ● Chapter 2.7.2 ● Chapter 2.2.2 and 2.5.5 ● Chapter 2.7.2 ● Chapter 2.6.2 and 2.6.3 ● Chapter 2.7.3 ● Chapter 2.7.3
5	*Some important aspects of climate appear not to have changed.* ● Chapter 2.2.2 ● Chapter 2.2.5 ● Chapter 2.7.3 ● Chapter 2.7.3

Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate system.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
5	Chapeau: "Changes in climate occur ..." Chapter 1, Chapter 3.1, Chapter 4.1, Chapter 5.1, Chapter 6.1, 6.2, 6.9, 6.11 and 6.13
7	*Concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities.* Carbon dioxide: ● Chapter 3.3.1, 3.3.2, 3.3.3 and 3.5.1 ● Chapter 3.5.1 ● Chapter 3.2.2, 3.2.3, 3.5.1 and Table 3.1 ● Chapter 3.5.1 and 3.5.2 Methane: ● Chapter 4.2.1 Nitrous oxide: ● Chapter 4.2.1 Halocarbons: ● Chapter 4.2.2 Radiative forcing of well-mixed gases: ● Chapter 4.2.1 and Chapter 6.3 Stratospheric ozone: ● Chapter 4.2.2 and Chapter 6.4 Tropospheric ozone: ● Chapter 4.2.4 and Chapter 6.5
9	*Anthropogenic aerosols are short-lived and mostly produce negative radiative forcing.* ● Chapter 5.2 and 5.5.4 ● Chapter 5.1, 5.2 and Chapter 6.7 ● Chapter 5.3.2, 5.4.3 and Chapter 6.8
9	*Natural factors have made small contributions to radiative forcing over the past century.* ● Chapter 6.11 and 6.15.1 ● Chapter 6.9 and 6.15.1 ● Chapter 6.15.1

Confidence in the ability of models to project future climate has increased.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
9	Chapeau: "Complex physically-based ..." Chapter 8.3.2, 8.5.1, 8.6.1, 8.10.3 and Chapter 12.3.2
9	● Chapter 7.2.1, 7.5.2 and 7.6.1 ● Chapter 8.4.2 ● Chapter 8.6.3 and Chapter 12.3.2 ● Chapter 8.5.5, 8.7.1 and 8.7.5

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
10	Chapeau: "The SAR concluded: The balance of evidence suggests ..." Chapter 12.1.2 and 12.6
10	● Chapter 12.2.2, 12.4.3 and 12.6 ● Chapter 12.4.1, 12.4.2, 12.4.3 and 12.6 ● Chapter 12.2.3, 12.4.1, 12.4.2, 12.4.3 and 12.6 ● Chapter 12.4.3 and 12.6. ● Chapter 12.6 ● Chapter 12.4.3 ● Chapter 12.4.3 and 12.6
10	"In the light of new evidence and taking into account the ..." Chapter 12.4 and 12.6
10	"Furthermore, it is very likely that the 20th century warming has ..." Chapter 11.4

Human influences will continue to change atmospheric composition throughout the 21st century.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
12	Chapeau: "Models have been used to make projections ..." Chapter 4.4.5 and Appendix II
12	*Greenhouse gases* ● Chapter 3.7.3 and Appendix II ● Chapter 3.7.1, 3.7.2, 3.7.3 and Appendix II ● Chapter 3.7.3 and Appendix II ● Chapter 3.2.2 and Appendix II ● Chapter 4.4.5, 4.5, 4.6 and Appendix II ● Chapter 3.7.3
12	*Aerosols* ● Chapter 5.5.2, 5.5.3 and Appendix II
12	*Radiative forcing over the 21st century* ● Chapter 6.15.2 and Appendix II

Global average temperature and sea level are projected to rise under all IPCC SRES scenarios.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
13	*Temperature* ● Chapter 9.3.3 ● Chapter 9.3.3 ● Chapter 2.2.2, 2.3.2 and 2.4 ● Chapter 9.3.3 and Chapter 10.3.2 ● Chapter 8.6.1, Chapter 12.4.3, Chapter 13.5.1 and 13.5.2 ● Chapter 10.3.2 and Box 10.1 ● Chapter 9.3.2
13	*Precipitation* ● Chapter 9.3.1, 9.3.6, Chapter 10.3.2 and Box 10.1
15	*Extreme events* Table 1: Chapter 2.1, 2.2, 2.5, 2.7.2, 2.7.3, Chapter 9.3.6 and Chapter 10.3.2 ● Chapter 2.7.3 and Chapter 9.3.6
16	*El Niño* ● Chapter 9.3.5 ● Chapter 9.3.5
16	*Monsoons* ● Chapter 9.3.5
16	*Thermohaline circulation* ● Chapter 9.3.4
16	*Snow and ice* ● Chapter 9.3.2 ● Chapter 11.5.1 ● Chapter 11.5.1 ● Chapter 11.5.4
16	*Sea level* ● Chapter 11.5.1

Anthropogenic climate change will persist for many centuries.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
17	● Chapter 3.2.3, Chapter 4.4 and Chapter 6.15 ● Chapter 9.3.3 and 9.3.4 ● Chapter 11.5.4 ● Chapter 11.5.4 ● Chapter 11.5.4

Further work is required to address remaining gaps in information and understanding.

SPM Page	Cross-Reference: SPM Topic – Chapter Section
17 – 18	All bullet points: Chapter 14, Executive Summary

SUMMARY FOR POLICYMAKERS

CLIMATE CHANGE 2001: IMPACTS, ADAPTATION, AND VULNERABILITY

A Report of Working Group II of the Intergovernmental Panel on Climate Change

This summary, approved in detail at the Sixth Session of IPCC Working Group II (Geneva, Switzerland • 13-16 February 2001), represents the formally agreed statement of the IPCC concerning the sensitivity, adaptive capacity, and vulnerability of natural and human systems to climate change, and the potential consequences of climate change.

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CONTENTS

1. Introduction

The sensitivity, adaptive capacity, and vulnerability of natural and human systems to climate change, and the potential consequences of climate change, are assessed in the report of Working Group II of the Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*.[1] This report builds upon the past assessment reports of the IPCC, reexamining key conclusions of the earlier assessments and incorporating results from more recent research.[2,3]

Observed changes in climate, their causes, and potential future changes are assessed in the report of Working Group I of the IPCC, *Climate Change 2001: The Scientific Basis*. The Working Group I report concludes, *inter alia*, that the globally averaged surface temperatures have increased by 0.6 ± 0.2°C over the 20th century; and that, for the range of scenarios developed in the IPCC *Special Report on Emission Scenarios* (SRES), the globally averaged surface air temperature is projected by models to warm 1.4 to 5.8°C by 2100 relative to 1990, and globally averaged sea level is projected by models to rise 0.09 to 0.88 m by 2100. These projections indicate that the warming would vary by region, and be accompanied by increases and decreases in precipitation. In addition, there would be changes in the variability of climate, and changes in the frequency and intensity of some extreme climate phenomena. These general features of climate change act on natural and human systems and they set the context for the Working Group II assessment. The available literature has not yet investigated climate change impacts, adaptation, and vulnerability associated with the upper end of the projected range of warming.

This Summary for Policymakers, which was approved by IPCC member governments in Geneva in February 2001, describes the current state of understanding of the impacts, adaptation, and vulnerability to climate change and their uncertainties. Further details can be found in the underlying report.[4] Section 2 of the Summary presents a number of general findings that emerge from integration of information across the full report. Each of these findings addresses a different dimension of climate change impacts, adaptation, and vulnerability, and no one dimension is paramount. Section 3 presents findings regarding individual natural and human systems, and Section 4 highlights some of the issues of concern for different regions of the world. Section 5 identifies priority research areas to further advance understanding of the potential consequences of and adaptation to climate change.

2. Emergent Findings

2.1. *Recent Regional Climate Changes, particularly Temperature Increases, have Already Affected Many Physical and Biological Systems*

Available observational evidence indicates that regional changes in climate, particularly increases in temperature, have already affected a diverse set of physical and biological systems in many parts of the world. Examples of observed changes include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, poleward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence of insects, and egg-laying in birds (see Figure SPM-1). Associations between changes in regional temperatures and observed changes in physical and biological systems have been documented in many aquatic, terrestrial, and marine environments. [2.1, 4.3, 4.4, 5.7, and 7.1]

The studies mentioned above and illustrated in Figure SPM-1 were drawn from a literature survey, which identified long-term studies, typically 20 years or more, of changes in biological and physical systems that could be correlated with regional changes in temperature.[5] In most cases where changes in biological and physical systems were detected, the direction of change was that expected on the basis of known mechanisms. The probability that the observed changes in the expected direction (with no reference to magnitude) could occur by chance alone is negligible. In many parts of the world, precipitation-related impacts may be important. At present, there is a lack of systematic concurrent climatic and biophysical data of sufficient length (2 or more decades) that are considered necessary for assessment of precipitation impacts.

Factors such as land-use change and pollution also act on these physical and biological systems, making it difficult to attribute changes to particular causes in some specific cases. However, taken together, the observed changes in these systems are consistent in direction and coherent across diverse localities

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[1] *Climate change* in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where *climate change* refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Attribution of climate change to natural forcing and human activities has been addressed by Working Group I.

[2] The report has been written by 183 Coordinating Lead Authors and Lead Authors, and 243 Contributing Authors. It was reviewed by 440 government and expert reviewers, and 33 Review Editors oversaw the review process.

[3] Delegations from 100 IPCC member countries participated in the Sixth Session of Working Group II in Geneva on 13-16 February 2001.

[4] A more comprehensive summary of the report is provided in the Technical Summary, and relevant sections of that volume are referenced in brackets at the end of paragraphs of the Summary for Policymakers for readers who need more information.

[5] There are 44 regional studies of over 400 plants and animals, which varied in length from about 20 to 50 years, mainly from North America, Europe, and the southern polar region. There are 16 regional studies covering about 100 physical processes over most regions of the world, which varied in length from about 20 to 150 years. See Section 7.1 of the Technical Summary for more detail.

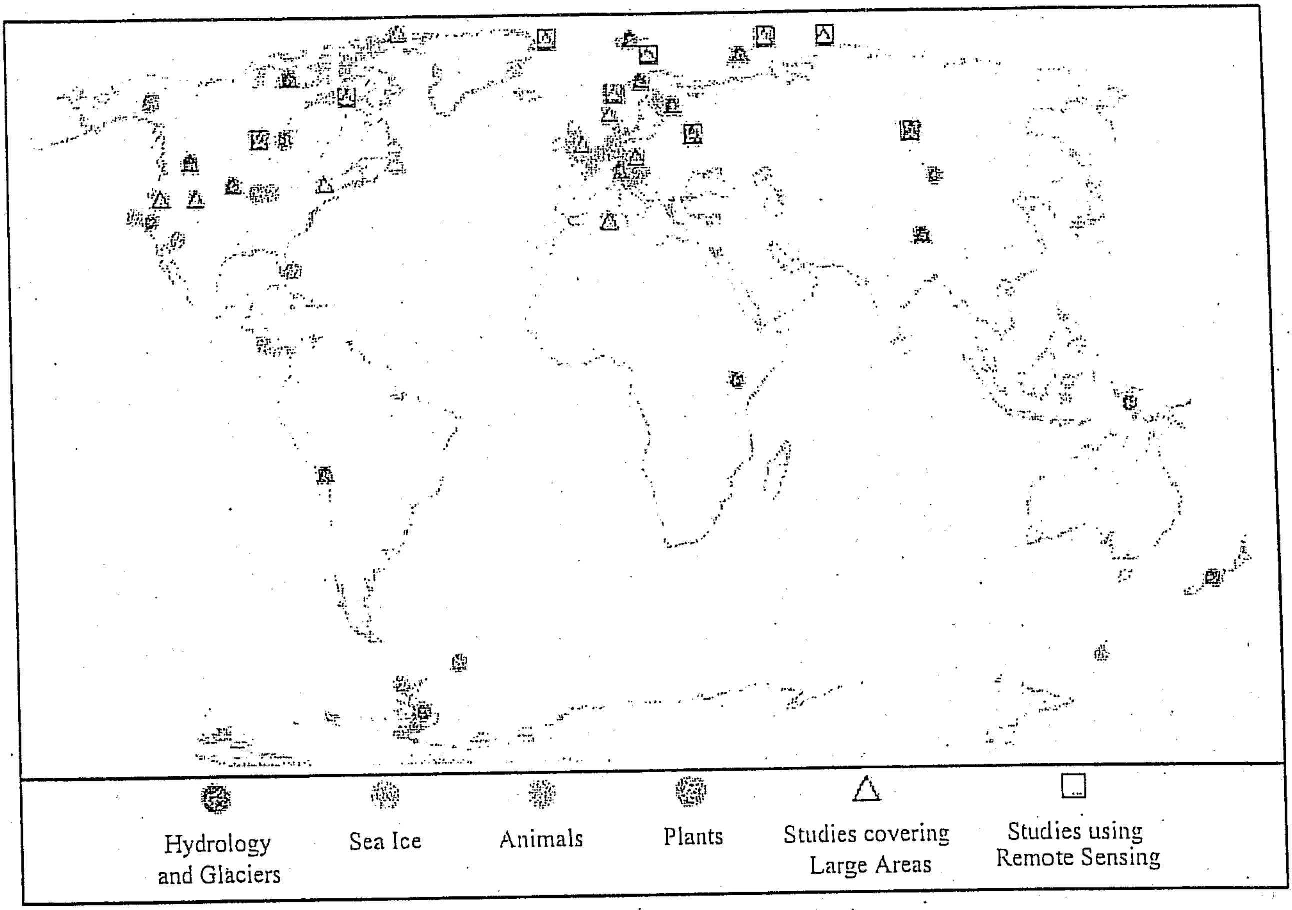

Figure SPM-1: Locations at which systematic long-term studies meet stringent criteria documenting recent temperature-related regional climate change impacts on physical and biological systems. Hydrology, glacial retreat, and sea-ice data represent decadal to century trends. Terrestrial and marine ecosystem data represent trends of at least 2 decades. Remote-sensing studies cover large areas. Data are for single or multiple impacts that are consistent with known mechanisms of physical/biological system responses to observed regional temperature-related changes. For reported impacts spanning large areas, a representative location on the map was selected.

and/or regions (see Figure SPM-1) with the expected effects of regional changes in temperature. Thus, from the collective evidence, there is *high confidence*[6] that recent regional changes in temperature have had discernible impacts on many physical and biological systems.

[6]In this Summary for Policymakers, the following words have been used where appropriate to indicate judgmental estimates of confidence (based upon the collective judgment of the authors using the observational evidence, modeling results, and theory that they have examined): *very high* (95% or greater), *high* (67-95%), *medium* (33-67%), *low* (5-33%), and *very low* (5% or less). In other instances, a qualitative scale to gauge the level of scientific understanding is used: *well established, established-but-incomplete, competing explanations*, and *speculative*. The approaches used to assess confidence levels and the level of scientific understanding, and the definitions of these terms, are presented in Section 1.4 of the Technical Summary. Each time these terms are used in the Summary for Policymakers, they are footnoted and in *italics*.

2.2. *There are Preliminary Indications that Some Human Systems have been Affected by Recent Increases in Floods and Droughts*

There is emerging evidence that some social and economic systems have been affected by the recent increasing frequency of floods and droughts in some areas. However, such systems are also affected by changes in socioeconomic factors such as demographic shifts and land-use changes. The relative impact of climatic and socioeconomic factors are generally difficult to quantify. [4.6 and 7.1]

2.3. *Natural Systems are Vulnerable to Climate Change, and Some will be Irreversibly Damaged*

Natural systems can be especially vulnerable to climate change because of limited adaptive capacity (see Box SPM-1), and some of these systems may undergo significant and irreversible damage. Natural systems at risk include glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands. While some species may increase in abundance or range, climate change will increase existing risks of extinction of some more vulnerable species and loss of biodiversity. It is *well-established*[6] that the geographical extent of the damage or loss, and the number of systems affected, will increase with the magnitude and rate of climate change (see Figure SPM-2). [4.3 and 7.2.1]

2.4. *Many Human Systems are Sensitive to Climate Change, and Some are Vulnerable*

Human systems that are sensitive to climate change include mainly water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries); human settlements, energy, and industry; insurance and other financial services; and human health. The vulnerability of these systems varies with geographic location, time, and social, economic, and environmental conditions. [4.1, 4.2, 4.3, 4.4, 4.5, 4.6, and 4.7]

Projected adverse impacts based on models and other studies include:

- A general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature [4.2]
- A general reduction, with some variation, in potential crop yields in most regions in mid-latitudes for increases in annual-average temperature of more than a few °C [4.2]
- Decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics [4.1]
- An increase in the number of people exposed to vector-borne (e.g., malaria) and water-borne diseases (e.g., cholera), and an increase in heat stress mortality [4.7]
- A widespread increase in the risk of flooding for many human settlements (tens of millions of inhabitants in settlements studied) from both increased heavy precipitation events and sea-level rise [4.5]
- Increased energy demand for space cooling due to higher summer temperatures. [4.5]

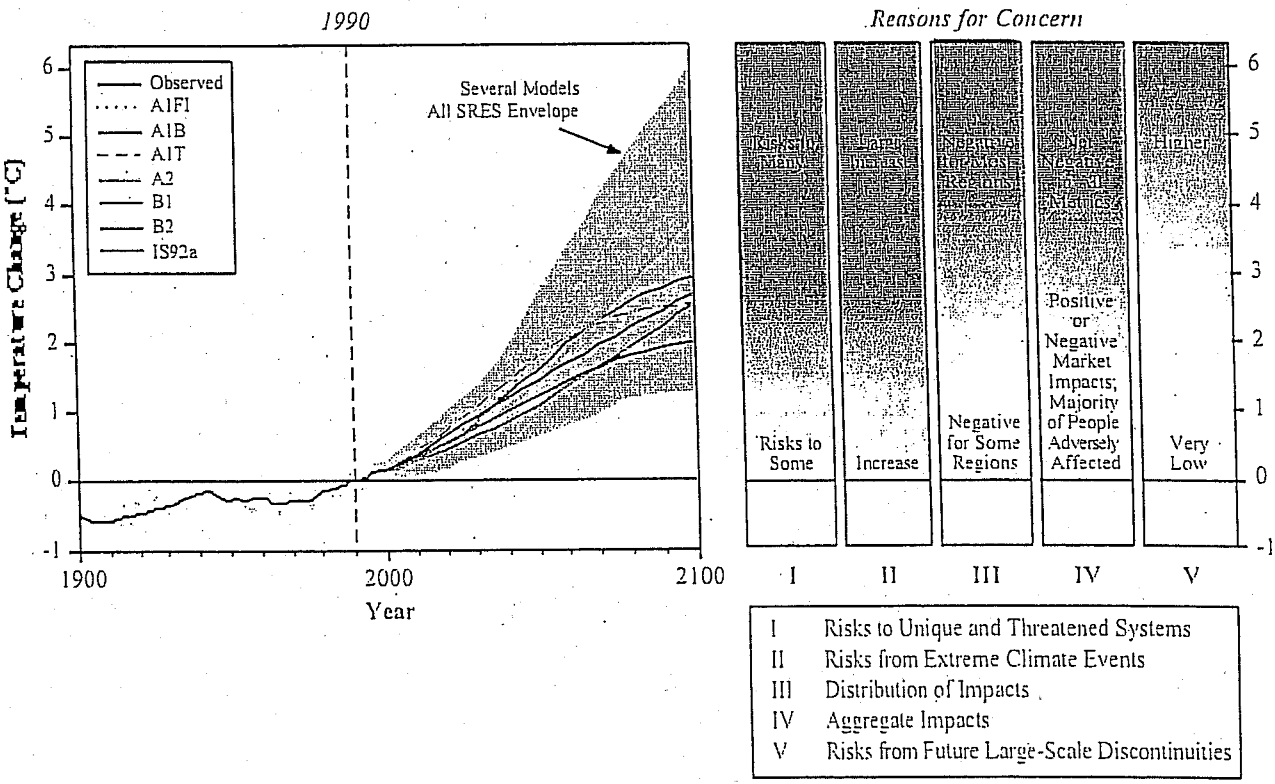

Figure SPM-2: Reasons for concern about projected climate change impacts. The risks of adverse impacts from climate change increase with the magnitude of climate change. The left part of the figure displays the observed temperature increase relative to 1990 and the range of projected temperature increase after 1990 as estimated by Working Group I of the IPCC for scenarios from the *Special Report on Emissions Scenarios*. The right panel displays conceptualizations of five reasons for concern regarding climate change risks evolving through 2100. White indicates neutral or small negative or positive impacts or risks, yellow indicates negative impacts for some systems or low risks, and red means negative impacts or risks that are more widespread and/or greater in magnitude. The assessment of impacts or risks takes into account only the magnitude of change and not the rate of change. Global mean annual temperature change is used in the figure as a proxy for the magnitude of climate change, but projected impacts will be a function of, among other factors, the magnitude and rate of global and regional changes in mean climate, climate variability and extreme climate phenomena, social and economic conditions, and adaptation.

Box SPM-1. Climate Change Sensitivity, Adaptive Capacity, and Vulnerability

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Projected beneficial impacts based on models and other studies include:

- Increased potential crop yields in some regions at mid-latitudes for increases in temperature of less than a few °C [4.2]
- A potential increase in global timber supply from appropriately managed forests [4.3]
- Increased water availability for populations in some water-scarce regions—for example, in parts of southeast Asia [4.1]
- Reduced winter mortality in mid- and high-latitudes.[4.7]
- Reduced energy demand for space heating due to higher winter temperatures. [4.5]

2.5. *Projected Changes in Climate Extremes could have Major Consequences*

The vulnerability of human societies and natural systems to climate extremes is demonstrated by the damage, hardship, and death caused by events such as droughts, floods, heat waves, avalanches, and windstorms. While there are uncertainties attached to estimates of such changes, some extreme events are projected to increase in frequency and/or severity during the 21st century due to changes in the mean and/or variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming (see Figure SPM-2). Conversely, the frequency and magnitude of extreme low temperature events, such as cold spells, is projected to decrease in the future, with both positive and negative impacts. The impacts of future changes in climate extremes are expected to fall disproportionately on the poor. Some representative examples of impacts of these projected changes in climate variability and climate extremes are presented in Table SPM-1. [3.5, 4.6, 6, and 7.2.4]

2.6. *The Potential for Large-Scale and Possibly Irreversible Impacts Poses Risks that have yet to be Reliably Quantified*

Projected climate changes[7] during the 21st century have the potential to lead to future large-scale and possibly irreversible changes in Earth systems resulting in impacts at continental and global scales. These possibilities are very climate scenario-dependent and a full range of plausible scenarios has not yet been evaluated. Examples include significant slowing of the ocean circulation that transports warm water to the North Atlantic, large reductions in the Greenland and West Antarctic Ice Sheets, accelerated global warming due to carbon cycle feedbacks in the terrestrial biosphere, and releases of terrestrial carbon from permafrost regions and methane from hydrates in coastal sediments. The likelihood of many of these changes in Earth systems is not well-known, but is probably very low; however, their likelihood is expected to increase with the rate, magnitude, and duration of climate change (see Figure SPM-2). [3.5, 5.7, and 7.2.5]

If these changes in Earth systems were to occur, their impacts would be widespread and sustained. For example, significant slowing of the oceanic thermohaline circulation would impact deep-water oxygen levels and carbon uptake by oceans and marine ecosystems, and would reduce warming over parts of Europe. Disintegration of the West Antarctic Ice Sheet or melting of the Greenland Ice Sheet could raise global sea level up to 3 m each over the next 1,000 years[8], submerge many islands, and inundate extensive coastal areas. Depending on the rate of ice loss, the rate and magnitude of sea-level rise could greatly exceed the capacity of human and natural systems to adapt without substantial impacts. Releases of terrestrial carbon from permafrost regions and methane from hydrates in coastal sediments, induced by warming, would further increase greenhouse gas concentrations in the atmosphere and amplify climate change. [3.5, 5.7, and 7.2.5]

2.7. *Adaptation is a Necessary Strategy at All Scales to Complement Climate Change Mitigation Efforts*

Adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs

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[7] Details of projected climate changes, illustrated in Figure SPM-2, are provided in the Working Group I Summary for Policymakers.

[8] Details of projected contributions to sea-level rise from the West Anarctic Ice Sheet and Greenland Ice Sheet are provided in the Working Group I Summary for Policymakers.

Table SPM-1: Examples of impacts resulting from projected changes in extreme climate events.

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	Representative Examples of Projected Impacts[b] *(all high confidence of occurrence in some areas[c])*
Simple Extremes	
Higher maximum temperatures; more hot days and heat waves[d] over nearly all land areas (*very likely*[a])	• Increased incidence of death and serious illness in older age groups and urban poor [4.7] • Increased heat stress in livestock and wildlife [4.2 and 4.3] • Shift in tourist destinations [Table TS-4 and 5.8] • Increased risk of damage to a number of crops [4.2] • Increased electric cooling demand and reduced energy supply reliability [Table TS-4 and 4.5]
Higher (increasing) minimum temperatures; fewer cold days, frost days, and cold waves[d] over nearly all land areas (*very likely*[a])	• Decreased cold-related human morbidity and mortality [4.7] • Decreased risk of damage to a number of crops, and increased risk to others [4.2] • Extended range and activity of some pest and disease vectors [4.2 and 4.3] • Reduced heating energy demand [4.5]
More intense precipitation events (*very likely*[a] over many areas)	• Increased flood, landslide, avalanche, and mudslide damage [4.5] • Increased soil erosion [5.2.4] • Increased flood runoff could increase recharge of some floodplain aquifers [4.1] • Increased pressure on government and private flood insurance systems and disaster relief [Table TS-4 and 4.6]
Complex Extremes	
Increased summer drying over most mid-latitude continental interiors and associated risk of drought (*likely*[a])	• Decreased crop yields [4.2] • Increased damage to building foundations caused by ground shrinkage [Table TS-4] • Decreased water resource quantity and quality [4.1 and 4.5] • Increased risk of forest fire [5.4.2]
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities (*likely*[a] over some areas)[e]	• Increased risks to human life, risk of infectious disease epidemics, and many other risks [4.7] • Increased coastal erosion and damage to coastal buildings and infrastructure [4.5 and 7.2.4] • Increased damage to coastal ecosystems such as coral reefs and mangroves [4.4]
Intensified droughts and floods associated with El Niño events in many different regions (*likely*[a]) (see also under droughts and intense precipitation events)	• Decreased agricultural and rangeland productivity in drought- and flood-prone regions [4.3] • Decreased hydro-power potential in drought-prone regions [5.1.1 and Figure TS-7]
Increased Asian summer monsoon precipitation variability (*likely*[a])	• Increased flood and drought magnitude and damages in temperate and tropical Asia [5.2.4]
Increased intensity of mid-latitude storms (little agreement between current models)[d]	• Increased risks to human life and health [4.7] • Increased property and infrastructure losses [Table TS-4] • Increased damage to coastal ecosystems [4.4]

[a] Likelihood refers to judgmental estimates of confidence used by TAR WGI: *very likely* (90-99% chance); *likely* (66-90% chance). Unless otherwise stated, information on climate phenomena is taken from the Summary for Policymakers, TAR WGI.

[b] These impacts can be lessened by appropriate response measures.

[c] High confidence refers to probabilities between 67 and 95% as described in Footnote 6.

[d] Information from TAR WGI, Technical Summary, Section F.5.

[e] Changes in regional distribution of tropical cyclones are possible but have not been established.

and will not prevent all damages. Extremes, variability, and rates of change are all key features in addressing vulnerability and adaptation to climate change, not simply changes in average climate conditions. Human and natural systems will to some degree adapt autonomously to climate change. Planned adaptation can supplement autonomous adaptation, though options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems. Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts. [6]

Experience with adaptation to climate variability and extremes can be drawn upon to develop appropriate strategies for adapting to anticipated climate change. Adaptation to current climate variability and extremes often produces benefits as well as forming a basis for coping with future climate change. However, experience also demonstrates that there are constraints to achieving the full measure of potential adaptation. In addition, maladaptation, such as promoting development in risk-prone locations, can occur due to decisions based on short-term considerations, neglect of known climatic variability, imperfect foresight, insufficient information, and over-reliance on insurance mechanisms. [6]

2.8 *Those with the Least Resources have the Least Capacity to Adapt and are the Most Vulnerable*

The ability of human systems to adapt to and cope with climate change depends on such factors as wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities. There is potential for developed and developing countries to enhance and/or acquire adaptive capabilities. Populations and communities are highly variable in their endowments with these attributes, and the developing countries, particularly the least developed countries, are generally poorest in this regard. As a result, they have lesser capacity to adapt and are more vulnerable to climate change damages, just as they are more vulnerable to other stresses. This condition is most extreme among the poorest people. [6.1; see also 5.1.7, 5.2.7, 5.3.5, 5.4.6, 5.6.1, 5.6.2, 5.7, and 5.8.1 for regional-scale information]

Benefits and costs of climate change effects have been estimated in monetary units and aggregated to national, regional, and global scales. These estimates generally exclude the effects of changes in climate variability and extremes, do not account for the effects of different rates of change, and only partially account for impacts on goods and services that are not traded in markets. These omissions are likely to result in underestimates of economic losses and overestimates of economic gains. Estimates of aggregate impacts are controversial because they treat gains for some as canceling out losses for others and because the weights that are used to aggregate across individuals are necessarily subjective. [7.2.2 and 7.2.3]

Notwithstanding the limitations expressed above, based on a few published estimates, increases in global mean temperature[9] would produce net economic losses in many developing countries for all magnitudes of warming studied (*low confidence*[6]), and losses would be greater in magnitude the higher the level of warming (*medium confidence*[6]). In contrast, an increase in global mean temperature of up to a few °C would produce a mixture of economic gains and losses in developed countries (*low confidence*[6]), with economic losses for larger temperature increases (*medium confidence*[6]). The projected distribution of economic impacts is such that it would increase the disparity in well-being between developed countries and developing countries, with disparity growing for higher projected temperature increases (*medium confidence*[6]). The more damaging impacts estimated for developing countries reflects, in part, their lesser adaptive capacity relative to developed countries. [7.2.3]

Further, when aggregated to a global scale, world gross domestic product (GDP) would change by ± a few percent for global mean temperature increases of up to a few °C (*low confidence*[6]), and increasing net losses would result for larger increases in temperature (*medium confidence*[6]) (see Figure SPM-2). More people are projected to be harmed than benefited by climate change, even for global mean temperature increases of less than a few °C (*low confidence*[6]). These results are sensitive to assumptions about changes in regional climate, level of development, adaptive capacity, rate of change, the valuation of impacts, and the methods used for aggregating monetary losses and gains, including the choice of discount rate. [7.2.2]

The effects of climate change are expected to be greatest in developing countries in terms of loss of life and relative effects on investment and the economy. For example, the relative percentage damages to GDP from climate extremes have been substantially greater in developing countries than in developed countries. [4.6]

2.9. *Adaptation, Sustainable Development, and Enhancement of Equity can be Mutually Reinforcing*

Many communities and regions that are vulnerable to climate change are also under pressure from forces such as population growth, resource depletion, and poverty. Policies that lessen pressures on resources, improve management of environmental risks, and increase the welfare of the poorest members of society can simultaneously advance sustainable development and equity, enhance adaptive capacity, and reduce vulnerability to climate and other stresses. Inclusion of climatic risks in the design and implementation of national and international development initiatives can promote equity and development that is more sustainable and that reduces vulnerability to climate change. [6.2]

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[9] Global mean temperature change is used as an indicator of the magnitude of climate change. Scenario-dependent exposures taken into account in these studies include regionally differentiated changes in temperature, precipitation, and other climatic variables.

3. Effects on and Vulnerability of Natural and Human Systems

3.1. *Hydrology and Water Resources*

The effect of climate change on streamflow and groundwater recharge varies regionally and between climate scenarios, largely following projected changes in precipitation. A consistent projection across most climate change scenarios is for increases in annual mean streamflow in high latitudes and southeast Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa, and Australia (*medium confidence*[6]) (see Figure SPM-3); the amount of change, however, varies between scenarios. For other areas, including mid-latitudes, there is no strong consistency in projections of streamflow, partly because of differences in projected rainfall and partly because of differences in projected evaporation, which can offset rainfall increases. The retreat of most glaciers is projected to accelerate, and many small glaciers may disappear (*high confidence*[6]). In general, the projected changes in average annual runoff are less robust than impacts based solely on temperature change because precipitation changes vary more between scenarios. At the catchment scale, the effect of a given change in climate varies with physical properties and vegetation of catchments, and may be in addition to land-cover changes. [4.1]

Approximately 1.7 billion people, one-third of the world's population, presently live in countries that are water-stressed (defined as using more than 20% of their renewable water supply, a commonly used indicator of water stress). This number is projected to increase to around 5 billion by 2025, depending on the rate of population growth. The projected climate change could further decrease the streamflow and groundwater recharge in many of these water-stressed countries—for example in central Asia, southern Africa, and countries around the Mediterranean Sea—but may increase it in some others. [4.1; see also 5.1.1, 5.2.3, 5.3.1, 5.4.1, 5.5.1, 5.6.2, and 5.8.4 for regional-scale information]

Demand for water is generally increasing due to population growth and economic development, but is falling in some countries because of increased efficiency of use. Climate change is unlikely to have a big effect on municipal and industrial water demands in general, but may substantially affect irrigation withdrawals, which depend on how increases in evaporation are offset or exaggerated by changes in precipitation. Higher temperatures, hence higher crop evaporative demand, mean that the general tendency would be towards an increase in irrigation demands. [4.1]

Flood magnitude and frequency could increase in many regions as a consequence of increased frequency of heavy precipitation events, which can increase runoff in most areas as well as groundwater recharge in some floodplains. Land-use change could exacerbate such events. Streamflow during seasonal low flow periods would decrease in many areas due to greater evaporation; changes in precipitation may exacerbate or offset the effects of increased evaporation. The projected climate change would degrade water quality through higher water temperatures and increased pollutant load from runoff and overflows of waste facilities. Quality would be degraded further where flows decrease, but increases in flows may mitigate to a certain extent some degradations in water quality by increasing dilution. Where snowfall is currently an important component of the water balance, a greater proportion of winter precipitation may fall as rain, and this can result in a more intense peak streamflow which in addition would move from spring to winter. [4.1]

The greatest vulnerabilities are likely to be in unmanaged water systems and systems that are currently stressed or poorly and unsustainably managed due to policies that discourage efficient water use and protection of water quality, inadequate watershed management, failure to manage variable water supply and demand, or lack of sound professional guidance. In unmanaged systems there are few or no structures in place to buffer the effects of hydrologic variability on water quality and supply. In unsustainably managed systems, water and land uses can add stresses that heighten vulnerability to climate change. [4.1]

Water resource management techniques, particularly those of integrated water resource management, can be applied to adapt to hydrologic effects of climate change, and to additional uncertainty, so as to lessen vulnerabilities. Currently, supply-side approaches (e.g., increasing flood defenses, building weirs, utilizing water storage areas, including natural systems, improving infrastructure for water collection and distribution) are more widely used than demand-side approaches (which alter the exposure to stress); the latter is the focus of increasing attention. However, the capacity to implement effective management responses is unevenly distributed around the world and is low in many transition and developing countries. [4.1]

3.2. *Agriculture and Food Security*

Based on experimental research, crop yield responses to climate change vary widely, depending upon species and cultivar; soil properties; pests, and pathogens; the direct effects of carbon dioxide (CO_2) on plants; and interactions between CO_2, air temperature, water stress, mineral nutrition, air quality, and adaptive responses. Even though increased CO_2 concentration can stimulate crop growth and yield, that benefit may not always overcome the adverse effects of excessive heat and drought (*medium confidence*[6]). These advances, along with advances in research on agricultural adaptation, have been incorporated since the Second Assessment Report (SAR) into models used to assess the effects of climate change on crop yields, food supply, farm incomes, and prices. [4.2]

Costs will be involved in coping with climate-induced yield losses and adaptation of livestock production systems. These agronomic and husbandry adaptation options could include, for example, adjustments to planting dates, fertilization rates, irrigation applications, cultivar traits, and selection of animal species. [4.2]

When autonomous agronomic adaptation is included, crop modeling assessments indicate, with *medium* to *lowconfidence*[6], that climate change will lead to generally positive responses at less than a few °C warming and generally negative responses for more than a few °C in mid-latitude crop yields. Similar assessments indicate that yields of some crops in tropical locations would decrease generally with even minimal increases in temperature, because such crops are near their maximum temperature tolerance and dryland/rainfed agriculture predominates. Where there is also a large decrease in rainfall, tropical crop yields would be

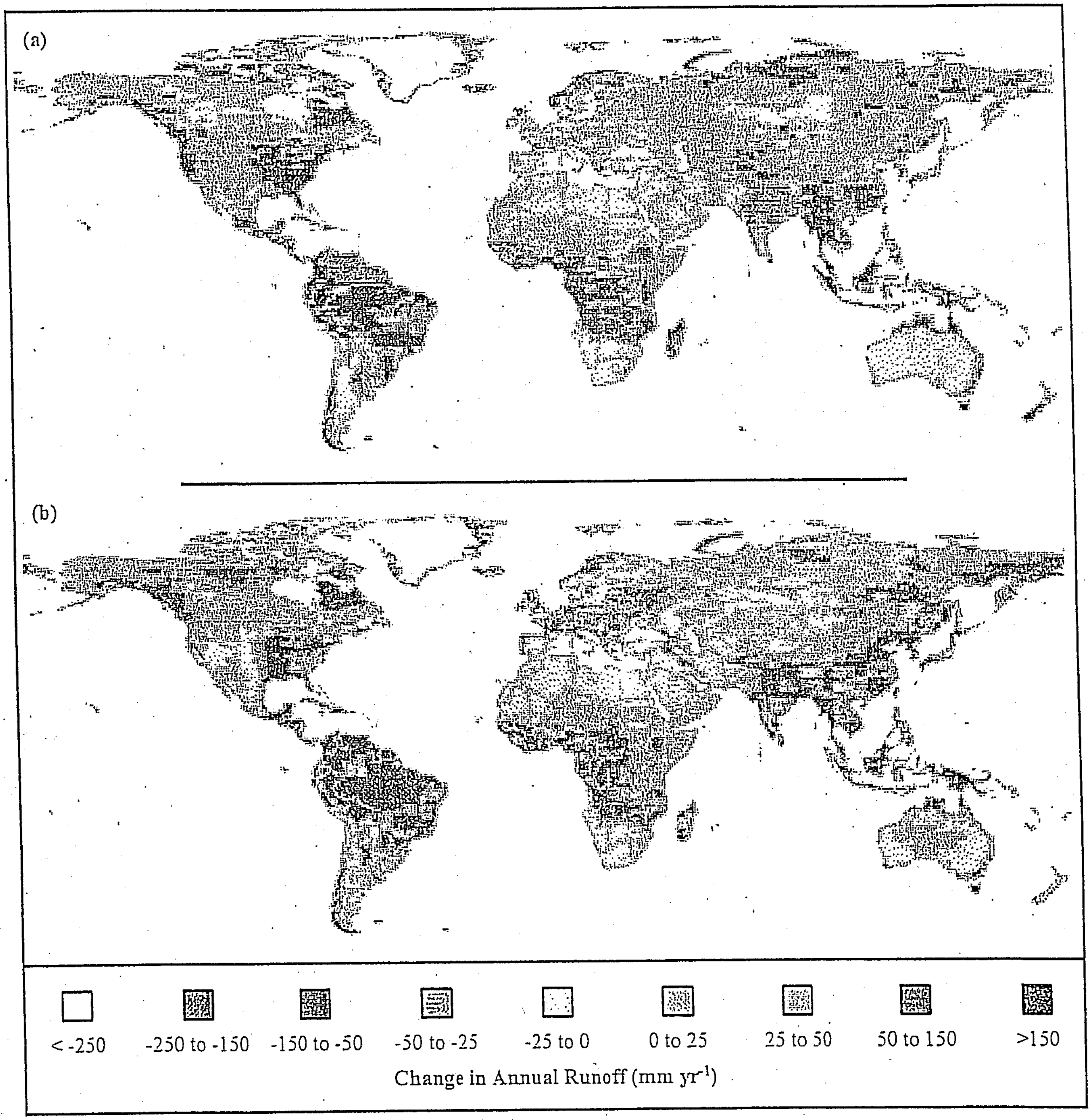

Figure SPM-3: Projected changes in average annual water runoff by 2050, relative to average runoff for 1961–1990, largely follow projected changes in precipitation. Changes in runoff are calculated with a hydrologic model using as inputs climate projections from two versions of the Hadley Centre atmosphere-ocean general circulation model (AOGCM) for a scenario of 1% per annum increase in effective carbon dioxide concentration in the atmosphere: (a) HadCM2 ensemble mean and (b) HadCM3. Projected increases in runoff in high latitudes and southeast Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa, and Australia are broadly consistent across the Hadley Centre experiments, and with the precipitation projections of other AOGCM experiments. For other areas of the world, changes in precipitation and runoff are scenario- and model-dependent.

even more adversely affected. With autonomous agronomic adaptation, crop yields in the tropics tend to be less adversely affected by climate change than without adaptation, but they still tend to remain below levels estimated with current climate. [4.2]

Most global and regional economic studies not incorporating climate change indicate that the downward trend in global real commodity prices in the 20th century is likely to continue into the 21st, although confidence in these predictions decreases farther into the future. Economic modeling assessments indicate that impacts of climate change on agricultural production and prices are estimated to result in small percentage changes in global income (*low confidence*[6]), with larger increases in more developed regions and smaller increases or declines in developing regions. Improved confidence in this finding depends on further research into the sensitivity of economic modeling assessments to their base assumptions. [4.2 and Box 5-5]

Most studies indicate that global mean annual temperature increases of a few °C or greater would prompt food prices to increase due to a slowing in the expansion of global food supply relative to growth in global food demand (*established, but incomplete*[6]). At lesser amounts of warming than a few °C, economic models do not clearly distinguish the climate change signal from other sources of change based on those studies included in this assessment. Some recent aggregated studies have estimated economic impacts on vulnerable populations such as smallholder producers and poor urban consumers. These studies find that climate change would lower incomes of the vulnerable populations and increase the absolute number of people at risk of hunger, though this is uncertain and requires further research. It is established, though incompletely, that climate change, mainly through increased extremes and temporal/spatial shifts, will worsen food security in Africa. [4.2]

3.3. *Terrestrial and Freshwater Ecosystems*

Vegetation modeling studies continue to show the potential for significant disruption of ecosystems under climate change (*high confidence*[6]). Migration of ecosystems or biomes as discrete units is unlikely to occur; instead at a given site, species composition and dominance will change. The results of these changes will lag behind the changes in climate by years to decades to centuries (*high confidence*[6]). [4.3]

Distributions, population sizes, population density, and behavior of wildlife have been, and will continue to be, affected directly by changes in global or regional climate and indirectly through changes in vegetation. Climate change will lead to poleward movement of the boundaries of freshwater fish distributions along with loss of habitat for cold- and cool-water fishes and gain in habitat for warm-water fishes (*high confidence*[6]). Many species and populations are already at high risk, and are expected to be placed at greater risk by the synergy between climate change rendering portions of current habitat unsuitable for many species, and land-use change fragmenting habitats and raising obstacles to species migration. Without appropriate management, these pressures will cause some species currently classified as "critically endangered" to become extinct and the majority of those labeled "endangered or vulnerable" to become rarer, and thereby closer to extinction, in the 21st century (*high confidence*[6]). [4.3]

Possible adaptation methods to reduce risks to species could include: 1) establishment of refuges, parks, and reserves with corridors to allow migration of species, and 2) use of captive breeding and translocation. However, these options may have limitations due to costs. [4.3]

Terrestrial ecosystems appear to be storing increasing amounts of carbon. At the time of the SAR, this was largely attributed to increasing plant productivity because of the interaction between elevated CO_2 concentration, increasing temperatures, and soil moisture changes. Recent results confirm that productivity gains are occurring but suggest that they are smaller under field conditions than indicated by plant-pot experiments (*medium confidence*[6]). Hence, the terrestrial uptake may be due more to change in uses and management of land than to the direct effects of elevated CO_2 and climate. The degree to which terrestrial ecosystems continue to be net sinks for carbon is uncertain due to the complex interactions between the factors mentioned above (e.g., arctic terrestrial ecosystems and wetlands may act as both sources and sinks) (*medium confidence*[6]). [4.3]

Contrary to the SAR, global timber market studies that include adaptations through land and product management, even without forestry projects that increase the capture and storage of carbon, suggest that a small amount of climate change would increase global timber supply and enhance existing market trends towards rising market share in developing countries (*medium confidence*[6]). Consumers may benefit from lower timber prices while producers may gain or lose depending on regional changes in timber productivity and potential dieback effects. [4.3]

3.4. *Coastal Zones and Marine Ecosystems*

Large-scale impacts of climate change on oceans are expected to include increases in sea surface temperature and mean global sea level, decreases in sea-ice cover, and changes in salinity, wave conditions, and ocean circulation. The oceans are an integral and responsive component of the climate system with important physical and biogeochemical feedbacks to climate. Many marine ecosystems are sensitive to climate change. Climate trends and variability as reflected in multiyear climate-ocean regimes (e.g., Pacific Decadal Oscillation) and switches from one regime to another are now recognized to strongly affect fish abundance and population dynamics, with significant impacts on fish-dependent human societies. [4.4]

Many coastal areas will experience increased levels of flooding, accelerated erosion, loss of wetlands and mangroves, and seawater intrusion into freshwater sources as a result of climate change. The extent and severity of storm impacts, including storm-surge floods and shore erosion, will increase as a result of climate change including sea-level rise. High-latitude coasts will experience added impacts related to higher wave energy and permafrost degradation. Changes in relative sea level will vary locally due to uplift and subsidence caused by other factors. [4.4]

Impacts on highly diverse and productive coastal ecosystems such as coral reefs, atolls and reef islands, salt marshes and mangrove forests will depend upon the rate of sea-level rise relative to growth rates and sediment supply, space for and obstacles to horizontal migration, changes in the climate-ocean environment such as sea surface temperatures and storminess, and pressures from human activities in coastal zones. Episodes of coral bleaching over the past 20 years have been associated with several causes, including increased ocean temperatures. Future sea surface warming would increase stress on coral reefs and result in increased frequency of marine diseases (*high confidence*[6]). [4.4]

Assessments of adaptation strategies for coastal zones have shifted emphasis away from hard protection structures of shorelines (e.g., seawalls, groins) toward soft protection measures (e.g., beach nourishment), managed retreat, and enhanced resilience of biophysical and socioeconomic systems in coastal regions. Adaptation options for coastal and marine management are most effective when incorporated with policies in other areas, such as disaster mitigation plans and land-use plans. [4.4]

3.5. *Human Health*

The impacts of short-term weather events on human health have been further elucidated since the SAR, particularly in relation to periods of thermal stress, the modulation of air pollution impacts, the impacts of storms and floods, and the influences of seasonal and interannual climatic variability on infectious diseases. There has been increased understanding of the determinants of population vulnerability to adverse health impacts and the possibilities for adaptive responses. [4.7]

Many vector-, food-, and water-borne infectious diseases are known to be sensitive to changes in climatic conditions. From results of most predictive model studies, there is *medium* to *high confidence*[6] that, under climate change scenarios, there would be a net increase in the geographic range of potential transmission of malaria and dengue–two vector-borne infections each of which currently impinge on 40-50% of the world population.[10] Within their present ranges, these and many other infectious diseases would tend to increase in incidence and seasonality–although regional decreases would occur in some infectious diseases. In all cases, however, actual disease occurrence is strongly influenced by local environmental conditions, socioeconomic circumstances, and public health infrastructure. [4.7]

[10] Eight studies have modeled the effects of climate change on these diseases, five on malaria and three on dengue. Seven use a biological, or process-based approach, and one uses an empirical, statistical approach.

Projected climate change will be accompanied by an increase in heat waves, often exacerbated by increased humidity and urban air pollution, which would cause an increase in heat-related deaths and illness episodes. The evidence indicates that the impact would be greatest in urban populations, affecting particularly the elderly, sick, and those without access to air-conditioning (*high confidence*[6]). Limited evidence indicates that in some temperate countries reduced winter deaths would outnumber increased summer deaths (*medium confidence*[6]); yet, published research has been largely confined to populations in developed countries, thus precluding a generalized comparison of changes in summer and winter mortality. [3.5 and 4.7]

Extensive experience makes clear that any increase in flooding will increase the risk of drowning, diarrhoeal and respiratory diseases, and, in developing countries, hunger and malnutrition (*high confidence*[6]). If cyclones were to increase regionally, devastating impacts would often occur, particularly in densely settled populations with inadequate resources. A reduction in crop yields and food production because of climate change in some regions, particularly in the tropics, will predispose food-insecure populations to malnutrition, leading to impaired child development and decreased adult activity. Socioeconomic disruptions could occur in some regions, impairing both livelihoods and health. [3.5, 4.1, 4.2, 4.5, and 4.7]

For each anticipated adverse health impact there is a range of social, institutional, technological, and behavioral adaptation options to lessen that impact. Adaptations could, for example, encompass strengthening of the public health infrastructure, health-oriented management of the environment (including air and water quality, food safety, urban and housing design, and surface water management), and the provision of appropriate medical care facilities. Overall, the adverse health impacts of climate change will be greatest in vulnerable lower income populations, predominantly within tropical/subtropical countries. Adaptive policies would, in general, reduce these impacts. [4.7]

3.6. *Human Settlements, Energy, and Industry*

A growing and increasingly quantitative literature shows that human settlements are affected by climate change in one of three major ways:

1) The economic sectors that support the settlement are affected because of changes in resource productivity or changes in market demand for the goods and services produced there. [4.5]
2) Some aspects of physical infrastructure (including energy transmission and distribution systems), buildings, urban services (including transportation systems), and specific industries (such as agroindustry, tourism, and construction) may be directly affected. [4.5]
3) Populations may be directly affected through extreme weather, changes in health status, or migration. The problems are somewhat different in the largest (<1 million) and mid- to small-sized population centers. [4.5]

The most widespread direct risk to human settlements from climate change is flooding and landslides, driven by projected increases in rainfall intensity and, in coastal areas, sea-level rise. Riverine and coastal settlements are particularly at risk (*high confidence*[6]), but urban flooding could be a problem anywhere that storm drains, water supply, and waste management systems have inadequate capacity. In such areas, squatter and other informal urban settlements with high population density, poor shelter, little or no access to resources such as safe water and public health services, and low adaptive capacity are highly vulnerable. Human settlements currently experience other significant environmental problems which could be exacerbated under higher temperature/increased precipitation regimes, including water and energy resources and infrastructure, waste treatment, and transportation [4.5]

Rapid urbanization in low-lying coastal areas of both the developing and developed world is greatly increasing population densities and the value of human-made assets exposed to coastal climatic extremes such as tropical cyclones. Model-based projections of the mean annual number of people who would be flooded by coastal storm surges increase several fold (by 75 to 200 million people depending on adaptive responses) for mid-range scenarios of a 40-cm sea-level rise by the 2080s relative to scenarios with no sea-level rise. Potential damages to infrastructure in coastal areas from sea-level rise have been projected to be tens of billions US$ for individual countries—for example, Egypt, Poland, and Vietnam. [4.5]

Settlements with little economic diversification and where a high percentage of incomes derive from climate-sensitive primary resource industries (agriculture, forestry, and fisheries) are more vulnerable than more diversified settlements (*high confidence*[6]). In developed areas of the Arctic, and where the permafrost is ice-rich, special attention will be required to mitigate the detrimental impacts of thawing, such as severe damage to buildings and transport infrastructure (*very high confidence*[6]). Industrial, transportation, and commercial infrastructure is generally vulnerable to the same hazards as settlement infrastructure. Energy demand is expected to increase for space cooling and decrease for space heating, but the net effect is scenario- and location-dependent. Some energy production and distribution systems may experience adverse impacts that would reduce supplies or system reliability while other energy systems may benefit. [4.5 and 5.7]

Possible adaptation options involve the planning of settlements and their infrastructure, placement of industrial facilities, and making similar long-lived decisions in a manner to reduce the adverse effects of events that are of low (but increasing) probability and high (and perhaps rising) consequences. [4.5]

3.7. *Insurance and Other Financial Services*

The costs of ordinary and extreme weather events have increased rapidly in recent decades. Global economic losses from catastrophic events increased 10.3-fold from 3.9 billion US$ yr^{-1} in the 1950s to 40 billion US$ yr^{-1} in the 1990s (all in 1999US$, unadjusted for purchasing power parity), with approximately one-quarter of the losses occurring in developing countries. The insured portion of these losses rose from a negligible level to 9.2 billion US$ yr^{-1} during the same period. Total costs are a factor of two larger when losses from smaller, non-catastrophic weather-related events are included. As a measure of increasing insurance industry vulnerability, the ratio of global property/casual insurance premiums to weather related losses fell by a factor of three between 1985 and 1999. [4.6]

The costs of weather events have risen rapidly despite significant and increasing efforts at fortifying infrastructure and enhancing disaster preparedness. Part of the observed upward trend in disaster losses over the past 50 years is linked to socioeconomic factors, such as population growth, increased wealth, and urbanization in vulnerable areas, and part is linked to climatic factors such as the observed changes in precipitation and flooding events. Precise attribution is complex and there are differences in the balance of these two causes by region and type of event. [4.6]

Climate change and anticipated changes in weather-related events perceived to be linked to climate change would increase actuarial uncertainty in risk assessment (*high confidence*[6]). Such developments would place upward pressure on insurance premiums and/or could lead to certain risks being reclassified as uninsurable with subsequent withdrawal of coverage. Such changes would trigger increased insurance costs, slow the expansion of financial services into developing countries, reduce the availability of insurance for spreading risk, and increase the demand for government-funded compensation following natural disasters. In the event of such changes, the relative roles of public and private entities in providing insurance and risk management resources can be expected to change. [4.6]

The financial services sector as a whole is expected to be able to cope with the impacts of climate change, although the historic record demonstrates that low-probability high-impact events or multiple closely spaced events severely affect parts of the sector, especially if adaptive capacity happens to be simultaneously depleted by non-climate factors (e.g., adverse financial market conditions). The property/casualty insurance and reinsurance segments and small specialized or undiversified companies have exhibited greater sensitivity, including reduced profitability and bankruptcy triggered by weather-related events. [4.6]

Adaptation to climate change presents complex challenges, but also opportunities, to the sector. Regulatory involvement in pricing, tax treatment of reserves, and the (in)ability of firms to withdraw from at-risk markets are examples of factors that influence the resilience of the sector. Public- and private-sector actors also support adaptation by promoting disaster preparedness, loss-prevention programs, building codes, and improved land-use planning. However, in some cases, public insurance and

Table SPM-2: Regional adaptive capacity, vulnerability, and key concerns.[a,b]

Region	Adaptive Capacity, Vulnerability, and Key Concerns
Africa	• Adaptive capacity of human systems in Africa is low due to lack of economic resources and technology, and vulnerability high as a result of heavy reliance on rain-fed agriculture, frequent droughts and floods, and poverty. [5.1.7] • Grain yields are projected to decrease for many scenarios, diminishing food security, particularly in small food-importing countries (*medium to high confidence*[6]). [5.1.2] • Major rivers of Africa are highly sensitive to climate variation; average runoff and water availability would decrease in Mediterranean and southern countries of Africa (*medium confidence*[6]). [5.1.1] • Extension of ranges of infectious disease vectors would adversely affect human health in Africa (*medium confidence*[6]). [5.1.4] • Desertification would be exacerbated by reductions in average annual rainfall, runoff, and soil moisture, especially in southern, North, and West Africa (*medium confidence*[6]). [5.1.6] • Increases in droughts, floods, and other extreme events would add to stresses on water resources, food security, human health, and infrastructures, and would constrain development in Africa (*high confidence*[6]). [5.1] • Significant extinctions of plant and animal species are projected and would impact rural livelihoods, tourism, and genetic resources (*medium confidence*[6]). [5.1.3] • Coastal settlements in, for example, the Gulf of Guinea, Senegal, Gambia, Egypt, and along the East–Southern African coast would be adversely impacted by sea-level rise through inundation and coastal erosion (*high confidence*[6]). [5.1.5]
Asia	• Adaptive capacity of human systems is low and vulnerability is high in the developing countries of Asia; the developed countries of Asia are more able to adapt and less vulnerable. [5.2.7] • Extreme events have increased in temperate and tropical Asia, including floods, droughts, forest fires, and tropical cyclones (*high confidence*[6]). [5.2.4] • Decreases in agricultural productivity and aquaculture due to thermal and water stress, sea-level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical, and temperate Asia; agriculture would expand and increase in productivity in northern areas (*medium confidence*[6]). [5.2.1] • Runoff and water availability may decrease in arid and semi-arid Asia but increase in northern Asia (*medium confidence*[6]). [5.2.3] • Human health would be threatened by possible increased exposure to vector-borne infectious diseases and heat stress in parts of Asia (*medium confidence*[6]). [5.2.6] • Sea-level rise and an increase in the intensity of tropical cyclones would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity of rainfall would increase flood risks in temperate and tropical Asia (*high confidence*[6]). [5.2.5 and Table TS-8] • Climate change would increase energy demand, decrease tourism attraction, and influence transportation in some regions of Asia (*medium confidence*[6]). [5.2.4 and 5.2.7] • Climate change would exacerbate threats to biodiversity due to land-use and land-cover change and population pressure in Asia (*medium confidence*[6]). Sea-level rise would put ecological security at risk, including mangroves and coral reefs (*high confidence*[6]). [5.2.2] • Poleward movement of the southern boundary of the permafrost zones of Asia would result in a change of thermokarst and thermal erosion with negative impacts on social infrastructure and industries (*medium confidence*[6]). [5.2.2]

relief programs have inadvertently fostered complacency and maladaptation by inducing development in at-risk areas such as U.S. flood plains and coastal zones. [4.6]

The effects of climate change are expected to be greatest in the developing world, especially in countries reliant on primary production as a major source of income. Some countries experience impacts on their GDP as a consequence of natural disasters, with damages as high as half of GDP in one case. Equity issues and development constraints would arise if weather-related risks become uninsurable, prices increase, or availability becomes limited. Conversely, more extensive access to insurance and more widespread introduction of micro-financing schemes and development banking would increase the ability of developing countries to adapt to climate change. [4.6]

4. Vulnerability Varies across Regions

The vulnerability of human populations and natural systems to climate change differs substantially across regions and across

Table SPM-2 (continued)

Region	Adaptive Capacity, Vulnerability, and Key Concerns
Australia and New Zealand	• Adaptive capacity of human systems is generally high, but there are groups in Australia and New Zealand, such as indigenous peoples in some regions, with low capacity to adapt and consequently high vulnerability. [5.3 and 5.3.5] • The net impact on some temperate crops of climate and CO_2 changes may initially be beneficial, but this balance is expected to become negative for some areas and crops with further climate change (*medium confidence*[6]). [5.3.3] • Water is likely to be a key issue (*high confidence*[6]) due to projected drying trends over much of the region and change to a more El Niño-like average state. [5.3 and 5.3.1] • Increases in the intensity of heavy rains and tropical cyclones (*medium confidence*[6]), and region-specific changes in the frequency of tropical cyclones, would alter the risks to life, property, and ecosystems from flooding, storm surges, and wind damage. [5.3.4] • Some species with restricted climatic niches and which are unable to migrate due to fragmentation of the landscape, soil differences, or topography could become endangered or extinct (*high confidence*[6]). Australian ecosystems that are particularly vulnerable to climate change include coral reefs, arid and semi-arid habitats in southwest and inland Australia, and Australian alpine systems. Freshwater wetlands in coastal zones in both Australia and New Zealand are vulnerable, and some New Zealand ecosystems are vulnerable to accelerated invasion by weeds. [5.3.2]
Europe	• Adaptive capacity is generally high in Europe for human systems; southern Europe and the European Arctic are more vulnerable than other parts of Europe. [5.4 and 5.4.6] • Summer runoff, water availability, and soil moisture are likely to decrease in southern Europe, and would widen the difference between the north and drought-prone south; increases are likely in winter in the north and south (*high confidence*[6]). [5.4.1] • Half of alpine glaciers and large permafrost areas could disappear by end of the 21st century (*medium confidence*[6]). [5.4.1] • River flood hazard will increase across much of Europe (*medium to high confidence*[6]); in coastal areas, the risk of flooding, erosion, and wetland loss will increase substantially with implications for human settlement, industry, tourism, agriculture, and coastal natural habitats. [5.4.1 and 5.4.4] • There will be some broadly positive effects on agriculture in northern Europe (*medium confidence*[6]); productivity will decrease in southern and eastern Europe (*medium confidence*[6]). [5.4.3] • Upward and northward shift of biotic zones will take place. Loss of important habitats (wetlands, tundra, isolated habitats) would threaten some species (*high confidence*[6]). [5.4.2] • Higher temperatures and heat waves may change traditional summer tourist destinations, and less reliable snow conditions may impact adversely on winter tourism (*medium confidence*[6]). [5.4.4]
Latin America	• Adaptive capacity of human systems in Latin America is low, particularly with respect to extreme climate events, and vulnerability is high. [5.5] • Loss and retreat of glaciers would adversely impact runoff and water supply in areas where glacier melt is an important water source (*high confidence*[6]). [5.5.1] • Floods and droughts would become more frequent with floods increasing sediment loads and degrade water quality in some areas (*high confidence*[6]). [5.5] • Increases in intensity of tropical cyclones would alter the risks to life, property, and ecosystems from heavy rain, flooding, storm surges, and wind damages (*high confidence*[6]). [5.5] • Yields of important crops are projected to decrease in many locations in Latin America, even when the effects of CO_2 are taken into account; subsistence farming in some regions of Latin America could be threatened (*high confidence*[6]). [5.5.4] • The geographical distribution of vector-borne infectious diseases would expand poleward and to higher elevations, and exposures to diseases such as malaria, dengue fever, and cholera will increase (*medium confidence*[6]). [5.5.5] • Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea-level rise (*medium confidence*[6]). [5.5.3] • The rate of biodiversity loss would increase (*high confidence*[6]). [5.5.2]

populations within regions. Regional differences in baseline climate and expected climate change give rise to different exposures to climate stimuli across regions. The natural and social systems of different regions have varied characteristics, resources, and institutions, and are subject to varied pressures that give rise to differences in sensitivity and adaptive capacity. From these differences emerge different key concerns for each of the major regions of the world. Even within regions however, impacts, adaptive capacity, and vulnerability will vary. [5]

Table SPM-2 (continued)

Region	Adaptive Capacity, Vulnerability, and Key Concerns
North America	• Adaptive capacity of human systems is generally high and vulnerability low in North America, but some communities (e.g., indigenous peoples and those dependent on climate-sensitive resources) are more vulnerable; social, economic, and demographic trends are changing vulnerabilities in subregions. [5.6 and 5.6.1] • Some crops would benefit from modest warming accompanied by increasing CO_2, but effects would vary among crops and regions (*high confidence*[6]), including declines due to drought in some areas of Canada's Prairies and the U.S. Great Plains, potential increased food production in areas of Canada north of current production areas, and increased warm-temperate mixed forest production (*medium confidence*[6]). However, benefits for crops would decline at an increasing rate and possibly become a net loss with further warming (*medium confidence*[6]). [5.6.4] • Snowmelt-dominated watersheds in western North America will experience earlier spring peak flows (*high confidence*[6]), reductions in summer flows (*medium confidence*[6]), and reduced lake levels and outflows for the Great Lakes-St. Lawrence under most scenarios (*medium confidence*[6]); adaptive responses would offset some, but not all, of the impacts on water users and on aquatic ecosystems (*medium confidence*[6]). [5.6.2] • Unique natural ecosystems such as prairie wetlands, alpine tundra, and cold-water ecosystems will be at risk and effective adaptation is unlikely (*medium confidence*[6]). [5.6.5] • Sea-level rise would result in enhanced coastal erosion, coastal flooding, loss of coastal wetlands, and increased risk from storm surges, particularly in Florida and much of the U.S. Atlantic coast (*high confidence*[6]). [5.6.1] • Weather-related insured losses and public sector disaster relief payments in North America have been increasing; insurance sector planning has not yet systematically included climate change information, so there is potential for surprise (*high confidence*[6]). [5.6.1] • Vector-borne diseases—including malaria, dengue fever, and Lyme disease—may expand their ranges in North America; exacerbated air quality and heat stress morbidity and mortality would occur (*medium confidence*[6]); socioeconomic factors and public health measures would play a large role in determining the incidence and extent of health effects. [5.6.6]
Polar	• Natural systems in polar regions are highly vulnerable to climate change and current ecosystems have low adaptive capacity; technologically developed communities are likely to adapt readily to climate change, but some indigenous communities, in which traditional lifestyles are followed, have little capacity and few options for adaptation. [5.7] • Climate change in polar regions is expected to be among the largest and most rapid of any region on the Earth, and will cause major physical, ecological, sociological, and economic impacts, especially in the Arctic, Antarctic Peninsula, and Southern Ocean (*high confidence*[6]). [5.7] • Changes in climate that have already taken place are manifested in the decrease in extent and thickness of Arctic sea ice, permafrost thawing, coastal erosion, changes in ice sheets and ice shelves, and altered distribution and abundance of species in polar regions (*high confidence*[6]). [5.7] • Some polar ecosystems may adapt through eventual replacement by migration of species and changing species composition, and possibly by eventual increases in overall productivity; ice edge systems that provide habitat for some species would be threatened (*medium confidence*[6]). [5.7] • Polar regions contain important drivers of climate change. Once triggered, they may continue for centuries, long after greenhouse gas concentrations are stabilized, and cause irreversible impacts on ice sheets, global ocean circulation, and sea-level rise (*medium confidence*[6]). [5.7]

In light of the above, all regions are likely to experience some adverse effects of climate change. Table SPM-2 presents in a highly summarized fashion some of the key concerns for the different regions. Some regions are particularly vulnerable because of their physical exposure to climate change hazards and/or their limited adaptive capacity. Most less-developed regions are especially vulnerable because a larger share of their economies are in climate-sensitive sectors and their adaptive capacity is low due to low levels of human, financial, and natural resources, as well as limited institutional and technological capability. For example, small island states and low-lying coastal areas are particularly vulnerable to increases in sea level and storms, and most of them have limited capabilities for adaptation. Climate change impacts in polar regions are expected to be large and rapid, including reduction in sea-ice extent and thickness and degradation of permafrost. Adverse changes in seasonal river flows, floods and droughts, food security, fisheries, health effects, and loss of biodiversity are among the major regional vulnerabilities and concerns of Africa, Latin America, and Asia where adaptation opportunities are generally low. Even in regions with higher adaptive capacity, such as North America and Australia and New Zealand, there are vulnerable communities, such as indigenous peoples, and the possibility of adaptation of ecosystems is very limited. In Europe, vulnerability is significantly greater in the south and in the Arctic than elsewhere in the region. [5]

Table SPM-2 (continued)

Region	Adaptive Capacity, Vulnerability, and Key Concerns
Small Island States	• Adaptive capacity of human systems is generally low in small island states, and vulnerability high; small island states are likely to be among the countries most seriously impacted by climate change. [5.8] • The projected sea-level rise of 5 mm yr^{-1} for the next 100 years would cause enhanced coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources, and high resource costs to respond to and adapt to these changes (*high confidence*[6]). [5.8.2 and 5.8.5] • Islands with very limited water supplies are highly vulnerable to the impacts of climate change on the water balance (*high confidence*[6]). [5.8.4] • Coral reefs would be negatively affected by bleaching and by reduced calcification rates due to higher CO_2 levels (*medium confidence*[6]); mangrove, sea grass bed, and other coastal ecosystems and the associated biodiversity would be adversely affected by rising temperatures and accelerated sea-level rise (*medium confidence*[6]). [4.4 and 5.8.3] • Declines in coastal ecosystems would negatively impact reef fish and threaten reef fisheries, those who earn their livelihoods from reef fisheries, and those who rely on the fisheries as a significant food source (*medium confidence*[6]). [4.4 and 5.8.4] • Limited arable land and soil salinization makes agriculture of small island states, both for domestic food production and cash crop exports, highly vulnerable to climate change (*high confidence*[6]). [5.8.4] • Tourism, an important source of income and foreign exchange for many islands, would face severe disruption from climate change and sea-level rise (*high confidence*[6]). [5.8.5]

[a] Because the available studies have not employed a common set of climate scenarios and methods, and because of uncertainties regarding the sensitivities and adaptability of natural and social systems, the assessment of regional vulnerabilities is necessarily qualitative.
[b] The regions listed in Table SPM-2 are graphically depicted in Figure TS-2 of the Technical Summary.

5. Improving Assessments of Impacts, Vulnerabilities, and Adaptation

Advances have been made since previous IPCC assessments in the detection of change in biotic and physical systems, and steps have been taken to improve the understanding of adaptive capacity, vulnerability to climate extremes, and other critical impact-related issues. These advances indicate a need for initiatives to begin designing adaptation strategies and building adaptive capacities. Further research is required, however, to strengthen future assessments and to reduce uncertainties in order to assure that sufficient information is available for policymaking about responses to possible consequences of climate change, including research in and by developing countries. [8]

The following are high priorities for narrowing gaps between current knowledge and policymaking needs:

- Quantitative assessment of the sensitivity, adaptive capacity, and vulnerability of natural and human systems to climate change, with particular emphasis on changes in the range of climatic variation and the frequency and severity of extreme climate events
- Assessment of possible thresholds at which strongly discontinuous responses to projected climate change and other stimuli would be triggered
- Understanding dynamic responses of ecosystems to multiple stresses, including climate change, at global, regional, and finer scales
- Development of approaches to adaptation responses, estimation of the effectiveness and costs of adaptation options, and identification of differences in opportunities for and obstacles to adaptation in different regions, nations, and populations
- Assessment of potential impacts of the full range of projected climate changes, particularly for non-market goods and services, in multiple metrics and with consistent treatment of uncertainties, including but not limited to numbers of people affected, land area affected, numbers of species at risk, monetary value of impact, and implications in these regards of different stabilization levels and other policy scenarios
- Improving tools for integrated assessment, including risk assessment, to investigate interactions between components of natural and human systems and the consequences of different policy decisions
- Assessment of opportunities to include scientific information on impacts, vulnerability, and adaptation in decisionmaking processes, risk management, and sustainable development initiatives
- Improvement of systems and methods for long-term monitoring and understanding the consequences of climate change and other stresses on human and natural systems.

Cutting across these foci are special needs associated with strengthening international cooperation and coordination for regional assessment of impacts, vulnerability, and adaptation, including capacity-building and training for monitoring, assessment, and data gathering, especially in and for developing countries (particularly in relation to the items identified above).

Joint science academies' statement: Global response to climate change

Climate change is real

There will always be uncertainty in understanding a system as complex as the world's climate. However there is now strong evidence that significant global warming is occurring[1]. The evidence comes from direct measurements of rising surface air temperatures and subsurface ocean temperatures and from phenomena such as increases in average global sea levels, retreating glaciers, and changes to many physical and biological systems. It is likely that most of the warming in recent decades can be attributed to human activities (IPCC 2001)[2]. This warming has already led to changes in the Earth's climate.

The existence of greenhouse gases in the atmosphere is vital to life on Earth – in their absence average temperatures would be about 30 centigrade degrees lower than they are today. But human activities are now causing atmospheric concentrations of greenhouse gases – including carbon dioxide, methane, tropospheric ozone, and nitrous oxide – to rise well above pre-industrial levels. Carbon dioxide levels have increased from 280 ppm in 1750 to over 375 ppm today – higher than any previous levels that can be reliably measured (i.e. in the last 420,000 years). Increasing greenhouse gases are causing temperatures to rise; the Earth's surface warmed by approximately 0.6 centigrade degrees over the twentieth century. The Intergovernmental Panel on Climate Change (IPCC) projected that the average global surface temperatures will continue to increase to between 1.4 centigrade degrees and 5.8 centigrade degrees above 1990 levels, by 2100.

Reduce the causes of climate change

The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action. It is vital that all nations identify cost-effective steps that they can take now, to contribute to substantial and long-term reduction in net global greenhouse gas emissions.

Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change. As the United Nations Framework Convention on Climate Change (UNFCCC) recognises, a lack of full scientific certainty about some aspects of climate change is not a reason for delaying an immediate response that will, at a reasonable cost, prevent dangerous anthropogenic interference with the climate system.

As nations and economies develop over the next 25 years, world primary energy demand is estimated to increase by almost 60%. Fossil fuels, which are responsible for the majority of carbon dioxide emissions produced by human activities, provide valuable resources for many nations and are projected to provide 85% of this demand (IEA 2004)[3]. Minimising the amount of this carbon dioxide reaching the atmosphere presents a huge challenge. There are many potentially cost-effective technological options that could contribute to stabilising greenhouse gas concentrations. These are at various stages of research and development. However barriers to their broad deployment still need to be overcome.

Carbon dioxide can remain in the atmosphere for many decades. Even with possible lowered emission rates we will be experiencing the impacts of climate change throughout the 21st century and beyond. Failure to implement significant reductions in net greenhouse gas emissions now, will make the job much harder in the future.

Prepare for the consequences of climate change

Major parts of the climate system respond slowly to changes in greenhouse gas concentrations. Even if greenhouse gas emissions were stabilised instantly at today's levels, the climate would still continue to change as it adapts to the increased emission of recent decades. Further changes in climate are therefore unavoidable. Nations must prepare for them.

The projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources, agriculture, natural ecosystems and human health. The larger and faster the changes in climate, the more likely it is that adverse-effects will dominate. Increasing temperatures are likely to increase the frequency and severity of weather events such as heat waves and heavy rainfall. Increasing temperatures could lead to large-scale effects such as melting of large ice sheets (with major impacts on low-lying regions throughout the world). The IPCC estimates that the combined effects of ice melting and sea water expansion from ocean warming are projected to cause the global mean sea-level to rise by between 0.1 and 0.9 metres between 1990 and 2100. In Bangladesh alone, a 0.5 metre sea-level rise would place about 6 million people at risk from flooding.

Developing nations that lack the infrastructure or resources to respond to the impacts of climate change will be particularly affected. It is clear that many of the world's poorest people are likely to suffer the most from climate change. Long-term global efforts to create a more healthy, prosperous and sustainable world may be severely hindered by changes in the climate.

The task of devising and implementing strategies to adapt to the consequences of climate change will require worldwide collaborative inputs from a wide range of experts, including physical and natural scientists, engineers, social scientists, medical scientists, those in the humanities, business leaders and economists.

Conclusion

We urge all nations, in the line with the UNFCCC principles[4], to take prompt action to reduce the causes of climate change, adapt to its impacts and ensure that the issue is included in all relevant national and international strategies. As national science academies, we commit to working with governments to help develop and implement the national and international response to the challenge of climate change.

G8 nations have been responsible for much of the past greenhouse gas emissions. As parties to the UNFCCC, G8 nations are committed to showing leadership in addressing climate change and assisting developing nations to meet the challenges of adaptation and mitigation.

We call on world leaders, including those meeting at the Gleneagles G8 Summit in July 2005, to:

- Acknowledge that the threat of climate change is clear and increasing.
- Launch an international study[5] to explore scientifically-informed targets for atmospheric greenhouse gas concentrations, and their associated emissions scenarios, that will enable nations to avoid impacts deemed unacceptable.
- Identify cost-effective steps that can be taken now to contribute to substantial and long-term reduction in net global greenhouse gas emissions. Recognise that delayed action will increase the risk of adverse environmental effects and will likely incur a greater cost.
- Work with developing nations to build a scientific and technological capacity best suited to their circumstances, enabling them to develop innovative solutions to mitigate and adapt to the adverse effects of climate change, while explicitly recognising their legitimate development rights.
- Show leadership in developing and deploying clean energy technologies and approaches to energy efficiency, and share this knowledge with all other nations.
- Mobilise the science and technology community to enhance research and development efforts, which can better inform climate change decisions.

Notes and references

1 This statement concentrates on climate change associated with global warming. We use the UNFCCC definition of climate change, which is 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

2 IPCC (2001). Third Assessment Report. We recognise the international scientific consensus of the Intergovernmental Panel on Climate Change (IPCC).

3 IEA (2004). World Energy Outlook 4. Although long-term projections of future world energy demand and supply are highly uncertain, the World Energy Outlook produced by the International Energy Agency (IEA) is a useful source of information about possible future energy scenarios.

4 With special emphasis on the first principle of the UNFCCC, which states: 'The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof'.

5 Recognising and building on the IPCC's ongoing work on emission scenarios.

Academia Brasiliera de Ciências
Brazil

Royal Society of Canada,
Canada

Chinese Academy of Sciences,
China

Academié des Sciences,
France

Deutsche Akademie der Naturforscher
Leopoldina, Germany

Indian National Science Academy,
India

Accademia dei Lincei,
Italy

Science Council of Japan,
Japan

Russian Academy of Sciences,
Russia

Royal Society,
United Kingdom

National Academy of Sciences,
United States of America

Joint Intervenors
Exhibit 7

BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

In the Matter of the Application by Otter Tail Power Company on behalf of the Big Stone II Co-owners for an Energy Conversion Facility Siting Permit for the Construction of the Big Stone II Project	))))	Case No EL05-22

Surrebuttal Testimony of Ezra D. Hausman, Ph.D. Synapse Energy Economics, Inc.

On Behalf of
Minnesotans for An Energy-Efficient Economy
Izaak Walton League of America – Midwest Office
Union of Concerned Scientists
Minnesota Center for Environmental Advocacy

June 20, 2006

I. PROFESSIONAL QUALIFICATIONS AND SUMMARY

Q. Please state your name, position and business address for the record.

A. My name is Ezra D. Hausman, Ph.D. I am a Senior Associate with Synapse Energy Economics, Inc., 22 Pearl Street, Cambridge, MA 02139.

Q. On whose behalf are you testifying?

A. My testimony is jointly sponsored by Minnesotans for An Energy-Efficient Economy, Izaak Walton League of America-Midwest Office, the Union of Concerned Scientists and the Minnesota Center for Environmental Advocacy ("Joint Intervenors").

Q. Have you previously submitted testimony in this proceeding?

A. Yes. I submitted Direct Testimony in this proceeding on May 19, 2006.

Q. What is the purpose of this surrebuttal testimony?

A. The purpose of this surrebuttal testimony is to respond to the rebuttal testimony of co-owner witness Ward Uggerud, Senior Vice President of Otter Tail Power Company.

Q. What particular aspects of your direct testimony were addressed by Mr. Uggerud?

A. Mr. Uggerud challenged my conclusion that "Big Stone Unit II will have a significant, long-term, and costly adverse impact on the environment both in South Dakota and throughout the region, the continent and the planet."

Q. What was the basis of Mr. Uggerud's disagreement with this statement?

A. Mr. Uggerud noted that the emissions from the proposed Big Stone II plant will total less than "two one-hundredths of one percent" of anthropogenic CO_2 emissions in 2010, and that, by implication, this would not represent a significant contribution to atmospheric CO_2 and to global climate change.

Q. Do you take issue with Mr. Uggerud's quantitative calculation of Big Stone II's relative contribution to anthropogenic CO_2 emissions?

A. No. I believe it is a reasonable calculation subject to uncertainty in both Big Stone's future emissions and global emissions in 2010.

Q. Does this alleviate your concern that Big Stone II would represent a significant, long-term and costly contribution to anthropogenic CO_2 and to global climate change?

A. It does not. As with most other environmental issues, the problem of anthropogenic CO_2 is the result of the combined action of numerous sources, both "point" sources and "non-point" sources. Point sources are single, large sources of a given pollutant, often including large industrial sources such as electric power generating facilities. Non-point sources are more diffuse sources, such as individual automobiles. It is often the case that regulation or elimination of point sources is a much more cost-effective approach to reducing emissions than regulation of non-point sources.

In the case of CO_2, the sources of pollution are spread around every country on the globe, involving tens or hundreds of thousands of point sources, and probably hundreds of millions of non-point sources. In this context, a single source which would represent almost two one-hundredths of one percent of global anthropogenic emissions represents an enormous contribution to anthropogenic emissions and global climate change.

Q. Do you agree with Mr. Uggerud's contention that your statement, cited earlier, "lacks perspective, to say the least"?

A. I agree that I had not specifically put Big Stone II's emissions into a quantitative perspective in my direct testimony. However, providing such a perspective on Big Stone II's CO_2 annual emissions, as Mr. Uggerud has done, serves only to support my statement that the proposed unit would produce "significant, long-term, and costly adverse impact on the environment both in South Dakota and throughout the region, the continent and the planet."

Q. Does this conclude your surrebuttal testimony?

A. Yes.