

**Project Title: The Electric Power Industry and
Climate Change – Discussion Paper (P-09)**

Summary	Interest in identification of possible research topics that address the interaction between the power system and climate change was expressed at the 2006 PSerc summer workshop. Conversations at the workshop called for clarification of possible research topics that could be considered by the Stem Committees. In response to these conversations, this project proposes a short discussion paper (10 to 15 pages) to identify possible research topics related to the power system-climate change interaction, in order to inform Stem Committee deliberations on their research plans for the 2007 and future research solicitations.			
Research Stem	This proposal will involve all three stems, with the Markets Stem as the lead stem.			
Academic Team Members	Project Leader: Tom Overbye (UIUC, overbye@uiuc.edu , 217-333-4463); Team members: Judith Cardell (Smith College, jcardell@smith.edu) Ian Dobson (University of Wisconsin-Madison, dobson@engr.wisc.edu); Ward Jewell (Wichita State University, ward.jewell@wichita.edu); Mladen Kezunovic (Texas A&M University, kezunov@ece.tamu.edu); PK Sen (Colorado School of Mines, psen@mines.edu); Dan Tylavsky (Arizona State University, tylavsky@asu.edu)			
Industry Team Members	Lisa Beard (TVA); Hamid Elahi and Devin Van Zandt (GE); Floyd Galvan (Entergy); Jay Giri (AREVA); David Hawkins (CAISO); Bob Saint (NRECA)			
Start Date and End Date When the Final Report will be Submitted for Publication	Start Date: January 1, 2007 if possible, depending upon the availability of funds. End Date: Prior to the June 30, 2007 IAB meeting			
Requested Funding from Base PSERC Budget	Researchers	CY 2007	CY 2008	Total
	Cardell			
	Dobson			
	Jewell			
	Kezunovic			
	Overbye			
	Sen			
	Tylavsky			
	Total			
Supplemental Funding				

Project Description: The interaction of the electric power industry with the climate is manifest both in the effect that severe weather has on the power system and through the contribution of electric power to the production of greenhouse gases and other pollutants. The objective of this paper is to identify a list of possible research topics for PSerc to pursue in areas related to power industry-climate change interaction,

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and to have the paper available for use in the 2007 Stem Committee meetings as the 2007 research solicitations are developed. The need for this paper became apparent at the 2006 PSerc summer meeting in Ashland WI, at which a wide range of opinions and background knowledge were made evident. Future PSerc research projects that are related either directly or indirectly to climate change issues will benefit from the development of a discussion paper on the major issues and ensuing discussions on PSerc's capabilities and interests in addressing these issues.

Environmental discussions frequently refer to the need and ability for *adaptation* and *mitigation*. In terms of electric power systems and climate change, adaptation includes the hardening of power system equipment and developing new system operating strategies in response to changing weather patterns, as well as implementing system upgrades, new market rules, energy conservation and expanded DSM programs. Power systems have been designed during a period of relatively stable weather and these design assumptions may be strained by new weather patterns. The extreme weather of interest includes directly destructive events such as hurricanes and ice storms as well as extremes of heat and cold, which affect both individual equipment failure and system operations. Since power systems need to be designed and operated with respect to the extremes of weather, it is necessary to quantify the likely changes in the statistics of these extremes due to changes in climate. The prospects for estimating the frequency and impact of equipment and system failures will be evaluated in the discussion paper.

Mitigation refers to the need to lessen the negative impacts of climate change on society and the economy, as well as mitigating the power industry's production of pollutant emissions. This area of power system-climate interaction focuses on the production of greenhouse gases through the combustion and energy conversion processes. Combustion by-products such as CO₂, SO₂, and NO_x, among others, have been identified as greenhouse gases, and are of interest to researchers in many disciplines, industry leaders and government officials. This attention focuses not only upon the production of these gases, but also their accumulation in the atmosphere, the limited absorptive capacity of the atmosphere, and the subsequent affect of these gases on the earth's atmosphere and climate. The paper will identify possible research topics for PSerc in the area of mitigating pollutant emissions. It will also identify key scientific and engineering articles and reports on this topic in order to build a common understanding among PSerc members.

Along with the adaptation to and mitigation of climate change itself, the power industry is confronted with the need to adapt to current and anticipated market structures and government mandates, and also to mitigate their impact on the industry. To be effective in this area, the power engineering community must become an active participant in shaping the markets and policies. This discussion paper will identify existing and anticipated market structures and government policies that address climate issues and impact the power industry, and will list possible research topics in this area. The purpose of this effort is to allow PSerc to have a voice in defining the markets and policies, to the extent that this is of interest to PSerc members.

Building upon the discussions at the recent PSerc meeting in Ashland, WI, the research team for this proposal recognizes that the scope of this topic is tremendous, with many aspects falling outside the expertise of PSerc members. However, there is also significant overlap between these issues and PSerc in terms of interest, ability and significance to PSerc members. PSerc members represent a large segment of the power industry and together are in a unique position to contribute to the preparedness of the power industry in response to extreme weather events, the national climate change discussion in academia and industry, and policy and market development at the federal and state levels. PSerc can contribute by researching and clarifying (i) the capability of the power infrastructure to respond to climate change, (ii) the relative impact on climate change issues of different system operating strategies (*e.g.*, dispatch), system configurations (*e.g.*, microgrids) and expansion plans, and (iii) the impacts of market rules and policy mandates on the operations of the power system, and subsequently on the national economy.

It is important to emphasize that we are not proposing that PSerc itself will perform research in the climate or health sciences, but rather that through this discussion paper, we gain a solid understanding of the research topics that PSerc might address, and clarify where PSerc is and is not qualified and interested in contributing to research relating to interactions between electricity production and climate change. It is interesting to note that a number of research projects previously or currently funded by

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PSerc address the power system-climate change interaction. In particular, research into micro-grids, renewable energy, real-time pricing and demand response all include elements that lessen the power systems contribution to greenhouse gases. It is also anticipated that a few related proposals will be submitted as part of the 2006 solicitation. This evident interest in the area of power system-climate change interaction will be focused and enhanced through the list of possible research topics to be proposed in this discussion paper.

Expected Outcomes: The outcomes of the proposed discussion paper are for it to provide

- A list of possible research topics for PSERC to consider in the 2007 research solicitation, addressing the areas listed in the work plan section below.
- A framework for the Stem Committees to use at the May 2007 IAB meeting in developing the 2007 research solicitations. Though this proposal was developed to respond to an area of concern in the Markets Stem portion of the 2006 research solicitation on the “Electric Industry Response to Global Climate Change,” the topic is relevant to all three stems.
- The May 2007 PSERC tele-seminar, in order to further discuss the topic in anticipation of the May 2007 IAB stem meeting.
- A presentation at the May 2007 IAB meeting.
- A framework for mutual understanding among PSerc members on the topic of climate change, and a starting point for discussions at the 2007 PSerc summer workshop on the topic of PSerc’s role in research and industry planning in the face of extreme weather events, climate change, long term industry planning, and related market structures and policy mandates.
- A framework from which to understand the capabilities of PSerc university members and possible research projects that may be undertaken with PSerc resources

Potential future uses for the proposed discussion paper are (i) to present the discussion paper to PSerc members via site visits and engage them in a dialog to make the paper more reflective of the needs and objectives of the power industry, and (ii) to develop an executive forum on interaction between the impacts of climate change and power industry.

Potential Benefits: From initial group discussions that took place in Ashland, WI on the importance to the PSerc membership of severe weather events and climate change issues, it became clear that there is a significant range of interest in and understanding of climate change and its relevance to PSerc members. The discussion paper will identify a number of possible research topics and facilitate the development of Stem Committee research plans in the area of power system–climate change interaction.

Note that future research effort in this area will not only increase understanding of the power system-climate change interactions, but also is likely to indicate which measures, that might be taken by the power industry as a result of climate change, would also strengthen the power system with respect to other issues. Examples include (i) upgrading to new components that can withstand extreme heat could also help reduce aging related failures, (ii) efficient upgrades could use designs that also limit local environmental hazards, and (iii) efforts to limit or mitigate cascading failure due to extreme weather would also strengthen the power system against terrorist ability to exploit the possibility of cascading failure.

Potential Applications: This study will identify research topics that are intended to lead to future applications.

Technical Approach: The paper will be prepared by a team of industry and university members, along with research assistants, through a literature search and discussions among the team members.

Work Plan:

For each task below, the team will

- Identify possible research topics through literature review and conversations between university researchers and industry members. Conversations will be via email, Stem Committee meetings, and phone conversations.
- Summarize supporting background information explaining why the topic is significant to the industry, policy makers and society.
- Identify existing recommendations from the literature that impact the power industry regarding:
 - What to do – proposed solutions to climate change issues, and
 - How to do it – technologies and strategies to address climate and health issues

TASK 1: The interaction between the production of greenhouse gases and the production and delivery of electricity, considering technologies for generation, transmission and distribution, as well as strategies for system planning and operation.

- Ward Jewell, Tom Overbye, P K Sen, Dan Tylavsky, Judy Cardell

TASK 2: Extreme weather statistics and events, and the potential impact on power system blackouts and component failures

- Ian Dobson, Mladen Kezunovic

TASK 3: Electricity market issues that relate to climate change (*e.g.*, emissions trading).

- Judy Cardell

TASK 4: Federal and state policies on climate change, to the extent that they are relevant to the electric power industry.

- Judy Cardell, Ward Jewell

TASK 5: Long range planning of other industries with respect to climate change, *e.g.*, the insurance/financial sector, the petroleum industry, water resources, health sciences, transportation and aviation

- Dan Tylavsky, Ward Jewell

GENERAL TIMELINE

- Through the period of January to March 2007 the team will be working on developing the list of possible research topics.
- An initial draft of the paper will be completed by April 30, 2006, to be presented via the May tele-seminar and made available for the May 2007 IAB meeting for use in the Stem Committee discussions in developing the 2007 research solicitations.
- A final version of the paper incorporating comments from the May IAB meeting will be completed by June 30, 2007, to be circulated for use at the 2007 summer workshop.

Work Supported by Additional Membership Funds: For the tasks given above, no additional membership funds have been committed.

Related Work: The purpose of this discussion paper is to identify and review related work in order to then identify possible research topics for PSerc.

How this Work Differs from Related Work: As noted above, this discussion paper is drawing upon related work, from disciplines and researchers outside of PSerc, for its completion.

Relationship of this Work to the Research Plan and Topic Areas for this Solicitation: The Markets Stem specified the “Electric Industry Response to Global Climate Change” as an area of concern. This

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topic arose out of lengthy discussions between industry and university members at the 2006 PSerc summer workshop, leading to the observation that the subject of power industry-climate change interactions was so broad that effort was required to identify possible research topics in the area. The paper proposed here will identify possible research topics in order to focus Stem Committee conversations and research solicitations.

Collaboration Plan: To encourage collaboration among the project advisors and the research team

- (1) We will communicate with each other as work progresses, predominantly via email.
- (2) Researchers and project advisors will share working documents among the team via email, and in person at the PSERC meetings.
- (3) We will have monthly conference calls with the research team and project advisors.
- (4) Students will be involved as research assistants, in finding relevant background information and helping to propose research topics.