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The Electric Power Industry and Climate Change: Power System Research Possibilities

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PSERC Tele-Seminar
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Overview

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- This tele-seminar provides an overview of a PSERC project looking at the electric power industry and climate change
- University project researchers were Tom Overbye (lead), Judy Cardell, Ian Dobson, Ward Jewell, Mladen Kezunovic, P.K. Sen, and Daniel Tylavsky
- PSERC industry members included AREVA T&D, CAISO, Duke, Entergy, GE, NRECA, TVA

White Paper Introduction

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- The Power Industry and Climate Change
  - How climate change affects the power industry
    - Equipment impacts
    - Fuel supply impacts (primarily hydro)
    - Changes in other industries
  - How the power industry may affect climate change
    - Primarily carbon dioxide emissions
- We are power system researchers, not meteorologists; we cannot provide expert insight on any climate change theory

What is Known: CO_2 in Air is Rising

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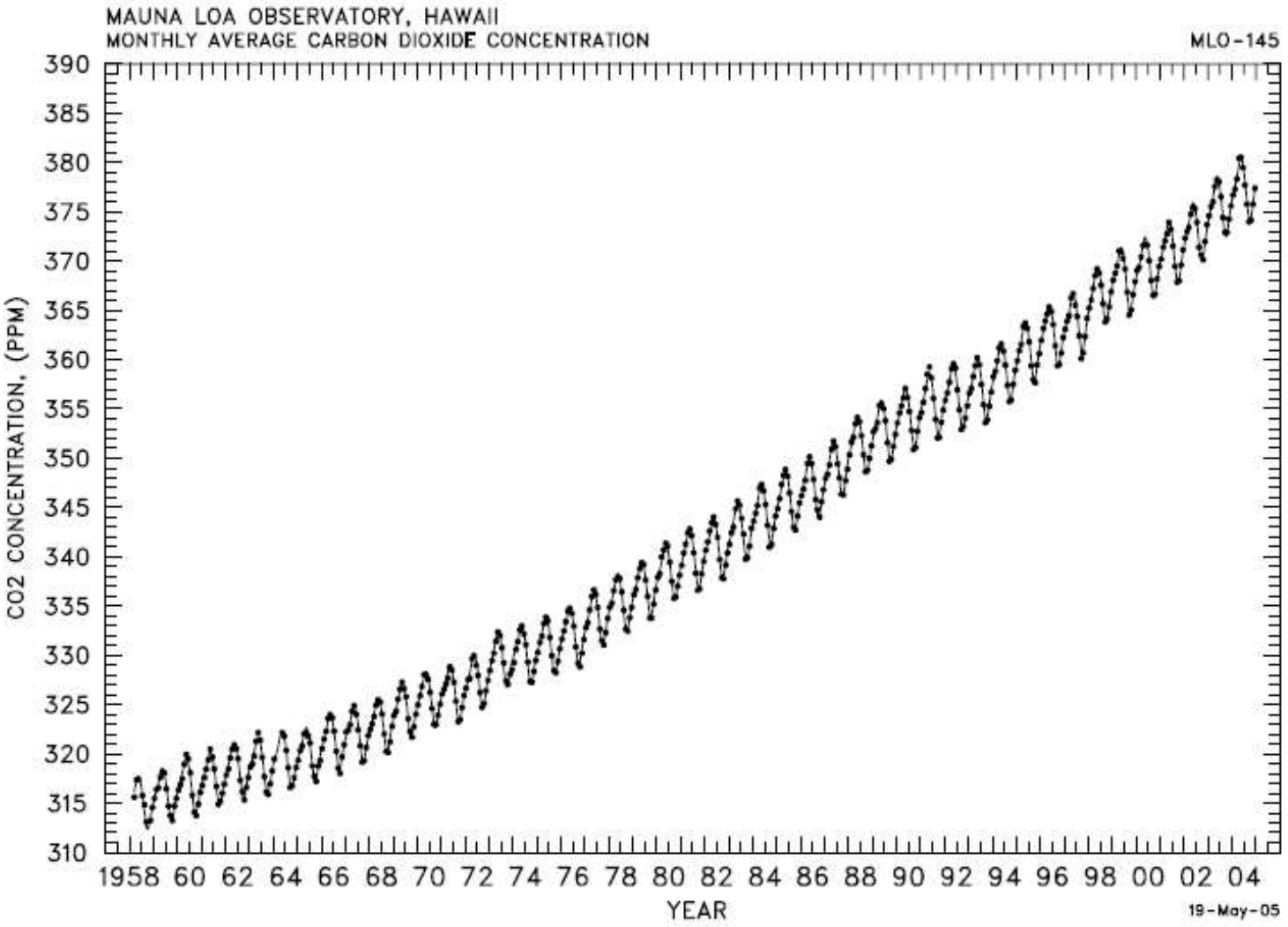

Value was about 280 ppm in 1800, 384 in 2007

Rate of increase is about 3ppm per year

Source: http://cdiac.ornl.gov/trends/co2/sio-mlo.htm

As is Worldwide Temperature

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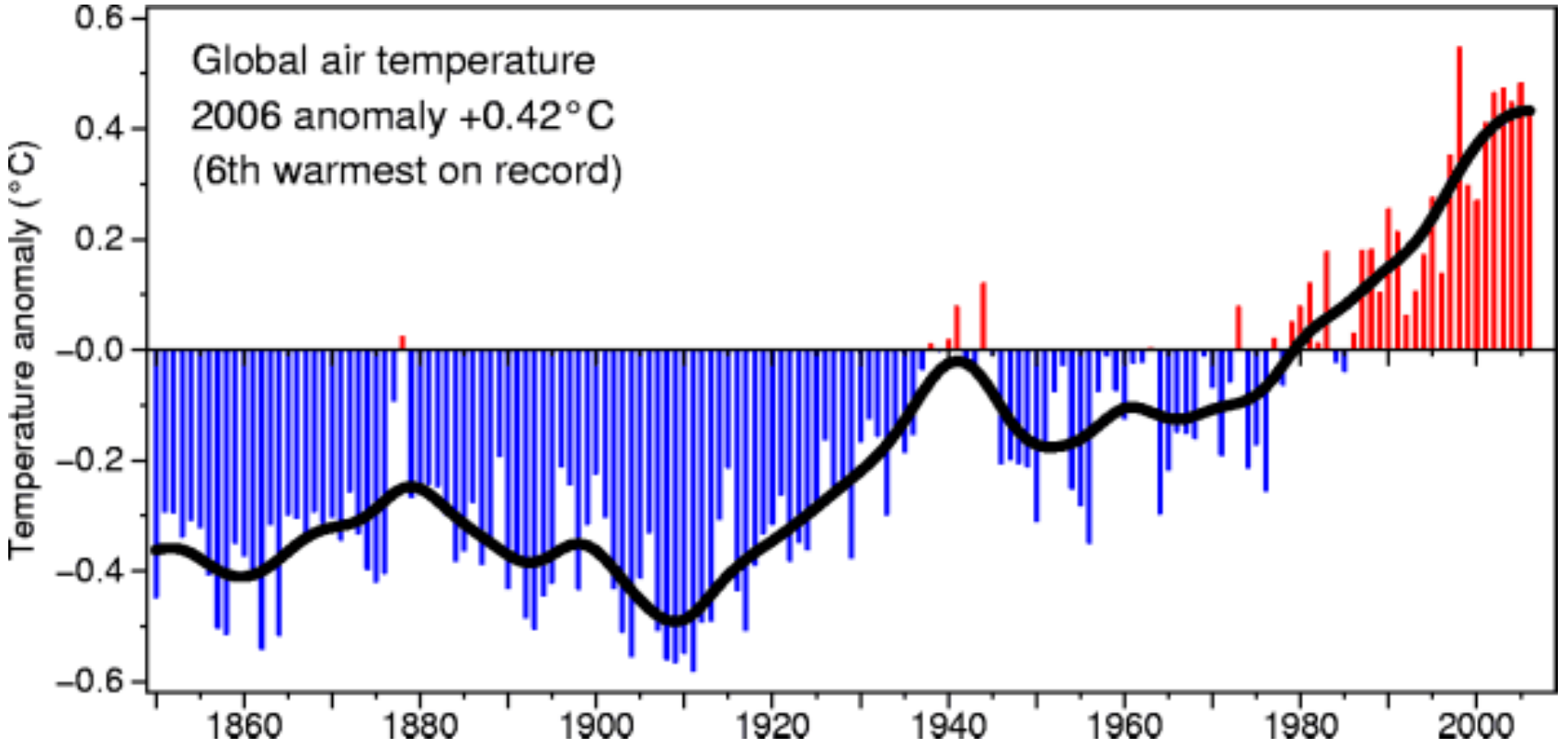

Baseline is 1961 to 1990 mean

Source: http://www.cru.uea.ac.uk/cru/info/warming/

CO_2 and Global Warming

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- **"Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."**
  Quote from Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis, Summary for Policymakers, p. 10
- **Authors believe it is prudent to consider impact of CO_2 reductions on power system operations**

US Energy Pie: Total of 100 Quad

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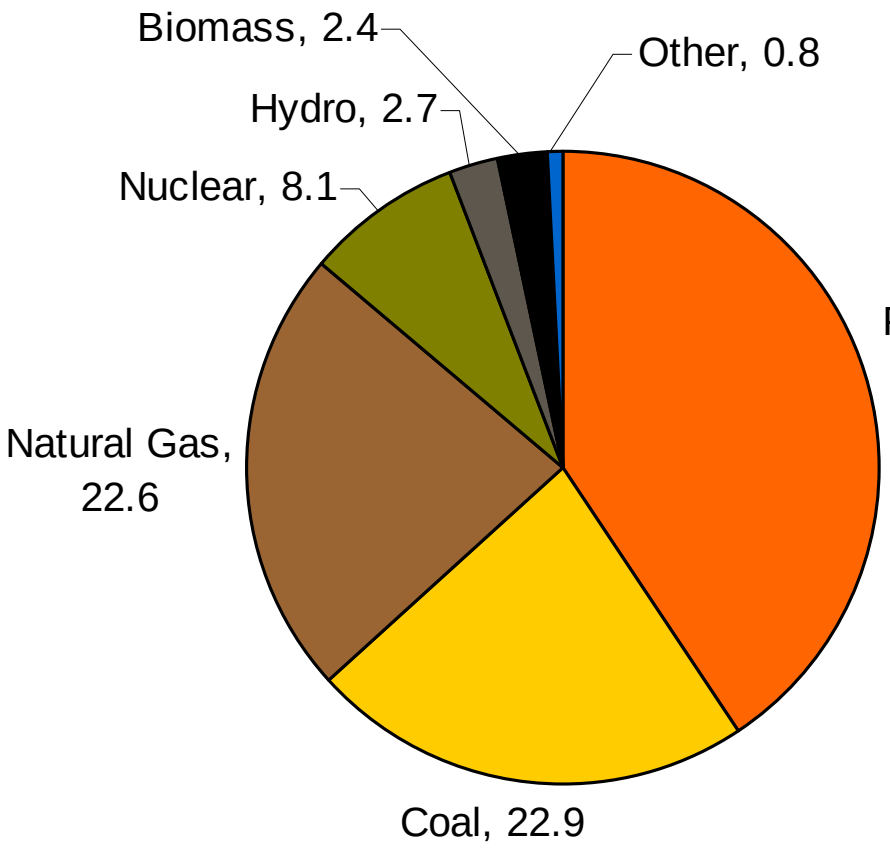
About 86% Fossil Fuels



CO_2 Emissions (millions of metric tons, and per quad)

Petroleum:	2598,	64.0
Natural Gas:	1198,	53.0
Coal:	2115,	92.3

1 Quad = 293 billion kWh (actual)

1 Quad = 98 billion kWh (used, taking into account efficiency)

Source: EIA Energy Outlook 2007, Table 1, 2005 Data

Some CO_2 Reduction Options

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- Energy efficiency and conservation
- Biofuels: Converting all our corn (81 million acres) to ethanol gives about 2.6 quad
- Nuclear: One 1200 MW reactor = 0.1 quad
- Coal: Practicality of sequestration is unknown
- Wind: In 2005 provided 0.15 quad. A significant increase would require lots of new transmission system capacity
- Pluggable Hybrids: Could reduce gasoline useage; current gas usage about 17 quad

Science & Technology Research Topics

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1. Develop a model to simulate the new transmission grid and system operation scenarios.
2. Develop and analyze methods to improve energy conservation and efficiency.
3. Analyze the effects on system load shape, transmission system expansion, system dispatch, and new control needs in response to an increased use of plug-in hybrid vehicles.
4. Analyze the impact of an expansion of nuclear energy, in terms of impacts on the transmission system and power system operation, and in GHG reductions.
5. Analyze system impacts and control needs of a significant penetration of large, remote wind farms.

Extreme Weather

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- Slow increase in *average* global temperature not an issue.
- But increases in *extremes* of heat, rain, winds and changes in water runoff could be significant for power system design and operation.
- Key is the rate of change in extremes versus the rate of power system upgrade.

Extreme Weather Research Topics

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1. Use predictions of regional climate change to estimate the rate of change of power system design parameters.
2. Robust monitoring and control techniques for harsh weather and increased load demand.
3. Combine climate predictions of extreme weather with emerging blackout risk assessment.
4. Better restoration in case of natural disasters.

Government Policies

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- Project objectives
  - Investigate how potential and actual government policies will affect power system and electricity market operations.
  - Assist PSERC industries to respond to these climate change related policies.
  - Allow PSERC researchers to be in a position to inform policy makers about the impacts of climate change related policies on the electric power system.

Government Policies

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- International
  - United Nations Kyoto Protocol, 1997
  - President Bush disengaged in 2001
  - US goal would have been to reduce CO_2 emissions to 7% below 1990 levels by 2008-2012
- Federal
  - 1990/92: CO_2 monitoring
  - Four mandatory limit bills now in Congress
- Carbon Capture and Sequestration
  - Probable technology for coal
    - Cost for retrofitting plants could affect dispatch
    - Issues with locating plants near sequestration site
  - EEI and regional initiatives support

State Government Policies

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- RGGI – Regional Greenhouse Gas Initiative
  - Mandatory cap-and-trade beginning in 2009
  - Nine northeast and mid-Atlantic states
- WRCAI – Western Regional Climate Action Initiative
  - Regional emissions market and monitoring
  - To begin summer 2008
- California Assembly Bill 32
  - Reduce GHG to 1990 levels by 2020
  - Reduce to 80% below 1990 levels by 2050
  - Mandatory reduction beginning 2012

Government Policies Research Topics

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1. Analyze the effect of system operations from changing dispatch patterns that result from production caps and changes in merit order as a result of emissions regulations.
2. Analyze the impact on both existing generating plants and the power system from possible government regulations constraining the dispatch of specific types of generators.
3. Analyze the effect of bills such as AB32 on power system operations.
4. Analyze the effect of inconsistent/conflicting regional emissions policies (in conjunction with an analysis of inconsistent/conflicting regional permit markets) in contrast to uniform, national policies.

Market Mechanisms

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- Responsive demand and conservation
  - Price-, Incentive-, Reliability-based
  - Manual and automatic response
- Carbon tax
  - Economist support for a carbon tax
  - Transparent mechanism
- Cap-and-trade emissions trading
  - Emissions limits; permits to produce pollutants; permits can be traded
  - Significant market design and permit allocation issues

Market Mechanisms

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- Renewables portfolio standards, RPS
  - State based initiatives, with discussion on developing a federal RPS
  - Mandate MW, MWh or % energy from renewables
    - 4% by 2009 (MA) v. 30% by 2020 (MN)
  - Trading allowed via renewable energy certificates (RECs)
  - ‘Tier 1’ and ‘Tier 2’ resources
- Market design for issues for cap-and-trade, responsive demand and portfolio standards

Market Mechanisms Research Topics

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1. Research the effect of conflicts and/or inconsistencies between *regional* cap-and-trade markets, and conflicts with renewable portfolio standards (RECs).
2. Develop new planning and risk management tools, focusing on the risk introduced by uncertainty in climate change and government policies designed to address climate change issues.
3. Analyze the effect on system and market operations if automated control systems are installed at customer locations.
4. Develop optimal bidding strategies for multi-period electricity markets with uncertainty in GHG policies and mandates.

Industry Planning

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- Demand reduction and conservation
- Improved efficiency of the electricity infrastructure
- Increase emphasis on renewables (wind, solar, biomass, biofuel) and distributed generation
- Nuclear generation
- CO_2 reduction, capture, transformation and sequestration.
- Other industries are making long range plans.
  - (Market share, Anticipate Regs, Avoid $ Loss, Avoid Litigation)

Industry Planning Research Topics

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1. Develop efficient and fast computational methods that operate in real time to analyze the trade-offs between profits and power system security and reliability.
2. Analyze the efficiencies of market structures where carbon trading is allowed within the electric power industry and between the electric power industry and other GHG producing industries.
3. Evaluate the consequences on system stability and responsiveness that is lost by reducing hydro-generation.
4. Develop technology, system control methods, and market designs to improve power-system efficiency and demand-side management.

Expanding Previous PSerc Themes

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1. Incorporate climate change analysis into optimal power flow and unit commitment tools.
2. Analyze methods to adapt system operations and control to changes imposed by environmental regulations.
3. Analyze the effect of emissions constraints upon resource location and scheduling.
4. Develop tools to improve understanding and operations in an environmentally constrained system.

Conclusions

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- New PSERC challenge is to address power system–climate change interactions
  - Anticipated climate changes and subsequent policies will affect the power industry
  - PSERC researchers have the required competencies
- White paper, PSERC report 07-16
  - Comments sought by June 15, 2007
  - http://www.pserc.org/ecow/get/publicatio/reports/reportsfor/
    - Draft report available only to members at present