

Carnegie Mellon Electricity Industry Center Overview

www.cmu.edu/electricity

Overview

Carnegie Mellon Electricity Industry Center (CEIC)

- One of 26 Sloan Industry Centers that have been created at 19 different universities.
 - CEIC is different from the other Sloan Centers in that it was created jointly with EPRI and has a somewhat more strategic focus.
 - Founded in August 2001 after competitive proposals.
 - Close partnership with industry principals and field-intensive research.
 - Improve American competitiveness and spur economic growth.
- We define ‘Electricity Industry’ broadly to include the companies that supply the equipment, all the organizations that build and operate the nation’s electric power system, agencies that shape and regulate the system as well as customers who use the power.
- Support
 - Initial funding: \$1.75 Million over 3 years from Sloan and EPRI.
 - Renewed for a second three years.
 - Co-funding for specific projects from industry and government.
- Co-Directors: Professor Lester Lave and Professor Granger Morgan.
- Executive Director: Professor Jay Apt.
- 18 Faculty and 22 Ph.D. Students.

CEIC's Focus

- The focus of CEIC is strategic.
- We address issues of middle and longer-term importance to the industry, as well as some non-traditional issues not being addressed by others.

Our Role

- Help to shape the electricity industry through strategic research and technology-informed policy.
- Increase the competitiveness of an industry which has received under-investment in R&D and policy.

CEIC Advisory Committee

Rita Bajura, Former Director, National Energy Technology Laboratory

Carl Bauer, Director, National Energy Technology Laboratory

Joe Belechak, COO and Senior VP, Duquesne Light Company

Tom Casten, Chairman and CEO, Private Power, LLC

Ralph Cavanagh, Natural Resources Defense Council

Richard Cowart, Director, Regulatory Assistance Project

Erroll Davis, Jr., Chancellor, University of Georgia; Former CEO, Alliant Energy

Bruce Edelston, Director, Policy and Planning, Southern Company Services

Steven G. Hickok, Deputy Administrator, Bonneville Power Administration

G. Edison Holland, Executive VP & General Counsel, Southern Company

James Hunter, Director, Utilities Department, IBEW

Kathryn Jackson, Executive Vice President, Tennessee Valley Authority

Ed Martin, President and CEO, Wabash Valley Power Association

Michael Morris, Chairman, President, and CEO, American Electric Power

Earl Nye, Chairman, TXU

Karl V. Pfirrmann, President, Western Region, PJM Interconnection, L.L.C.

Mark R. Pfloderer Vice President and Chief Technology Officer, Caterpillar

Jim Pope, General Manager, Northern California Power Agency

Robert P. Powers, Executive Vice President, Generation, American Electric Power

James Rogers, Chairman, President, and CFO, Cinergy

Ric Rudman, Former COO, Electric Power Research Institute

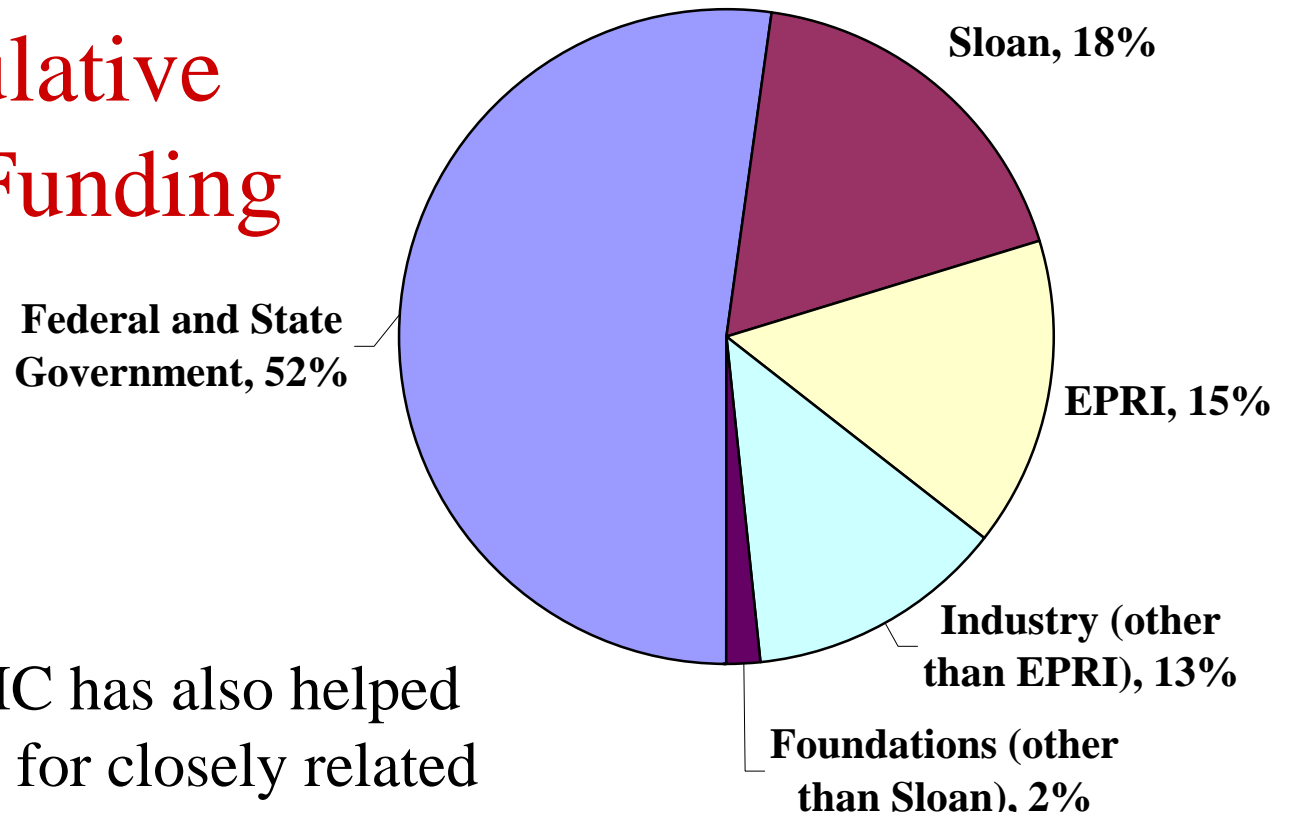
Les Silverman, Director, McKinsey & Company

Steve Specker, President and CEO, Electric Power Research Institute

Le Tang, ABB Corporate Research

Susan F. Tierney, Managing Principal, The Analysis Group, Inc.

CEIC Cumulative Sources of Funding



The presence of CEIC has also helped us to secure funding for closely related topics such as Ed Rubin's group doing work on IGCC w/CCS; \$6.9-million NSF Center on Climate Decision Making; new support of \$2-million from MacArthur, some of which will go to support work on electric power and critical social services, etc.

Collaborations at Carnegie Mellon

- Center for Energy and Environmental Studies
- Center for Financial Markets
- Center for Public Policy
- Center for the Study and Improvement of Regulation
- Green Design Initiative
- Institute for Complex Engineered Systems
- Center for Climate and Related Decision Making in the Face of Irreducible Uncertainties
- The Center for Atmospheric Particle Studies
- WaterQUEST
- MacArthur-supported work on security aspect of Engineered Civil Systems
- Software Engineering Institute
- Power Systems Energy Research Center

People

Co-Directors:

Lester B. Lave, Tepper and EPP
M. Granger Morgan, EPP and ECE

Executive Director:

Jay Apt, Tepper and EPP

Participating Faculty:

Linda Argote, Tepper
Cliff Davidson, CEE and EPP
Paul Fischbeck, SDS and EPP
Baruch Fischhoff, SDS and EPP
Chris Hendrickson, CEE
Marija Ilic, ECE and EPP
Bruce Krogh, ECE
H. Scott Matthews, CEE and EPP

Benoit Morel, EPP and Physics
William Rosenberg, EPP
Bryan Routledge, Tepper
Edward Rubin, EPP and MechE
Duane J. Seppi, Tepper
Sarosh Talukdar, ECE and EPP
Rahul Tongia, EPP and SCS

Adjunct Research Faculty:

Alex Farrell, Energy and Resources Group, UC Berkeley
Howard Lipson, Software Engineering Institute and EPP
Neil D. Strachan, Policy Studies Institute, U.K.

Doctoral Students

(the folks who do
most of the work!)

Michael Ashworth, SCS
Chantal Brandon, Tepper
Elisabeth Gilmore, EPP
Paul Hines, EPP
Ari Kang, Tepper
Warren Katzenstein, EPP
Douglas King, EPP
Ryan Kurlinski, EPP
Huaiwei Liao, ECE
Joe Marriott, EPP
Sean McCoy, EPP
Kyle Meisterling, EPP
William Morrow, CEE and EPP



Adam Newcomer, EPP
Sompop Pattanariyankool, Tepper
Ben Peterson, Tepper
David Rode, SDS/EPP
Kathleen Spees, EPP
Joshua Stolaroff, EPP
Rahul Walawalkar, EPP
Richard Wu, EPP
Zhang Yi, ECE

Education Activities

- Ph.D. education: 22 Ph.D. students at CMU - probably the largest effort of its kind in the world focused on interdisciplinary problems of the electricity industry.
- Course development: University courses in Tepper, EPP, and ECE. Examples:
 - Engineering and Economics of Electric Power Systems
 - The Transformation of Energy Markets
 - Electric Energy Processing: Fundamentals and Application
 - Special Topics In Systems and Control: Large-scale dynamic systems
 - Problem Design and Verification
- New MS program in power engineering in ECE
- Conferences & workshops

Assist government agencies and regulators

- Helped shape coal gasification provisions of Energy Policy Act of 2005
- EPA Science Advisory Board, EPA Clean Air Council, 5 NAS/NRC panels
- Formal comments to FERC Standard Market Design
- FERC meetings
- House Distributed Energy Caucus briefing
- CEIC and DOE joint briefing to Hill staff
- Infrastructure terrorism briefings to Hill staff and DHS
- Pennsylvania DEP \$120k grant for critical missions
- Work supports the DHS Center for Risk and Economic Analysis of Terrorism Events

A neutral party in private and public debates

- Workshops on security, carbon management, T&D
- CECA Energy Security and Electric Industry Restructuring Forum
- CECA Transmission Infrastructure Forum
- US House Distributed Energy Caucus
- Energy Modeling Forum
- Aspen Summer Institute
- EPRI Climate Contingency Plan
- Alliant Energy “Energy Policy and Global Climate Change”

Current Research Areas

- Markets and Investment
- Security, Reliability, and Distributed Energy Resources
- Environmental Issues
- Advanced Generation, Transmission, Sensing, and Control
- Demand Side Issues
- Human Resources and Management Issues

Supported by:

The Alfred P. Sloan Foundation
Electric Power Research Institute
U.S. National Science Foundation
U.S. Environmental Protection Agency
U.S. Department of Energy
Tennessee Valley Authority
U.S. Office of Naval Research
McDermott Technology
American Public Power Assn
Florida Power and Light
ELCON

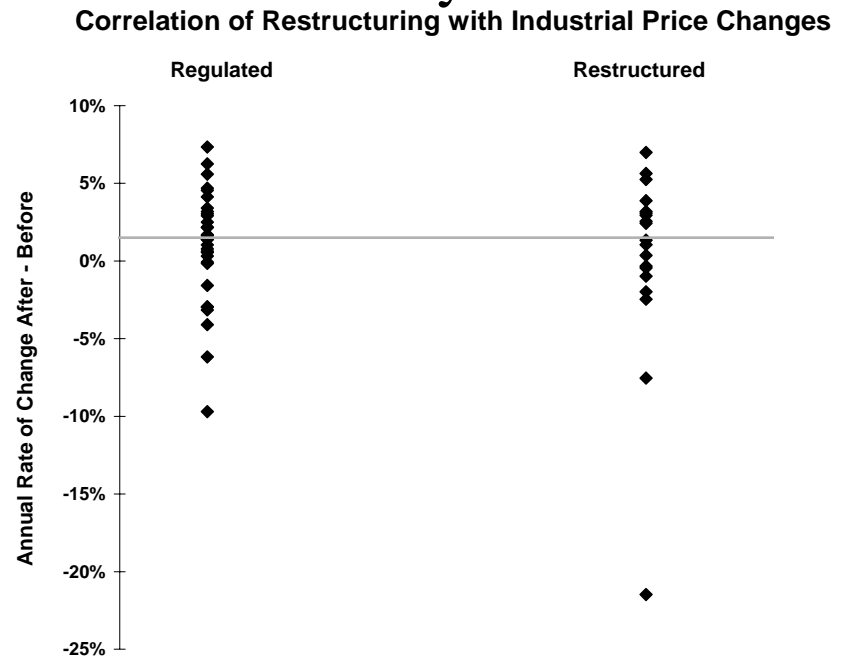
National Rural Electrical Coop Assn
ABB
Alliant Energy
Commonwealth of Pennsylvania
Customized Energy Solutions Ltd.
RK Mellon Foundation
Carnegie Bosch Institute
The Pew Climate Change Center
The Southern Company
The Allegheny Conference
JP Morgan

Markets and Investments

Examples:

- Competition has not lowered US industrial electricity prices – Prof. Jay Apt
- Are FTR Markets Efficient? – Dr. Dalia Patiño-Echeverri.
- Deregulation's Effect on the Price of Electricity – Dr. Seth Blumsack.

Other examples include work on: pricing ancillary services; LMC, and simulation models of market performance.



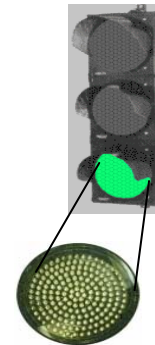
Security, Reliability, and Distributed Energy Resources

Examples:

- Protecting Essential Services - Ph.D. student Kyle Meisterling.
- Dual Use Technologies: Protecting against nature and attacks - Professor Lester Lave.

We have done a variety of other studies in this area and have new support from the MacArthur Foundation to undertake additional studies on securing critical social services when power goes out.

A simple example:
LED traffic lights with solid state controllers and trickle charge battery backup.

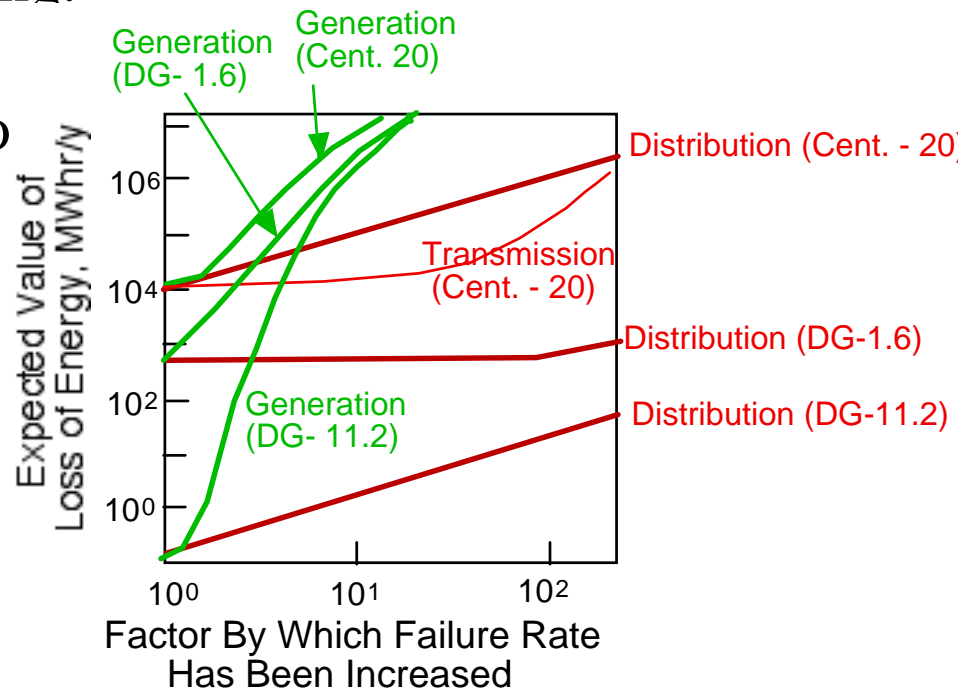


Security, Reliability, and Distributed Energy Resources

Examples:

- The Cost of Peak Power using Installed DG - Ph.D. student Elisabeth Gilmore.
- Efficient Utility Rate-Setting for Customer-Generators Ph.D. student Douglas King.

We have already graduated two Ph.D.s in this area. Work has included: various economic assessments; analysis of security benefits from massive decentralization; a variety of studies of regulatory issues, studies of vulnerability in Pittsburgh and PA, etc.

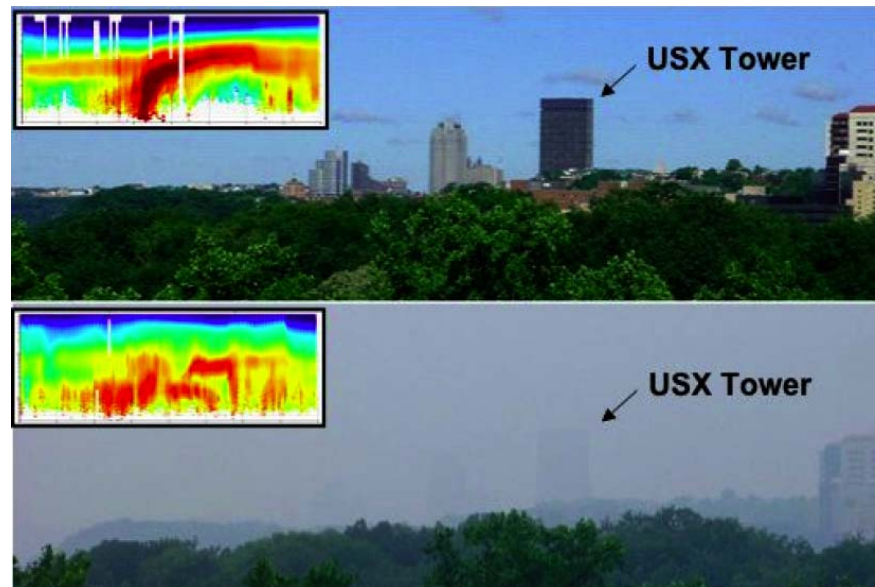


Environmental Issues

Examples:

- Predicting future costs of IGCC with CCS - Professor Ed Rubin.
- Direct CO₂ Capture from the Air - Josh Stolaroff.
- CO₂ Underground Storage Issues - Professor Granger Morgan.

We are also doing work on a variety of issues in conventional air pollution control; on Hg control; on fine particulates; on photochemical air pollution; on the environmental impacts of coal extraction; etc.

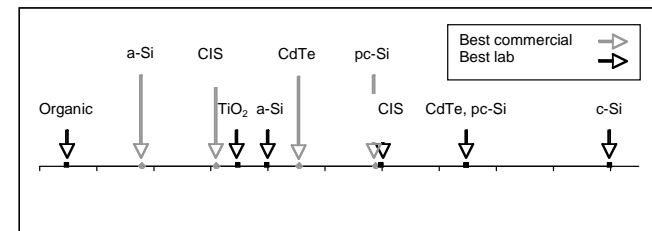


Advanced Generation, Transmission, Sensing, and Control

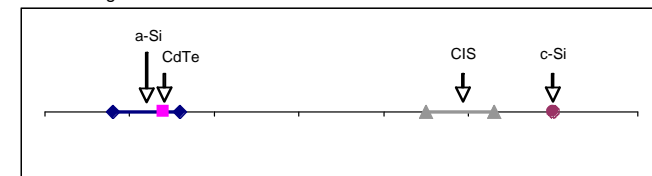
Examples:

- Wind: Carbon Mitigation Cost, and Optimal Grid Integration - Professor Jay Apt.
- Energy Storage in the New York ISO - Ph.D. student Rahul Walawalkar.

In generation we are also: assessing advanced photovoltaics; exploring sources of innovation in wind; costing RPSs; doing extensive work on advanced coal technology; etc. While we will not talk about it today, we have also recently completed a Ph.D. on transmission siting.



Best PV Efficiencies. Current best reported commercial efficiencies for four PV technologies and best reported lab efficiencies for six PV technologies.

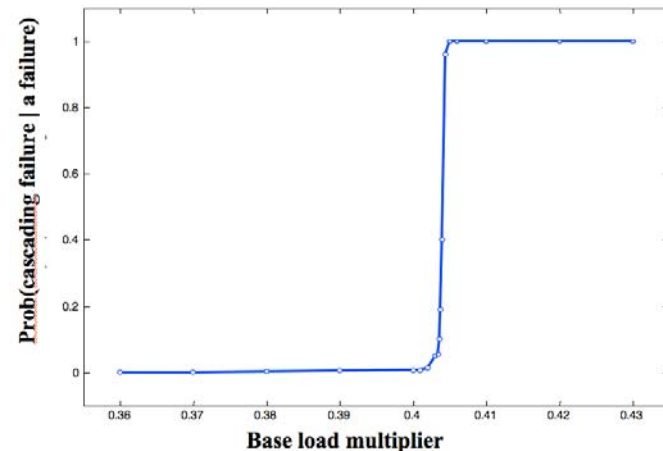


Representative PV Costs. Approximate module cost/m² for four commercially produced PV technologies.

Advanced Generation, Transmission, Sensing, and Control...(Cont.)

Examples:

- Can Cascading Failures be Eliminated? - Prof. Sarosh Talukdar.
- How the Number of Cascading Failures can be Reduced - Ph.D. student Paul Hines.
- Multi-Layered Architecture for Reliable and Secure Large-Scale Networks - Professor Lester Lave.



Demand Side Issues

Ph.D. student Kathleen Spees is starting to work on demand response in promoting reliability and lowering costs.

Ph.D. student Inés Azevedo is starting a project on estimating the potential impact on electricity demand over time of solid state lighting. Later she hopes to go on to explore other technologies.

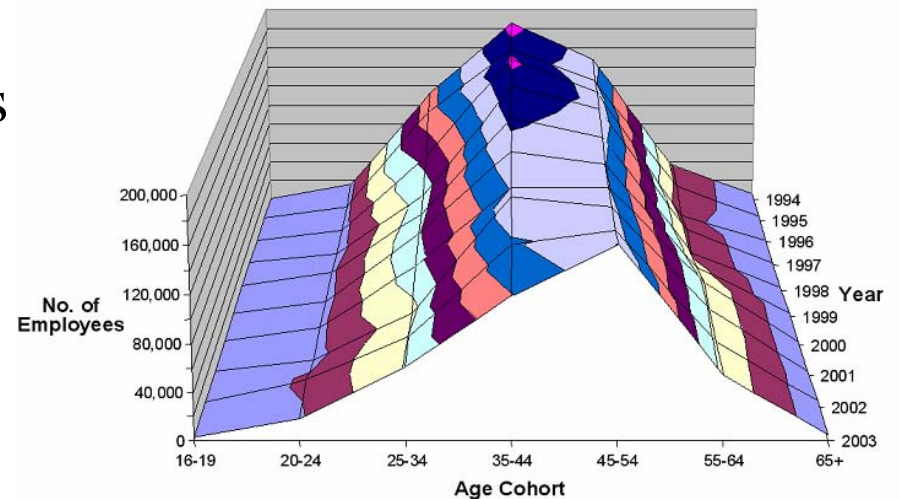
And much of our DG work and some of our system control work has a demand side focus.

Human Resources and Management Issues

A recent survey we conducted found that almost every company named workforce aging as the more pressing HR issue in the electricity industry. Retirement-driven turnover is expected to cause substantial losses of key knowledge and experience over the next 5 to 10 years.

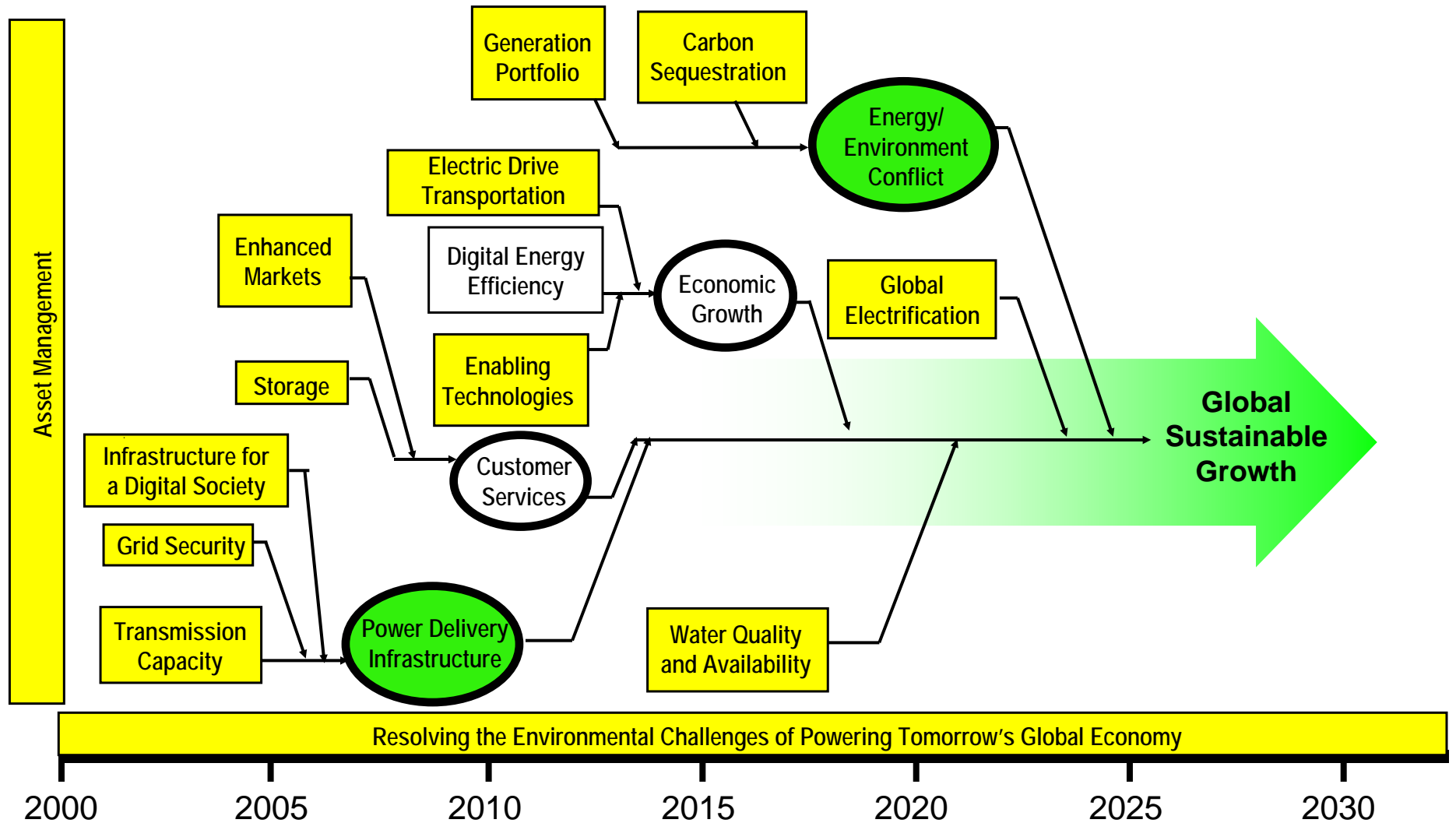
Our Center ran an invitational workshop on April 12-13, 2006 that assembled senior executives from both operations and HR to discuss and prioritize the problems and present and evaluate possible solutions.

Workforce aging is a more pressing issue in the electric power industry than in any other industry in the world.



(Source: Ashworth 2005).

CEIC Research and EPRI Roadmap Limiting Challenges



Filled blocks represent areas of Carnegie Mellon Electricity Industry Center Research



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Publications, workshops, etc.

You can find a complete list of workshops we have run, papers we have published, and other materials on the Center's website.

The next two slides mention a couple of unusual recent reports...



Publications

NOTE* The files below require Adobe Acrobat Reader, the latest version of which can be downloaded [here](#).

PhD Dissertations

["Future Electricity Generation: An Economic and Environmental Life Cycle Perspective on Near-, Mid- and Long-Term Technology Options and Policy Implications", Joule Andrea Bergerson, 2005](#)

[Mapping Alternatives: Facilitating Citizen Participation in Development Planning and Environmental Decision Making, Shalini P. Vajihala 2005](#)

["The Economics and Environmental Impacts of Large-Scale Wind Power in a Carbon Constrained World", Joseph DeCarolis, 2004](#)

["Two Essays on Problems of Deregulated Electricity Markets", Dmitri Perekhodtsev, 2004](#)

["Electric Power Systems Under Stress: An Evaluation of Centralized Versus Distributed System Architectures", Hisham Zerriffi, 2004](#)

Periodicals and other publications

[Comments on Wholesale and Retail Electricity Competition to the Electric Energy Market Competition Interagency Task Force and the Federal Energy Regulatory Commission](#)

[Op-Ed Piece \(The New York Times, August 13, 2005\) Electricity Traffic Control](#)

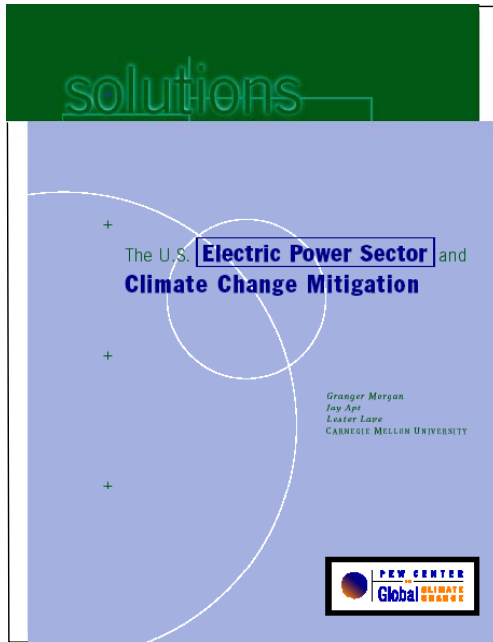
[The U.S. Electric Power Sector and Climate Change Mitigation](#)

[Critical Electric Power Issues in Pennsylvania: Transmission, Distributed Generation, and Continuing Services when the Grid Falls](#)

[Article from Summer 2004 *Issues in Science & Technology*, "Electrical Blackouts: A Systemic Problem"](#)

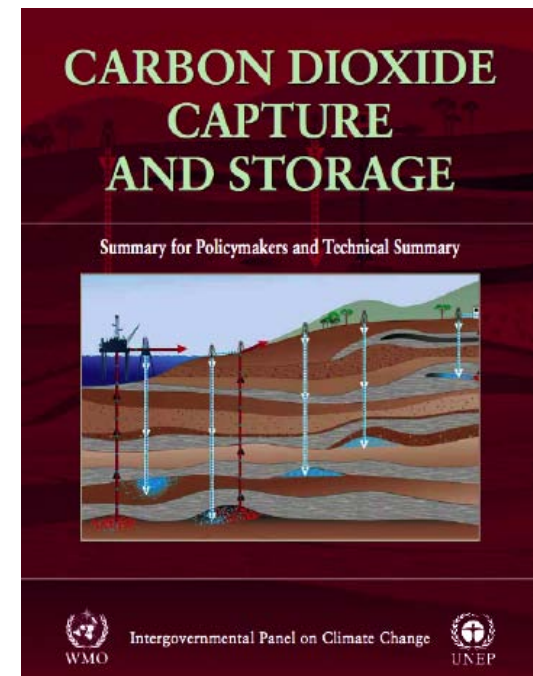
[Op-Ed Piece \(*Pittsburgh Post Gazette*, August 15, 2004\) Let There Be Light](#)

Recent Reports



The U.S. Electric Power Sector and Climate Change Mitigation, 2005, Pew Center for Global Climate Change: Washington.

Ed Rubin wrote the technical summary for the recent IPCC report on CCS which was approved and accepted by IPCC Working Group III at the 24th Session of the IPCC in Montreal, Sept. 26, 2005.



Reports...(Cont.)

Critical Electric Power Issues in Pennsylvania: Transmission, Distributed Generation and Continuing Services when the Grid Fails

Produced by the Carnegie Mellon Electricity Industry Center for the Pa. Department of Environmental Protection Feb. 2005

Edward G. Rendell
Governor

Kathleen A. McGinty
Secretary

This report, commissioned by the DEP and produced by the Carnegie Mellon Electricity Industry Center, details the issues and provides a road map to increased electrical security by providing numerous recommendations to improve the performance of the grid both in terms of operations and infrastructure improvements, improve the regulatory environment in order to foster the deployment of distributed generation, and increase the survivability of critical systems in the event of a grid failure.

By following this road map, we can find our way not only to increased security, but increased efficiency in electricity generation and transmission as well, resulting in a real energy cost savings for ourselves and future Pennsylvanians. This will help ensure a brighter future for the Commonwealth and will secure Pennsylvania's role as a national leader in secure and efficient electricity generation and transmission.

Sincerely,



Kathleen A. McGinty
Secretary

by

Jay Apt and Granger Morgan

with contributions by

Paul Hines, Douglas King, Nicholas McCullar, Kyle Meisterling, Shalini Vajjhala, Hisham Zerriffi, Paul Fischbeck, Marija Ilic, Lester Lave, Dmitri Perekhodstev, and Sarosh Talukdar

Carnegie Mellon Electricity Industry Center



Outreach Activities

- Congress: Briefings for members & staff
- Industry: EPRI RAC & Summer Study, Company visits, JP Morgan Public Power Finance Conference
- Regulatory agencies: EPA SAB, FERC, State commissioners
- General: American National Standards Institute
Consumer Energy Council of America
Aspen Energy Policy Forum
- Workshops: e.g. Security Workshop, Transmission & Distribution, Ethics and Changing Electricity Markets
- Press: *NY Times* and *Washington Post* Op-Eds, *The Wall Street Journal*, PBS, CNBC, answering reporters' questions
- Policy Literature: *Issues in Science & Technology*, *Science*, *ES&T*
- Scientific Publications