wind week

Integration Workshop

January 17th – 22nd , 2011

Introduction & Opening Remarks

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MIT Wind Week 2011: Wind Integration Workshop
January 21, 2011

The MIT Energy Community

- **Cutting-Edge Research and Education**
  - 200+ (of 1000) faculty working in energy
- **Vibrant Study Community**
  - 2000+ member MIT Energy Club
- **Active Entrepreneurship**
  - New companies constantly forming, MIT Clean Energy Prize, …
- **Strong Interdisciplinary Collaborations**
  - On-campus and with industry, government, NGOs, …
- **Engaged Alumni**
  - Mentoring students, new ventures, …

mitenergyclub

Mission: To create an integrated, well-educated MIT Energy Community across campus through events and initiatives focused on fact-based energy analysis

- Largest, most active student energy organization on MIT's campus
- 2000+ members (students from every academic department, alumni, community affiliates)
- Scientists, engineers, policymakers, entrepreneurs, investors
- Organized 600+ events since founding in 2004.

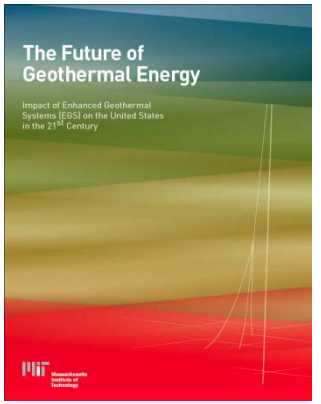
www.mitenergyclub.org

MITei

MIT Energy Initiative

An Institute-wide initiative designed to help transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems.

Outreach

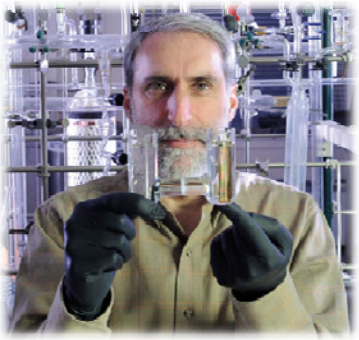


Campus Energy

greeningMIT

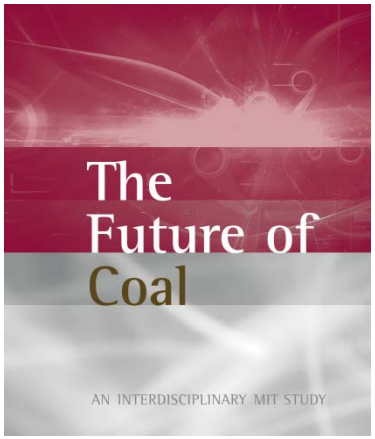
Education

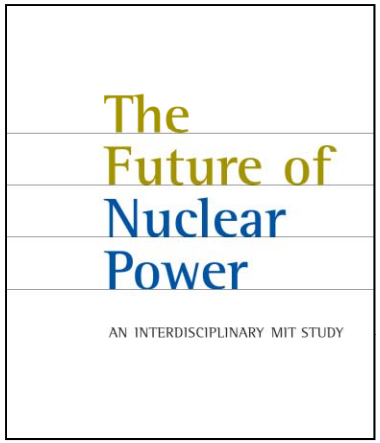
Research

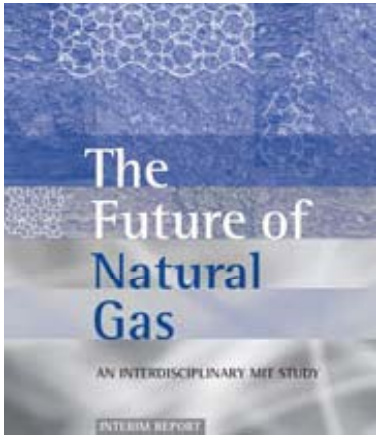


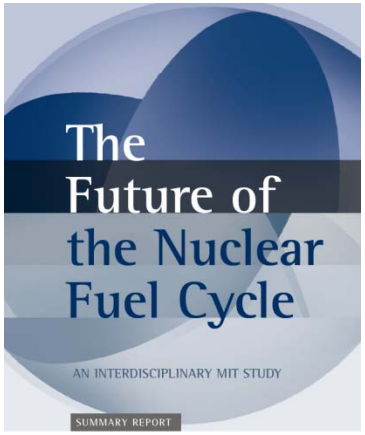
http://web.mit.edu/mitei/

MIT "FUTURE OF..." STUDIES









- MIT faculty have, over the last several years, conducted several ***in-depth multidisciplinary energy studies*** designed to inform future energy options, research, technology choices, and public policy development.

- These studies — ***grounded in science, supported by objective economic/policy analysis, comprehensive in scope and input*** — underscore MIT's role as an "honest broker" on energy issues.

"THE FUTURE OF THE GRID" MOTIVATION

- The US electric grid today faces a number of new challenges and, because of advances in technology, new opportunities.*

- We aim to provide an objective analysis of the new challenges and opportunities the US grid faces, focusing on two questions:
  - *Can existing institutions and policies be relied upon to meet the new challenges and seize the emerging opportunities?*
  - *If not, what changes are required?*

* There is also an enormous amount of hype around the "smart grid."

RESEARCH TEAM

Co-Directors:

- Richard Schmalensee
  Howard W Johnson Prof. of Economics and Management
  Former Dean, Sloan School of Management

Faculty/Staff:

- Khurram Afridi
  Visiting Associate Professor
  Electrical Engineering & Computer Science
- Gary DesGroseilliers (Executive Director)
  Executive Director
  MIT Future of the Electric Grid Study
- Amro Farid
  Visiting Professor
  Assistant Professor, Masdar Institute of Science and Technology
- Jerrold M. Grochow
  Former Vice President
  Information Services and Technology, MIT
- Timothy D. Heidel (Research Director)
  Postdoctoral Associate
  MIT Energy Initiative
- William Hogan
  Raymond Plank Professor of Global Energy Policy
  HEPG Research Director
  Mossavar-Rahmani Center for Business and Government
  John F. Kennedy School of Government, Harvard
- Henry D. Jacoby
  William F. Pounds Professor of Management Emeritus
  Professor of Applied Economics
  Center for Energy and Environmental Policy Research
- John G. Kassakian
  Professor of Electrical Engineering
  Former Director, Laboratory for Electromagnetic and Electronic Systems
- James L. Kirtley
  Professor
  Electrical Engineering & Computer Science
- Harvey Michaels
  Energy Efficiency Research Director/Lecturer
  Department of Urban Studies and Planning
- Ignacio Perez-Arriaga
  Visiting Professor
  Engineering Systems Division
- David J. Perreault
  Associate Professor
  Electrical Engineering & Computer Science
- Nancy L. Rose
  Professor
  Department of Economics
- Gerald L. Wilson
  Professor Emeritus
  Electrical Engineering & Computer Science
  Former Dean, School of Engineering

Students:

Nabi Abudaldah, Minjie Chen, Samantha Gunter, P. Jordan Kwok, Vivek A. Sakhrani, Jiankang Wang, Andrew Whitaker, Xiang Ling Yap

ADVISORY COMMITTEE

The Honorable J. Bennett Johnston, Jr.
MIT Future of the Electric Grid Study Advisory Committee Chairman
Former Chairman, U.S. Senate Committee on Energy and Natural Resources

- George W. Arnold
  National Coordinator for Smart Grid Interoperability
  National Institute of Standards and Technology
- Lisa M. Barton
  Vice President of Transmission Strategy and Business Development
  American Electric Power
- William W. Berry
  Former President, CEO, and Chairman
  Dominion Resources
- Robert Gilligan
  Vice President. Transmission and Distribution
  GE Energy Infrastructure
- Michael Howard
  Senior Vice President
  Research and Development
  Electric Power Research Institute
- Laura Ipsen
  Senior Vice President/General Manager, Smart Grid
  Cisco
- Paul Joskow
  President
  Alfred P. Sloan Foundation
- Elizabeth Anne “Betsy” Moler
  (Recently Retired)
  Former, Executive Vice President, Government Affairs and Public Policy, Exelon Corporation
- Pedro J. Pizarro
  Executive Vice President, Power Operations
  Southern California Edison
- Miguel Angel Sanchez Fornie
  Director, Systems Control & Telecommunications
  Iberdrola
- Basem Sarandah
  President and CEO
  Nexant, Inc.
- Charles J. Smith
  Executive Director
  Utility Wind Integration Group
- Peter Terwiesch
  Chief Technology Officer
  ABB Asea Brown Boveri, Ltd.
- Susan Tierney
  Managing Principal
  Analysis Group
- Gordon Van Welie
  President and CEO
  ISO New England Inc.
- Stephen G. Whitley
  President and CEO
  New York ISO

Key Grid Challenges and Opportunities

- Environmental/climate concerns potentially leading to more grid-scale renewables and requiring multi-state transmission expansion and changes to the operation of the power system
- Remote sensing and automated operating technologies that have the potential to increase transmission system capacity and reliability
- Policies favoring distributed generation and electric and plug-in hybrid vehicles, possibly requiring changes in distribution systems
- New technologies that can potentially make load more responsive to system conditions, thus reducing the need for peak capacity
- Increasing data communications within the grid, leading to increased cyber-security and information privacy challenges

DRAFT Study Outline

1. The Electric Grid: History, Challenges and Opportunities

2. Enhancing the Transmission System *(focused on new sensing and operational technologies)*

3. Integrating Large Scale Renewable Generation *(focused on system operation challenges with large scale variable generation)*

4. Transmission for Large Scale Renewable Generation *(focused on transmission planning, cost allocation, siting)*

5. Enhancing the Distribution System *(new distribution system technologies; distributed generation; electric vehicles)*

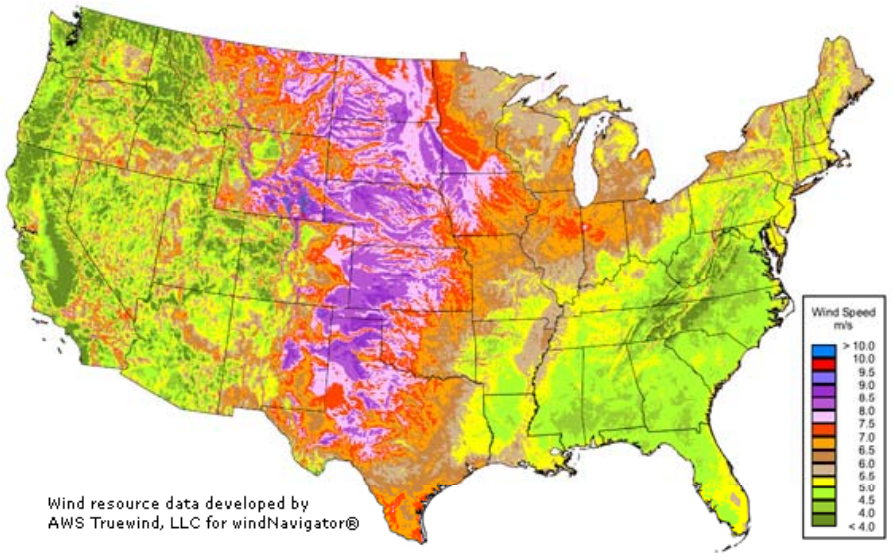
6. Engaging Electricity Customers *(new technologies, including AMI, that could enhance demand responsiveness to system conditions; consumer behavior)*

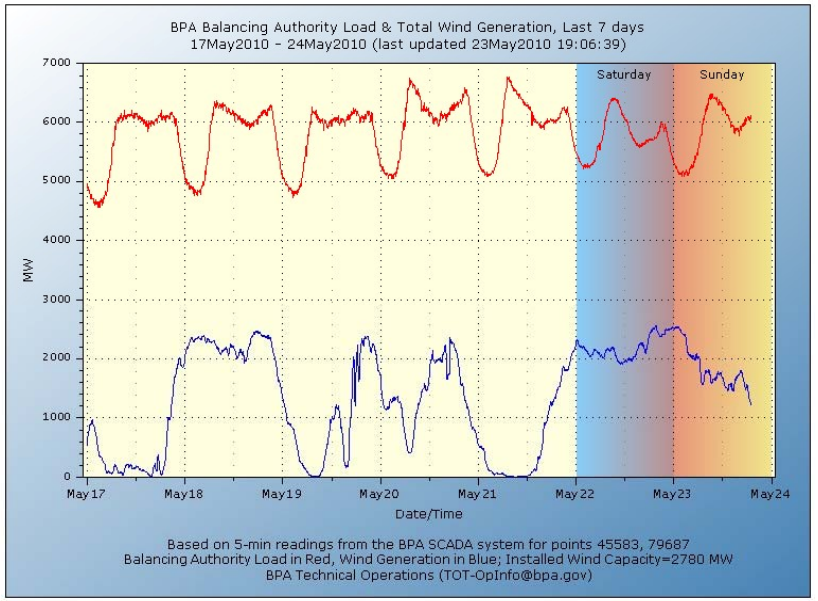
7. Distribution Regulation *(incentive regulation and rate design issues arising due to technology or demand changes)*

8. Data Communications, Cyber-Security, and Information Privacy

CHALLENGE: RENEWABLE GENERATION

- A variety of federal and state policies (including RPS, tax incentives, research funding, etc.) are accelerating growth in renewable generation.
- Wind is (and will likely remain) the leading renewable electricity generation technology.





→ High penetrations of wind generation will likely require more transmission. (Including transmission extending beyond traditional jurisdictional boundaries.)

→ Wind is variable and imperfectly predictable. Therefore, wind generation cannot be dispatched like conventional resources and poses system operation challenges.

CHALLENGE: RENEWABLE GENERATION

- Long-distance transmission for remote grid-scale renewables poses both technical and policy challenges:
  - Planning must now account for new goals ("policy lines")
  - Planning and allocating costs of transmission across traditional regional boundaries is difficult (currently use ad hoc, case-by-case processes)
  - A natural tension exists between establishing (more) standardized processes while accommodating significant regional differences.
- Distributed renewables (e.g., rooftop solar, small-scale wind) pose different technical and policy challenges
  - May need to configure distribution systems for two-way power flow to maintain worker safety, power quality, and reliability
  - Must provide incentives for the necessary investment – even though it will lead to lower sales; need sophisticated "uncoupling"?

CHALLENGE: RENEWABLE GENERATION

- Variability and uncertainty of power output complicates power system operation.

- A wide variety of "tools" that could mitigate the impacts of variable renewable generation have been proposed.
  - Tools that aim to **reduce the effective variability and uncertainty** include forecasting, coordination between balance areas, and market design.
  - **Tools that reduce the impact of variability and uncertainty include** flexible generation, curtailment procedures, demand response, and storage.
  - The efficacy of these "tools" will be limited by **exacerbating factors** (transmission constraints and loss of system inertia). They may also be limited by existing policy and/or regulatory frameworks.

- Ongoing research and development efforts are trying to assess the full potential and feasibility of each these tools.