Working to Build the Future Workforce in Electric Power and Energy

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Prepared for the National Research Council's
Energy and Mining Workforce Committee
August 22, 2011

Objectives

- Provide an overview of the work that is being done to prepare the future electric power and energy workforce
- Suggest workforce questions, issues and opportunities, with a particular emphasis on the grid as requested by the Committee
- Identify sources of recommendations for addressing energy workforce challenges

Overview

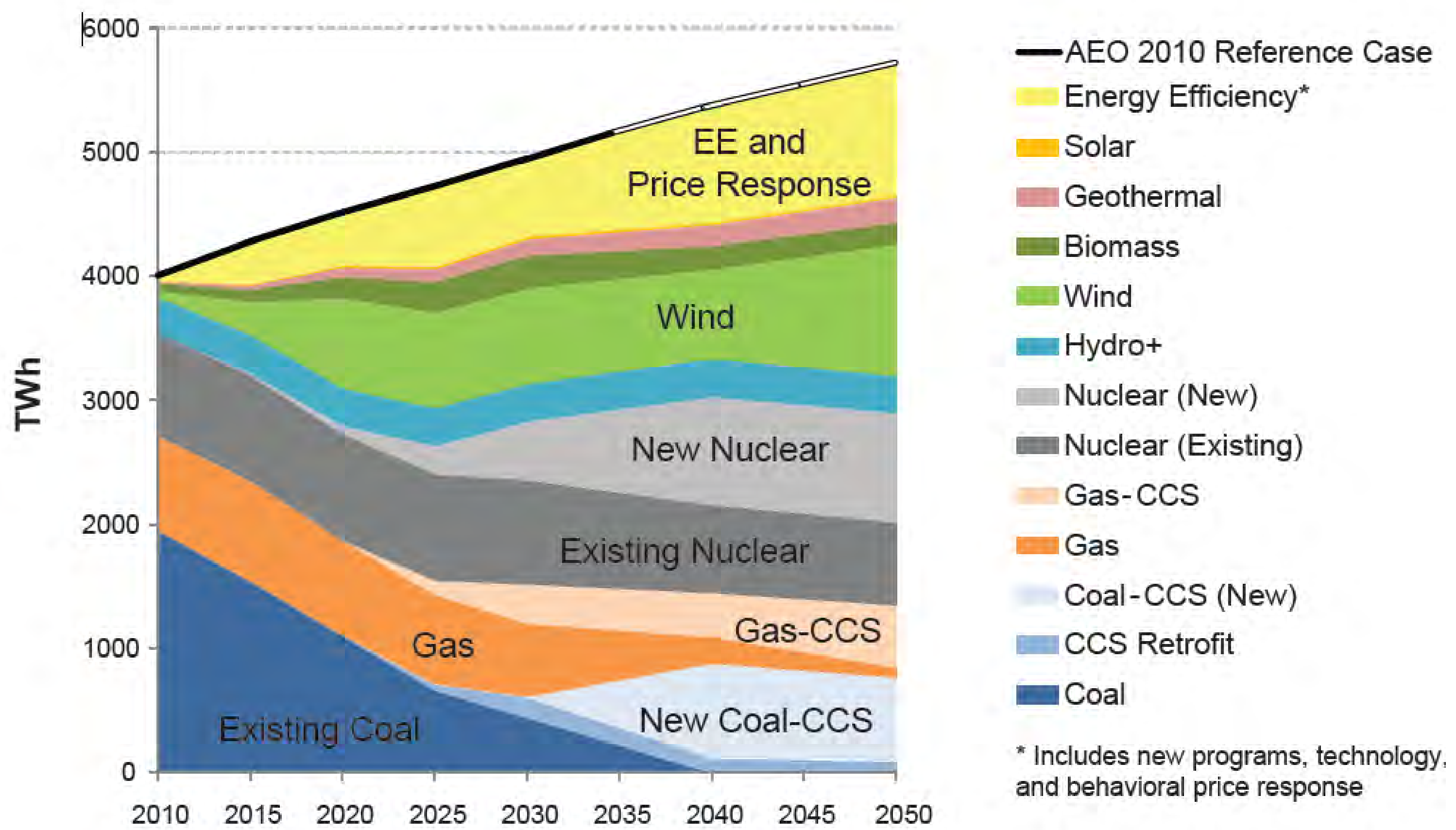
- National concerns
  - effects on grid reliability and capability of losing knowledge and expertise due to retirements
  - filling the pipeline of students
  - improving employability and retention
  - achieving effective education
- As a nation, is the scale, scope and effectiveness of how we are responding to these concerns sufficient to build the workforce of the future?

Drivers of Workforce Requirements in the Electric Energy Sector

- Electric demand growing via electrification.
- Infrastructure is aging (already old).
- Retirements are increasing while younger, less experienced, culturally different workers, are entering the workforce.
- Grid modernization has become a priority.
- Societal needs are changing (e.g., goals for high penetration of renewable generation, more customer engagement)

Electrification Trend

- ~1% annual growth to 2035 (EIA 2011 Annual Energy Outlook)
- Broadening portfolio of ways to meet the need

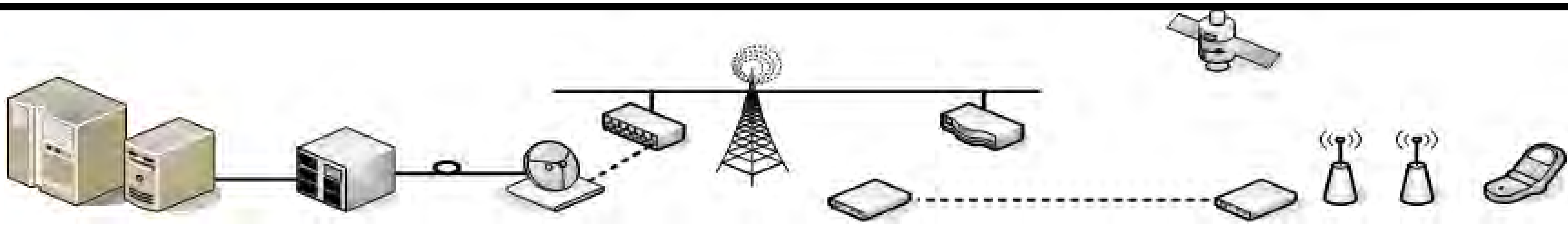


Bryan Hannegan,"Prism 2.0: Preliminary Insights from EPRI's Regional Model." Presentation at the EPRI 2010 Summer Seminar. August 2, 2010.

Major Investments Needed

- $1.5 to $2.0 Trillion by 2030 with $880 B for transmission and distribution (Brattle Group 2008)
- $338 to $476 Billion for Smart Grid investments until 2020 (EPRI 2011)
- Examples
  - Transportation electrification
  - Transmission integrating renewable generation
  - Replacing aging infrastructure
  - Climate change: adaptation and mitigation

Storage, Sensors, Self-Healing… in the Grid



Communication Media: BPL, Wi-Max, Satellite, Fiber, DSL, Wi-Fi, RF Mesh, etc.

Smart Grid Infrastructure: Software/database, network communication and monitoring, and control architecture

Renewables Integration	Substation/Feeder Integration	Self Healing	Residential Customer Demand Response Integration
			

Smart Grid: System Functions vs. Customer Functions

Smart Grid Brings New Challenges

- Interoperability
- Cybersecurity
- Grid reliability
- System monitoring, control and protection
- Communications
- Decentralized vs. centralized control
- Customer engagement
- Capital investment (utility, users)
- Access to information vs. privacy

Electric Energy Jobs

- Electric generation, transmission, distribution (400,000 est.)
- 1/3 lineworkers, plant/field operators, technicians, pipefitters/field operators. 6% engineers. May 2009 BLS estimate of utility electrical engineers in generation, transmission and distribution: 13,530.
- Manufacturing, services (engineering, design, etc.), industrial energy users, other industries (aerospace, ship-building, etc.)

Utility Energy Field	2009 National Jobs
Electric Distribution	149,375
Fossil	141,229
Nuclear	56,410
Natural Gas Distribution	112,883
Bulk Transmission	28,877
Other	10,370
Total	535,085

Center for Energy Workforce Development (2009)

More Information Needed

- Extent to which contracted labor and out-sourcing is substituting for in-house labor.
  - Effects on building the future workforce?
  - Effects on workforce need estimates?
- Current and future role of non-US citizens
  - Limits on hiring non-US citizens without a green card (i.e., security, cost of processing visas, etc.)

Examples of New Workforce Needs

- 2022: 150,000 professional and skilled craft for construction
- By 2030: 60,000 to operate and maintain electric generation systems
- 10,000-15,000 to construct transmission facilities
- 90,000 for smart grid (while 25,000 will be redeployed)
- 11,000 for energy efficiency

Task Force on America’s Future Energy Jobs. June 2011

A Projection for a Smart Grid

- Short-term: 280,000 new positions from smart grid projects
- Long-term: 140,000 “high value” jobs
- Also loss of jobs due to new technology
- Big boost for equipment suppliers, suppliers of enabled services of distribution smart grid services

The US Smart Grid Revolution:
KEMA's Perspectives for Job Creation. 2009.

DOE Workforce Trends Report

- Analysis of lineworker and T&D engineers supply and demand (BLS, DOL)
  - Shortage of lineworkers (>45,000) – most acute in 2010. (Note: CEWD 2009 estimate = 69,000)
  - No forecasted shortage in power engineers (11,000) (Note: jobs estimate only includes utilities)
- Recommendations to Congress
  - Foster math and science education
  - Build interest in energy-related careers
  - Note: viewed as long-term solution

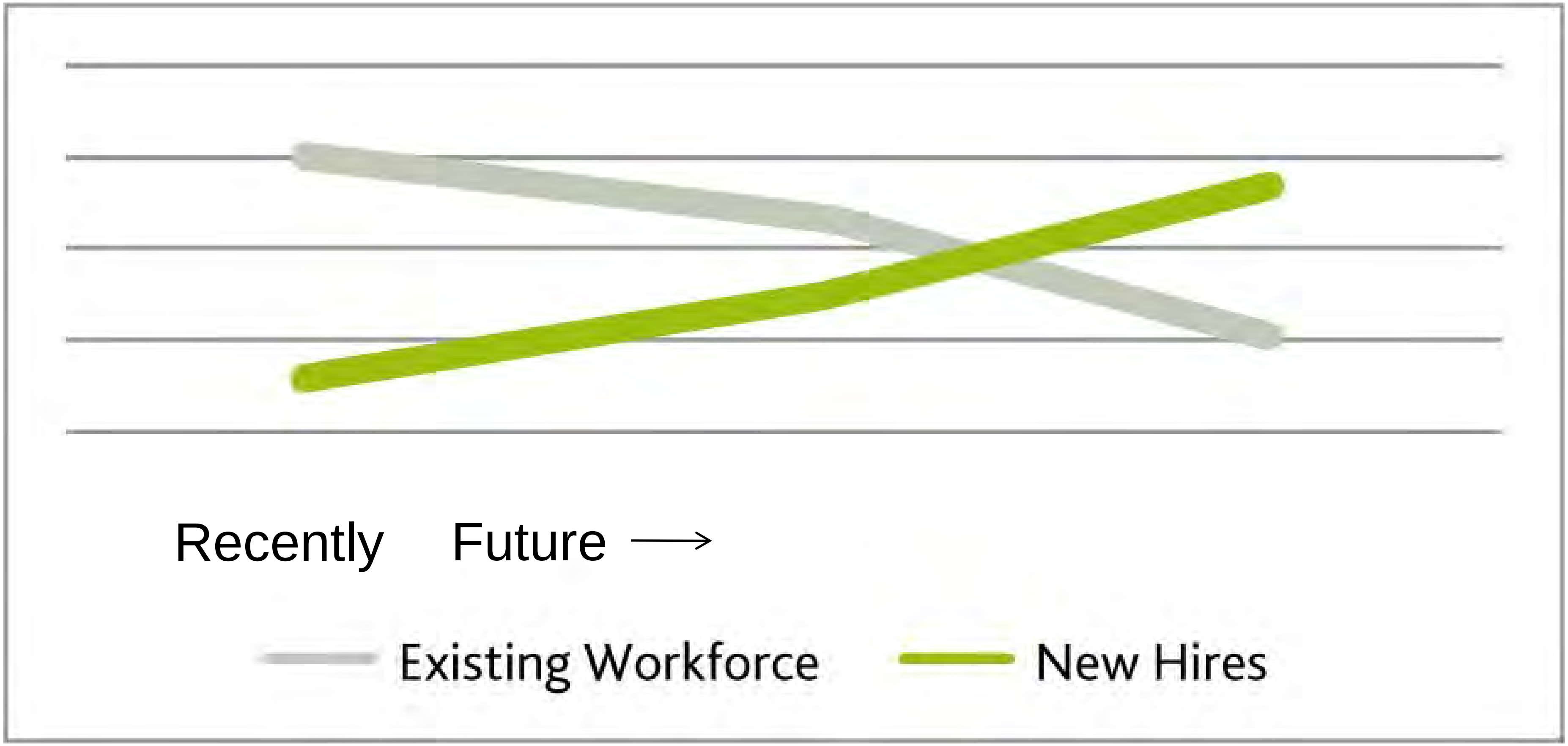
Workforce Trends in the Electric Utility Industry. A Report to the US Congress Pursuant to Section 1101 of the Energy Policy Act of 2005. U.S. DOE. August 2006.

CEWD 2009 Survey: Employee Losses through 2015

Job Category	Percentage of Potential Attrition & Retirements	Estimated Number of Replacements
Technicians	50.7	27,800
Non-Nuclear Plant Operators	49.2	12,300
Engineers	51.1	16,400
Pipefitters / Pipelayers	46.1	8,900
Lineworkers	42.1	30,800

Gaps in the Energy Workforce Pipeline: 2009 CEWD Survey Results. Center for Energy Workforce Development. Based on 535,000 est. of employees in electric utilities and integrated electric and gas utilities. Due to delayed retirement plans, the Task Force on America's Energy Jobs postulated a "silver tsunami" may occur when retirements actually occur.

Characterizing the Cumulative Workforce Needs Over Time



Note: More data needed to add substance to this chart.

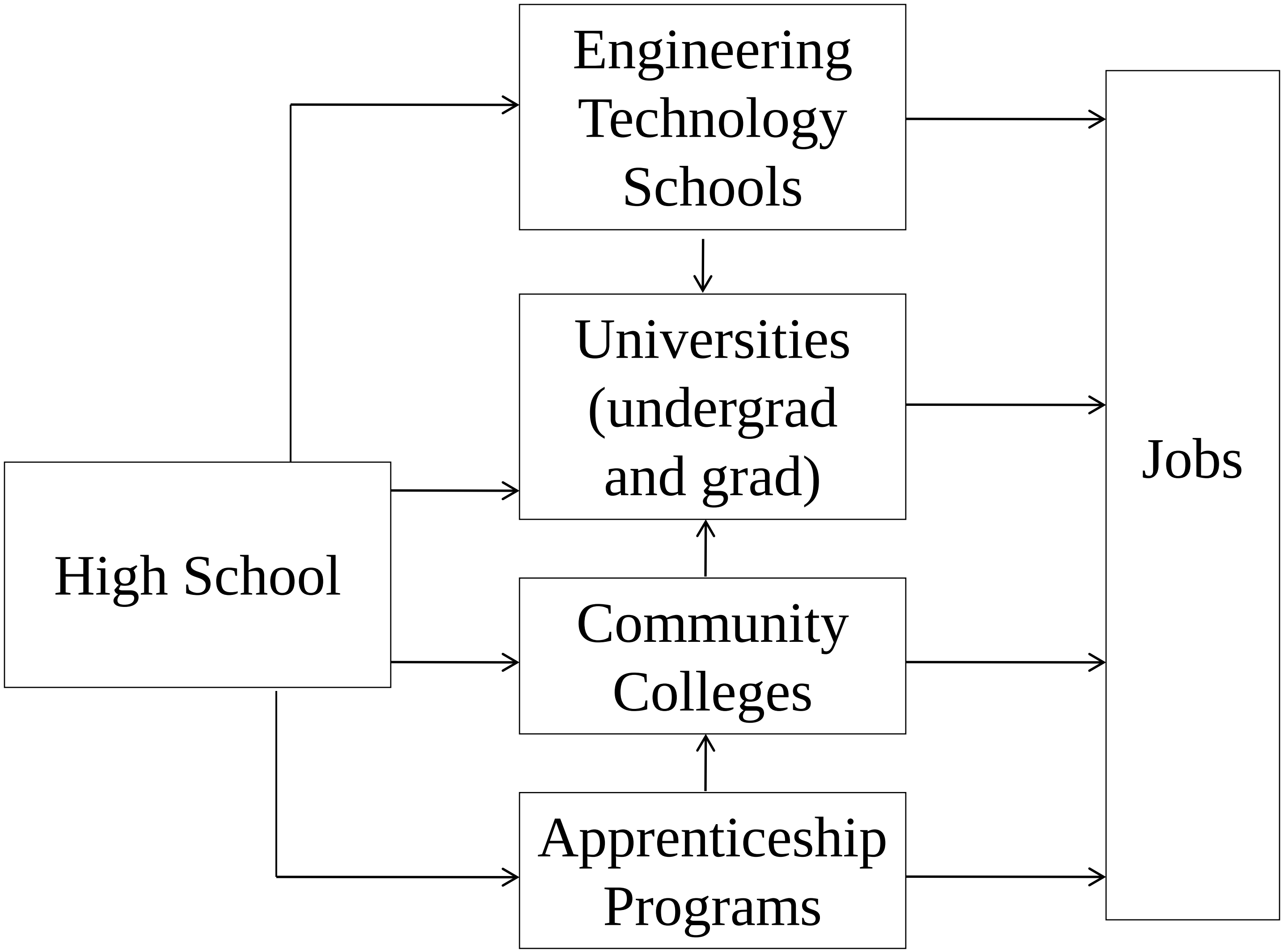
The reliability of the North American electric utility grid is dependent on the accumulated experience and technical expertise of those who design and operate the system. As the rapidly aging workforce leaves the industry over the next five to ten years, the challenge to the electric utility industry will be to fill this void…

2006 Long-Term Reliability Assessment
North American Electric Reliability Corp.
See also the *2007 Long-Term Reliability Assessment*.

Hiring

- Hiring experienced engineers is a critical need (relatively low number mid-career engineers).
- Hiring slow now in utilities, but not as much so for other companies.
- Utilities more likely to hire BS grads than MS/PhD grads.
- Hiring of international students not done or limited in many companies.
  - More likely to be done in manufacturing, engineering services, consultants, research organizations.
- Median salaries for power engineers lowest among major EE fields

Conventional Education Pathways



Additional Training Opportunities

- Utilities are finding that fewer new applicants can pass the background checks, drug screening and pre-employment tests.
- Pass rates on pre-employment tests:<50%
- Company-sponsored training
- Courses before pre-employment testing
- Boot camps (e.g., low-income initiative targeting 16-26 year olds by Center for Energy Workforce Development)
  - Industry fundamentals
  - Lineworker, line construction
- Professional development
- Retraining engineers for an energy career

Challenges

- Getting students interested and prepared for energy jobs or post-high school education
- Improving diversity in the workforce and reaching targeted segments
- Providing support for students to get and keep them committed to energy careers
- Advancing education value, quality and cost efficiency

Career-Choice Decision Factors

- What made you decide on your career path?
  - Interesting career (67%)
  - Opportunity to help solve significant societal challenges (38%)
  - Make the world a better place to live (33%)
  - Good pay opportunities (30%)
  - High likelihood of getting a job (20%)

IEEE PES International Survey of Power Engineering Students
June 2007

Influential People in Career Choices

- Who influenced your career choice?
  - Guidance counselor/mentor/teacher (26%)
  - Talking with people in the industry (22%)
  - Parent's suggestions (12%)
  - Friend's suggestions (6%)
  - Media (2%)

IEEE PES International Survey of Power Engineering Students
June 2007

Making Face to Face Contacts

FPL is committed to education

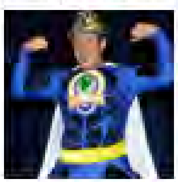
Whether it's energy conservation discussions in grade school classrooms or nuclear science training at universities, FPL is passionately committed to education. Through FPL's continued support, employees and their communities are able to engage in numerous educational opportunities.

Professor Whys

This interactive show teaches kids in public schools the science behind electricity

+ Learn More

Captain Conservation



FPL's energy conservation superhero offers an educational program for public schools

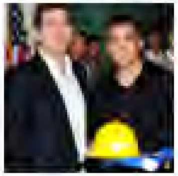
+ Learn More

Solar Stations

This program promotes solar education in schools and offer grants that teach about energy

+ Learn More

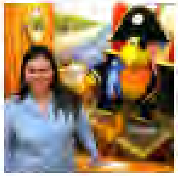
Workplace Partnerships



FPL has created job-training programs with local communities and state colleges

+ Learn More

Energy Encounter



Visit over 30 interactive displays on energy, electricity, nuclear power and the environment

+ Learn More

FPL for Kids

Educational games, experiments and information for kids, parents and teachers

+ Learn More

Developing Effective Websites

Stimulating Competitions

IEEE PES Smart Grid Competition, DOE's National Science Bowl, FIRST Family of Programs, …

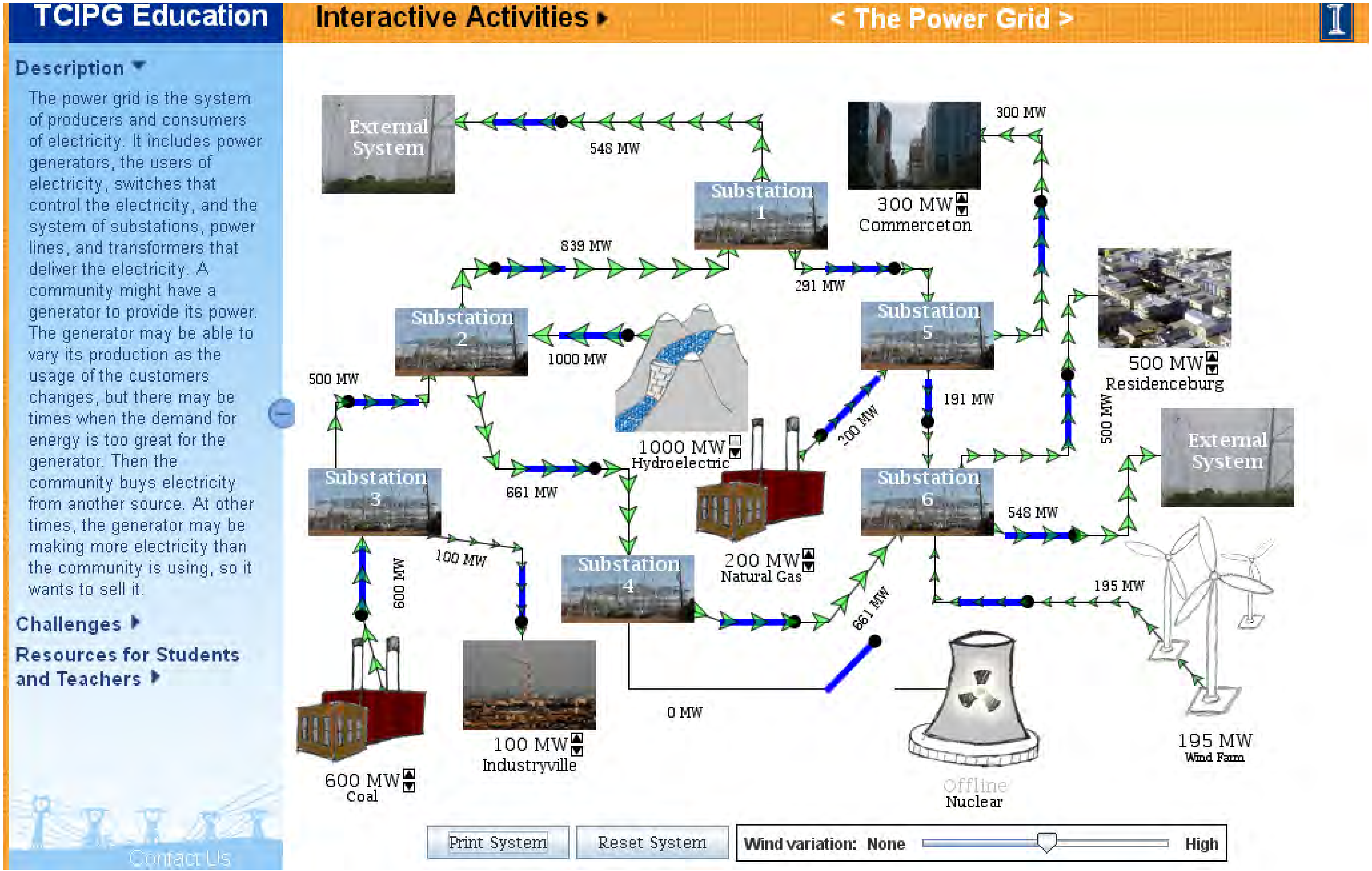
Creating Motivational Videos

"The Power Industry Needs You – Why Choose Power as a Career?"
IEEE Power & Energy Society, 2010

Reaching Out to Targeted Sectors

Supporting Teachers

Lesson plans, materials, applets, guest speakers, targeted learning programs, academies, field trips, NSF research experiences, etc.



Two Efforts to Help Teachers

- National Energy Education Development Project: a comprehensive energy education project
- National Energy Foundation: Promotes, and provides resources for, education related primarily to energy, water, natural resources, science and math, technology, conservation…

Questions

- Will the future political environment support continuation or growth of the outreach efforts?
  - Outreach to K-12 requires resources and time
- What is the scale, scope and effectiveness of the efforts at schools nationwide? Is it sufficient?
- How can entrepreneurial development of curricular support (e.g., lesson plans, applets) be made more effective?
  - No guidelines. Need to help "developers" produce and market good products.

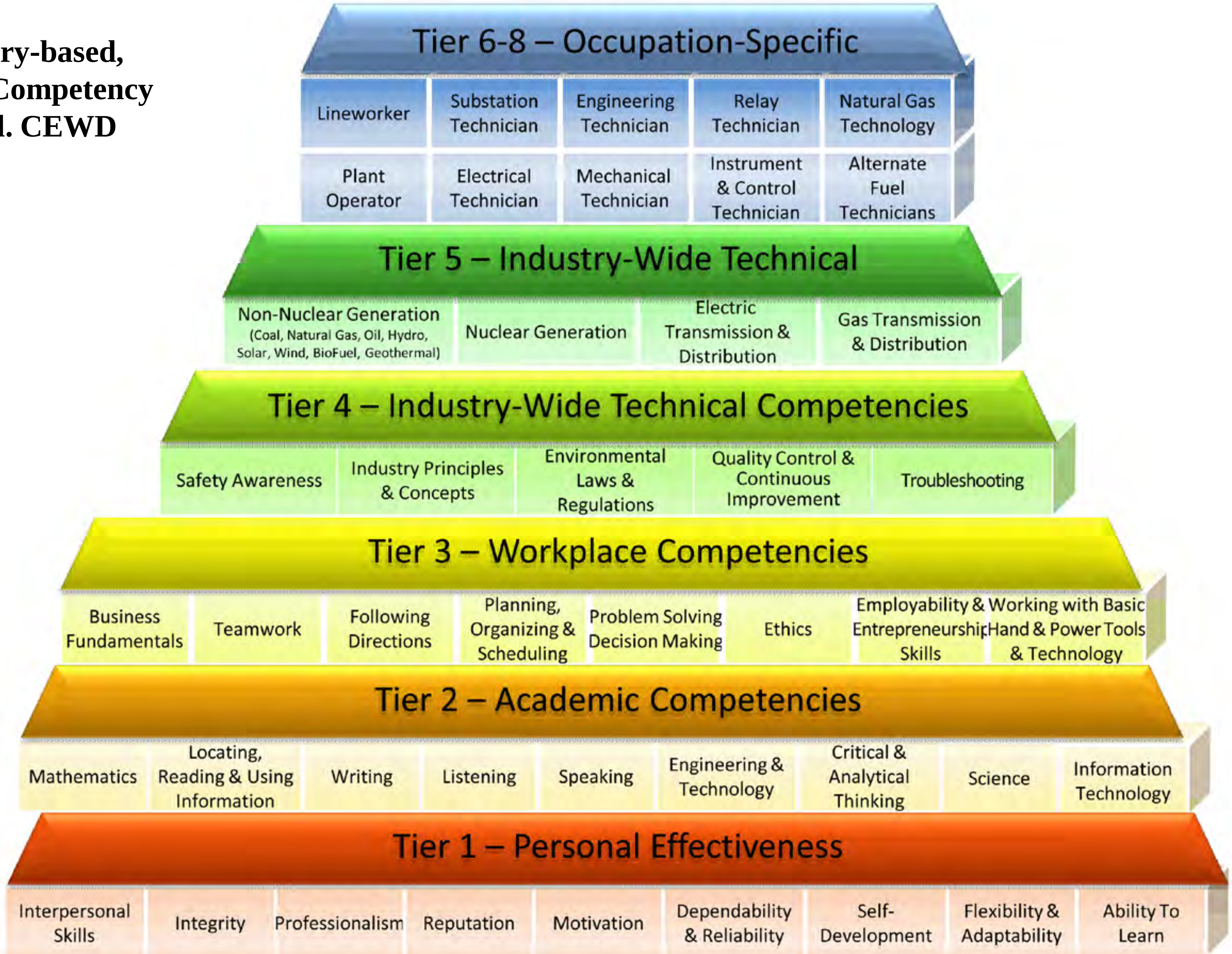
Creating Systematic Career Pathways Programs

CEWD Get Intro Energy Career Pathway Model

- Provide outreach and support to students and potential applicants (e.g., career awareness, mentoring)
- Provide an education framework for career preparation (e.g., stackable credentials, uniform curriculum, education network)
- Encourage partnerships, building on the Energy Workforce Consortia model (28 state consortia in operation)

Educating within a Framework

Industry-based, Energy Competency Model. CEWD



Supporting Students – University Example

IEEE Power & Energy Society's Scholarship Plus Initiative™ to encourage university students to pursue power and energy engineering careers

- Now selecting first scholarship awardees
- Funding
  - PES provided $1,000,000 seed funding
  - Target goal of $10M in philanthropic donations over 2 years
- Offering
  - Providing scholarship support: $2,000, $2,000 and $3,000 in years 1, 2 and 3. Likely to raise scholarship level next year.
  - Facilitating mentoring and career experiences for the awardees
  - Targeting U.S. citizens or permanent residents

University Power Engineering Programs

- Universities with power engineering courses and graduate students: over 100
  - Faculty sizes, number of courses, number of students vary considerably
  - Number of substantial programs: perhaps 20-30
- The Numbers
  - 200 (est.) full-time equivalent faculty / instructors in power engineering
  - 40% (est.) of university power engineering faculty eligible for retirement by 2013. Perhaps one-half will do so.
  - 1,500 (est.) graduating undergrads, 550 enrolled Masters, 550 enrolled Ph.D.'s

Challenge: Getting the Data

- Undergrads usually don’t declare concentrations
- Detailed faculty data on power engineering not regularly available
- Course offerings, faculty retirement data, etc. generally not available from typical sources
- Coming soon: IEEE PES Power & Energy Education Committee Survey of Higher Education

University Power Engineering Program Trends to Mid-2000's

- Declining student enrollments except at the doctoral level
- Untenured faculty declined from 20% in early 90s to 12% of total (takes 5-6 years to get tenure)
- Approximately 3 faculty members hired for every 4 that left
- Reported total research funding per institution declined.

IEEE PES Power Energy Education Committee Survey Results for Various Academic Years. Informal surveys. See also "Professional Resources to Implement the Smart Grid." Heydt, et.al. 2009.

Recent Trends

- Course enrollments rising
- New focus on energy engineering rather than just electric power – often multidisciplinary
- New or rejuvenated programs, some with smart grid theme. Advice for new programs funded by NSF and Office of Naval Research.
- Increasing variety in delivery methods (On-line, on-site, etc.)
- Faculty hiring: temporarily jumped following ARRA funding for smart grid deployment
- Losses in historically strong research universities not being corrected due to lack of research support

Growth In Undergrad Engineering Enrollments: 2007-2010

Engineering Field	Growth
All Engineering	16.9%
Mechanical Engineering	16.9%
Civil Engineering	13.2%
Electrical/Computer Engineering	6.8%

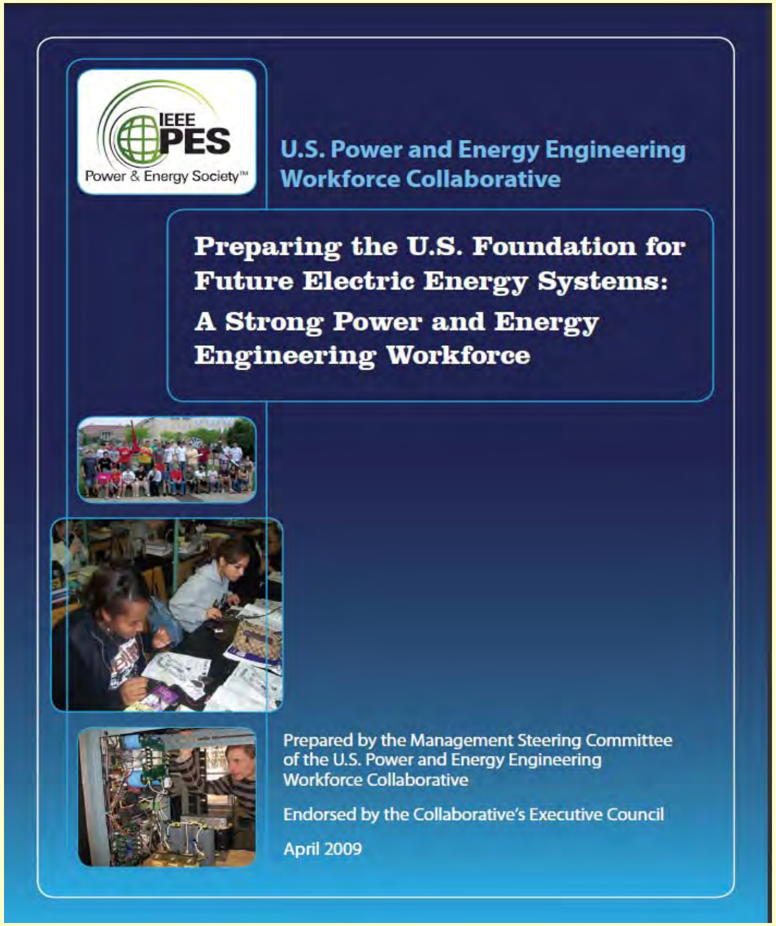
Profiles of Engineering & Engineering Technology Colleges. 2010 Edition. American Society for Engineering Education.

2007 Future Power Engineer Workforce NSF Workshop Recommendations

- Create a single, collaborative voice for workforce solutions
- Paint future challenges to enhance the image and increase interest in related careers
- Stimulate interest and prepare students for a post-high school engineering education
- Make the higher education experience relevant, stimulating and effective
- Strengthen the case to build, enhance and sustain university programs
- Increase university research funding to find innovative solutions and enhance student education

PES Workforce Collaborative Goals

1. Double the number of power graduates
2. Provide $4 million undergraduate power engineering scholarships
3. Create 2,000 internship opportunities
4. Hire 80 new power faculty members in the US over the next five years
5. Raise annual university research funding to $50 million per year
6. Create five University Centers of Excellence to conduct power research and education



In easy-to-reference lists, the report outlines specific steps for industry, government and educators to meet these goals.

Without strong support for strategic research in power systems engineering and without qualified replacements for retiring faculty, the strength of our Nation’s university-based power engineering programs will wane, and along with them, the foundation for innovation in the power sector to meet our energy challenges in the 21st century.

Workforce Trends in the Electric Utility Industry, U.S. DOE, August 2006.

Without a sizable research portfolio, it is not possible for a disciplinary area such as electric power to get new faculty positions or resources.

Professor Vijay Vittal, Director, Power Systems Engineering Research Center in filed comments to FERC in RM06-16, July 2006.

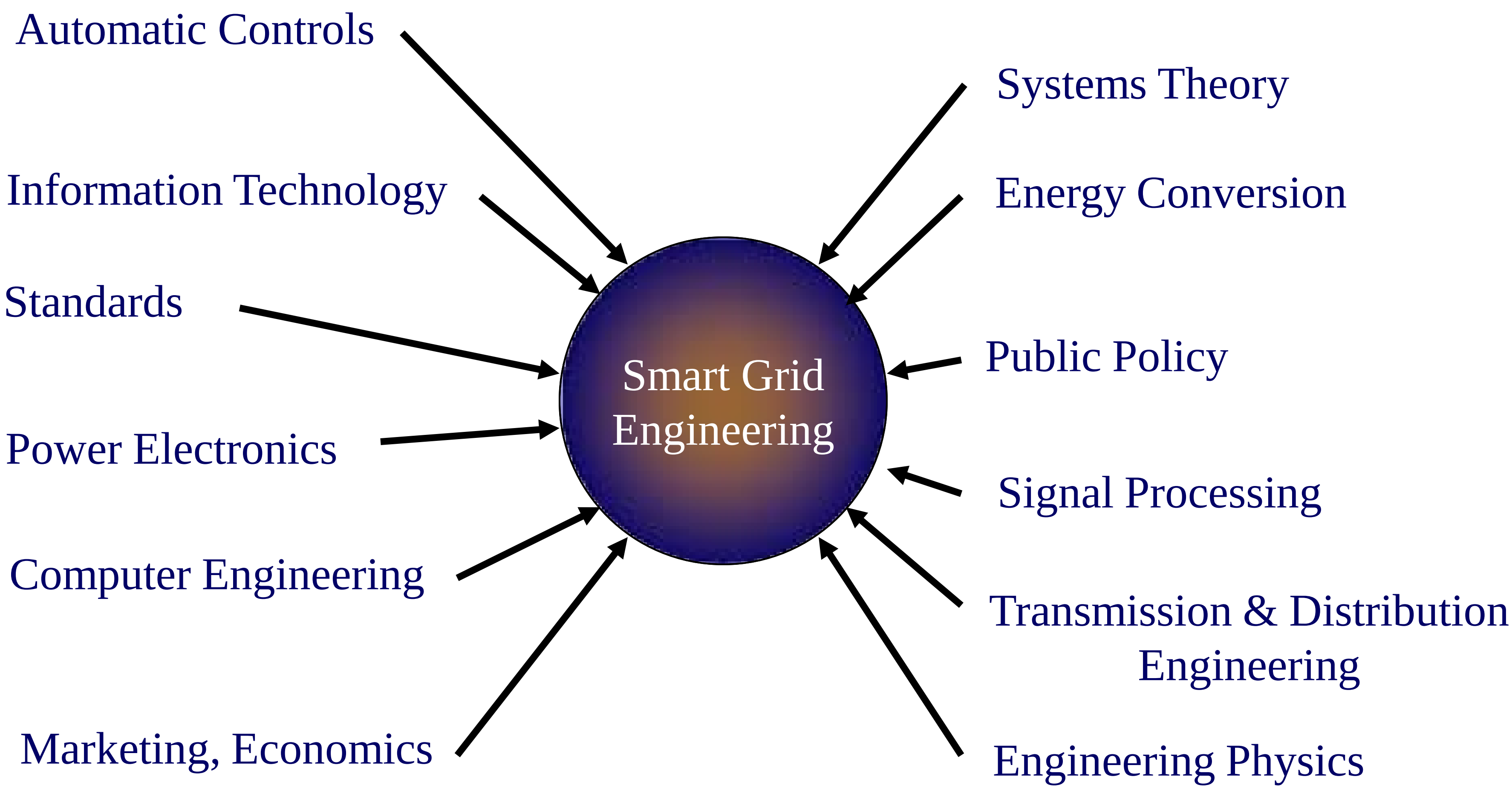
University administrations need to know there is a long term commitment to university research in the area. The students need to know there are high paying, interesting jobs.

Professor Robert J. Thomas, Cornell University, in “Meeting the Twin Challenges of Education and an Aging Workforce in the Electric Power Industry.” *The CIP Report.* Nov. 2006.

Traditional Power Engineering Topics

Electric Machinery
Energy Conversion
Energy Development and Power Generation
Energy Management Systems
Energy System Design
High Voltage AC/DC, FACTS
Industrial and Commercial Power Systems
Motor Drives and Controls
Power Electronic Applications
Power Quality
Power System Relaying and Protection
Power System Stability and Control
Power System Transients
Power Systems Instrumentation and Measurement
Power Systems Operations, Planning

Smart Grid Engineering Components



"Professional Resources to Implement the 'Smart Grid' ". Gerald T. Heydt and others. North American Power Symposium, 2009.

Curriculum Enhancements

- Direct digital control
- Power system dynamics and stability
- Power quality and signal analysis
- "Middleware" migration
- Environmental and policy aspects
- Reliability and risk assessment
- Economic analysis, energy markets
- New concepts for power system monitoring, protection and control
- Communications, IT

"Professional Resources to Implement the 'Smart Grid' ", Gerald T. Heydt and others, North American Power Symposium, 2009.

Smart Grid Education Recommendations

- Design retraining programs that speak directly to the training gaps of existing electric energy industry workers;
- Design engineering and technical curricula for future employees that resonate with the needs of the smart grid workforce, such as broad analytical skills, strong engineering fundamentals, and strong business acumen
- Design retraining efforts to familiarize workers with smart grid technology and systems
- Educate current students who will be the smart grid workforce of tomorrow.

The US Smart Grid Revolution: Smart Grid Workforce Trends 2011. KEMA and GridWise Alliance. July 2011.

Smart Grid Competencies

The competencies required by lineworkers, power plant operators, relay and substation technicians, and other skilled craft positions in the electric energy industry will not change. New training will be required to understand the new technology and new procedures or protocols.

The Smart Grid Evolution: Impact on Skilled Utility Technician Positions. Center for Energy Workforce Development.

Smart Grid Education and Training Growing

- ARRA Funding: $100 million for 54 smart grid workforce training programs (universities, community colleges, utilities, vendors, etc.)
- Professional development: universities, EPRI, vendors, consultants, professional societies, associations, national labs, unions, etc.
- PSERC Future Grid Initiative – creating courses, materials and reference videos

IEEE Power & Energy Society

- The PES Plain Talk Courses For Non-Engineering Power Professionals
  - Power System Basics: Electric Utility Operation Inside and Out
  - Distribution System: Delivering Power to the Customer
  - Transmission System: The Interconnected Bulk Electric System

- IEEE eLearning Smart Grid 101 Series
- Distribution Automation – an Enabling Technology for Smart Grid
- Cyber Security for the Smart Grid
- NIST Smart Grid Conceptual Model
- Smart Devices for the Smart Grid
- Smart Grid Integration
- Standards for the Smart Grid
- The “Smarter” Grid – What is it?
- Smart Grid: From Concept to Reality

Smart Grid Education Challenges

- Education and training needs evolving
  - Body of knowledge still growing
  - Applications using the data are still being developed.
  - Programs, practices and standards still in-progress.
- Number of employees actually needing the information growing as deployment continues – but not every engineer and technician today
- Technical knowledge needs often are company-specific.
- Need for sound smart grid curricula and materials
- People still need the basic competencies.

Future Grid Education Challenges

- Understanding and quantifying uncertainty
- Decision-making under risk
- New analytical tools for operations and planning (still a work in progress)
- Multi-disciplinary balance (engineering, business, economics, public policy, etc.)
- Engineering curricula balance: power system fundamentals vs. energy systems, power electronics, communications, IT, etc.

Education: Value, Quality, and Sustainability

- Describe and track use of the nation's energy education systems
- Develop an effective, portable national credentialing system (positive value proposition may drive this)
- Conduct evaluations to see what is working, what is not, and why
    - Look for big impact opportunities (having many diffuse, uncoordinated, "one-off", activities may not be enough)

Education: Value, Quality, and Sustainability

- Systematically collect and openly disseminate foundational competency expectations for employment. Share methods for identifying those expectations.
- Explore ways to promote sharing of training and education materials.
  - Look where common curricula could be developed or education modules shared.

Education: Value, Quality, and Sustainability

- Establish business models for sustainable education and training programs
  - Develop and get institutional support for a transparent process for creating effective education and training materials that can be used by K-12 teachers
- Encourage collaboration and dialog on effective education and training practices
  - Share lessons learned
  - Expand the body of knowledge, such as National Academies report “Successful STEM Education: A Workshop Summary”. Make reports accessible to a broad audience.

Recommendations from Task Force on American's Jobs

- Establish regional, multi-stakeholder workforce consortia
- Improve data collection
- Best practices and training standards for energy sector jobs
- Support for individuals
- Education and career counseling

Task Force on America's Future Energy Jobs.
National Commission on Energy Policy. June 2011.

Recommendations from the 100 Day Energy Action Plan

- Direct the Secretary of Labor to create a $300 million “Clean Energy Workforce Readiness Program,” augmented by state and private sector funding, to foster partnerships between the energy industry, universities, community colleges, workforce boards, technical schools, labor unions and the U.S. military to attract, train and retain the full range of skilled workers for America’s clean energy industries.
- Require all federal agencies to commit 1 percent of their R&D budgets to competitive, portable undergraduate and graduate fellowships in energy-related disciplines for American students.
- Direct the Secretary of Labor to assess, classify and widely publicize the demand-driven needs for energy-related occupations and align federal workforce investment programs and state-directed resources to support skills training and career path development in energy fields for American citizens.

Prioritize: A 100-Day Energy Action Plan for the Next President.
Council on Competitiveness. 2008.

Managing the Workforce Transition to Reduce Loss of Knowledge

- Workforce planning: identification and evaluation of knowledge and skills at risk and strategies to address the risk.
- Automating: applying technology to complete tasks.
- Recording: putting knowledge into accessible records.
- Educating: transferring knowledge to the next generation of engineers and technicians.
- Hiring retirees to help.

"Strategies to Address the Problem of Exiting Expertise in the Electric Power Industry." Dennis Ray and Bill Snyder. 2005.

Work “place” Challenges

- Understanding and responding to the differences between younger and older generations
- Getting flexibility for succession planning when the pressure is to keep employment low (and to minimize energy price increases)
- Maintaining morale and career excitement while providing quality training when the pressure is for rapid organizational change (e.g., wind energy integration)
- Retention challenging when cost-control is a priority.

Researchable Questions

- What is the current state of the energy education system? What are the implications of state and federal funding cut-backs?
- What knowledge and skills need to be learned? What are effective education/training frameworks and methods? Why?
- What will the long-term demand be for workers? What are the options for meeting the demand and how should those options be evaluated?

For the National Academies

- National Academies have been helping!
  - Successful STEM Education: A Workshop Summary
  - Engineer Girl: http://www.engineergirl.org
  - Engineer Your Life: http://www.engineeryourlife.org
  - Changing the Conversation: http://engineeringmessages.org
  - Rising Above the Gathering Storm
  - And more…
- What more could the National Academies do?
  - Present work to reach broader audiences,
  - Coordinate with related efforts
  - Engage the various communities in fruitful discussions

Will we have the workforce we need in the coming years?

- Do we have a plan or coordinated plans?
- Are the programs working? Are they sustainable?
- Do we see the needed number of students in the pipeline?
- Are we collaborating better?
- Are we less stressed about the workforce outlook?

Who’s Responsible for Solutions

- Universities
- Community Colleges
- K-12 teachers, counselors, admin.
- Parents
- K-12 service organizations
- Research organizations
- Professional societies
- Industry associations
- Employers
- North American Electric Reliability Corp.
- CEWD
- State regulators
- Federal regulators
- National regulatory associations
- Congress
- State legislatures
- State workforce agencies
- Department of Labor
- Department of Energy
- National Science Foundation
- State and national consortia
- National Academies
- And many more

References by Slide Number

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FPL is Committed to Education Website (Slide 23)

Get into Energy Website (Slide 24)

FIRST Website (Slide 25)

The Power Industry Needs You – Why Choose Power as a Career? Video. IEEE Power & Energy Society. 2010. (Slide 26)

Helmets to Hardhats Website. See also Troops to Energy Jobs. Center for Energy Workforce Development. (Slide 27)

The Power Grid Tutorial. Trustworthy Cyber Infrastructure for the Power Grid. University of Illinois at Urbana/Champaign (Slide 28)

National Energy Education Development Project (Slide 29)

National Energy Foundation Website (Slide 29)

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