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Professional Resources to Implement the "Smart Grid"

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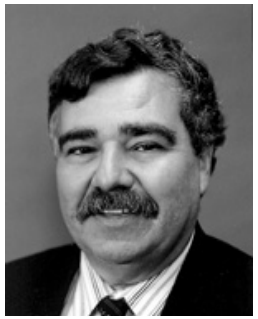
PSERC

WICHITA STATE UNIVERSITY



THE UNIVERSITY of WISCONSIN MADISON

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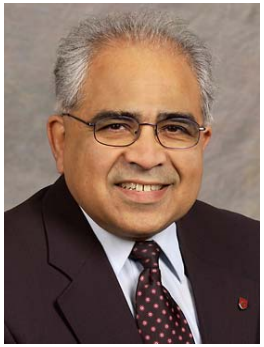
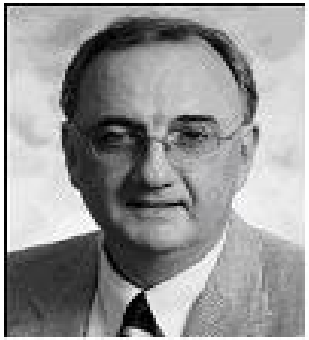
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN





WASHINGTON STATE UNIVERSITY

A&M

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCIENCE with PRACTICE

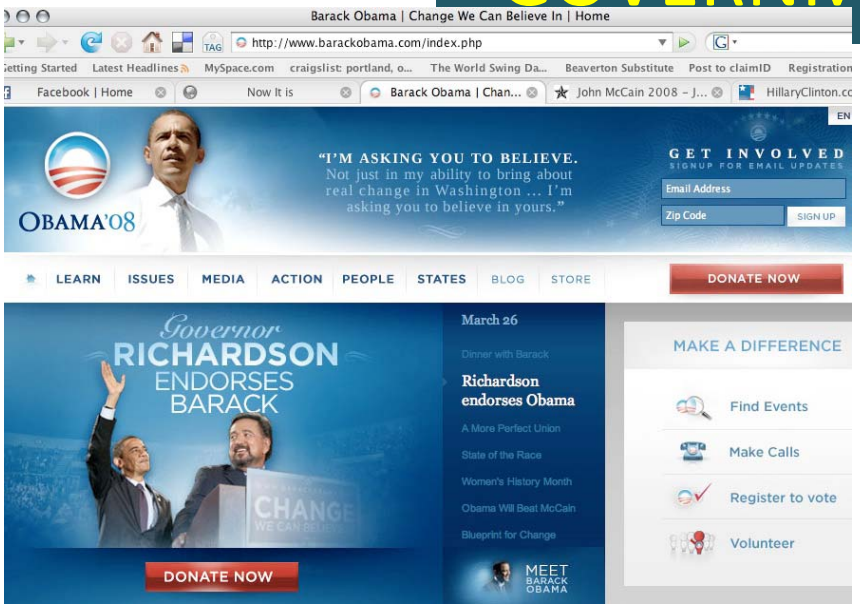
ASU

Motivation

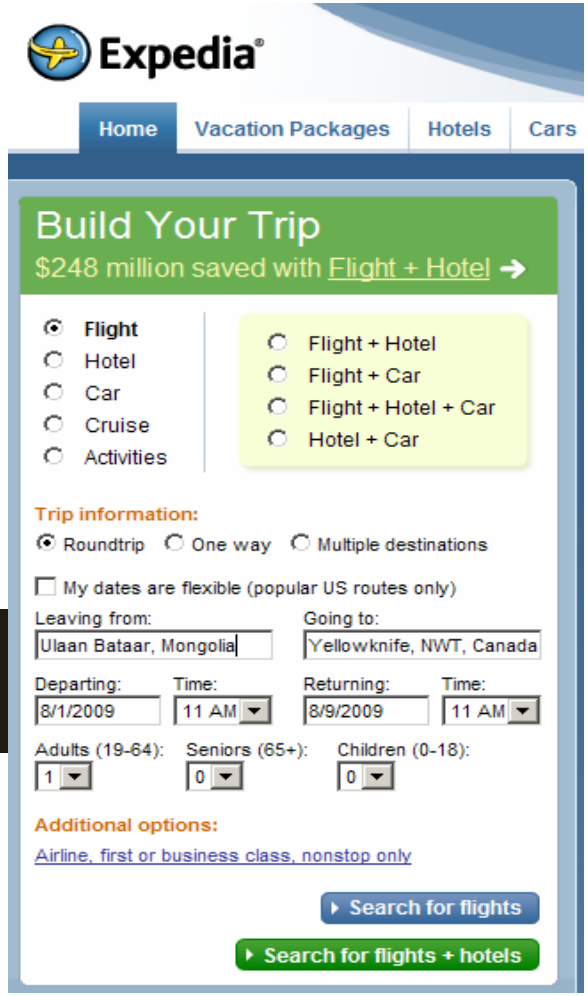
MANY CIVIL INFRASTRUCTURES

TELEPHONE

GOVERNMENT



TRAVEL



What is the main contemporary driving force in engineering today?

What strategy can be followed to implement sustainability, reliability, and energy availability?

What will the next generation of power and energy systems be like?

INTEGRATION OF DIGITAL TOOLS INTO POWER ENGINEERING: REALIZING THE FULL PROMISE OF THE INTERNET

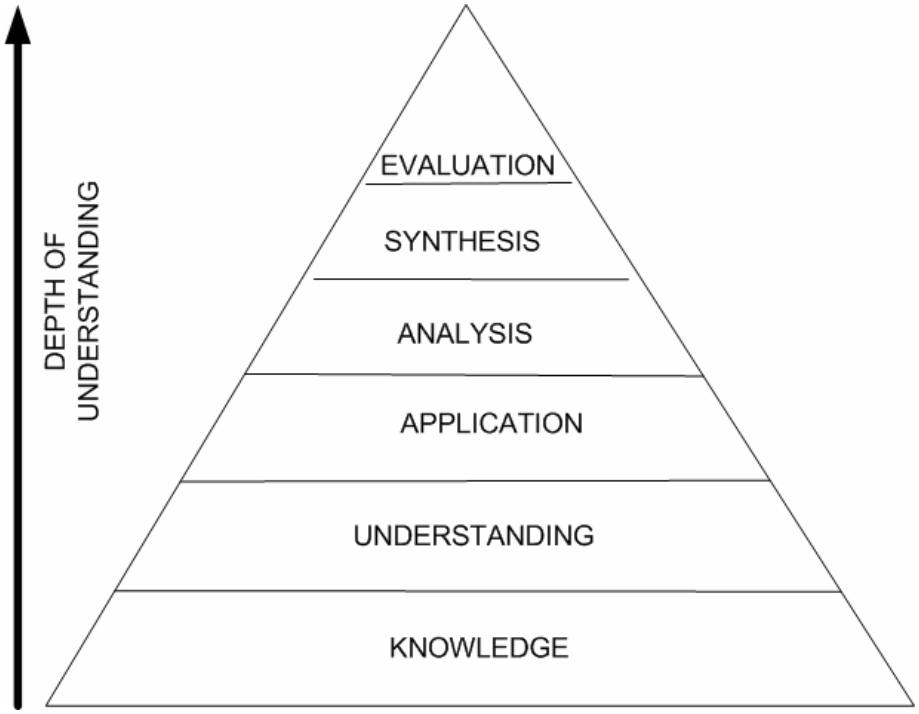
The "Smart Grid"

- Self-healing from power disturbance events
- Enabling active participation by consumers in demand response, operating resiliently against physical and cyber attack
- Providing power quality for 21st century needs
- Accommodating all generation and storage options
- Enabling new products, services, and markets
- Optimizing assets and operating efficiently.

- Efficient
- Accommodating
- Motivating
- Opportunistic
- Quality focused
- Resilient
- "Green"

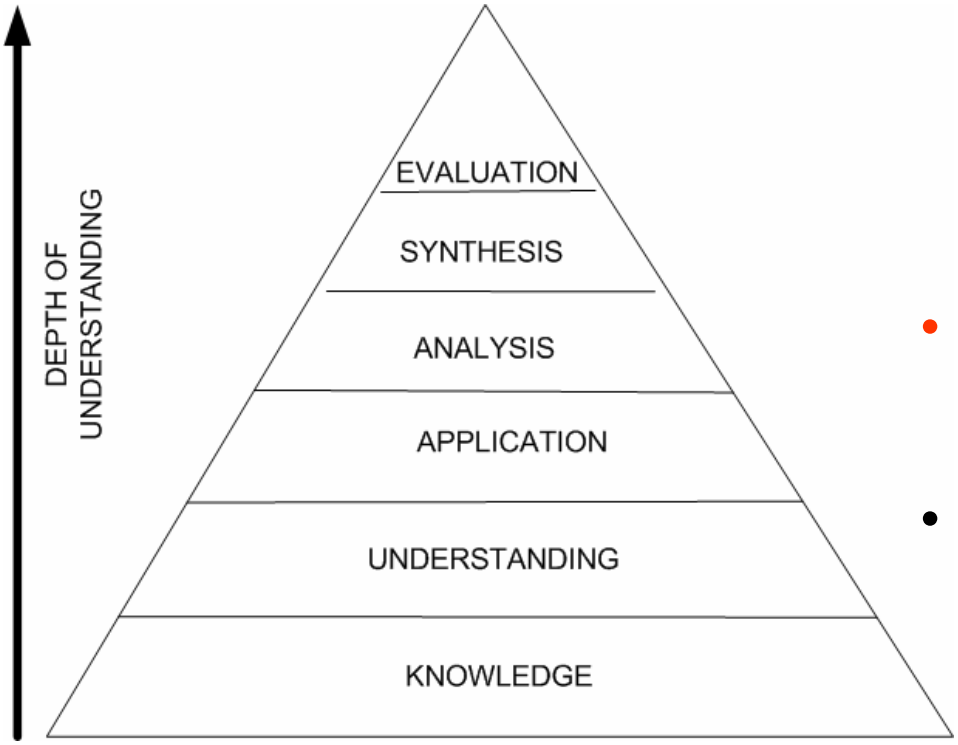
The "Smart Grid"

Bloom's taxonomy

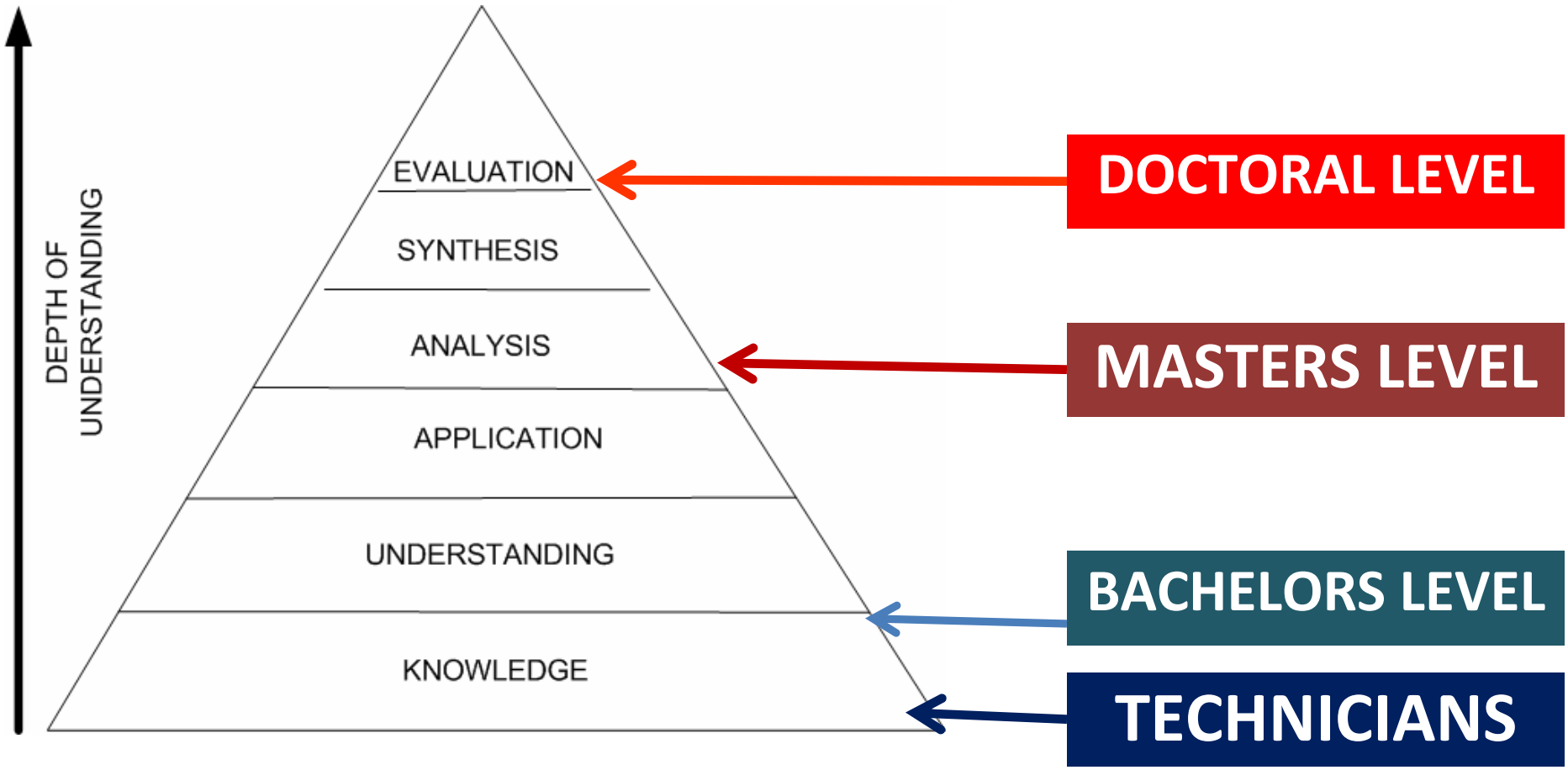


- **The lowest level is termed *knowledge*: this level entails memorization and duplication of existing material. This level is largely duplicative in nature and does not lend itself to innovation and new ideas.**
- ***Understanding* is different from replication of standardized designs as in the lowest level. In this level, the educated engineer begins to comprehend why the standardized designs are replicated.**

Bloom's taxonomy

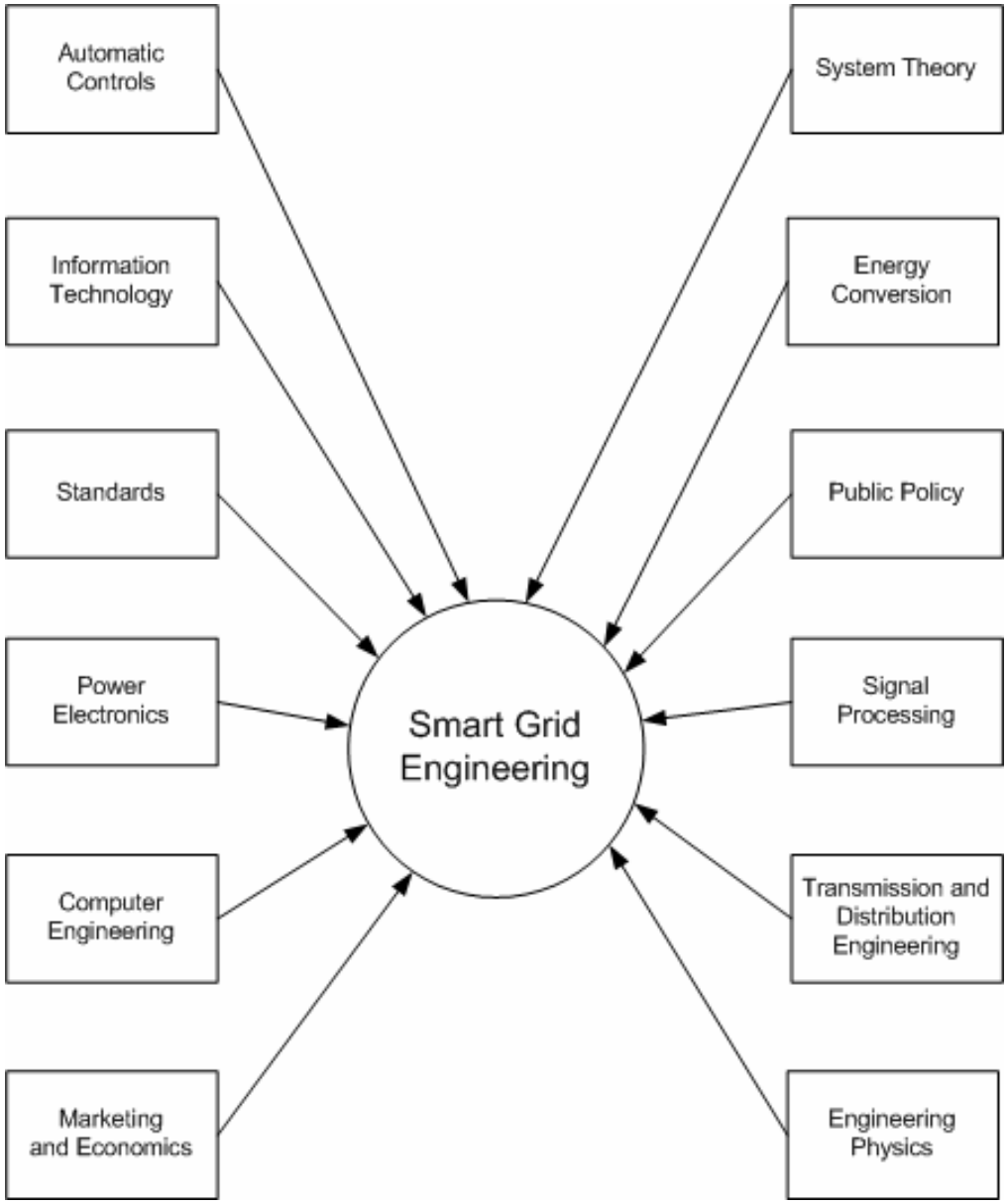


- ***Application***, **one finds use in engineering in general, but still not allowing innovation in design.**
- **At the *analysis* level, one begins to recognize cognitive capability in students to use the students' learning for the dissection of new conditions and how to handle them in an engineering sense.**
- **The *synthesis* level allows the practitioner to arrange and realize designs. It is believed that in the smart grid milieu, this is approximately the objective of the Master of Science level.**
- **The highest level of Bloom's taxonomy relates to the deepest level of understanding which allows one to argue and debate alternatives, to evaluate arguments, and to place solutions in engineering practice and policy. This highest level is termed *evaluation*.**

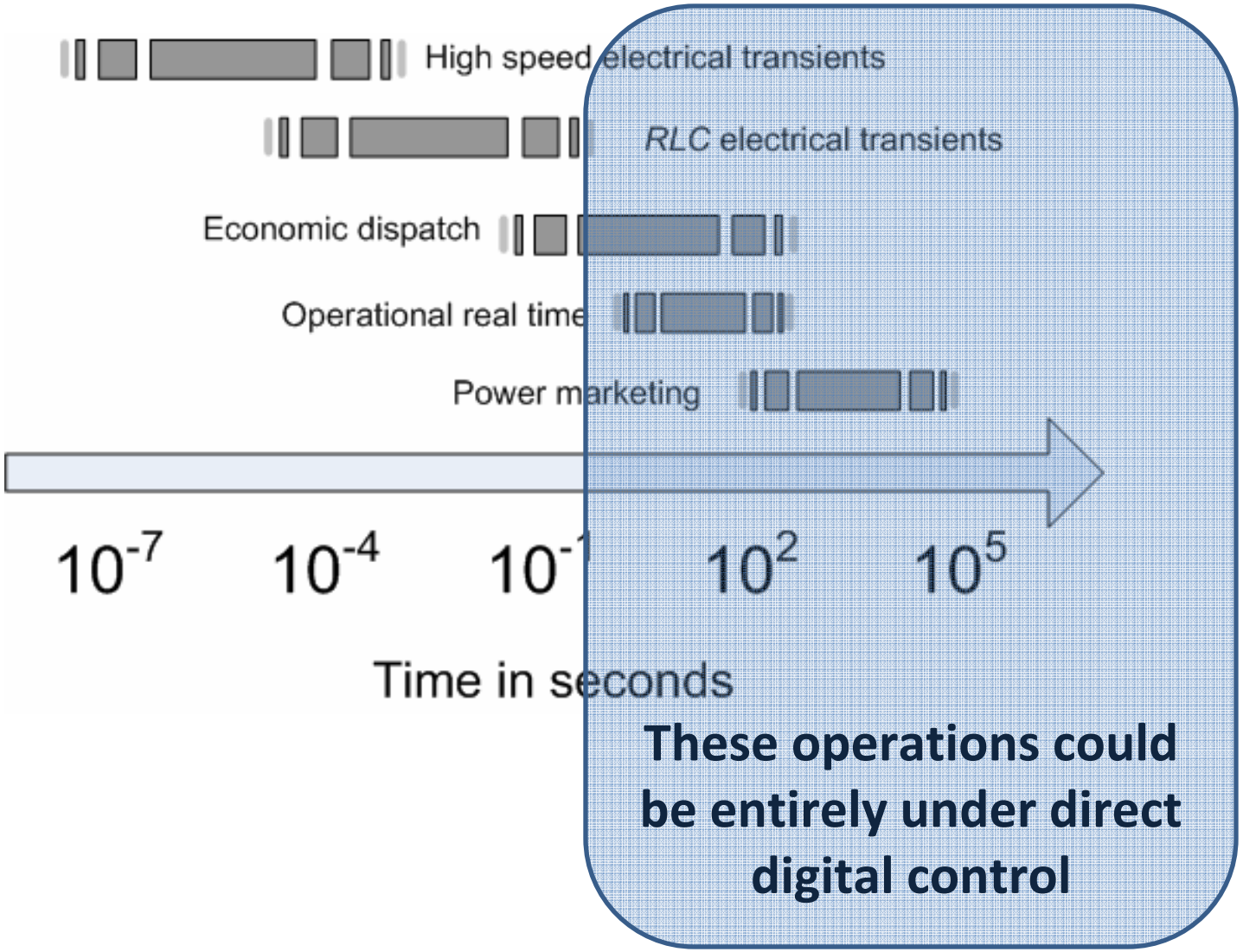


Bloom's taxonomy

Components of smart grid engineering



Timing horizons of legacy power system controls



Where will the power engineers come from to engineer the ‘smart grid’?

ENROLLMENTS IN POWER ENGINEERING EDUCATIONAL PROGRAMS: THE SUPPLY OF QUALIFIED ENGINEERS

Distribution of undergraduate and graduate students by university taking power systems analysis (or comparable) as an undergraduate elective course

Students	Universities	Percent
1-5	3	3.9%
6-10	13	16.9%
11-15	14	18.2%
16-20	13	16.9%
21-30	18	23.4%
31-40	12	15.6%
41-50	1	1.3%
51-60	1	1.3%
61-70	2	2.6%
Total	77	100.0%

Distribution of graduate student enrollments in power engineering

Number of students	Universities	Percent
1-5	18	25.4%
6-10	18	25.4%
11-15	8	11.3%
16-20	9	12.7%
21-30	9	12.7%
31-40	3	4.2%
41-50	4	5.6%
51-60	1	1.4%
= 65	1	1.4%
Total	71	100.0%

Job category	Percentage of potential attrition and retirements	Estimated number of replacements	Estimated retirements only
Technicians	49.0	27,000	20,500
Non-nuclear plant operators	47.6	12,000	9,000
All engineers	44.7	14,500	10,000
Pipe fitters / pipe layers	45.0	8,500	6,500
Line workers	40.2	29,500	19,000

Estimated potential replacements by 2013 for selected job categories

Power and Engineering Workforce Collaborative, "Preparing the foundation for future electric energy systems: a strong power and energy engineering workforce"

The efforts reported in this IEEE PES initiative include three approaches to ensuring a strong US electric power engineering workforce in the future. The first focuses on ensuring sufficient research support for universities across the country – ideally in every state. The second effort focuses on ensuring strong collaboration between industry and universities. The third approach focuses on professional image and outreach to K-12 students. The six objectives of this collaborative are:

- Create a single, collaborative voice on solutions to engineering workforce challenges
- Strengthen extraordinary efforts to build, enhance, and sustain university power engineering programs
- Envision the future challenges in electric energy supply and demand and develop an image that increases interest in power and energy engineering careers
- Stimulate career interest and prepare students for a post-high school engineering education in power and energy engineering
- Make the higher education experience relevant, stimulating, and effective in creating high quality professionals
- Encourage and support increased university research to enhance student education through innovation.

Additional information on the collaborative can be obtained from the following web site:

www.ieee.org/go/pes-collaborative

Areas integrated into a 'smart grid' curriculum

- ***Direct digital control***
- ***Identification of new roles of system operators***
- ***Power system dynamics and stability***
- ***Electric power quality and concomitant signal analysis***
- ***Transmission and distribution hardware and the migration to middleware***
- ***New concepts in power system protection***
- ***Environmental and policy issues***
- ***Reliability and risk assessment***
- ***Economic analysis, energy markets, and planning***

Conclusions

The main conclusion of this paper is that there needs to be recognition for the in-depth coverage of integrative elements of the smart grid objectives in power engineering education. The in-depth coverage needs to go beyond the concept of casual explanations in an undergraduate program by a single instructor with no research background. Rather, the recommendation is to include material at the analytical level of Bloom's taxonomy on the subjects of:

- **Direct digital control**
- **Identification of new roles of system operators**
- **Power system dynamics and stability**
- **Electric power quality and concomitant signal analysis**
- **Transmission and distribution hardware and the migration to middleware**
- **New concepts in power system protection**
- **Economic analysis, energy markets, and planning**
- **Environmental and policy issues.**

The recommendation is that the depth of coverage be achieved by graduate education in these areas, enhanced by industry recommended challenges integrated into the educational experience by faculty with strong research backgrounds.

Questions / Comments / Discussion