Carnegie Mellon

Engineering and Economics for Electric Energy Systems

18-875, 19-633; 45-855 A3 Mini and 45-856 A4 Mini

Course motivation

- To educate the 21st century electric energy leaders
- They must learn:
  - (1) Engineering principles underlying complex electric energy systems;
  - (2) Economic policy and regulation of past, present and future industry; and
  - (3) Inter-dependence of engineering, economics and finance.
- Emphasis on systems engineering for future electric energy systems, instead of on specific hardware technologies.
- Acknowledgement: NSF Education Project "Educating 21st Century Power Engineers", EEC-0343760.

Multi-disciplinary team teaching

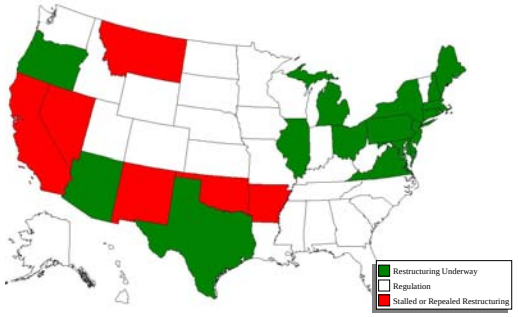
(Prof Lester Lave, Tepper Business School, EPP and Prof Marija Ilic, ECE, EPP)

- Tremendous challenge in communicating engineering problems to MBAs and regulatory economics to engineering students.
- The course has been offered annualy since 2001; the enrollment has grown from 10 to 40 PhDs, MBA, & ECE BS students.
- Syllabus, .ppt lectures and reading material available on http://www.cmu.edu/blackboard/
- Shown sample examples of topics covered.
- software Graphical Interactive Power Systems Simulator (GIPSNUMERICAL EXAMPLES that relate economics and engineering concepts are essential! Educational YS) very helpful, see http://www.eesg.ece.cmu.edu.

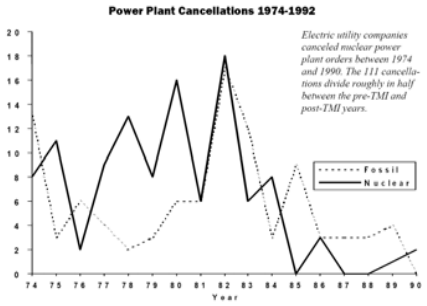
Principal Industry Challenges

- Rapid, uneven restructuring of industry
- Increasingly stringent environmental regulation
- Technological change in generation
- Technological change in transmission & system coordination
- Opportunity to enter related businesses
- Changing nature of demand
- Globalization
- Chronic under-investment in R&D and infrastructure
- Reliability, security, & survivability

Electricity Deregulation Status, 2004



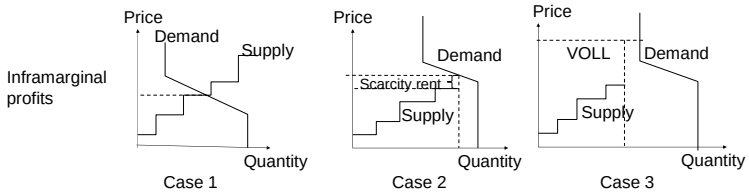
Power Plant Cancellation



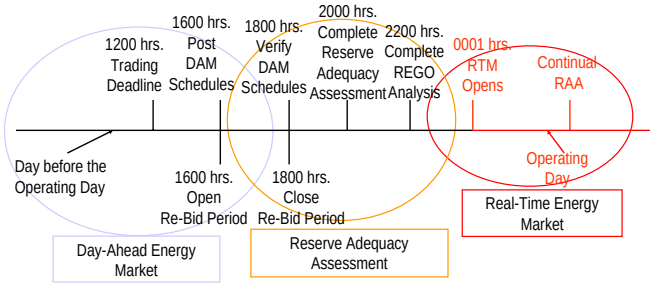
Source: Nuclear Energy Institute, http://www.nei.org/documents/Fact%20Sheet_Three%20Mile%20Island%20Myths%20and%20Facts_0304.pdf

Resource Adequacy Problem in the Changing Industry

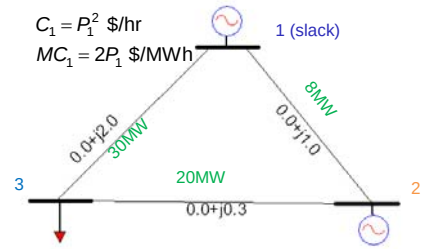
In a perfect competitive market, the optimal investments in generation capacity and the optimal technology mix are achieved in a long-term equilibrium that reflect supply and demand choices for reliability and cost



Market timeline



Transmission congestion management—engineering and economics problem



B_3 (Benefit) $= -33P_3$ $/hr
$MB_3 = -33$$/MWh

$C_2 = 1.675P_2^2$ $/hr
$MC_2 = 3.350P_2$ $/MWh

- Two generators (bus 1 and 2)
- One load (bus 3)
- Three lines

Line	Reactance x (p.u)	Capacity (MW)
Line 1-2	1	8
Line 1-3	2	30
Line 2-3	1/3	20

Question: How do we get the optimal operating point and locational marginal prices (LMPs) at all nodes?

[1] T.W. Gedra. On Transmission Congestion and Pricing. *IEEE Transactions on Power Systems*, Vol. 14, no. 1, Feb 1999

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