CPET 581 Smart Grid & Energy Management
2013/9/13
6:00-8:45PM Friday
Lecture 5

Topics of Discussion

- U.S. Electric Power Generation, Transmission, Distribution & Integration of Renewable Energy into Electric Grid
- Independent System Operators (ISO) & Regional System Operators (RSO)
- Electric Power Reliability Management
- Terms: Installed capacity, Capacity Factor, Electric Power Reliability Management, Summer Reliability, Demand-Side Management, Peak Demand , Peak Demand Program
- Cost of Whole Sale & Retail Electricity
- The basic structure of a market for the electricity
- EIA - Electricity Wholesale Market Data
- Distributed Energy Resources, Smart Grid Technologies, and New Markets and Business Models

1. **U.S. Electric Power Generation, Transmission, Distribution and Integration of Renewable Energy into Electric Grid**
   - Electric Power Generation, http://en.wikipedia.org/wiki/Electric_power_transmission
   - How the Power Grid Works – Video, http://science.howstuffworks.com/environmental/3049-how-the-power-grid-works-video.htm
   - Cost Facts: 60 percent – Generation, 10 percent – Transmission, 30 percent – distribution, www.spp.org
   - U.S Transmission Grid
     - Edison Electric Institute, (more than 200,000 miles of high-voltage lines, 230 kV and greater), http://www.eei.org/issuesandpolicy/transmission/Pages/default.aspx
     - National Grid, Energy Delivery, https://www.nationalgridus.com/transmission/index.asp
       - owns and operates an electricity transmission system of approximately 8,600 miles spanning upstate New York, MA, Rhode Island, New Hampshire and Vermont
       - Voltage ranging from 69 kV to 345 kV, overhead lines; nearly 90 miles of underground cable and 524 substations
   - The U.S. Electric Power Industry Infrastructure: Functions and Components, U.S. Energy Information System, http://www.eia.gov/cneaf/electricity/chg_stru_update/chapter3.html
   - WECC Regional Transmission Expansion Planning, http://www.wecc.biz/committees/BOD/TEPPC/Pages/RTEP.aspx
   - Transmission Grid Integration, NREL, http://www.nrel.gov/electricity/transmission/
     - Webinars, http://www.nrel.gov/electricity/transmission/webinars.html
       - Grid Integration of Wind Energy, June 19
       - Renewable Energy Integration Challenge: How States are Managing the Rapid Growth of Renewable Energy, Glen Anderson, NCSL Energy System, ,
         - Renewable Energy Integration Challenge: Mitigation Options, Lori Bird, 2013/4/28, http://www.nrel.gov/electricity/transmission/pdfs/webinar_20130425_slides.pdf

        - Audio recording
    - Costs of Integrating Renewable Energy into the Electric Grid, Speakers: Kevin Porter, Aaron Bloom, and Michael Milligan, Feb. 20, 2013, http://www.nrel.gov/electricity/transmission/pdfs/webinar_20130220_slides.pdf

U.S. Power Grid and Power Industries

- Background & History of the U.S. Power Grid, https://sites.google.com/site/theuspowergrid/
- Edison Power Grid

Electric Power Transmission History – The Edison Tech Center, http://edisontechcenter.org/HistElectPowTrans.html

Major Power Industries

- American Electric Power, http://www.aep.com/
    - AEP Ohio, https://www.aepohio.com/
    - AEP Texas, https://www.aeptexas.com/
    - Appalachian Power (Tennessee, Virginia, West Virginia), https://www.appalachianpower.com/
    - Indiana Michigan Power, https://www.indianamichiganpower.com/
    - Kentucky Power, https://www.kentuckypower.com/
    - PSO (Oklahoma), https://www.psoklahoma.com/contact/
    - SWEPCO (East TX, North TX, LA, AR), https://www.swepco.com/
    - National Accounts, https://www.aepnationalaccounts.com/
    - Alternative Electricity Suppliers
- Duke Energy, Charlotte, N.C., , http://www.duke-energy.com/
    - Provides electric and gas services to approximately 7.1 million customers in its regulated service territories in North Carolina, South Carolina, Florida, Indiana, Ohio and Kentuky.
    - Investors, http://www.duke-energy.com/investors/
    - Company News, http://www.duke-energy.com/investors/news-events.asp
        - Duke Energy Renewables acquires one of the largest urban municipal solar projects in California, http://www.duke-energy.com/news/releases/2013081501.asp
            - Sunset Reservoir Solar Power Project (4.5 megawatt AC Solar – 24,000 solar panels mounted on the top of the Sunset Reservoir) in San Francisco developed by Recurrent Energy, since 2010.
        - Duke Energy Opens Joint Information Center
    - 2012 Annual Report, 308 pages, http://www.duke-energy.com/
    - 2012 Sustainability Report, 36 pages,, http://sustainabilityreport.duke-energy.com/
    - Duke Energy Renewables, http://www.duke-energy.com/commercial-renewables/default.asp
        - Renewable Energy Monitoring Center, http://www.duke-energy.com/remc/default.asp
            - Own and operate about 1,700 megawatts (MW) of renewable energy
            - 1,600 MW wind power
            - 100 MW solar power
            - Renewable Generation Facilities, http://www.duke-energy.com/pdfs/Renewables-N-America-Facilities.pdf

        - Outland Energy Services, http://outlandenergy.com/
        - Solar Power Projects, http://www.duke-energy.com/pdfs/Solar-Power-Projects-Fact-Sheet.pdf
        - Wind Power Projects, http://www.duke-energy.com/pdfs/Wind-Power-Projects-Fact-Sheet.pdf
        - U.S. Department of Energy Solar
    - Business Sectors: Residential, Business, Large Business
- Southern California Edison – SCE, www.sce.com
- Potomac Edison – FirstEnergy
- Ohio Edison – FirstEnergy

2. Independent System Operators (ISO) & Regional System Operators (RSO)

- Electric Power Transmission History – The Edison Tech Center, http://edisontechcenter.org/HistElectPowTrans.html
- Edison Power Grid

U.S. Power Grid and 3 Major Interconnections

- Learn more about Interconnections, http://energy.gov/oe/recovery-act/recovery-act-interconnection-transmission-planning/learn-more-about-interconnections
    - Eastern Interconnections
    - Western Interconnections
    - Texas or ERCOT (Electric Reliability Council of Texas), http://www.ercot.com/

ISO & RSO

- Alberta Electric System Operator, http://www.aeso.ca/
- California ISO, http://www.caiso.com/Pages/default.aspx
- Midwest ISO (MISO), established 1998,, https://www.misoenergy.org/Pages/Home.aspx
    - Headquater
    - Members, https://www.misoenergy.org/StakeholderCenter/Members/Pages/Members.aspx
        - Transmission Owners (TO)
        - Independent Power Producers and Exempt Wholesale Generators (IPP)
        - Power Marketers and Brokers (PMs)
        - Municipals, Cooperatives, and Transmission Dependent Utilities (Munis/Coops/TDUs)
        - Public Consumer Advocates (non-member sector)
        - State Regulatory/Authorities (non-member sector)
        - Environmental/Other Stakeholder Organizations (non-member sector)
        - Eligible End Use Customers
        - Coordinating Members
- New York ISO, http://www.nyiso.com/public/index.jsp
- New England ISO, http://www.iso-ne.com/
- Texas ERCOT, http://www.ercot.com/
- PJM Interconnection (Pennsylvania, Jersey, Maryland), http://www.pjm.com/about-pjm.aspx
- Southwest Power Pool (SSP RT), www.spp.org

- Ontario IESO, http://www.ieso.ca/
- ISO/RTO Council, http://www.isorto.org/site/c.jhKQIZPBImE/b.2603295/k.BEAD/Home.htm
    - 10 ISOs and Regional System Operators in North America
    - AESO Current Supply Demand Report, http://ets.aeso.ca/ets_web/ip/Market/Reports/CSDReportServlet
    - California ISO Supply & Demand, http://www.caiso.com/outlook/SystemStatus.html
    - ERCOT Grid Information, http://www.ercot.com/gridinfo/
    - IESO (Ontario),
    - ISONE (New England), http://isoexpress.iso-ne.com/guest-hub;jsessionid=82E3C5CF45E704D32A2F8E2DFFCCD05A
    - MISO, https://www.misoenergy.org/Pages/Home.aspx
    - NYISO Market & Operations, http://www.nyiso.com/public/markets_operations/market_data/pricing_data/index.jsp
    - PJM, https://edata.pjm.com/eData/index.html
    - SPP, Real-Time Data, http://www.spp.org/RealTimeData.asp

3. **Electric Power Reliability Management** Corporations (monitor, enforce compliance with reliability standards)
    - NERC: North American Electric Reliability Corporation, http://www.nerc.com/pa/rrm/Pages/default.aspx
        - Account Log-In/Register: http://www.nerc.com/Pages/AccountLoginRegister.aspx
        - Key Players, http://www.nerc.com/AboutNERC/keyplayers/Pages/default.aspx
            - Florida Reliability Coordinating Council (FRCC), https://www.frcc.com/default.aspx
            - Midwest Reliability Organization (MRO), http://www.midwestreliability.org/
            - Northeast Power Coordinating Council (NPCC), https://www.npcc.org/default.aspx
            - Reliability First Corporation (RFC), https://rfirst.org/Pages/Rfirst.aspx
            - SERC Reliability Corporation (SERC), http://www.serc1.org/Application/HomePageView.aspx
            - Southwest Power Pool, RE (SPP), http://www.spp.org/
            - Texas Reliability Entity (TRE), http://www.texasre.org/Pages/Default.aspx
            - Western Electricity Coordinating Council (WECC), http://www.wecc.biz/Pages/Default.aspx
    - American Wind Energy Association
    - National Renewable Energy Laboratory
    - US Energy Information Administration,

4. **Terms: Installed capacity, Capacity Factor, Electric Power Reliability Management, Summer Reliability, Demand-Side Management, Peak Demand , Peak Demand Program**

    - Power generation
        - Capacity factor
        - Base load plant/generation: designed for maximum efficiency and are operated continuously at high output.
            - Geothermal plants, nuclear plants, coal plants and bioenergy plants that burn solid materials are almost always operated as base load plants

- Name plate capacity
- Storage capacity

5. Cost of Wholesale and Retail Electricity

- Electricity Primer – The Basic of Power and Competitive, 2007
  - Electricity Primer, http://www.epsa.org/industry/primer/EPSAs_Electricity_Primer__May_2007_.pdf
  - Electricity 101
  - What is a wholesale electricity market,
  - How is electricity sold at retail?
  - What are RTO and organized markets?
  - How wholesale electricity prices are set?
  - Competition in electricity markets

NYISO Wholesale vs. Retail Electricity,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/wholesale_retail/index.jsp

NY ISO - Cost of Wholesale Electricity,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/cost_of_electricity/index.jsp

- Locational Based Marginal Price (LBMP):
  - the cost of energy production + the transportation (losses and congestion) cost
- NYPA Transmission Adjustment Charge (NTAC)
  - Flat per MW charge to compensate the New York Power Authority for transmission system operation and maintenance
- Reserve
  - Market-based payment to generators providing short-term (10 and 30 minute) reserve power
- Regulation
  - Market-based payment to generators helping to maintain frequency in real-time
- NYISO Cost of Operation
  - Flat per MW fee to cover the cost of operating the NYISO
- Uplift
  - Charge for resources that must be committed outside of market mechanism
- Voltage Support
  - Flat per MVAr payment to generators with the ability to maintain voltage
- Black-Start
  - Cost-based payment to generators with the ability to restart after a black-out

The basic structure of a market for the electricity

- Consumer surplus
- Congestion rents
- Market power
- Architecture of electric markets

Modeling Strategic Behavior

- Price-based models
- Quality-based models

The Locational Marginal Pricing System of PJM

- Congestion charges and financial transmission rights
- 3-Bus examples

- EIA
    - Electricity Wholesale Market Data – EIA
        - Analysis & Projection
        - Electricity Monthly Update – Regional Wholesale Markets: June 2013, http://www.eia.gov/electricity/monthly/update/wholesale_markets.cfm
        - Wholesale Market Data, Intercontinental Exchange (ICE) data, Aug. 22, 2013, http://www.eia.gov/electricity/wholesale/
            - Daily Volumes
            - High & Low Prices
            - Weighted Average
            - Trading Hub
    - Regional Wholesale Markets – Electricity Monthly Update – EIA
- Electric Power Supply Association (EPSA):
    - Electricity Primer – The Basic of Power and Competitive, 2007
        - Electricity Primer, http://www.epsa.org/industry/primer/EPSAs_Electricity_Primer__May_2007_.pdf
        - Electricity 101
        - What is a wholesale electricity market,
        - How is electricity sold at retail?
        - What are RTO and organized markets?
        - How wholesale electricity prices are set?
        - Competition in electricity markets
    - The Future of Electricity Generation, Electric Power Supply Association (ESA), http://www.epsa.org/documents/industry/EPSA_Power_On_brochure_FINAL.pdf

NY ISO - Cost of Wholesale Electricity, http://www.nyiso.com/public/about_nyiso/understanding_the_markets/cost_of_electricity/index.jsp

- Locational Based Marginal Price (LBMP):
    - the cost of energy production + the transportation (losses and congestion) cost
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- Black-Start
    - Cost-based payment to generators with the ability to restart after a black-out

Electricity Market,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/energy_market/index.jsp
- Day-Ahead Market
- Real-Time Market
- Bilateral Transactions

The Ancillary Service Markets,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/ancillary_services/index.jsp
- Reserve
- Regulation

The Capacity Market,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/capacity_market/index.jsp
- Locational Capacity
- Demand Response (DR)

Financial Markets,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/financial_markets/index.jsp
The Benefits of Markets,
http://www.nyiso.com/public/about_nyiso/understanding_the_markets/benefits_of_markets/index.jsp
- Generation addres
- New transmission
- Efficiency enhanced
- Green power growing
- Emissions declining
- Innovations fostered
- Lower wholesale power costs
- Jobs & investments

Installed capacity
Capacity Factor
Summer Reliability
Peak Demand
Peak Demand Program

Electric Market, Bloomberg, http://topics.bloomberg.com/electricity-market/

- Electricity Market Videos
    - Barclays, Traders Fined $488 Amid Energy Probe, 2013/7/17, http://www.bloomberg.com/video/barclays-traders-fined-488m-amid-energy-probe-nWSdSgXpQqewUxpR~YHOsg.html/
- JPMorgan Accused of Gaming Energy Bids as FERC Deal Looms, 2013/7/30, http://www.bloomberg.com/news/2013-07-29/jpmorgan-accused-of-manipulating-energy-markets-in-u-s-.html
- FERC Accuses JPMOrgan Chase of Manipulating Electricity Market, Reuters/Huff Post Business, 2013/8/26, http://www.huffingtonpost.com/2013/07/29/ferc-jpmorgan_n_3672846.html

FERC Electric Power Markets: National Overview, Federal Energy Regulatory Commission, 2012-2013, http://www.ferc.gov/market-oversight/mkt-electric/overview.asp

- Electric Market Overview
- Generation Output and Temperature
- On-Peak Spot Electric Prices
- Spot Prices
- Coal Prices

Electricity Market & Policy Group, Lawrence Berkeley National Laboratory, http://emp.lbl.gov/

- Demand Response & Smart Grid
- Electricity Reliability
- Energy Efficiency
- Regional Electrical System Planning
- Renewable Energy
- Transmission
- Publications
    - 2013 Publications, http://emp.lbl.gov/reports
    - 2012 Wind Technologies Market Report, 2013, Wiser, Ryan H., and Bolinger, Mark, Aug. 2013, http://emp.lbl.gov/sites/all/files/lbnl-6356e-ppt.pdf (Presentation Report); and paper http://emp.lbl.gov/sites/all/files/lbnl-6356e.pdf
    - Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012, Barbose, Galen L, Darghouth, Naim, Weaver, Sa,amtha, and Wiser, Ryan H, 2013

Capacity factor, http://en.wikipedia.org/wiki/Capacity_factor

- The net Capacity Factor of a power plant is the ratio of its actual output over a period of time, to its potential output (maximum) if it were possible for it to operate at full nameplate capacity indefinitely. To calculate the capacity factor, take the total amount of Energy (MWh) the plant produced during a period of time and divide by the amount of energy that plant would have produced at full capacity. The Capacity Factor vary greatly depending on the type of fuel that is used and the design of the plant. The capacity factor should not be confused with the availability factor, capacity credit (firm capacity) or with efficiency,
- Sample calculations
    - Baseload power plant

        - A base load power plant with a capacity of 1,000 megawatts (MW) might produce 648,000 MWh in a 30 day month and the maximum capacity (1000 x 24 hr/day x 30 day), the capacity factor is Actual Output / Max Output = 0.9 (90%)
    - Wind farm
        - The Burton World Wind farm, England, consists of ten Enercon E70-E4 wind turbine @ 2MW nameplate capacity for a total of 20MW. In 2008 the wind farm generates 43,416 MWh of electricity. The capacity factor for its wind farm in 2008 (leap year) was just under 25%.
        - 43,416 MWh/(20MW x 366 days x 24 hr/days) = 0.2471 ≈ 0.25
    - Hydroelectric dam
        - Yantze Three Gorges Dam, China, http://en.wikipedia.org/wiki/Three_Gorges_Dam
            - As of 2010, Three Gorges Dam is the largest generating station in the world by nameplate capacity.
            - In 2009, not yet fully complete, it has 26 main generator units @700 MW and two auxiliary generator units @50 MW for a total capacity of 18,300 MW. Total generator in 2009 was 79.47 TW-h, for a capacity factor of just under 50%:
            - 79.47 TWh = 79,47,000 MWh
            - 79,470,000 MWh/(365 days x 24 hr/day x 18,300 MW) = 0.4957 ≈ 0.5
        - Hoover Dam (Boulder Dam), http://en.wikipedia.org/wiki/Hoover_Dam
            - Has a nameplate capacity of 2080 MW and an annual generation averaging 4.2 TWh (the annual generation has varied between a high of 10.348 TW-h in 1984, and a low of 2.648 TW-h in 1956. Taking the average figure for annual generation gives a capacity factor of
                - 4,200,000 MW-h/(365 days x 24 hr/day x 2,080) = 0.23
- Reasons for reduced capacity factor (less than 100%)
    - (1) Out of service or operating at reduced output for part of the time due to equipment failures or routine maintenance
    - (2) Electricity is not needed; or because the price of electricity is too low to make production economical
- Base Load Plants:
    - Designed for maximum efficiency and are operated continuously at high output
    - Geothermal plants, nuclear plants, coal plants and bioenergy plants that burn solid materials are almost always operated as base load plants
- Peaking Load Plants
    - May operate for only a few hours per year; or up to several hours per day
    - Relative expensive cost, uneconomical, even wasteful, to make a peaking power plant as efficient as a base load plant because they do not operate enough to pay for the extra equipment cost, and perhaps not enough to offset the embodies energy of the additional components
- Load following power plants
- Capacity factor and renewable energy
- Typical capacity factor

What is capacity factor, http://www.eia.gov/tools/faqs/faq.cfm?id=187&t=3

Capacity is a measure of how often an electric generator runs for a specific period of time. It compares how much electricity a generator actually produces with the maximum it could produce at continuous full power operation during the same period.

For example, if a 1 MW generator produced 5,000 MWh over a year, its capacity factor would be 0.57 because 5,000 MWh equals 57% of the amount of electricity the generator could have produced if it operated the entire year (8,760 hours) at full capacity and produced 8,760 MWh of electricity.

Generators with relatively low fuel costs are usually operated to supply baseload power, and typically have average annual capacity factors of 0.70 or more. Generators with lower capacity factors may indicate they are in operation during peak demand periods and/or have high fuel costs, or their operation depends on the availability of the energy source, such as hydro, solar, and wind energy.

Typical Capacity Factors, http://en.wikipedia.org/wiki/Capacity_factor
EIA Electric Power Annual 2009, released 2011,
http://www.eia.gov/electricity/annual/archive/03482009.pdf

- Chapter 1. Capacity
- Chapter 2. Generation and Useful Thermal Output
- Chapter 3. Fuel and Emissions
- Chapter 4. Demand, Capacity Resources, and Capacity Margins
- Chapter 5. Characteristics of the Electric Power Industry
- Chapter 6. Trade
- Chapter 7. Retail Customers, Sales, and Revenue
- Chapter 8. Revenue and Expense Statistics
- Chapter 9. Demand-Side Management

Typical Capacity Factors, Table 5-2

- Natural gas plant: 11.4%
- Oil: 7.8%
- Hydroelectric: 39.8%
- Other renewables (Wind/Solar/Biomass): 33.9%
- Coal: 63.8%
- Nuclear: 90.3%

Variability

- Wind farms 20-40%
- Photovoltaic solar in MA 13-15%
- Photovoltaic solar in Arizona 19%
- CSP solar in CA 33%
- CSP solar with storage in Span 75%
- Hydroelectricity world wide average 44%, range from 10%-90%, depends on
  - Design (small plant in big river will always have enough water to operate)
  - Water availability (with or without regulation via storage dam; regulation of the annual flow of the river)
- Nuclear power 70% (1971-2009 average of USA plants)
- Nuclear power 91.2% (2010 average of US plants)

Summer Reliability

- Indiana Michigan Power Summer 2008 Preparedness, Presentation to the Indiana Utility Regulatory Commission, June 3, 2008, http://www.in.gov/iurc/files/IM2008Summer_Reliability.pdf
    - Total Demand
    - Interruptible Demand
    - Net Demand

Peak Demand Program

- I&M Residential peak reduction ($40 in bill credit), https://indianamichiganpower.com/save/programs/ResidentialPeakReduction.aspx?ctype=h

6. EIA - Electricity Wholesale Market Data

- Electricity Monthly Update – Regional Wholesale Markets: June 2013, http://www.eia.gov/electricity/monthly/update/wholesale_markets.cfm
- Wholesale Market Data, Intercontinental Exchange (ICE) data, Aug. 22, 2013, http://www.eia.gov/electricity/wholesale/
    - Daily Volumes
    - High & Low Prices
    - Weighted Average
    - Trading Hub

7. Distributed Energy Resources, Smart Grid Technologies, and New Markets and Business Models

References

- Text Book of IT 507 and TECH 646: ***Applied Statistics and Probability for Engineers***, 4th edition, by Douglas C. Montgomery and George C. Runger, Published by John Wiley & Sons, Inc,
- "Energy Management and SmartGrid," April 22, 2013, 29 pages, by Rosatio Miceli, Energies, http://www.mdpi.com/1996-1073/6/4/2262
- Energy Statistics and Forecasting, http://www.eia.gov/
- Consumption & Efficiency, EIA, http://www.eia.gov/consumption/
- Fed Stats, Dept. of Energy, http://www.fedstats.gov/key_stats/index.php?markup=XHTML&pageType=program&id=energy
- Bureau of Ocean Energy Management, http://www.boem.gov/Statistics-and-Facts/
    - Video, Wind Energy Area (WEA), BOEM-Platts Energy Interview, http://www.boem.gov/BOEM-Newsroom/Video/BOEM-Platts-Energy-Interview.aspx
- New Energy for America, Bureau of Land Management, U.S. Dept of the Interior: , http://www.blm.gov/wo/st/en/prog/energy.html
    - Active Renewable Energy Projects, http://www.blm.gov/pgdata/content/wo/en/prog/energy/renewable_energy/active_renewable_projects.html
    - Best Management Practices, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices.html

    - Renewable Energy Home Page, http://www.blm.gov/wo/st/en/prog/energy/renewable_energy.html
    - Wind Energy, http://www.blm.gov/wo/st/en/prog/energy/wind_energy.html
    - Solar Energy, http://www.blm.gov/wo/st/en/prog/energy/solar_energy.html
    - Oil & Gas Statistics, , http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html
    - Oil and Gas Inspections and Enforcement
    - LR 2000
    - Public Land Statistics
    - NEPA
    - Mining Law
    - General Land Office Record
- World Energy Statistics, http://www.enerdata.net/enerdatauk/press-and-publication/publications/world-energy-statistics-supply-and-demand.php
- Power Management Statistics (IT & Computer), http://www.it.northwestern.edu/hardware/eco/stats.html
- Sustainability at NC State Energy Management, http://sustainability.ncsu.edu/about/energy-management
    - Energy Management Plan, Nov. 18, 2010, 72 pages, http://sustainability.ncsu.edu/wp-content/uploads/2010/12/Strategic-Energy-Management-Plan.pdf
- ISO 5001 "on fire" – Energy management standard goes global,
- Building Energy Data Book, http://buildingsdatabook.eren.doe.gov/
- Energy Management Handbook – BSR, 50 page, April 2012, http://www.bsr.org/reports/bsr-energy-management-handbook.pdf
- Energy Management Tools, http://www.freeenergymanagertools.com/
    - Energy CAP, http://www.energycap.com/products/energycap-express-learn-more
        - Video Demo
    - Free Building Energy Rating Portal, http://www.buildingratingsportal.com/
    - Weather Data Depot, http://www.weatherdatadepot.com/
    - Free Building Benchmarks, http://www.buildingbenchmarks.com/
    - WegoWise, https://www.wegowise.com/home
    - eGRID Databasr of Power Plant Emission, http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html
    - Greenhouse Gas Emission Equivalencies Calculator, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
    - Convert Energy Units of Measure, http://www.onlineconversion.com/energy.htm
    - Enterprise SmartGrid, http://www.enterprisesmartgrid.org/
    - Energy University, http://www2.schneider-electric.com/sites/corporate/en/products-services/training/energy-university/energy-university.page
    - EnergyDeck, http://www.energydeck.com/home/
    - Energy Star Tools and Resource Library, http://www.energystar.gov/buildings/home?c=business.bus_index
    - Energy Efficiency Software and Database Tools, http://apps1.eere.energy.gov/buildings/tools_directory/
    - Consumption & Efficiency, http://www.eia.gov/consumption/
    - Simple Energy Management Software, http://www.energylens.com/
    - Noesis Online Energy Collaboration Tools, https://www.noesisenergy.com/site/

- Commercial Energy Calculator, http://bge.apogee.net/comsuite/bizframe.aspx?url=/comcalc
- Understanding Demand, http://bge.apogee.net/comsuite/bizframe.aspx?url=/ces/default_ed.asp
- Commercial Energy Systems, http://bge.apogee.net/comsuite/bizframe.aspx?url=/ces