

DRAFT**Power/Utility Engineering Curriculum for High School**

(Suggested for grades 9-12 over a 3-4 year period; duration of each lesson will depend in-part on the number of class hours per week and the inclusion of laboratory activities).

UNIT 1: INTRODUCTION TO ENERGY

Lesson 1: A History of Power Systems

- Notable inventors and innovations
- History of advancement and use of power systems

Lesson 2: Energy

- Define energy
 - Types and forms of energy
 - Laws governing energy
 - Kinetic energy
 - Potential energy
 - Energy and heat transfer
 - Change in kinetic/potential/internal energy
 - Briefly introduce and relate to heat and work

Lesson 3: Work

- Define work
 - Work from conservative forces
 - Work from non-conservative forces
 - Net work

Lesson 4: Mechanical Power

- Define power
- Linking concepts of power to work and energy
 - Ensure students understand the difference between work, energy, power
- Activity: Have students demonstrate difference between work, energy, power by demonstrating in front of the class an example of each

Lesson 4.5: Power generation

- Terms: Kilowatt, megawatt, megawatt hour, etc.
- Power systems: major components of each and fuel types

Lesson 5: The Utility Industry Today

- Purpose of utility industry
- Overview on utilities
 - Describe the importance and prevalence of utilities in our everyday lives
 - Emphasize how much the modern world depends on utilities
 - Discuss suppliers, architects, engineers, construction workers, regulators, industry associations

Lesson 6: Introduction to Energy Sources

- Discuss global and domestic energy mix
 - How much energy is produced by each resource

- Renewable and nonrenewable
- Geographic distribution of resources
- Discuss current and future trends in energy use
 - Increasing efficiency and renewables in West
 - Increasing fossil fuel use in developing nations
 - China, India, etc.

UNIT 2: NONRENEWABLE ENERGY SOURCES For each resource, discuss formation, exploration, extraction, conversion for use, combustion or reaction.

Lesson 1: Petroleum

- Brief history of petroleum use as energy source
- Source/Process
 - Statistical values as a nonrenewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Describing how much of world's energy is produced by petroleum
 - Environmental/Economic Impact
 - Chemistry
 - Major petroleum industry stakeholders
 - Career pathways: types of jobs

Lesson 2: Coal

- Brief history of coal use as energy source
- Source/Process
 - Statistical values as a nonrenewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Reviewing how much of world's energy is produced by coal
 - Environmental/Economic Impact
 - Chemistry

Lesson 3: Natural Gas

- Brief history of natural gas use as energy source
- Source/Process
 - Statistical values as a nonrenewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Reviewing how much of world's energy is produced by natural gas
 - Environmental/Economic Impact
 - Chemistry

Lesson 4: Nuclear

- Brief history of nuclear as energy source
- Source/Process
 - Statistical values as a nonrenewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Reviewing how much of world's energy is produced by nuclear
 - Environmental/Economic Impact

- Chemistry
- Case study: Harrisburg, Pennsylvania - 3 Mile Island

Lesson 5: Environmental Impact of Energy

- Discussion of impact of different energy sources on the environment
 - Especially fossil fuels
 - Light amount of scientific information and background on the impact of energy use on climate change
- Discussion of history of US and global environmental policy and notable international agreements
 - EPA standards, mitigation of environmental impacts (i.e. scrubber technologies); equipment mitigation, process mitigation, policy mitigation.

Lesson 6: Case Study - Nonrenewable Energy Sources Overview

- Case study on the usage/costs of nonrenewable energy sources and the pros/cons of their continued use
 - Split class up into the three groups - have them study one energy source and present

UNIT 3: RENEWABLE ENERGY SOURCES

Lesson 1: Wind Power

- Brief history of wind as energy source
- Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Describing how much of world's energy is produced by wind power

Lesson 2: Solar Power

- Brief history of solar as energy source
- Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Difference between PV, hot water, concentrated solar power
 - Photovoltaic effect
 - Describing how much of world's energy is produced by solar power

Lesson 3: Hydroelectricity

- Brief history of hydroelectricity as energy source
- Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Describing how much of world's energy is produced by hydroelectric power
 - Hydrokinetics (brief intro)

Lesson 4: Biofuel

- Brief history of biofuel as energy source
- Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Describing how much of world's energy is produced by biofuels

- Cellulosic
- Algae
- Corn
 - Conflict between food and fuel production

Lesson 5: Other Renewables

- Geothermal
 - Brief history of geothermal as energy source
 - Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Describing how much of world's energy is produced by geothermal
 - Discuss geothermal potential in various countries
- Hydrogen fuel cells
 - Brief history of fuel cells as energy source
 - Source/Process
 - Statistical values as a renewable energy source
 - Describing the energy input that goes into the process and the energy output
 - Discuss fuel cell potential
- Trends
 - Combined heat and power
 - Water pipe turbines
 - Utilizing lost heat or lost resources (methane)

Lesson 6: Case Study - Renewable Energy Sources Overview

- Case study on the usage/costs of renewable energy sources and the pros/cons of their continued use
 - Split class up into the four groups - have them study one energy source and present

UNIT 4: ENERGY/POWER UTILITIES IN THE UNITED STATES TODAY

Lesson 1: Overview of the Energy/Power Utilities industry today

- Introduction to how energy/power utilities are regulated both by private/public sectors
- Different power/energy companies and how they provide energy
 - Southern Co, Dept. of Energy
 - PSCs and their role.
 - EMCs
 - Energy cities

Lesson 2: Economics

- Microeconomics
 - Demand, supply, equilibrium
 - Costs, Profit, Revenue
 - Oligopoly, monopoly, perfect competition (market structure overview)
- Macroeconomics
 - National output (GDP, capital)

- Unemployment rates
- Inflation/Deflation

Lesson 3: Economics of the Power Industry

- Economics/finances of utility industry today
 - Power dispatch
 - How rates are established for kW*hr
 - Cost model
- Case Study- obtain power bills from different states
 - Examples: New York, California, Florida, Kentucky... and explain the parts of the bills and the differences between them: difference in costs, pricing, etc.
- Costs of nonrenewables vs. renewables
 - Costs of oil, coal, nuclear, natural gas (fracking)
 - Shifts and implications of decreased prices for oil, coal mining, etc.
 - Costs of solar, wind, hydro, biofuel industry - the shifts and implications of decreasing costs of solar, and how that affects the industry
 - Industry reactions towards decreased prices of nonrenewables
 - Utilities
 - Conventional energy companies (oil, gas)
- Case Study- growing solar industry, implications/reactions from energy utility industry - focus on Georgia and movements in legislation
 - How solar is changing the way people pay for and obtain energy (off-grid systems)
 - Residential PV systems, Southern Co's backing of the bill

Lesson 4: Regulations and Policies of Utility Industry

- How economics affects the regulations – what happens vs what is supposed to happen
- Clean Air Act
- Clean Water Act
- Trends in policies
- Regulatory bodies: EPA, FERC, NERC, NRC
- Case Study- EPA 111D rule for carbon pollution standards (coal): reasons behind regulation, implications
- Case Study- How fracking industry changed dynamics of energy state
- Case Study- How Hurricane Katrina affected oil industry prices

Lesson 5: The Electric Grid and Power Quality

- Makeup of US electric grid
 - Age
 - Possible future problems and solutions
- Power quality and reliability
 - Blackouts and brownouts
 - Causes
 - Weather
 - Accidents
 - Animals
 - Sabotage
 - Electrical failure

- Mechanical failure
 - Age
 - Cases - *Electric Energy: An Introduction*, pgs 537-538
- Brownouts
 - Intentional vs. unintentional
- Fixes?

UNIT 5: ENERGY/POWER UTILITIES IN THE WORLD

Lesson 1: Energy Use in Other Nations

- Energy Use in the Developed World
 - Europe
 - France
 - Importance of nuclear power
 - Germany
 - Trend away from nuclear toward renewables
 - Iceland
 - Geothermal
 - Energy mix and future trends
 - Japan
 - Importance of energy imports and nuclear power
 - Energy mix and future trends
 - Impacts of the earthquake/tsunami
- Differences between utilities and energy use in US and other developed nations

Lesson 2: Energy and Development

- Review of history of energy resource development
 - Focusing on how energy has aided in the development of Western nations
 - Industrial revolution (coal), early international sea travel (coal), automobiles (oil), military technology advancement (oil, nuclear), etc.
- Correlation between per capita energy use and human development
 - Explain concepts of per capita energy use and Human Development Index (HDI)
 - Potential for increased energy use to aid development in developing nations

Lesson 3: Current Energy Status of Developing Nations

- Reliance on fossil fuels and energy imports
- Pollution impact
- Absence of energy infrastructure
- Lack of electricity in South Asia or sub-Saharan Africa
- Lack of inherent energy resources in Caribbean island nations
 - Haiti, Dominican Republic
- Efforts to achieve universal energy access and the global development community's efforts

Lesson 4: Renewable Energy Trends in Developing Nations

- Introduction to the various renewable energy sources utilized currently in developing nations
 - Applications in different regions
 - Middle East
 - Latin America & Caribbean

- Africa
- Benefits and drawbacks to renewable energy
 - Benefits and drawbacks of each type of renewable energy
 - Wind
 - Solar
 - Hydro
- Statistics on the prevalence of renewable energy in developing nations
 - Use of renewables has been increasing steadily and at rates higher than those of developed countries
- Mitigating factors: world bank infrastructure financing
- Activity- Have students divide into three groups, with each taking a region (South Asia, sub-Saharan Africa, and Caribbean, for example) with poor energy access. Have each group discuss and present which renewable energy source would likely be the best to implement in each region. Why? What are the advantages and drawbacks?

UNIT 6: ENERGY AND POLITICS

Lesson 1: Energy and US Politics

- Domestic politics
 - Climate concerns
 - Prosperity vs. changes in energy use
 - Debates
 - Lost jobs in fossil fuels vs. gained jobs in renewables
 - Economic consequences of reducing energy use or switching to more renewables.
 - Preponderance of fossil fuel and fossil fuel companies in US
 - Corporate lobbies
 - Keystone XL

Lesson 2: Energy and International Politics

- Energy and US foreign relations
 - Middle East nations
 - Importance of oil trade
 - Relations with oil producers
 - Saudi Arabia
- Energy and other foreign relations - basic overview
 - Russia and EU
 - Energy-based codependence
 - Russia and China
 - Burgeoning relationship based in large part on Russian energy supplies to China
 - South China Sea dispute
 - Based in large part on underwater energy resources

Lesson 3: A History of Energy and Politics

- Brief and basic analysis of historical cases
 - Iranian nationalization of oil industry and 1953 coup
 - Overthrow of Mossadegh and reinstatement of Shah

- Soviet Union in Afghanistan - 1979
 - Fears of incursions into the Middle East
 - Carter Doctrine
- 1991 Gulf War
 - Attempt by Iraq to gain control of Kuwaiti oil supplies
- Russia in Eastern Europe
 - Energy as a weapon
 - Cutting off natural gas supplies to Ukraine

UNIT 7: ENERGY TRENDS AND TECHNOLOGY

Lesson 1: Current Trends in Energy Technology

- Fracking, tight oil, and natural gas
 - Advancement of hydraulic fracking technology has allowed for significant growth in U.S. domestic oil and natural gas production
- Case Study - how has U.S. energy policy changed due to increase in energy resource production?

Lesson 2: Current Trends in Energy Technology, Continued

- Microgrids
 - What is a microgrid?
 - Differences between microgrids and traditional power grids
 - Applications of microgrids
 - Developing nations
 - Increased electricity reliability
 - Incorporation of renewables
- Smart grids
 - Applications of smart grids
 - Benefits of smart grids
 - Increased electricity efficiency

Lesson 3: Current Trends in Energy Technology, Continued

- Electric Vehicles
 - Use of electric vehicles (EVs) is increasing in the U.S.
 - Advancements in battery capacity have made EVs more competitive with conventional vehicles
 - Increased range and reduced charging time
 - Advancements in technology are steadily bringing EV costs down
 - Nissan Leaf in GA, Tesla vehicles
- Activity: Have students break into four groups and pick a technology (TV, Blu-ray players, smart phones, etc). Each group will research and present briefly on the price of the technology now as compared to 5-10 years ago (depending on the tech selected).

Lesson 4: Energy storage

- History of batteries and battery innovation
- Batteries and energy storage
 - The intermittent nature of most renewable power (solar, wind, hydro) makes energy storage a useful tool
 - Battery technology provides a way of storing energy for later use

- Advancements in battery technology are making renewables more competitive with nonrenewable energy sources
- Different kinds of battery tech

Lesson 5: Grid Parity

- Concept of levelized cost of energy (LCOE)
- “Grid parity”
 - The point at which one can generate their own energy at the same price it would take to purchase it from a utility
 - Phases of grid parity
 - Parity for whom?
 - This means people could, in theory, go “off-grid”
 - Advantages and disadvantages of going “off-grid”
- Geography of grid parity
 - Where? When?
 - Rocky Mountain Institute report is helpful here
 - Hawaii and other island communities
 - Activity - have class discuss possible advantages and disadvantages of going “off-grid.”
Divide into four groups - ask each group to decide whether they would go “off-grid” and why or why not

Lesson 6: Effects of trends on utilities in U.S.

- The concept of “grid parity” affects electric utility companies in U.S.
 - They will be forced to compete with the possibility of going off-grid and will likely have to provide incentives for staying “on-grid” for those who wish to pursue solar generation
 - net metering, feed-in tariffs
- Case Study: How have utilities already been affected by an increase in the distributed generation of renewable energy? How have different companies in different states responded? How might they be affected in the future?