UNIT A

THE GRID AND ELECTRICITY PRODUCTION WITH RENEWABLE ENERGY

NM Standards and Benchmarks

Social Studies

Economics Strand, Content Standard IV-B:
Analyze and evaluate how economic systems impact the way individuals, households, businesses, governments, and societies make decisions about resources and the production and distribution of goods and services.
Performance Standard #8:
Evaluate economic systems by their ability to achieve broad societal goals (e.g., efficiency, equity, security, employment, stability, economic growth).

Science

Strand III, Science and Society, Content Standard I:
Examine and analyze how scientific discoveries and their applications affect the world, and explain how societies influence scientific investigations and applications.
Performance Standard #4:
Understand the scientific foundations of common technologies (e.g., kitchen appliances, radio, television, aircraft, rockets, computers, medical X-rays, selective breeding, fertilizers and pesticides, agricultural equipment).

Career Readiness, Content Standard III and IV

Students will demonstrate the technological knowledge and skills required for future careers.
Students will develop and demonstrate responsible and ethical workplace behaviors.

Mathematics

Strand: Data Analysis and Probability
Students will understand how to formulate questions, analyze data, and determine probabilities.

Content

In this unit, students will learn about how electricity is generated using fossil fuels and how the electrical grid is used to transmit electricity. As alternatives to fossil fuels, renewable energy technologies, such as solar, wind, and geothermal reduce greenhouse gas emissions and air pollution and conserve our natural resources for future use. The class will gain an understanding of the fundamentals of electricity, how solar photovoltaic panels and wind turbines work, and what some of the challenges are to connect renewable power to the electrical grid. Students will engage in laboratory exercises to understand the applied science of these technologies. Employment opportunities in wind, solar and geothermal, as well as available education and training programs will be discussed.

Vocabulary

electrical grid
smart grid
microgrid
electrical transmission
centrally produced vs. regionally produced
line loss
base load vs. peak load
charge
current
alternating current/AC
direct current/DC
voltage
power
resistance
Ohm's Law
photovoltaic (PV)
inverter
charge controller
turbine
wind power
concentrating solar
geothermal
hydropower
tidal power

Time Allocation

2 weeks

Essential Questions

- What careers are emerging in the production of electricity from renewable energy in an effort to reduce our dependence on fossil fuels, to reduce the advance of rapid climate change, and to make responsible use of our natural resources?
- What are the skill sets needed to be successful in these career pathways?
- How and where can I learn the necessary skills to secure a good green job in a field that interests me?

Focus Questions

- What are basic electrical parameters including electrical charge, current, voltage, power, and resistance?
- How are PV modules configured in series and parallel to build voltage, current and power output for interfacing with inverters, charge controllers, batteries, and other equipment?
- What are similarities and differences between electricity production using solar PV vs. a turbine?

Introduction

(1 class)

Objective:

Students will demonstrate understanding of the environmental, social, and economic implications of the current electrical grid system and conversion to renewable energy.

Activity:

1) What is electricity? What is the electrical grid and how does it work?

   Invite an electrician from your community to talk to your class and explore with students how electricity is generated and how electricity is transmitted via the electrical power grid. Coal, natural gas, and nuclear energy are the principal fuels that power the nation's electrical grid. How do these fuels generate electricity? What are some of the current problems with the grid and efficient transmission of electricity? What is the difference between a base load vs. peak load plant? What are the issues associated with the grid and renewable energy production? How can the "smart grid" and "micro grid" overcome some of these problems? What jobs might be available in creating this much-needed infrastructure?

   Resources:

   - Renewable Energy Basics
     http://www.nrel.gov/learning/re_basics.html
   - Energy Delivery and Storage Basics
     http://www.nrel.gov/learning/delivery_storage.html
   - How Power Grids Work
     http://science.howstuffworks.com/environmental/energy/power.htm
   - How Grid Energy Storage Works
     http://science.howstuffworks.com/environmental/green-tech/sustainable/grid-energy-storage.htm

Applied Science in Basic Electricity

(1 class)

Objective:

Student will demonstrate basic competency in the applied science involved in the technology.

Laboratory Science Application

Siphons and Circuits - By demonstrating how water passes through tubing, students can imagine how electricity flows through a circuit.

Materials: Siphons and Circuits Study Guide and Discussion Questions, diagrams included and equipment specified in the lab activity and homework (See Appendix A)

Resources:

- *Schools with Sol, Supplemental Reading, Exercises, and Lesson Plans* (March 2007, by NMSEA for NM Energy, Minerals, and Natural Resources Department) See Appendix A.1
- Solar Energy Basics http://www.nrel.gov/learning/re_solar.html
- North American Board of Certified Energy Practitioners PV Entry Level Program Objectives, September 2009, Electrical Basics, 3.1/3.5 http://www.nabcep.org/resources

Homework: Students complete the exercise. "Pumps and Batteries" adapted from *Schools with Sol* pages 8-13. Students will be able to visualize the movement of energy through two different systems (a water circuit and an electric circuit) to understand Ohm's law.

Applied Science in Batteries and Photovoltaics (PV) as Sources of Power

(1 – 2 classes)

Objective:

Student will demonstrate basic competency in the applied science involved in the technology.

Laboratory Activity:

1) Wiring Batteries and Photovoltaic Panels – This hands-on activity will allow students to wire battery modules and photovoltaic panels in parallel and in series.

Materials: "Battery Cells and Modules" and "Photovoltaic Cells and Modules" based on pages 14-17 and 19-22, *Schools with Sol*. (See Appendix A.2) 1 copy of the lab activity pages listed above and a calculator for each student.

Resources:

- *Schools with Sol, Supplemental Reading, Exercises, and Lesson Plans* (March 2007, by NMSEA for NM Energy, Minerals, and Natural Resources Department).
- North American Board of Certified Energy Practitioners PV Entry Level Program Objectives, September 2009, PV System Electrical Design 8.2 http://www.nabcep.org/resources

Assessment: Participation in discussion, engagement, 70% or better on homework exercise.

2) Guest from NMSEA SunChaser Program (Optional or Alternative)

This 50-minute oral presentation, demonstration, and lab activity could replace or supplement activities above. Contact www.nmsea.org to schedule an instructor or to purchase kits (NMSEA EDU-KIT PV101 available from NMSEA for $240 plus shipping. Call (505) 246-0400). (See oral presentation materials in Appendix A.3.)

Materials: a NM Solar Energy Association Battery and PV module wiring kit (includes 4 AA 1.5 V batteries, demonstration battery module board, three 7.25 x 11.5 inch 5W solar (PV) panels, one multi-meter and one copy each of diagrams and student data sheet) and a calculator for each group of 3 – 4 students.

Assessment: correctly assembled, wired PV panel as recorded on the data sheet (Appendix A.3).

Employment and Training Prospects in Active Solar

(1 - 2 classes)

Objective:

The student will identify green jobs in active solar, training resources and skill sets necessary for a career in these occupations.

Activities:

1) Share the following information:

In New Mexico, the Solar Energy Industry Association anticipates 19,000 new jobs created in New Mexico by 2016 in the solar industry alone. This is the highest per capita gain in the country. The American Solar Energy Society estimates that the renewable energy and energy

efficiency industries could create 37 million new jobs in the U.S. by 2030. New Mexico's share of that would be 236,800 jobs. The hottest sectors include solar thermal, solar photovoltaics, biofuels, and fuel cells (in terms of revenue growth). Currently, the solar industry directly supports about 46,000 jobs in the United States, with expected growth expected to surpass 60,000 in 2010.

Career pathways in the solar sector with increased demand include (from NM Green Jobs Guidebook):

Solar PV System Installer
Solar Thermal System Installer
Sales Representatives/Estimator
Site Surveyors/Assessor
Solar Engineer/Designer
Solar Installation Manager/Project Foreman

2) Review green job occupations typical educational requirements (programs and courses) http://www.greenjobs.state.nm.us/programs.html

3) Invite a licensed, local contractor to class who is doing PV installation and who, preferably, has gone through a green jobs training program. Ask them to discuss the types of career pathways that might be available to students in the PV arena.

4) Watch videos of jobs in solar industry:
   - Native American-owned Sacred Power PV Panel Producer - http://www.nmdws.fatcow.com/wired/sacred_power.html
   - Oregon Tradeswomen – Electrician http://www.youtube.com/user/tradeswomen#p/u/14/pbNHHXzXLoU
   - Solar Installer from Phoenix Learning Center http://www.youtube.com/watch?v=s7oxudDxH68
   - Electrical Training for a New Career http://www.youtube.com/watch?v=dTOXB_tYveo&feature=related
   - A day in the life of an electrician installing solar thermal panels http://www.youtube.com/watch?v=gHBKUvRyCpY

   Resources:
   - NM Green Job Portal www.greenjobs.state.nm.us
   - NM Green Job Career Pathways http://www.greenjobs.state.nm.us/pdf/GreenPathways.pdf
   - NM Green Jobs Educational Opportunities http://www.greenjobs.state.nm.us/education.html
   - NM Green Certifications http://www.greenjobs.state.nm.us/pdf/GreenCertificates.pdf
   - Renewable Energy Programs in Solar
     - **New Mexico State University -** Solar, wind, and energy
     - **Eastern New Mexico University -** Solar photovoltaic

- **Central NM Community College (CNM)**
  - Solar panel installation
  - Solar, wind and photovoltaic technician
  - Alternative energy system design
- **NMSU-Doña Ana Community College -** Solar, wind and geothermal
- **Northern New Mexico College -** Solar and other renewable energies
- **San Juan College -** Renewable energy
- **Santa Fe Community College -** Solar and other renewable energies

Applied Science in Turbine-produced Electricity

(1 - 2 classes)

Objective:

Student will demonstrate basic competency in the applied science involved in the technology.

Activities:

1) Introduction of sources of turbine-produced electricity. Today, we'll be learning the basic science behind a wind turbine. Ask students to be thinking about the similarities and differences between electricity production at a geothermal plant vs. a wind farm. Concentrated solar and hydroelectric power also use turbines. How are these technologies similar and different?

   Resources:
   - Wind Energy Basics
     http://www.nrel.gov/learning/re_wind.html
   - Geothermal Energy Basics
     http://www.nrel.gov/learning/re_geothermal.html
   - Concentrating Solar Power Basics
     http://www.nrel.gov/learning/re_csp.html
   - Hydropower Basics
     http://www1.eere.energy.gov/windandhydro/hydro_basics.html
   - *Money Morning* "Advancements in Geothermal"
     http://www.nuwireinvestor.com/articles/advancements-in-geothermal-energy-could-help-the-environment-and-investors-54618.aspx

Conceptual Science Application:

1) Producing electricity with a wind turbine

   How is electricity generated differently with wind power than with photovoltaics? "Wind Power Basics" (see Appendix A.4, Unit of Study 17, pp. 1-7 and the Reading Passage),

introducing the how's and why's of wind power, making watts from wind. Complete "introduction" and "reading passage."

Materials: Reading passage from "Wind Power Basics"

Resources:

- "Wind Power Basics", State Energy Conservation Office, Austin, TX (www.InfinitePower.org, 2008)

Laboratory Science Application:

1) Testing a Windmill Generator
   Construct the windmill generator according to directions, perform the experiment, and conduct data analysis by recording measurements and answering the questions. (See Appendix A.5)

   Materials: small electric fan or hair dryer, small DC toy motor, cork, DC voltmeter, stiff ruler or meter stick, 50 cm. of electrical wire with alligator clips, rubber bands, scotch tape, paper clips, wire cutters, scissors, pieces of cardboard, cork borer, goggles, student data sheets, assessment questions. Wind turbine kits are available at: http://www.kidwind.org/xcart/home.php?cat=4

   Assessment: completed windmill generator, completed student data sheet, assessment completed with 70% or better competency.

Employment and Training Prospects in Wind, Geothermal and Concentrating Solar

(1 - 2 classes)

Objective:

The student will identify green jobs in wind, geothermal and concentrating solar technologies and the training resources and skill sets necessary for a career in these occupations.

Activities:

1) Share the following information:

Background

- In 2009, the wind power sector invested $17 billion in the U.S. economy, employing approximately 85,000 people.

- Jobs include turbine component manufacturing, construction and installation of wind turbines, wind turbine operations and maintenance, and transportation and logistics.
- If the goal of 20% wind electricity by 2030 is to be reached, about 250,000 additional workers will be needed.
- According to the Greener Pathways report, these jobs are in wind power installation (construction and transportation); wind farm maintenance and operations; and, most of all, wind turbine manufacturing. Many of the jobs in wind turbine production are similar to traditional manufacturing jobs.
- Green jobs in geothermal energy include: welders; mechanics; pipe fitters; plumbers; machinists; electricians; carpenters; construction and drilling equipment operators and excavators; surveyors; architects and designers; geologists; hydrologists; electrical, mechanical, and structural engineers; HVAC technicians.

2) Watch the four minute video, "GE 1.5 MW Wind Turbine Construction" depicting 2010 Wind Turbine class at Mesalands Community College in Tucumcari constructing its first wind turbine.
   Link:
   http://windenergy.movieclipsfree.com/5330715350325854433366f/video_ge_1.5_mw_wind_turbine_construction

3) Discuss the gearing problems (gears wear out quickly) currently in wind turbines. Suggest that these gears have a short shelf-life and have to be replaced. R & D jobs are available to improve the gear-system lifetime. However, presently, individuals who aren't afraid of heights are needed to climb the turbines and replace the gear systems.

4) Watch the following videos:
   Climb a Wind Turbine – Portland General Electric
   http://www.youtube.com/watch?v=JR_IrBEbi6Q&feature=related
   On top of the world; a career as a Vestas service technician
   http://www.youtube.com/watch?v=P_ybsfyGIiw&feature=related
   A Day-in-the-Life of Wind Turbine Service Technician
   http://www.youtube.com/watch?v=J6Gykr__pzQ&feature=related

5) Watch the video "Green Careers: Clean Energy – Geothermal Power"
   http://www.youtube.com/watch?v=Y0Tv69wG-Ws&list=ULogHBZAJe95U&playnext=1

Resources:

- Bureau of Labor Statistics – Careers in Wind Energy
  http://www.bls.gov/green/wind_energy/
- New Mexico Green Jobs Portal
  www.greenjobs.state.nm.us
- New Mexico Green Jobs Guidebook http://newenergyeconomy.org/wp-content/uploads/2011/03/nmGreenJobsGuidebook.pdf
- Green job occupations typical educational requirements - Programs and Courses
  http://www.greenjobs.state.nm.us/programs.html

- NM Green Jobs Educational Opportunities
  http://www.greenjobs.state.nm.us/education.html
- NM Green Certifications
  http://www.greenjobs.state.nm.us/pdf/GreenCertificates.pdf
- Renewable Energy Programs
  - **New Mexico State University -** Solar, wind, and energy
  - **Central NM Community College (CNM)**
    - Solar, wind and photovoltaic technician
    - Alternative energy system design
  - **Mesalands Community College -** Wind energy technology
  - **NMSU-Doña Ana Community College -** Solar, wind and geothermal
  - **Northern New Mexico College -** Solar and other renewable energies
  - **San Juan College -** Renewable energy
  - **Santa Fe Community College -** Solar and other renewable energies

Experiential Component

(1 class)

Objective:

Students will demonstrate understanding of jobs in this career cluster through direct experience in the field.

Field Trip Options:

1) Visit local community college or university applied technologies program to learn about local training in solar and wind technologies. To find programs in your area, search the following resources:
   http://www.greenjobs.state.nm.us/pdf/EducationOccupations.pdf
   http://www.greenjobs.state.nm.us/pdf/GreenCertificates.pdf

2) Visit a renewable energy project in your area.

3) Alternative to field trip – Invite to the classroom a local expert in wind technology. Visit the New Mexico Green Chamber of Commerce (www.nmgreenchamber.com) or local community college or university applied technologies program to identify a wind power expert.

Formal Weekly Assessment

Objective:

Student will demonstrate with a 70% proficiency or better, his/her understanding of concepts and employment opportunities in this career cluster.

Assessment: weekly assessment based on Weekly Grading Rubric (See Appendix I.8)