KENAN FELLOWS PROGRAM
FOR TEACHER LEADERSHIP

All Call to Take It Off the Grid

Description

Students will explore the the electric grid and smart grid. They will compare and evaluate the advantages and disadvantages of the current and future power systems. They will focus their exploration on Photovoltaic energy (solar). Armed with this background knowledge students will explore the features of commercial solar phone chargers and use this research to design their own solar chargers. As an extension students will build their own solar chargers. This mini unit may be done as stations or small group activities.

Packet Contents

Introduction

When you plug in your phone to charge do you ever wonder where the power comes from and how that might change in the future? Student will start the unit with an introduction to the Smart Grid as they compare and evaluate the the pros and cons of the Smart grid. The unit is divided into four parts

- Smart Grid Exploration
- Alternative Energy Exploration

- Testing Solar Chargers
- Constructing Solar Chargers

The unit is designed to carried out as instructional centers that student circulate through. There are print copies provided if internet access is an issue.

Curriculum Alignment

Science & Technology -Middle School

NCSC 8.P.2 Explain the environmental implications associated with the various methods of obtaining, managing and using energy resources.

8.P.2.1 Explain the environmental consequences of the various methods of obtaining, transforming and distributing energy.

8.P.2.2 Explain the implications of the depletion of renewable and nonrenewable energy resources and the importance of conservation.

Essential Question(s)

- How can the way we obtain, transform, and distribute energy affect the environment?
- What is the difference between renewable and nonrenewable?
- Why is the conservation of energy important?
- What are the consequences of mismanaging our resources?

Next Generation Engineering Design -Students who demonstrate understanding can:

MS-ETS1-1.	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3.	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Outcomes

- Participants will explain the environmental implications associated with the various methods of obtaining, managing and using energy resources.
- Participants will compare the current electric grid with the smart grid, stating the advantages and disadvantages of each system. (as poster or chart)
- Participants will analyze data from tests to determine similarities and differences among several design solutions (solar chargers) to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Participants will design and build a solar powered USB charger.

Time and Location- The total unit can be completed in 2-3 weeks in a class or lab with access to internet and technology . There are options provided/suggested for classrooms with limited access to technology and the internet. The unit can be completed entirely or be taught independently in sections. See breakdown

- Part I Smart Grid Exploration -3-6 days

Optional

- Part II Solar Charger exploration /design evaluation 2-5 (5 days if including experimentation with solar chargers)
- Part III Building a solar charger 2 days / Due to safety concerns this is best done in small groups.

Materials

Facilitator List

- *Internet access /Projector /Student access to internet at stations*
- *Handout and presentation -see shared links*
- *Commercial solar chargers (Ideally 1 per group of 4 / at least 4 different chargers under $25)*
- *Optional -volt meter*

https://www.amazon.com/Best-Sellers-Electronics-Cell-Phone-Solar-Chargers/zgbs/electronics/2407762011

Facilitator Preparations

- Reserve technology for class stations
- Become familiar with grid and smart grid technology
- Make copies of student sheets (if internet access not available)
- Review and build (model) solar charger

- Download Tesla Town app on devices (free app)
- Purchase -materials for solar chargers

Participant List

- *Student access to devices with internet at stations (8-10)-laptops, tablets or smart phones*
- *Participant worksheets SS1-SS5,Station Student Guide*
- *Hard copies (if internet access is not available) back ground /* Real Science Application
- *1 computers for every 4 participants*
- *1 solar charger for groups of 4 (different designs and brands)* [Funding suggestion- Ask parents to purchase a solar charger from list and loan or donate it to the class for the exploration]
- *1 per group -Personal / or school devices (phones, Ipads or laptops)*
- *paper and pencils,*
- *art supplies,*

Safety

When constructing solar chargers, soldering must be done in a well ventilated environment under adult supervision.

SCHOLASTIC PARENTS: THE LEARNING TOOLKIT
Kid Maker: How to Solder -Here are step-by-step instructions on how to ignite your child's passion for soldering.

http://www.scholastic.com/parents/blogs/scholastic-parents-learning-toolkit/kid-maker-how-to-solder

Student Prior Knowledge

- Participants should have basic background on electricity and how we get energy from the traditional power grid (background provided). See **Real Science Application (links and print copies provided)**
- Basic understanding of circuits and soldering

Critical Vocabulary

https://docs.google.com/document/d/1Gz6ruw6Ky_oYOhnGjiY5kMqcbMVHglohrSb4ICDQaKE/edit?usp=sharing
Quizlet
https://quizlet.com/16999554/apes-chapter-13-vocab-flash-cards/

Background -Smart Grid

Smart grid" generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from the power plants and wind farms all the way to the consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers -- mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.

Activities /Centers

Teacher Instructions- These activities can be organized as centers with students circulating through, or as a whole group lessons. Start with the completion of the Learn and Want to Learn on the KWL chart. All students must complete the KWL and station #1. For the general population they must complete a total of 4 stations (including station #1). Students are to complete 4 assessment options. This requirement can be modified to differentiate.

Alternative- Use a project board or menu format to differentiate and allow for student choice and collaboration. Tired /menue assessment.

Introduction Lesson 1

KWL -Prior Knowledge - Have students complete the K & W columns on the KWL chart. (Print and distribute the KWL chart and rubric or share with students as google form) Student Sheet 2 (SS2 hyperlink below)

KWL -SS2

- **What is the Grid** ?-describe or draw
- What are the **advantages and disadvantages** of the current Grid?
- What makes up the grid?
- What is the **Smart Grid**? describe or draw
- How does the **Smart Grid differ** from the current **Grid?**
- What are the **advantages and disadvantages** of the Smart Grid?
- Share with your group -create a KWL chart with your group

Students are to circulate through Center Stations

Station #1 -Smart Grid Exploration All student complete on day 1 (1-2 days depending on the method of evaluation.) Students will watch the video clip **Scientific American's Introduction to the Smart** (see link)

Smart Grid Exploration - Students will explore the web site **Smart Grid Technology** -Integrating the 19th and 21st centuries to bring smart electricity to the masses. Students will create a Pro/Con Chart contrasting the current grid with the smart grid, Pro/Con Chart and Rubric
https://docs.google.com/document/d/1AjytRE-zCVqLT5PRWWe-i2Vl55ExM3IcPjYz1V1vXFg/edit?usp=sharing
Print copy if internet access is not available: **SS1 -Print copy**
https://docs.google.com/document/d/15WNIcro-F7JoZD0AtUdl6uDpvONxFkIZwPgTOUFwwxA/edit?usp=sharing
Additional Resources (This can be presented as a group presentation or as part of the center)
Grid Modernization and Renewables -presentation by Landon Mackey and Catie McEntee of the Freedm System Center-(this can be flipped)

https://docs.google.com/a/ncsu.edu/presentation/d/1Ft8JQFCOxYkmZSpfEUE_404ZQj3eaIbJyflymwyFgwY/edit?usp=sharing

Alternative Assessment - have student write what they learned about the current grid and the smart grid on sticky notes and place these on a piece of chart paper displayed in the classroom.

Station #2 (Optional) **Literacy (Real World)Connection -**Read the article and write a summary**.** Apple to Build a 3rd Solar Panel Farm in North Carolina

Web https://gigaom.com/2014/07/08/apple-to-build-a-3rd-massive-solar-panel-farm-in-north-carolina/
Print copy
https://docs.google.com/document/d/1xofLczRlPN_sNHZHfd9VoMfU2DpfCw-5r99LALInT1Y/edit?usp=sharing

Station #3 -**Renewable Energy** - (two stations for larger classes/ 1 station for smaller classes)

Research and summarize the points of interest for each of the following sources of energy. Then create a product to share the key points about these energy sources..Solar

- Wind
- Biomass
- Geothermal
- Hydrogen
- Advanced Vehicles & Fuels

Explore another smart grid technology- Create a poster, presentation or animoto or other presentation to promote its use or create a chart or diagram to compare & contrast the good and bad points and potential use now and future.

NREL- National Renewable Energy Laboratory
http://www.nrel.gov/workingwithus/learning.html
E.I.A. National energy Administration -Energy Kids
http://www.eia.gov/kids/index.cfm

Product Options Create a product to highlight the good and bad aspects of the current and future renewable energy options. .

- pamphlet
- infomercial
- Poster
- Animoto
- Movie trailer

Optional= Top 10 Energy Sources of the Future
https://www.youtube.com/watch?v=uStFvcz9Or4&t=124s

Station #4- Explore Smart Grid Tesla Town of the near future. Label the city design with captions explaining the uses of the smart grid. https://credc.mste.illinois.edu/applet/tt

Enter Tesla Town and explore electricity generation and delivery.

- Go into a hydroelectric power plant and see the turbine.
- Visit a solar powered house or a wind farm.
- Define electromagnetism
- Describe the future electricity generation and delivery systems.

Please note that while this application will run on any compatible device, it was designed for tablet-sized screens. On smaller devices, such as mobile phones, the text might be very hard to read.

The Power Grid https://credc.mste.illinois.edu/applet/pg

Description: The power grid is the system of producers and consumers of electricity. It includes power generators, the users of electricity, switches that control the electricity, and the system of substations, power lines, and transformers that deliver the electricity. A community might have a generator to provide its power. The generator may be able to vary its production as the usage of the customers changes, but there may be times when the demand for energy is too great for the generator. Then the community buys electricity from another source. At other times, the generator may be making more electricity than the community is using, so it wants to sell it.

NOTE: Since support for NPAPI has been phased out of Chrome, **the TCIPG Education applets will no longer work in Chrome broswer**. Alternative browsers like Firefox, Safari, and Internet Explorer should still run the applets, provided your version of Java is up to date.

Challenges:

1. When the applet opens, are the generators making more or less power than the communities are using?
2. Reset the system and notice the line leading from Substation 5 to Commerceton. How much power is this line carrying? Click on the up arrow to increase Commerceton's power demand. What happens to the arrows on the line? At what load do the arrows change to orange? What color are the arrows when the demand is 1000 MW? What happens when the load on the line is increased again? How can you fix it?
3. Reset the system, put the nuclear power plant online, and then increase the power demanded by Residenceburg to 1850 MW. What's causing a problem? Reduce the potentially dangerous line overload without taking the nuclear plant offline?
4. It's a hot summer day and power demand in Residenceburg is 1600 MW. Commerceton is demanding 850 MW, and Industryville needs 800 MW. Put all of your generators online at maximum capacity. Are all of your lines operating safely? Are you able to produce

enough power to meet the demand, or do you need to get power from the external system?

5. Reset the system, turn on the nuclear power plant, and then open the line between substations 1 and 2. What happens? What is the problem? Fix it by changing one switch?

Station 5- Photovoltaic Solar Energy- Create a poster pamphlet or presentation Explaining How Photovoltaic Solar Energy works

- Read the following article -How do Photovoltaics Work? (article)
  https://docs.google.com/document/d/1KG6xwrULMaKWPnxmhjXAdb3umJuTVYrt0IiIIHq7028/edit?usp=sharing

- Watch the TED Talk and answer the THINK questions How do solar panels work? - Richard Komp TEDED (4:58) (This lesson may be flipped) Complete the think questions.

  https://docs.google.com/document/d/1Yb4GH3xr62i-DgFYJX7NbfyOy19QoWCqMYpphBQ45Fc/edit?usp=sharing

  Print copy of Think questions
  http://ed.ted.com/lessons/how-do-solar-panels-work-richard-komp

Other video options Watch the video clips

- *How Does Solar Energy Work?* (3:15) https://www.youtube.com/watch?v=HciKU63dLtA
- *Bill Nye - How Stuff Works - Solar Energy - YouTube (2:54)* https://www.youtube.com/watch?v=av24fEMhDoU
- *How Photovoltaic Solar Cells Work* https://youtu.be/yz96MHXiAGE and summarize how a solar cell works.

PV Design Activity by Catie McEtree
https://docs.google.com/a/ncsu.edu/presentation/d/15UsM7DfPcaurVl18aC1_kdcY7yCIEOlEEWame_9YbwM/edit?usp=sharing

Station 6 -Battery Exploration Students describe how a battery works and then research. compare and evaluate rechargeable batteries.

- Describe how a battery works
  https://www.youtube.com/watch?v=Eo0q59NPNUQ
  Illustrate and describe how a rechargeable battery works
  https://www.youtube.com/watch?v=3KX_KuS6FPI
  Why Aren't All Batteries Rechargeable?
  https://www.youtube.com/watch?v=Eo0q59NPNUQ

- **Explore Rechargeable Batteries** -create a spreadsheet and make a recommendation based on data

Station 7 Conservation -Saving Energy

- View the following & list (bullet) ways to conserve energy.

  Vampire Power Awareness from iGo

  https://youtu.be/mNcHUrg9EQY
  Embed <iframe width="560" height="315" src="https://www.youtube.com/embed/mNcHUrg9EQY" frameborder="0" allowfullscreen></iframe>

  Standby Savers Smart Power Board (optional)(This can be a flipped assignment)

  https://www.youtube.com/watch?v=tHDF80pZ388&feature=youtu.be

Embed <iframe width="560" height="315" src="https://www.youtube.com/embed/tHDF80pZ388" frameborder="0" allowfullscreen></iframe>

- View the following & list (bullet) ways to conserve energy.
- List ways to save energy at school.
- Create a public service announcement or infomercial explaining ways students can conserve can conserve energy.

Station 8 Charging Devices Optional

Explore commercial solar chargers

- Illustrate or describe how a charging device works
- Develop spreadsheet & desirable features

All Call to Take it off the Grid -Comparing Commercial Solar Panels

Evaluating Solar Chargers -Research and complete spreadsheet (May be completed using hard copies of charger data sheet if on-line exploration is not available)

Solar Phone Chargers Comparison and Analysis SS3A Hard copy charger data sheets-
https://docs.google.com/document/d/1B3RtKAJYDUMWiDxiliy120oJWWcV376eNWjpCys6nII/edit?usp=sharing

- **Features**:water-resistant shock-resistant and dustproof solar phone charger, equipped with compass and 2LED flashlight.
- **Outputs /ports:** Dual USB covered by the side: universal 5V/1A and 5V/2.1A outputs are available for most digital devices; 2.1A port for iPad/Tablets, 1A ports for phone/Bluetooth or other 5V USB supported devices
- **Design**: made of durable and reliable material ABS+PC+Silicone, power bank
- **Additional features:** Powerful LED light: 2led lights can be used as flashlight with Steady-SOS-Strobe mode. Five pilot indicators show the status of battery charger timely. Green light on when charging by solar, blue light on when USB charging.

Station 9 Building a solar charger

Optional Activities -see Extension Activities for details. This can be set up as additional stations or presented as a group lesson.

Engage-

Show students an Image of smartphones or laptops in need of charging, plugged along wall. Ask students, “Have you ever been in a situation when you needed your phone and your phone needed to be charged? What could you do if you did not have access to power? What solution to this problem (which we have all faced either with a smartphone or another device) could also reduce our dependance on the grid?...**THINK SMART GRID”**

http://4.bp.blogspot.com/-fBulYkL-t-w/VHOCiaJh88I/AAAAAAAABqE/CrhSDmLkptU/s1600/charge-phone-mobile-handset.jpg

Brainstorm Ideas and then discuss the criteria to determine which ideas are the best options.

List the options or have students write the options on sticky notes to be posted.

What are our options? What are our constraints? (things that limit our options) possible responses:

- Money
- Efficiency
- Features
- Design
- Convenience

- Availability

If student do not suggest a solar charger show them one. Focus on the advantages of a small solar electric or photovoltaic (PV) system

Small Solar Electric Systems

A small solar electric or photovoltaic (PV) system can be a reliable and pollution-free producer of electricity for your home or office. Small PV systems also provide a cost-effective power supply in locations where it is expensive or impossible to send electricity through conventional power lines.
http://energy.gov/energysaver/small-solar-electric-systems

Station 9 Building a solar charger AA Solar Charger in Altoids Tin -This may be done as a small group activity, center or option for interested students..
https://docs.google.com/document/d/1jSS3b12UFNYNf2lIXZv6OA2duBfHNlBOTajvMfNP2gQ/edit?usp=sharing

Resources

III Calling Designers -Solar Charger Design Building Solar chargers

https://docs.google.com/document/d/1jSS3b12UFNYNf2lIXZv6OA2duBfHNlBOTajvMfNP2gQ/edit?usp=sharing
https://docs.google.com/document/d/1jSS3b12UFNYNf2lIXZv6OA2duBfHNlBOTajvMfNP2gQ/edit?usp=sharing

- Research various designs for home made solar chargers
    - **https://docs.google.com/document/d/1jSS3b12UFNYNf2lIXZv6OA2duBfHNlBOTajvMfNP2gQ/edit?usp=sharing**
    - http://ece.jagansindia.in/2012/04/solar-charger-for-phones-usb-battery/
- Design a chargers with a description of features -draw the chargers to scale and describe features
- Describe the steps to construct the charger
- List materials and resources

Extension Activities (Optional)

Smart grid Jobs and Careers
http://www.raleigh-wake.org/page/triangle-is-central-for-smart-grid-development
http://energy.gov/articles/power-jobs-smart-grid-workforce
http://energy.gov/eere/education/videos/smart-grid-animation
https://www.youtube.com/watch?v=JwRTpWZReJk

PV Design Activity by Catie McEtree Freedm System Center
https://docs.google.com/a/ncsu.edu/presentation/d/15UsM7DfPcaurVl18aC1_kdcY7yCIEOlEEWame_9YbwM/edit?usp=sharing

Building Solar Charger Design- Optional Extension *(OLO /Optional Learning Opportunity)*- Students create a viable design and are excited by this learning opportunity can join a small group to build a solar charger.

Materials for building ***Altoids USB Battery/Solar charger for iPhone and iPod***

- *Small metal box (Altoids -work well)*
- *4 – AAA Battery Holder (or 2 - 2 AAA wired together*

- *4 AAA rechargeable Batteries*
- *USB Socket (female)*
- *Solar Panel (3V output minimum, around 5V max)*
- *Blocking Diode (not LED)*
- *Some resistors (This is somewhat optional. You need them if you want your iPod/iPhone to recognize your charger. I'll explain exactly which ones to use later.)*
- *DPDT Toggle Switch*
- *Electrical wire*
- *Small Perf Board (Also optional)*
- *Soldering Iron/ solder*
- *Hot Glue*
- *Wire cutters*
- *Tin snips*

(More complex plans)

http://www.instructables.com/id/Altoids-USB-BatterySolar-charger-for-iPhone-and-i/

http://ece.jagansindia.in/2012/04/solar-charger-for-phones-usb-battery/#ixzz4EOmYUqU1

Activity Menu for Differentiation

Assessment

Rubric - Have student fill complete the rubric including the self evaluation -https://docs.google.com/document/d/1Fp8mWzLplhzYgFxX2eYiPYx55658pWyips9WT9XWFwY/edit?usp=sharing

Elaborate and share ideas on KWL

Formative Assessment 2A- (This can also be used as a summative assessment.) Have students make a mini poster, brochure or advertisement promoting the advantages of A small solar electric or photovoltaic (PV) system.
Assessment /Reflection #1 & 2
Alternative Assessment

- **Ad or Infomercial** -Students can create an ad (video, web or paper) to convince/ persuade fellow students about the importance of using alternative energy and particularly solar energy.
- **Persuasive Writing**- Interdisciplinary connection- Team with your Language Arts teacher to have students write a **persuasive essay** on:
    - Use of alternative energy
    - Grid vs Smart Grid
    - Supporting infrastructure to support the smart grid
    - Use of Photovoltaics to supplement energy

Community Engagement

Examples of engagement (this is by no means an exhaustive list, rather a few ideas)

- Contact a local solar panel installation company to speak to students
- Sharing participant work or projects- post student designs on web / tweet
- Site visits- visit a local PV field

- Invite a community engineer or planner to see how Solar and other Alternative energies are being used in the community
- Invite a community engineer or planner to explain how the community is moving toward the Smart Grid
- Speaker - Invite a member from industry to describe how their industry is supporting the Smart Grid and career paths that might be available to students

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Bibliography:

https://docs.google.com/document/d/1BGtrJACCqTURoY04EUT5jRM1084xTVNx743hzWCpyR0/edit?usp=sharing

http://easybib.com/key/c1cdb7

Credits

- Special thanks to Dr. Pamela Carpenter at Freedm System Center
- This plan was developed to get students engaged in learning about the smart grid. By building solar chargers students will participate in Problem Based Learning in STEM.
- Possible Extensions -Students adapt the charger designs and create “kid friendly instructions” that are posted on the web. Students can create an advertizing campaign to promote their design
- Adapt the plan -eliminate the build

References	**Embedded links** **Bibliography:** https://docs.google.com/document/d/1BGtrJACCqTURoY04EUT5jRM1084xTVNx743hzWCpyR0/edit?usp=sharing http://easybib.com/key/c1cdb7
Comments	• This plan was developed to get students engaged in learning about the smart grid. By building solar chargers students will participate in Problem Based Learning in STEM. • Possible Extensions -Students adapt the charger designs and create “kid friendly instructions” that are posted on the web. Students can create an advertizing campaign to promote their design • Adapt the plan -eliminate the build • Special thanks to Freedm System Center 

Resources

R.E.A.C.T. Renewable Energy Activities – Choices for Tomorrow Teacher’s Activity Guide for Middle Level Grades 6-8 National Renewable Energy Laboratory Education Programs 1617 Cole Blvd. Golden, Colorado 80401 Tel: (303) 275-3044 Home page: http://www.nrel.gov