Efficiency and Availability: Designing an Energy Self-Sufficient Community

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This curriculum unit is recommended for:
Science/Grade 8

Keywords: Energy, Infrastructure, Off the Grid, Carbon Emissions, Resources, Natural Gas, Oil, Coal, Solar, Hydropower, Wind, Geothermal, Nuclear, Efficiency

Teaching Standards: See Appendix (1) for teaching standards addressed in this unit.

Synopsis: Introducing students to energy goes hand in hand with matter. Students have mastered the basics of matter and atomic structure and are ready take the next step: energy. This curriculum unit explores the continuation of chemistry concepts, following matter, making heavy use of kinesthetic and creative learning styles with a focus on research and development of an idea. Technology and traditional instruction will be used to cover concepts before students begin their research and hands on activities of city design and efficiency, as well as keeping track of use and carbon emissions. Specific information covered includes the following: types of energy (solar, hydro, biomass, wind, nuclear, geothermal, oil, coal, and natural gas), inherited (non-renewable) resources, income (renewable) resources, carbon emissions, energy consumption, and city infrastructure. The activities in this curriculum unit can be replicated using online resources and some of the materials needed are contained in the Appendix or resources section. Teachers wanting to use a creative, kinesthetic approach to real life energy challenges and solutions will find the unit engaging while relying on students to complete research, calculations and following realistic guidelines to model how to get the most out of our available energy.

I plan to teach this unit during the coming year in to 128 *students in* Science/Grade 8.

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Introduction and Rationale

I do a survey at the beginning and end of every school year which primarily consists of the following question: "What is your least favorite subject?" Students can usually answer what they don't like quickly, but when pressed to answer why they don't like that subject, their usual response is because they don't feel they are very good at it. All students have their strengths and weaknesses, but engagement and giving students a vested interest in their work can lead to better performance and more of a feeling of accomplishment. An individual student, working in a team toward a common goal, can be brought around to enjoy a class they may feel inferior at because of the creative activities associated with a larger goal, in this case, designing a city block within the boundaries of certain criteria.

Of all the areas of science that I teach (all of the subjects within the earth, life, and physical disciplines) students are most interested in new concepts they haven't encountered in science yet. Chemistry, and by extension energy, is one example of these concepts. Students know their phones use electricity and if their battery gets low, they need to plug it into a wall to get more electricity, but what do they really know beyond that? The answer is that the energy they need is there when they need it, there is no reason to think about how it's being generated or recognition of the real cost of charging their phone every night. This lack of investigation is partially because of how entitled we are in a first world country and that students feel comfortable with the idea that if they ever need to know something, the internet is a click away. The goal is to inspire and engage students to actively monitor their energy consumption by having them design cities that they can see living in, in the future. It is both critical to inspire the minds of the next generation to actively design and create a product as well as planting the seed that there may not always being an easy, affordable way to access information (due to energy concerns) in the future.

The important principles for students in the core lesson of this curriculum unit are focused around the basic understanding of what types of energy there are and how they are generated. Students will also need to discover what the pros and cons are to each types of energy, a summary of what the world's energy usage looks like, how a small communities infrastructure works and how carbon emissions are affecting our planet. Students will use the most current version of BP Statistical Review of World Energy for reference as well as an inventory of usage of energy in their own homes.[2] Students will also need to check out information on how infrastructure is set up (such as roads, public transportation, community, and residential needs) in order to apply energy use appropriately. In a 21st century world, students will be able to use technology and learning styles (visual aids, audio, and kinesthetic models) to attain the information they require.

Students that complete my curriculum unit and subsequent chemistry related lessons are being prepared for high school as well as the problems of the real world. Most students will be taking an Environmental Science either freshman year or an AP equivalent later in school. Environmental Science is a great follow up to this specific unit. Students will be able to use the real life application of concepts energy demonstrated in this CU to succeed in this future course. This focus on energy applications will form a foundation for college classes for those students that want to continue in the field of science. All of these future academic goals require a strong, solid foundation in 8th grade science which this curriculum unit aims to build.

I teach 8th grade Science at Bailey Middle School in Cornelius, North Carolina, a suburb of Charlotte. Bailey is an Honors School of Excellence, a recognition that requires 90% of students to be at grade level and that the school met all 27 of its performance targets. Our school has achieved some of the highest scores for the EOG Science assessment for the second year since it was introduced. I moved to Charlotte after a year of teaching science in Louisiana for a year in 2011. Though originally a Social Studies Education major, I became certified in science through testing and have enjoyed it far more than I thought I would. I see the primary function of science class as a gateway for critical thinking in all subjects and as a necessity in education.

My classroom is outfitted as a designated 'science' classroom in the school, including features like safety stations for accidents, a closet for lab storage such as acids and other chemicals that are useful as demonstrations and lab table seating for ease of experiment conduction by students. Unlike my previous year in CTI, this actual science lab adds to some of the wonder that students feel when they enter my class. I supplement their mental picture of what a science lab and teacher should be like with a plethora of science experiments on an almost weekly basis. This allows students to feel like they are learning in a different environment than that of school while also taking their learning into their own hands. Learning by doing is an important part of science class and in a lab, students can facilitate their kinesthetic needs. The lab also has a teacher demonstration desk that I can do more dangerous or expensive reactions for students but still preserve the process, feel and a sense of participation from watching it happen right in front of them.

This curriculum unit has aspects in it that integrate basic knowledge required in any science curriculum. Students will need to be able to competently follow the scientific method to make inferences and develop hypothesis in order to answer questions posed while posing their own questions. Students will have to critically think about concepts and information learned to deduce the next part of higher level knowledge, a difficult process to both teach and apply. Technology can facilitate the acquisition of information to their peers and their instructor while also being a vital tool in research and development of finding solutions. Students also have to build off of previous concepts (both those taught before chemistry and those taught in previous grade levels), such as why all things in the universe are essentially either matter or energy and what the purpose of that categorization can mean. Students have most likely come into contact with these concepts, but have never delved further into why exactly these specific two types of things in the world and nothing else works. Additionally, concepts taught later in the school year or future years (such as evolution of life in biology and organic versus physical chemistry in high school and even college) are easier to understand due to student comprehension of the energy basics presented earlier in the year.

The information in this curriculum unit is meant to provide a teacher with not only the tools to achieve student success, but the reasoning behind their implementation, all the while gaining student interest. The intended audience is 8th grade teachers of chemistry, though any educator beyond grade 8 can make use of it. In an example lesson of similar quality and level, eight adults in small groups (pairs) completed the activity in close to an hour by being given explicit instructions to satisfactory results. The information in this curriculum unit is meant to provide a teacher with not only the tools to achieve student success and interest, but the reasoning behind their implementation.

My curriculum consists of one unit taught during the school semester called energy, which is the second part of chemistry. Students will use information taught previously on critical thinking, observation, and performing of labs to supplement this curriculum unit. The unit includes the following lessons:

1. Lesson 1: Energy Introduction, Energy Lobbying
2. Lesson 2: Energy Refocus and Check Core Concepts
3. Lesson 3: Energy Community

Background

The two types of resources available to humans are commonly referred to as renewable and non-renewable. Our fossil fuels – natural gas, oil, and coal – and technically nuclear energy are finite; they will not replenish quickly enough to be useful to humanity in the long run. These energy resources are referred to as non-renewable, though in the context of this paper they will be referred to as inherited. The other type are called renewable; resources which we can continue to harness indefinitely, such as water, solar, wind, and geothermal. These energy resources will also be referred to as income. Both, inherited and income resources are currently necessary to meet the world’s energy needs, but only the income resources will last beyond the next few generations.

All living things have always needed some form of energy to exist and reproduce since life first begin 3.7 billion years ago.[6] Humans, and by extension multi-celled organisms, are the culmination of those billions of years of evolution, and as such, are incredibly complex. The energy multi-celled organisms require is in different forms within the macromolecules: carbohydrates, proteins, amino acids, and various fats.[6] This is the first kind of energy that can be associated with life and is necessary to establish as a precursor to man's second type of energy: fire.

It was about 770,000 years ago in the Middle East, near modern day Israel, that two proto-humans first learned to create their own fire.[1] Harnessing this resource allowed a new form of energy to be readily available for use. A human could use fire to cook his food, warm his body, and provide light at times when an organism, which relies primarily on sight, would need it. The fire itself isn't able to be turned into another form of energy or harnessed in a way that its energy could be useful once put out, but it was technically a new form of energy technology.

Several hundred generations passed and fire continued to proliferate through the burning of biomass, in this case, wood. The Chinese are the first to finally use a new fuel for cooking and burning, effectively bringing about the introduction of coal as an energy source.[5] Coal remained hotter longer and burned more efficiently than wood, allowing more gain from fewer resources. The Chinese are also responsible for refining another of the three inherited fossil fuels: oil. With this refining and usage of oil, 2000 years after coal, it was able to be used in such a way as to slowly fuel a lamp's light output, like a wick to a candle.[7] We now could control the fire in a much more specific and complex way.

Europe finally came into the development of energy in 200 C.E. by using water wheels in streams and rivers to spin a giant wooden wheel.[9] These wheels are the early models for what would later be large turbines using steam to rotate them, converting their mechanical spinning into electricity. Another 800 years passed until the Persians built on this idea of using rotation to produce wind energy through giant wheels erected in the air, with pieces of cloth attached to poles to catch the wind. Notably, Europe seems to have capitalized on income resources, while Chinese discoveries focused on energy through inherited resources.

Another jump of a few hundred years puts energy in the 1600's heading toward the Industrial Revolution with the British learning the method of cooking coal into hot burning coke.[5] With the use of water pumps in the mid 1700's, coal mining became much more lucrative and easy to accomplish.[4] Coal use also spiked around this time in North America with the discovery of enormous coal deposits. Some estimates place coal usage at around 100,000 million tons of coal in 1850 to an almost 3000% increase one hundred years later, taking that amount of coal usage and increased it even further to meet the world's current demand for energy.[2,9]

The large deposits of oil and coal found in North America also sparked the integration of the third fossil fuel, natural gas, and subsequent drilling of its first well. Kicking things off in 1820, natural gas was a precursor to several important energy discoveries in the 19th century. Natural gas has not been very prevalent in comparison to oil or coal for several decades, but is currently in heavy production and usage.[2,9] In the same vein as natural gas, geothermal power was introduced to heat homes in Boise, Idaho, starting in the 19th century.

British scientist Michael Faraday's research on electricity and magnetism led to a motor that would become crucial to the generation of a type of energy that will become the standard for all machines that need energy: electricity. Earlier models of windmills and water wheels could now be used beyond crushing grain and the inherited resources could now be burned to heat water to force steam through power turbines to make electricity.[7] Focusing mirrors to heat water, France also brought about the original use of solar energy in 1860, to produce electricity.[1] Finally, the invention of alternating and direct current pioneered a model for getting power in the form of electricity to the entirety of a population.

Later in the 19th century geothermal power was used to heat homes in Boise, Idaho, showing the potential for heat specific fuel to be used efficiently without turbines. This left the only remaining resource as the type of energy generated through nuclear fission. The U.S. and Russia both placed their initial nuclear facilities in the 1950's, starting a trend that would eventually produce almost 20% of the electricity in the U.S. The production of nuclear facilities has lead to the modern day research into another type of energy production which we can possibly harness in the future, nuclear fusion.

As more and more funding and research goes into making production of energy more effective and cost efficient, there is a decrease in pricing and increase in quality of items. These changes make energy producers, like solar panels, affordable to families today whereas they would not have been an option a decade ago.

The current state of the world's energy is one of unsustainable practices. The majority of the world's energy use (around 95% in 2012) is coming from our inherited resources.[9] By some estimates, oil reserves, which provide for about 30% of the total of energy used in the world, will only last 50 years at current consumption rates.[3] Coal and natural gas are slightly better off with a few hundred years still possible at their current rates. With the elimination of oil and the constant increase in the world's energy needs, these estimates could be even lower based on the possible increase of use in the future, especially the increase rate in East Asia.

The only non-fossil fuel that is an inherited resource, nuclear fission, is more valuable in both energy produced and the length of time it may be available for use.

Nuclear reactors use certain radioactive isotopes that are unstable and decaying to produce energy by causing them to split apart their nuclei, into non-radioactive, lesser elements. The amount of energy produced by nuclear fission is thousands of times more than the combustion of oil or the burning of coal of the same mass.

Before moving on to income resources, it is important to cover carbon emissions and their effect on the earth. Inherited resources are burned in a chemical reaction with the oxygen in the air to produce the energy. This reaction releases a gas molecule called carbon dioxide. Carbon dioxide itself is not fatal to humans through inhalation, but it does cause heat from the sun to remain on the earth when it would radiate back into space. Carbon dioxide is called a greenhouse gas because the effect is similar to a greenhouse which captures the heat within instead of letting it escape into the atmosphere. Vehicles and energy production account for the majority of the carbon dioxide produced in the world via this reaction; these gases are referred to as carbon emissions. Humans and animals, which burn carbohydrates and fats, all produce carbon dioxide as well, while plants take in this carbon dioxide for photosynthesis to produce carbohydrates and oxygen. The movement of carbon dioxide is an important factor when determining which resources should be used and how.

With our inherited resources in high demand but dwindling supply, there is a recent push to the development and efficient use of income resources. These resources are all very difficult to scale up for a massive increase in energy use, but have the benefits of being almost infinite and non-pollutants.[1,8]

The sun is the primary resource used in almost every type of income resource, directly or indirectly. Solar energy can be directly used to move electrons generating electricity in photovoltaic cells. Solar panels are renewable as long as the sun exists and they do not generate carbon emissions while they are producing the electricity. However, storage and usage of the electricity generated by solar panels is problematic, as is their cost. It is estimated that by 2020, solar panels will be affordable to most income levels and easily integrated into residential areas.[1,3] In the same way, the sun is the entire reason that the Earth has wind movement. This wind can and is used to push enormous wind fans which can then be used to produce electricity. Wind turbines are cost intensive up front, like solar panels, and are considered an eyesore and noise problem by some. Both solar and wind power are not even close to as energy dense as oil, natural gas, or coal.

It is possible for there to be heat energy gathered from the Earth's core and tectonic movements. This energy can be harnessed and are necessary for geothermal units to heat water for the usual process of steam generating to spin turbines or for just heating homes. The movement of water can also be indirectly related to the sun, and the hydropower generated in this way capitalizes on water's movement. Both geothermal and hydro have up-front costs, with hydro also being responsible for destroying existing habitats.[3]

All sources of energy will be necessary if we are to feed the constant increase in the world's energy consumption in the next fifty years. The inherited resources of the world are unsustainable, but necessary for the immediate future. Income resources are now more effective than ever, but still don't exist in the quantities needed to make up for the void inherited resources will eventually leave. Carbon emissions must be kept under control so that there can be an earth that humans can live on in the future. The challenge of cheap, effective, infinite energy is definitely that; a challenge, but with advancements in technology, research, and exploration, it is a challenge that can be overcome.

Teaching Strategies and Content Objectives

Due to the extensive research that would be involved in the main activity of this project, students will use a few given websites and information to complete their required main activity. The real goal here is to promote kinesthetic learning for students by demonstrating their ability to construct a personalized hamlet with its own energy needs, generators, quality of life and carbon emission caps. Students will also be given any materials needed that is related to the core of the content and that they will be expected to know. Materials will be provided through the CMS, Charlotte-Mecklenburg School, system for this activity, with possible supplementary materials made available through colleges such as UNCC or Davidson College's chemistry departments. Materials not able to be obtained in either of these ways will be supplied by the teacher. Students will need to be able to present their findings and work in several formats including, but not limited to: group presentation, single presentations, kinesthetic examples, visuals, auditory, lab reports, the scientific method, and presentation technologies.

Students should be able to explain the basic type of energy generation, how they are used in the world, what the differences between their uses are and how they affect the populations of the world. Students should be able to identify the different types of energy and their own use of electricity. Students should be able to understand the difference between a source that is renewable and a non-renewable. Students should be able to explain their use of electricity, how electricity is generated, and why energy use and restriction is important. Finally, students should be able to explain why carbon emissions are important as well as the purpose of utilizing multiple types of energy generation for large scale energy production.

Activities

Appendix II – Required Information Sheets

Lesson 1 – Relating to Energy, an Introduction and Energy Lobbying

Students will be given a very brief introduction as to what energy is and the process of lobbying in the United States. I will then break students into groups of four to work on a peer-teach project that also involves a competitive aspect. Student groups will be given a source of energy (nuclear, coal, oil, natural gas, hydro, geothermal, biomass, solar, or wind) and are required to present it to the class. After their presentation, specific students from other groups are asked to question their energy source and force the presenter to defend their source.

Each student has a specific job within their group, but all students should contribute to the group's success. The researcher will be the head of finding credible information on their source of energy. The organizer will put the information together in a way students can both understand it and be actively involved. The presenter will be responsible for actually bridging the information from the group to the class successfully. The spy will be responsible for finding out possible detriments to the other group's energy types and questioning them on it after their presentation.

Students are graded on a scaled rubric with the lowest grade being an 80% (assuming they have done all the work). Students are allowed to vote at the end for which source they thought was the most persuasive and students cannot vote for their own group. The group that gets the most votes will receive a 100%, scaling down with votes until the 80% threshold. This activity is expected to last three class days.

Lesson 2 – Energy Refocusing

Students will be given a follow up lecture and note taking session the day after presentation to gives students a concrete set of notes to pull from for the formal assessment. The teacher will also correct any misconceptions and facilitate those who may have missed some information from the previous activity. The teacher will also cover concepts like electricity generation and carbon emissions to set up for the final activity. This activity is expected to last one class day.

Lesson 3 – Energy Hamlet

Students will be given an in-class project to complete using their information on energy sources. With different groups from the Energy Lobbying activity, students in groups of four will be tasked with designing a small community that can do the following: generate their own electricity for everyone in the community, keep their carbon emissions relatively low, provide basic infrastructure while adhering to a confined space, and determining their quality of life and its importance. Students will be given a sheet of graph paper that has exactly 1353 squares on which to design their community. Students are required to have enough energy, food sources, walkways, and housing to fit within this area. Students will also need to watch their carbon emissions from sources to ensure they don't produce too many greenhouse gases. Students are also given a cost parameter for their community and cannot exceed it. Any excess of any parameter will result in a lower grade for the group as a whole whereas staying with the parameters while achieving the requirements will give a 100%. This activity is expected to last three class days.

Conclusion

Students learn by doing. Rote memorization of a text for the sole goal of regurgitation at a given time is not the objective of teaching; even less so in science. A strong foundation is required to given students basic knowledge, but their application of said knowledge is the true test of their mettle. Dr. Durwin Striplin has told me on countless occasions that solving the energy problems of tomorrow require a creative mind interested in puzzles and challenges. I hope that I am giving student the ambition, the tools, and the space to become those creators and problem-solvers for the world that will be theirs one day. Only when allowed to flourish by themselves with a subtle guiding hand will they realize their true potential and come into their own as the great thinkers and scientists of tomorrow.

Appendix I – Common Core

Standard Integration

In the *Key Ideas and Details* section, students will be required to use the internet, texts, and independent notes taken to support any idea they use with their research work. The research work itself will be done stringently along the lines of a uniform guide worksheet that follows the criteria students have already learned or researched themselves. Students will need to know scientific terminology that they have learned in class and apply it to their experiments and activities. Student reasoning is also important in Science and the logical steps leading up to a correct inference. Students will also attain these inferences by using the materials available to them from the teacher.

Key Ideas and Details

CCSS.ELA-Literacy.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure

CCSS.ELA-Literacy.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6–8 texts and topics*.

Integration of Knowledge and Ideas

CCSS.ELA-Literacy.RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-Literacy.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Appendix II – Information Required for Student Work

Energy Voting My Energy Type: Wind Voting for: ________________________	**Energy Voting** My Energy Type: Hydro Voting for: ________________________
Energy Voting My Energy Type: Nuclear Voting for: ________________________	**Energy Voting** My Energy Type: Coal Voting for: ________________________
Energy Voting My Energy Type: Oil Voting for: ________________________	**Energy Voting** My Energy Type: Natural Gas Voting for: ________________________
Energy Voting My Energy Type: Biomass Voting for: ________________________	

Lesson 1 Resources

Sample Student Voting Leafs (dependent upon their energy type)

Additionally, there is a Power Point presentation that introduces this project to students.

Lesson 3 Resources

Energy Community Project

You are tasked with using the income from 50 people who want to create their own small community; however, this community will need energy to work at the most basic level! You also need to ensure these people have a place to live, grow enough food, don't produce too much pollution, and don't run out of money! Your community, called: ______________________________ has already had land appropriated for its use and will not take away from the income.

You must do the following for full credit:

- Have every person in a home with enough electricity to avoid spikes (partially empty homes are fine).
- Remain below a Carbon emission cap of 500.
- Spend less than the $2,000,000 available.
- Produce enough food that all people (50) are fed for a year.
- Have a pathway that connects all homes together and to the energy generator(s).
- Use areas of space left over for your own personal idea: be creative and give it an applicable energy need, carbon emission, and value to your society!

Housing

Small House (2 p) (10k) -Requires 4000 kWh, 3 *squares*

Med House (4 p) (15k) -Requires 7500 kWh, 7 *squares*

Large House (6 p) (20k) -Requires 10,000 kWh, 12 *squares*

Energy Generators

Natural Gas

- A natural gas well can fit in *1 square* and must be placed to access natural gas. There can only be one natural gas square per map. If natural gas is used, a *500 square* plant for storage and conversion to electricity via turbines must be placed, on which no other objects can be placed.

- Generates: **50,000 kWh per natural gas well + refinery**.

- Carbon Emissions **= 250 units (install + operation)**

- Cost: $**1,000,000.00 (well + refinery/plant)**

Coal

If coal is used, a *30 square* area needs to be placed as a mine on which no other objects can be placed. If coal is used, a *500 square* plant for storage and conversion to electricity via turbines must be placed, on which no other objects can be placed.

- Generates: **75,000 kWh per coal plant**.

- Carbon Emissions **= 400 units (install + operation)**

- Cost: $**1,000,000.00 (mine + plant)**

Oil

If oil is used, a *9 square* area needs to be placed as a well on which no other objects can be placed. If oil is used, a *400 square* plant for storage and conversion to electricity via turbines must be placed, on which no other objects can be placed.

- Generates: **60,000 kWh per oil plant**.

- Carbon Emissions **= 325 units (install + operation)**

- Cost: $**1,250,000.00 (well + plant)**

Solar Panel

- A solar panel can fit in any *one square* (even on buildings that are not solar panels or wind turbines or otherwise specified that they cannot be placed there).

- Generates: **250 kWh per solar panel**. Carbon Emissions **= 1 unit per panel (install)**

- Cost: $**1000.00 per panel**

<u>Wind Turbine</u>

- A wind turbine can fit in *four squares* (even on buildings that are not solar panels or wind turbines or otherwise specified that they cannot be placed there).

- Generates: **500 kWh per wind turbine**. Carbon Emissions **= 1 unit per turbine (install)**

- Cost: $**1500.00 per turbine**

<u>Hydro</u>

If hydro is used, a *100 square* area needs to be placed across a river reaching from bank to bank at least *3 lines thick*. If there is no water source available, hydro cannot be used. Only one hydro dam can be placed per water source. No other object can be placed on a hydro dam.

- Generates: **50,000 kWh per hydro plant**.

- Carbon Emissions **= 50 units (install + operation)**

- Cost: $**1,100,000.00 (dam + plant)**

<u>Biomass</u>

If biomass is used, any crop used for biomass cannot be used for food. No other object can be placed on a biomass square.

- Generates: **100 kWh per biomass square**.

- Carbon Emissions **= 0 units**

- Cost: $**5.00 (seeds + harvest) per square**

Nuclear is unavailable due to size, requirements for operation, building time, and resources required.

<u>Human Energy</u>

<u>Sm. Food Crop</u> *1 square* produces enough food for 5 people for one week. Any crop used for food cannot be used for biomass. No other object can be placed on a food crop square.

- Carbon Emissions **= 0 units**

- Cost: $**50.00 (seeds + harvest) per square**

<u>Lg. Food Crop</u> 3 *squares* produces enough food for 20 people for one week. Any crop used for food cannot be used for biomass. No other object can be placed on a food crop square.

- Carbon Emissions **= 0 units**

- Cost: $**300.00 (seeds + harvest) per 3 squares**

<u>Animal Pen</u> *25 squares* are required to produce food for 5 people for one year. Only one animal pen can be placed. Animal pens must be expanded by 1 line of squares above and to the side of the original pen to increase the numbers of animals held there. (Example: a *36 square* pen would hold 2 animals, feeding 10 people for one year, a *49 square* pen would feed 15 people for one year, etc.)

- Carbon Emissions **= 20 units per animal**

- Cost: **$2000.00 (purchase, feed, harvest, pen) per animal**

<u>Other</u>

<u>Tree</u> *4 squares* are required to plant a tree. No other object can be placed on a tree square.

- Carbon Emissions **= -1 unit per tree**

- Cost: $**50.00 per tree**

Pathway — All houses must be connected via a pathway which each other and all energy facilities. *1 square* is required for a pathway. No other object can be placed on a pathway square.

- Carbon Emissions **= 0**

- Cost: $**25.00 per square**

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A case file on the world's history of energy use, where energy use is focused and growing now and how to combat the problem of energy shortages in the future; an earlier version of this seminar's required text.