**Summary:** Students identify current energy use practices and incorporate renewable energy use into community planning.

# Sustainable Communities

**Grade Level:** 9–12 (5–8)

**Subject Areas:** Science, Social Studies, Technology Education

**Setting:** Classroom

**Time:**
**Preparation:** One to two hours
**Activity:** One week

**Vocabulary:** Centralized energy system, Decentralized energy system, Fenestration, Grid, Solar access

**Major Concept Areas:**
Theme II

- Development of energy resources
- Development of renewable energy resources
  - Solar energy

Theme III

- Quality of life
  - Lifestyles
  - Health and safety
  - Economic
  - Sociopolitical
  - Cultural

Theme IV

- Management of energy resource use
- Future outlooks for the development and use of energy resources

**Standards Addressed:**
Wisconsin Model Academic:
SC: A.12.2, B.12.4, C.12.2
SS: A.12.12, E.12.14
TE: A.12.2, C.12.2, D.12.6

Common Core ELA: RST.9-10.7, SL.9-10.1, SL.9-10.4

Common Core Math: MP2, MP3, 7.G.A.1

(Standards cont.)



## Objectives
Students will be able to

- list considerations for renewable energy use in a subdivision;
- define solar access; and
- discuss cost-benefit and drawbacks to developing a community utilizing renewable energy.

**Rationale**
Designing a residential subdivision will help students apply critical thinking skills related to environmental impacts and energy consumption.

## Materials

- Computers with mapping websites or mapping software, and/or tag board or residential parcel maps (optional)
- Drawing utensils or 3-D models of trees, hills, roads, homes, etc.

## Getting Ready
If available, contact a guest speaker from your local county, city, or village planning department (see **Orientation**).

## Background
In the not so distant past, humans developed buildings and communities with renewable energy in mind. Solar access and water access, along with wind patterns, were included in the decision-making. In modern society, these considerations have often dropped by the wayside. Communities also grew their own food, which not only provided healthy, fresh produce, but also saved energy in transporting food in from far away places. Working in gardens is also considered a healthy activity for mind and body. Individuals also have control over what pesticides, herbicides, and fertilizers are used to support their individual or community gardens.

In a time of rapid growth and population increases, community planners are faced with the task of balancing multiple objectives including economic feasibility, governmental regulations, social and cultural conditions, professional ethics, and environmental and architectural principles. The added planning and upfront costs that are incurred when using renewable energy can often hinder its use.

Since buildings and transportation in the U.S. account for about 70 percent of energy use, community planning can result in a big impact on energy savings. It has been found that a person living in a low-density subdivision that commutes in an individual car every day uses more energy than one who lives in a multi-family apartment building and uses mass transit.

Not everyone lives in multi-family dwellings and most Americans want to own a car. It is important for community and subdivision planning to consider the environmental and economic benefits of sustainable living and renewable energy (see ***Site Plan Review Principles***). They address wind patterns, solar access—the availability of unobstructed, direct sunlight—and energy efficiency in both the home and use of transportation. By designing a community with renewable energy, energy efficiency, and local food production in mind, residents can save money while reducing energy costs and living in a naturally comfortable home environment.

## Procedure
**Orientation**
Talk about the principles and issues involved in community planning (see ***Site Plan Review Principles***.) A government official involved with planning may provide a current community plan for consideration. Ask students what they need to consider in designing the home plots and open spaces for a small community. Have them share ideas with the class. Encourage them to reflect on what comes into a community (electricity, water, food, fuel) and what leaves a community (waste water, solid

NGSS: HS-ETS1-2, HS-ESS3-2, HS-ESS3-4

SEP: Constructing Explanations and Designing Solutions, Engaging in Argument from Evidence
DCI: ESS3.A: Natural Resources, ESS3.C: Human Impacts on Earth Systems, ETS1.C: Optimizing the Design Solution
CCC: Influence of Science, Engineering, and Technology on Society and the Natural World, Stability and Change

waste, heat). Consider other community needs such as transportation, recreation, privacy, etc.

Challenge students to identify which of the community activities are energy related. Discuss which energy resources are currently used by most communities (resources are suggested under the **Steps** below) and how they enter and leave the community. Introduce students to terms such as the electrical grid (living off and on the grid), and centralized and decentralized energy. Review costs and benefits of current energy use practices.

**Steps**

1. Explain that the mayor of town X has requested information about renewable energy systems and is interested in developing more energy resources for his/her community. NOTE: Town X can be a fictional town or students can select an actual community such as their own. Other options include providing a physical or digital map of a residential neighborhood for students or providing them tag board with pre-marked physical features such as rivers, wooded, plain, and wetland areas, topographical features, and existing structures (homes, old standing barn, power lines, etc.). Many mapping websites or free software, such as Google Earth, are available. These mapping tools allow users to draw and include other notations, such as pushpins, border lines, and notes to illustrate sustainable community improvements.

2. Inform the class that their goal is to assess a current residential or commercial neighborhood for renewable energy technologies. If they have not previously participated in site analysis, integrate concepts from the activities "Siting for Solar," "Where the Wind Blows," and "Let the Sun Shine In" to develop a base understanding among students. Remind students that before the installation of a renewable energy system, it is important that community planners consider options for using less energy and using energy efficiently. Have students explore how energy is being used currently. NOTE: See the KEEP website for survey instruments to assess community energy use.

3. Establish teams of three or four students for each residential area. If you are having students assess their neighborhood, give them a few days to document the significant environmental and physical features, etc. If assessing a real neighborhood, mapping websites/software such as Google Earth may be used to document existing buildings, roads, as well as power and water access features.

4. Explain that renewable energy technology and designing for passive solar access are components often left out of the design of a subdivision. Use the following questions to pose ideas for incorporating renewable energy into the students' site design:
   - What nonrenewable resources are currently heavily used? Is there a renewable energy source being utilized for heat or electricity? The Energy Information Administration's (EIA) Residential Energy Consumption survey provides facts and details on current household energy use, by region and state. The EIA also provides information on what resources are used to generate power in each state. Local electric, gas, and water utility companies may be able to provide detailed information about the energy resource mix and distribution network used to supply the community under study for this project.
   - Are there options for incorporating renewable energy sources in active systems? What would the upfront costs be for such a system? Example systems include geothermal, hydroelectric dams, photovoltaics (solar electric), wind turbines and biomass systems. Local companies may be able to provide general cost information for small, home or community-scale generating systems.
   - What passive solar options are there?
     - Are homes placed on the north/south axis?
     - What natural or constructed features may limit southern exposure for individual homes?
   - Are there opportunities to make vehicle or public transportation more efficient?
   - How might renewable technologies be incorporated into community travel and transportation?

5. Assign student groups the task of incorporating energy efficiency and renewable energy technologies for both buildings and transportation systems into their residential neighborhood. Give students a week to establish their design. Tell them to include all potential costs for development and have them estimate how much they will make (by selling plots or by building homes on the lots and selling them).

6. Part of a sustainable community is food energy for community residents. Consider opportunities to provide locally-grown produce. As an alternative to individual gardens, perhaps your community will provide community-shared gardens and/or space for farmers' markets.

7. Students may assemble the following as a portfolio of their group's sustainable community design:
   - A paper or computer representation of the sustainable community design including the community's location, notation of energy systems such as electric lines or generators, and representation of transportation routes including individual and mass transit (if applicable).
   - A list of the community's sustainable components with descriptions. Include what renewable energy systems are used, what efficiency measures are implemented, and note all other systems that make the community sustainable such as food gardens or green spaces.
   - List the costs associated with the community's sustainable features such as renewable energy and energy efficiency installation costs. Also include the cost savings from using the renewable energy, energy efficiency, and local food systems.

**Closure**

Have students present their findings to the entire class and lead a discussion on how they decided to lay out their subdivision. Have other students critically analyze each subdivision, making recommendations for improvement. Have students redesign their subdivision after student presentations and critiques. How do the designs change over time?

## Assessment

**Formative**

- Were students able to identify the many ways a community uses energy and suggest ways to use energy more efficiently?
- What energy efficiency and renewable energy considerations were incorporated into the student designs?
- Were students able to show the benefits and drawbacks to developing an energy efficient community utilizing renewable energy and local food systems?

**Summative**

Have students review their design utilizing the ***Site Plan Review Principles***. Using these principles, have students refine their proposals and indicate in writing what changes they would potentially make to improve their design.

## Extension

Have students, as an outside class assignment, locate a subdivision in town. Have them write up an analysis of the subdivision. What considerations were most important to the developer? What improvements would the student make?

Have students consider if using renewable energy might appeal more to designers of subdivisions near a city or in more rural areas.

What benefits or limitations would there be in incorporating energy efficiency, renewable technologies, and local food in a new development vs. incorporating them into an existing one?

## Final Connection

Determine level of intensity and depth you wish to go with the activity. This can easily serve as a one-period class activity with students thinking about general placement of homes, open spaces, and solar access. It can also be used as an entire unit, including detailed designs of a local parcel of land, with students researching local zoning ordinances, sewer/water requirements, housing market trends, and topographical maps for drainage patterns and solar access. Define a method for students to use in developing the map of their subdivision. Have them utilize drawing skills, three dimensional items and/or computer technology to show their results.

# Site Plan Review Principles

***In designing your subdivision, keep the following in mind:***

## 1. Humanism

Design for the human, pedestrian scale, to create a sense of community and neighborhood.

**Design should:**

- Have a human scale in proportion and perception;
- Accommodate cars, trucks, and transit while enhancing the pedestrian experience;
- Provide street networks, public spaces, buildings, and linkages between each to facilitate human interaction;
- Enable community centers as the focus of community interaction; and
- Provide opportunities to partake in growing food or access to local food.

## 2. Ecological Responsibility

Design must complement the natural landforms and be sensitive to local ecological conditions.

**Design should:**

- Strive to create a sustainable balance between new development and the environment;
- Mitigate any negative environmental impacts;
- Be located on suitable land;
- Use flexible regulatory tools to enhance and protect sensitive natural features and native plants;
- Complement the natural environment;
- Preserve significant visual landscape features;
- Preserve and enhance local natural features;
- Use conscientious energy conservation features such as substantial insulation, window placement to maximize passive solar, as well as solar and wind power systems, building orientation and strategic landscaping;
- Be sensitive to noise intrusions;
- Integrate recycling; and
- Encourage pedestrian orientation.

## 3. Pedestrianism

Design for pedestrian dimensions and distances through compact form, layout, and streetscape characteristics.

**Design should be defined by the following terms:**

- Sites are within walking distance to services, facilities, and employment;
- Highest densities being closest to the community core;
- Public transit facilities are provided;
- Linkages to other services and facilities by means of pedestrian paths;
- Assure continuity of the pedestrian experience;
- Crosswalks and depressed curb cuts are appropriately sized and located;
- Sidewalks are wide enough;
- Create security and proper proportion at the pedestrian scale;
- Pedestrian scale lighting and street furniture; and
- Proper signage.

## 4. Open Space

Open space is one of the most valuable commodities. Peripheral and internal open spaces provide recreational and civic areas. They can serve as a buffer against incompatible uses, ecological resources, definition of a neighborhood, and definition of community.

**Open space is integral to design and may serve many functions, such as:**

- Private spaces (private yards);
- Public spaces (pedestrian and bikeways, active and passive recreation, and community commons); and
- Peripheral spaces as transitions to agricultural, low-density developments, and natural areas).

## 5. The Core

Every community must have a core or community focus. Within the core are commercial, residential, and civic buildings and common areas, which provide a focal point for the community. The core is the most identifiable aspect of a community for its residents and for visitors. It is an activity center unifying the community and often is integral to the community's image.

**Design should:**

- Enhance the function of the core;
- Complement existing core activities; and
- Include a mixture of land uses, housing, jobs, and incomes to create a more balanced core.

## 6. Streetscape

Streetscapes create the form and scale of the site and must accommodate both pedestrians and vehicles.

**There are several basic streetscape design elements that are critical to good community development. They include the goals to:**

- Develop a hierarchy of streets in function and level of service;
- Establish design criteria for each level;
- Create a sense of focus and enclosure; and
- Establish pedestrian proportions and dimensions.

## 7. Variation

Variation within the design guidelines creates the most visually positive communities. Each community is unique because individuality is encouraged.

**Variation can best be achieved utilizing the following:**

- Varying lot widths and depths, block sizes, and alley configurations;
- Varying building footprints and setback lines;
- Mixing architectural types, building mass, and fenestration;
- Varying street elements and details; and
- Providing more architectural variety.