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Alternative Energy Overview

Worldwide demand for energy declined during the recession, causing energy prices to fall. This reduced the significant pressure built up over the past decade to aggressively develop alternative energy facilities. Despite this dampening in the alternative energy market, energy economists predict that over the long-term alternative energy technologies will ultimately have as big an impact on our society as semiconductor chips. Indeed, some forms of energy such as solar, onshore wind and bio-fuels, could substantially change the dynamics of the energy market in the near-term as they become price-competitive with conventional forms of energy.[1]

Camoin Associates and Advanced Energy Economics offer this paper as a primer for economic development officials on the various forms of alternative energy production. It gives a brief overview of the what, how and when for wind, nuclear, hydro, geothermal, solar, and biomass technologies. The goal is to educate economic developers so that they can incorporate alternative energy projects into their strategic plans and better assist their communities and businesses in harnessing the potential of alternative energy to improve their local business and investment climate.

Promoting Alternative Energy Development in Your Community

In response to a combination of public support for cleaner energy sources and businesses' need for reduced energy costs, many economic developers and community planners are starting to think about their options in terms of alternative energy. This white paper provides a general overview of some of the primary energy options available but recognizes that the local community and economic developers must be proactive in their approach to identifying the most feasible and desirable energy source for their community. The following is a variety of approaches that community and economic developers can use to identify and pursue their alternative energy goals.

- Comprehensive Planning: Either during a community-wide planning process or as an addendum to an existing plan, planners and public officials should go through a process to identify their existing energy needs, goals for alternative energy use, and action steps to get there. This comprehensive energy plan should:
  - Guide a community's development – identify sites for alternative energy facilities, identify industrial parks that may benefit from alternative energy, and establish areas for growth.
  - Allow a community to envision their future – work with the community to better understand their desires as well as concerns regarding the use of alternative energy. Create a vision statement for the community's energy future in terms of specific goals, how it applies to economic development, and how the community would like to move forward.
  - Be carried out by local zoning and land use regulations – the local zoning code should clearly reflect the goals of the community. Local regulations should allow for small scale wind power installations or biofuel use, should be a communities priority. Specific areas of the community that have been established as locations for wind should be zoned adequately to make it easier for developers as well as to increase predictability for neighbors.
  - Include a natural resource inventory – it is important to recognize what is available/not available in the community and how that impacts your ability to attract potential investors. There are a

[1] *What's Next for Alternative Energy?*, the Boston Consulting Group, November 2010, page 5. http://www.bcg.com/documents/file65187.pdf

variety of resources available to do this including using local knowledge such as colleges, local and state environmental offices, and local non-profit organizations.

    - A good first step is to identify any regional studies that have been conducted. It is likely that your community is located within a region that has been subject to at least one large-scale regional alternative energy feasibility study. These types of studies provide high-level information about natural resources pertaining to alternative energy that exist regionally, possibly supporting the need for further investigation at the local level. A few examples of these types of studies are provided in the links below.

  - Proactive approach rather than reactive – by analyzing the data, establishing existing conditions and including the public in planning for future energy options the community can be well prepared to put their plan into place rather than reacting to undesirable development proposals or a major increase in energy costs. Having some predictability is beneficial both for the community and the developer.
  - Set achievable goals at an appropriate scale for the community – based on the analysis conducted regarding alternative energy options for the community and the desires of the residents, economic developers should set a goal for renewable energy use. While it is admirable to set high goals, it is typically more useful to set achievable goals for the next 5-10 years that can be monitored and recalibrated as necessary. The plan should also take into account the community's location in context of and in proximity to cultural and social amenities when determining what may be appropriate for the community. For example, is transportation access possible for the large wind turbine components to get to the site or would large scale wind be unlikely due to your location near a major scenic destination? While these types of community characteristics might not make a certain type of alternative energy ideal, it in no way makes it impossible to pursue.
  - Have a step by step plan – the outcome of the alternative energy plan should be a step by step approach to how the community is going to achieve its goals and what the end product will look like. The plan should include who is in charge, the timeframe and even the potential costs of each step necessary to get the community to where it wants to be.

- In addition to completing a comprehensive energy plan, communities should also approach alternative energy using market-based research and analysis. By understanding the local economy and the role a community plays in the larger economy, local planners and economic developers may be able to identify industries locally and regionally that are strong and/or growing that might benefit from alternative energy use. Some types of alternative energy can be very specialized, for example an eco-industrial park that uses the heat waste of one industry as an input for a process of a nearby industry. Local knowledge of businesses and economic growth will make it possible for economic developers to make those connections.

- Communities could also conduct a cluster analysis to help identify the local potential for alternative energy sources while at the same time learning about their local economy and potentially identifying opportunities for growth. The cluster analysis will help the community to better understand their local strengths and where there is expected to be growth over the coming years and then use that information to determine how alternative energy may fit into that picture.

- As identified in this report, the cost of alternative energy is a typical hindrance to it being widely used throughout the United States. By identifying, maintaining information about, and possibly even providing funding opportunities to businesses and residents interested in pursuing alternative

energy projects, the community may be able to increase their renewable energy use. The Database of State Incentives for Renewables & Efficiencies (www.dsireuse.org) has information and local economic developers should stay up to date on any changes.

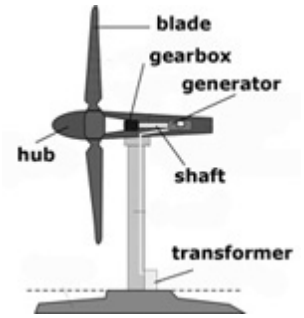
- Misinformation can act as a major breaking point for many alternative energy projects, making education of the public and local officials paramount in achieving local alternative energy goals. This can be done through public forums, pamphlets, articles in the local newspaper and an ongoing discussion regarding the benefits and costs of alternative energy. With so much information available, it can be hard for local residents to truly understand the impact that alternative energy projects and investments would have on them, so it is the role of the local officials to educate and continue to explain the true costs and benefits of these projects.

Helpful resources for economic developers and examples of other States' initiatives:

- Wind Energy Development and the Comprehensive Plan prepared by NYSERDA: http://www.powernaturally.org/programs/wind/toolkit/1_windenergydevplan.pdf
- Database of State Incentives for Renewables & Efficiencies: www.dsireuse.org
- Alternative and Renewable Energy Cluster Analysis for Michigan : http://www.wm-alliance.org/documents/publications/Alt_Energy_Cluster_Analysis_FINAL.pdf
- Economic Development Potential of Conventional and Potential Alternative Energy Sources in Appalachian Counties, June 2006: http://www.arc.gov/research/researchreportdetails.asp?REPORT_ID=18
- Potential for Renewable Energy Development in Massachusetts, September 2008: http://www.mass.gov/Eoeea/docs/doer/renewables/renew_potential_summary.pdf
- Renewable Energy in North Carolina: The Potential Supply Chain: http://www.ncsu.edu/iei/programs/energy-environment/documents/debbage-report.pdf

Wind Energy

Windmill Components



Wind is a form of solar energy caused by the uneven heating and cooling of the earth's surfaces and the atmosphere. For example, during the day, the sun heats the air above the continents faster than the air above the oceans. As the warm air rises over the continents, the cooler air over the water rushes in toward the land to replace the rising warmer air, creating wind. When the sun goes down this cycle reverses.

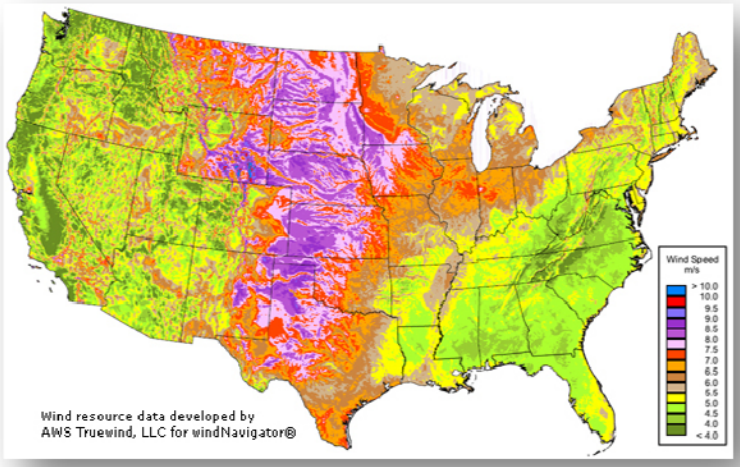
The turning blades of a wind turbine are designed to capture the kinetic energy of wind. Lift is created as wind flows over the blades forcing them to turn slowly. The spinning blades turn the main shaft, which is linked to a gearbox. The gearbox modifies the turning force to spin faster with less force in every revolution. The modified force is then transferred to a high-speed shaft that turns a generator to produce electricity.

Drawbacks of Wind Energy

With no mining, drilling, emissions, and virtually no water usage, wind power has a strong environmental edge over many other power sources. The main disadvantage of wind power is wind's intermittent and irregular nature. Wind is not constant or consistent; however, areas with annual average wind speeds around 6.5 meters per second at an elevation of 80 meters are generally considered adequate for power generation.[2] As illustrated in the following map of the continental United States, average wind speeds are highly variable from place to place. Additionally, low-density/rural regions tend to have the greatest wind potential and the energy produced must be transported over great distances to reach users.

The intermittent nature of wind also complicates the design of a windmill's internal mechanics. In most industrial applications, the driving force of the systems is relatively constant, and mechanical engineers design the system components to be most efficient, dependable, and long-lasting at that specific level of force or speed. In a windmill, however, the force that drives the mechanical system (i.e. the wind) is in flux. The constant stopping and starting and quick changes in force wreak havoc on the mechanical components of a windmill, particularly the gearbox. The following section discusses new windmill technologies that are beginning to be implemented to avoid this issue.

Average Wind Speed Across the U.S.



Other drawbacks to wind energy include a higher up front financial investment compared to fossil fuel energy sources, environmental concerns, noise generation, and aesthetic impacts to scenic views.

[2] U.S. DOE, Wind and Water Program Website. http://www.windpoweringamerica.gov/wind_maps.asp

New Technologies

One of the biggest concerns in the wind industry is the reliability of gearboxes, which are an expensive component of the turbine system that requires frequent maintenance and replacement. Gearboxes are designed with a 20-year life expectancy but most require significant repair or overhaul well short of this goal. Gearboxes are responsible for the greatest percentage of outage time as they contain many moving parts that wear out over time from the constant vibrating, pulsing, and fluttering of the rotor. Today's gearboxes are projected to only last 7-11 years.[3]

These issues have driven the industry away from gearbox-laden designs toward the development of direct drive turbine technologies. Direct drive turbines forgo the gearbox, reducing the number of components. The direct-drive turbine design connects the shaft directly to a permanent magnet generator. As the blades rotate, the magnets convert the spinning rotor movements directly into electrical power. Direct drive designs are able to produce electricity while spinning at the same low speed as the blades. Advantages of this technology include:

- No vibration from gearbox, resulting in less stress on the structure and less noise.
- Longer equipment life.
- More efficient operation, resulting in greater power output.
- Less maintenance on mechanical systems, resulting in financial savings.
- Safer for maintenance workers with fewer moving parts in confined spaces.

Future of Wind Energy

Many in the wind industry consider direct drive designs the "next generation" of turbines that have the potential to give the wind industry a significant boost in the coming years, particularly for offshore projects. Performing maintenance on an offshore turbine is much harder and more expensive, and offshore environments are harsher on mechanical systems than land-based environments.

Direct drive technology is opening new doors for the industry. In the spring of 2010, General Electric (GE) announced that they will supply 4-megawatt direct drive wind turbines to the very first freshwater offshore wind farm in the U.S. The 20 megawatt wind project will be sited in Lake Erie. Another giant in the power industry, Seimens, began selling a 3-megawatt turbine in the summer of 2010, and was scheduled to begin "serious production" in 2011.

Online Resources

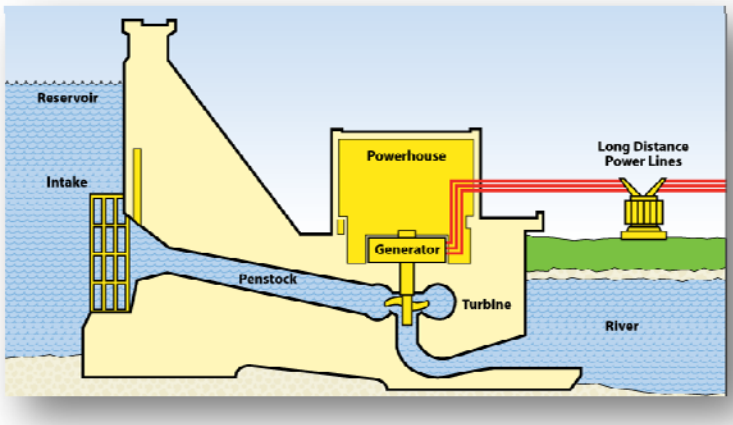
- Wind Power Today 2010: US DOE Wind and Water Program http://www1.eere.energy.gov/windandhydro/pdfs/47531.pdf
- Direct-drive turbines: The way of the Future? http://www.ecoseed.org
- The Gearbox Problem: http://www.northernpower.com/pdf/the-gearbox-problem.pdf
- US DOE Wind and Water Power Program http://www1.eere.energy.gov/windandhydro/wind_pubs.html

Images:
http://www.google.com/imgres?imgurl=http://www.windcapitalgroup.com/Images/InsideAWindTurbine.png&imgrefurl=http://www.windcapitalgroup.com/WindEnergy/WindWorks.aspx&usg=__drdcFyoxtr4T92jH31jN_lollV4=&h=262&w=350&sz=36&hl=en&start=42&sig2=DwFnT7tYnxELGbK

[3] Prigcorbe, Jordi, Alexis de-Beaumont. Wind Turbine Gearbox Reliability: the Impact of Rotor Support. June 2010. http://www.renewableenergyworld.com/rea/news/article/2010/06/wind-turbine-gearbox-reliability.

Hydroelectric Energy

Typical Hydroelectric Dam



Hydropower captures the energy of moving water to generate electricity. One of the oldest and most widely used renewable energy sources, hydropower accounts for about one-sixth of the world's energy supply and generates about 10% of the electricity in the U.S. [4]

Most hydroelectric power comes from the potential energy of dammed water. Potential energy becomes kinetic energy when the water is released through a large tube called a penstock. The gravitation force of falling water turns large turbines which convert the water's kinetic energy into mechanical energy. The rotating turbine spins a shaft leading to a generator, where the mechanical energy is converted into electricity. Using moving water to spin a turbine is the basic concept employed in most types of hydropower generation methods.

Reservoirs provide built-in energy storage that enables quick response to electricity demand fluctuations across the grid. Since operation of a hydropower plant can be highly automated, hydropower generally has a very low operating cost once constructed. Hydroelectric generation does not directly pollute the environment as with fossil-fuel based methods of electric generation. However, conventional methods of hydropower generation (i.e. damming rivers to create reservoirs) can have a significant environmental impact on fish migration, stream morphology, and other aquatic and riverine ecosystems.

Drawbacks of Hydroelectric Energy

In North America, a significant percentage of the existing hydropower capacity is already developed. Public opposition to large hydropower projects and the impact they have on the environment will likely hinder any future large-scale projects. As such, current research and development initiatives related to hydropower focuses on improving efficiency and mitigating environmental impacts of existing facilities.

Many existing conventional hydropower facilities are being "uprated" to increase efficiency and reduce environmental impacts with the addition of turbines to open bays, larger turbines, and new computerized control systems.

New Technologies

Hydrokinetic energy systems, a new generation of waterpower technologies, offer the possibility of generating electricity from water without dams and diversions. There are currently two types of hydrokinetic systems: rotating devices and wave energy converters. Rotating devices, most commonly used in streams, convert energy generated by horizontal movement of water into electricity by the use of rotors, similar to the basic technology involved in a wind turbine. Wave energy converters transfer energy based on the fluctuating height of ocean waves.[5] There are a wide variety of rotating devices and wave energy converter designs currently under development. The U.S. Department of Energy (DOE) lists

[4] Buffalo Niagra: Where Industry Creates Energy, KWR International, Inc.
[5] Manoment Center for Conservation Services, Hydrokinetic Energy, October 2009.

over 100 different technologies. [6] One concern with wave energy is the high cost and the low return of energy. Even with a very large wave energy converter it is virtually impossible that the energy generated would ever reach utility levels where it can become financially feasible.

One of the industry leaders in research and development of hydrokinetic technologies is Verdant Power. Based out of New York City, with offices in Seattle, Washington and Ontario, Canada, Verdant Power is a leader in the design and application of marine renewable energy solutions.

Future of Hydroelectric Energy

In the past few years, the U.S. government has made significant investments in the future of hydropower. In 2004, the DOE set a goal to increase growth in generation at existing hydropower plants and harness undeveloped hydropower capacity without constructing new dams. In 2009, $30.6 million in economic stimulus funding was allocated to seven hydropower projects to modernize their existing infrastructure. The DOE estimates that this investment will increase generation by 187,000 megawatt hours each year, or enough to meet the annual electric needs of more than 12,000 homes.[7]

To accelerate the development and commercial readiness of hydrokinetic technologies, in September 2010 the DOE announced the selection of 27 projects for more than $37 million in grant funding. Projects range from conceptual studies and research to prototype development and environmental testing. Despite these recent investments, hydrokinetic technologies are still in the very early stages of development.

Online Resources

- U.S. Department of Energy, Energy Efficiently and Renewable Energy, Wind and Water Power Program: http://www1.eere.energy.gov/windandhydro/water_power.html
- USDOE Hydropower 2004 Setting a Course for our Energy Future http://hydropower.inel.gov/techtransfer/pdfs/34916.pdf
- Verdant Power http://verdantpower.com/

Image:

http://www.alternative-energy-news.info/technology/hydro/

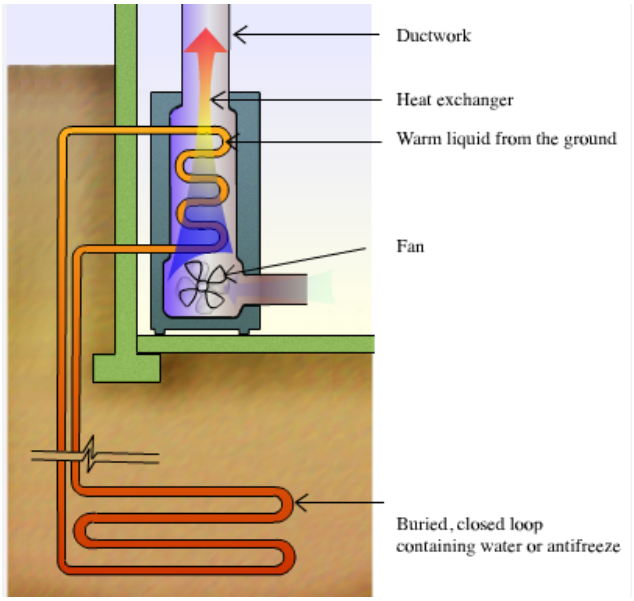
[6] U.S. Department of Energy, Energy Efficiently and Renewable Energy, Wind and Water Power Program: http://www1.eere.energy.gov/windandhydro/water_power.html
[7] Hydropower Upgrades to Yield Added Generation http://www.energy.gov/8260.htm.

Geothermal Energy

Geothermal energy is derived from the heat located below the surface of the Earth. The source of heat can range from just below the surface to several miles down. Most of the hot water reservoirs in the U.S. are located in the western states, Alaska and Hawaii but the right conditions are found throughout the world and some form of geothermal energy can be sourced almost anywhere. Seven states in the United States have geothermal power plants and in 2008 these plants provided 0.4% of total U.S. electricity generation (approximately 15 billion kilowatts[8]). Geothermal energy is typically considered to be underutilized with many positive aspects, including the fact that it emits very little (if any) greenhouse gas, it is reliable and readily available and it is located here within U.S. borders.

The use of geothermal energy ranges from simplistic to highly complex based on the depth of drilling required, what the end use of the energy will be and how much energy is needed. One simple way to utilize geothermal energy is to circulate naturally-occurring hot water near the Earth's surface through shallow buried pipes to melt ice/snow off sidewalks and roadways or to heat buildings and greenhouses.

Geothermal Heat Pump



Another, slightly more complicated, example of geothermal energy use is the Geothermal Heat Pump (GHP), which regulates the temperature of a building by using the stable ground temperature to draw heat in the winter and pull the heat out in the summer. This requires special pipes in the ground around the building, a special heat exchanger and ductwork throughout the building. Another benefit of the GHP is that heat removed from the house in the summer can be used to heat water. GHP systems can be expensive to install but they typically save the property owner in the long run in reduced energy costs and maintenance.

Finally, geothermal energy is also used to power turbines that drive generators. This typically involves drilling down very deep to access very hot water and associated steam to power turbines and generators.[9] Techniques for this include dry steam plants, flash steam plants and binary-cycle plants. The most common type of geothermal power generation plant is known as a flash steam plant. The flash steam plant pumps water at temperatures greater than 360°F (182°C) to the generation equipment located at the surface. Once the hot liquid is at the surface it is placed into a tank that is maintained at a much lower pressure which causes the liquid to vaporize immediately. This vapor is then used to drive a turbine that drives a generator. [10]

[8] http://www.eia.doe.gov/kids/energy.cfm?page=geothermal_home-basics last accessed February 20, 2011
Figure: http://www.consumerenergycenter.org/home/heating_cooling/geothermal.html
[9] http://www1.eere.energy.gov/geothermal/faqs.html last accessed February 20, 2011

[10] http://www1.eere.energy.gov/geothermal/powerplants.html last accessed 2/20/2011

Drawbacks of Geothermal

The primary drawback of geothermal energy is that it is not always easy or economical to access. Hydrothermal hot spots are the best source for major energy generation plants and they only occur when hot magma moves closer to the surface of the Earth and can heat ground water above temperatures of 212 degrees Fahrenheit. These conditions are typically located in the Western United States, Alaska and Hawaii. And finally, even if there is a hydrothermal hot spot available, adequate power transmission lines must be in close proximity, and enough surface water must be available to cool the generating equipment. These factors often make it difficult to utilize geothermal for large energy production.[11] For smaller geothermal use the major hot spots are not necessary and can be accessed throughout the world.

Another drawback of geothermal energy is the embodied carbon and energy in the machinery that is used for the process. In other words, while the actual use of geothermal does not emit carbon but production and transportation of the major machinery does and so the process cannot be considered carbon neutral.

New Technologies

The up and coming technology in geothermal energy is the use of hot dry rock (HDR) located deep below the Earth's surface to heat water for energy use. HDR technology works by pumping water through an injection well deep below the Earth's surface (3 or 4 miles)[12] at which point it flows over the hot crystalline rock causing it to become superheated and then it flows back to the production well. At the surface, the heat is extracted for use and the water is returned to the mine to complete the process again. One issue that has come up with HDR is the seismic activity caused by slight movements to rock blocks and a concern that this type of drilling and subsurface activity could create an earthquake. [13]

The drilling technology required for HDR needs to be further developed for it to become more financially feasible. The geothermal resources are in areas that are often corrosive, making it expensive to drill for these resources.[14]

Future of Geothermal Energy

Significant improvements in drilling technology are necessary to access HDR and it is still controversial due to the concern over possible seismic activity noted above. In the near future, increased use of geothermal energy is likely to be concentrated in the residential and small commercial building markets through the use of geothermal heat pumps (GHP) systems.

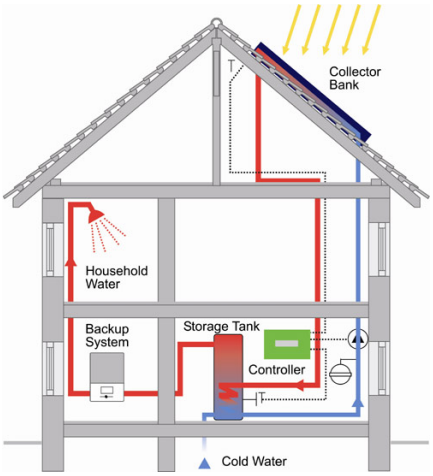
Online Resources

- http://www1.eere.energy.gov/geothermal/faqs.html
- http://www.nytimes.com/2009/06/24/business/energy-environment/24geotherm.html?_r=1&opattr=Deep_in_Bedrock%2C_Clean_Energy_and_Quake_Fears
- http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf
- http://www.ees.lanl.gov/ees11/geophysics/other/hdr.shtml

[11] http://www.energy-consumers-edge.com/pros_and_cons_of_geothermal_energy.html last accessed 2/20/2011
[12] http://www.energy-consumers-edge.com/pros_and_cons_of_geothermal_energy.html
[13] Glanz, James "Deep in Bedrock, Clean Energy and Quake Fears" New York Times. June 23, 2009
[14] http://www.energy-consumers-edge.com/pros_and_cons_of_geothermal_energy.html

Solar Energy

Thermal Heat Capture

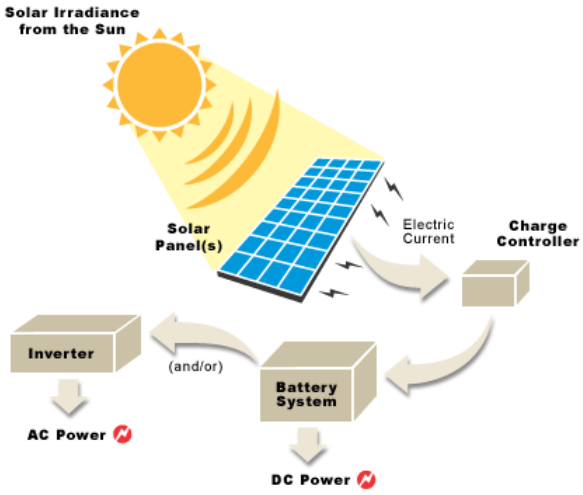


Solar power is derived by converting the sun's rays into other forms of energy, including thermal energy or electricity. One of the simplest ways to collect solar energy is thermal heat captured by strategically placing solar collectors to gather heat from the sun. The solar panels contain tubing called "solar thermal collectors," which have water (or other liquids) circulating through them. The water heats up and can then be used to heat a building or provide hot water to end users.[15]

In order to convert solar energy into electricity, photovoltaic (PV) cells are necessary and this electricity can be used to power almost anything, from calculators and watches to homes, cars and office buildings. PV cells are typically made from silicon-based material that absorbs the sun's light, which excites the electrons on the cell, thereby creating electricity. [16] These cells are used in flat-plate systems or concentrator systems.

The flat-plate system is the most common and is comprised of panels made of PV cells that are either fixed to a flat surface or able to rotate and track the movement of the sun over the course of the day. The fixed cells are less efficient, but they are fairly simple and able to be used almost anywhere, including on residential roofs.

Flat Panel System



The Concentrator Photovoltaic System (CPS) essentially reflects the sun's rays from a large surface area into a much smaller area where the PV cell is placed. The cells in a concentrator system are used more efficiently because the sunlight is concentrated when it hits them. For this reason, concentrator systems can be built using smaller amounts of the expensive silicon material than would be required for a flat panel system that produces the same amount of electricity. [17]

Drawbacks of Solar Energy

The primary drawback of solar power is cost. Solar power is very expensive relative to energy derived from fossil fuel, mainly because of the cost of the silicon required to make the PV cells and the expensive conversion systems required to transform the direct current (DC) power produced by the solar panels into alternating current (AC) power, which is what most household appliances utilize.[18]

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[15] Image: http://www.google.com/imgres?imgurl=http://www.capitalsolaruk.co.uk/img/solar-house.jpg&imgrefurl=http://www.capitalsolaruk.co.uk/solar.php&h=547&w=500&sz=50&tbnid=Tjxo3sBuAXbm-M:&tbnh=133&tbnw=122&prev=/images%3Fq%3Dhow%2Bdoes%2Bsolar%2Benergy%2Bwork&zoom=1&q=how+does+solar+energy+work&usg=__reVDugF-kKRuooKmEXYxJXAunaY=&sa=X&ei=pN-hTIPrFYGCIAeN1_2PBA&ved=0CDIQ9QEwAw

[16] http://www.alternate-energy-sources.com/how-does-solar-energy-work.html

[17] http://www.eere.energy.gov/basics/renewable_energy/concentrator_pv_systems.html last accessed 2/20/2011

[18] http://www.popularmechanics.com/science/environment/4287132 last accessed March 25,2011

In addition to the cost of solar systems, another drawback is that the sun's rays are not available 100% of the time. The batteries currently available to store electricity produced from the sun have limited capacity and are generally expensive. Therefore, solar power lacks reliability and continuity in many cases.

New Technologies

Technology is being developed that will solve some of the major drawbacks associated with solar energy. One example of new technology being developed is a new small device called a "microinverter" which can be installed directly on the solar panel causing it to output AC power, making it more user-friendly. This is intended to improve the ability for smaller scale operations to be financially feasible.

Microinverters in Use

In addition, researchers are working to find a replacement for silicon as the semiconductor material. One of the most promising candidates for the solar semiconductor of the future will be thin-film panels made of cadmium indium gallium selenide (CIGS).

Concentrated Solar Power (CSP) technology is also advancing to align power production with periods of peak demand and the storage of energy for periods of intermittent sunshine. CSP technology uses mirrors or lenses to concentrate a large area of sunlight into a small area to produce electrical power. The electrical power is generated when the heat (from the concentrated light) drives an engine that is connected to an electrical power generator. There are two common types of CSP models including troughs and dishes. This CSP technology will make it much more feasible for utility companies to invest in and generate solar energy since they will have the ability to store the energy until they need to dispatch it to consumers. [19]

Future of Solar Energy

The viability of solar energy is dependent on reducing the cost and making it possible to store the energy for use during cloudy days and even overnight. In the future, CSP technology will likely be the best tool for increasing the viability of solar energy for widespread use. The technology enhancements are creating ways to store excess capacity in preparation for increased demand. For areas where the larger systems would be infeasible, there are developments being made for single consumers which will increase the possibility, affordability and viability of individuals looking to use solar energy to reduce their dependence on fossil fuels.

Online Resources

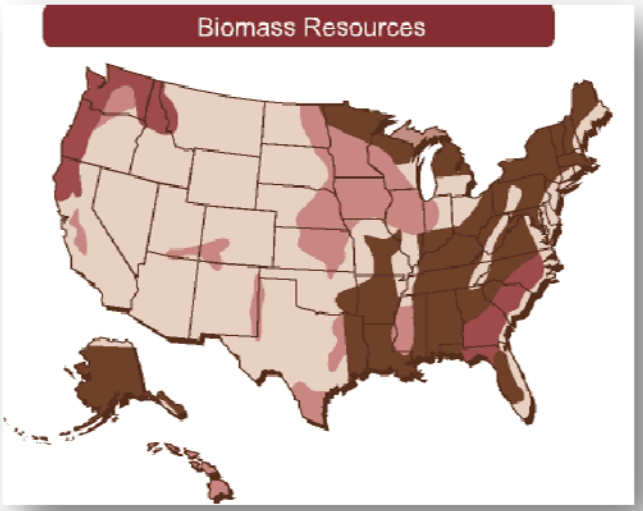
- http://www.eere.energy.gov/basics/renewable_energy/pv_cells.html
- http://www.popularmechanics.com/science/environment/4287132
- http://www.iea.org/papers/2010/csp_roadmap.pdf
- http://www1.eere.energy.gov/solar/pdfs/solar_program_mypp_2008-2012.pdf

Images:

http://www.alternative-energy-news.info/technology/solar-power/

[19] http://www.popularmechanics.com/science/environment/4287132 last accessed March 25,2011

Biomass Energy



Bioenergy encompasses a wide variety of renewable energy sources, from burning wood to heat a house to using crops such as corn to produce liquid transportation fuels. By definition, bioenergy is a renewable energy that is made by breaking down any organic material from plants or animals. The organic material that is the source of bioenergy is called "biomass" and includes agricultural and forestry residues, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes. These sources of biomass can be replanted and, therefore, bioenergy is considered renewable and sustainable. Another key aspect of bioenergy is that it can be found across the globe and is not concentrated in a certain geographic location, see map below for biomass resources in the United States. Next to hydropower, more electricity is generated from biomass than any other renewable energy resource in the United States; bioenergy currently supplies approximately 2.8% of the United State's total energy consumption (including electricity, process heat and transportation fuels). [20]

The production of electricity or heat from biomass resources is known as biopower. There are three primary technologies associated with biopower and they include direct combustion, co-firing and anaerobic digestion.

- The most common is *direct combustion*, which works in ways similar to fossil fuels in that the biomass is burned in a boiler to create high-pressure steam which then rotates a turbine connected to an electrical generator.
- *Co-firing* replaces a portion of the fossil fuel in high-efficiency coal-fired boilers with biomass. Co-firing has been successfully demonstrated in most boiler technologies and can significantly reduce the sulfur dioxide emissions of coal-fired power plants. Co-firing can be the least-cost renewable energy option for many power producers.
- *Anaerobic digestion*, or methane recovery, is typically used to convert organic waste into heat or electricity and it occurs when organic matter decomposes in the absence of oxygen and presence of bacteria. The decomposition produces methane and other byproducts that form a renewable natural gas.[21]

Biofuel is also consumed in the form of ethanol, a substance added to gasoline to reduce dependence on fossil fuels. Most modern cars run on blends containing 10% ethanol by volume without any need for modification. There are some cars that have been built to run on blends containing up to 85% ethanol. Typically, ethanol is made from corn but it can also be produced from other grains and biomass sources including the other parts of the corn plant, vegetable and forestry waste, straws, sugar cane, and other organic matter.

[20] Government Economic Development Initiatives for BioMass Power Projects. 2007 Fredrikson and Byron, P.A. http://www.fredlaw.com/bios/attorneys/taylortodd/BioMass.pdf. Last accessed 10/26/2010.
[21] http://www1.eere.energy.gov/biomass/abcs_biopower.html

In 2007, the ethanol industry, with plants throughout the "corn belt" and now expanding throughout the United States, consumed 3 billion bushels of corn (approximately 20% of the nation's corn supply).[22]

Biomass: Wood Chips

Drawbacks of Biomass Energy

The current concerns and drawbacks of using biomass for energy include two primary issues. The first issue is that biomass is not as efficient as some of the other forms of energy available such as coal and petroleum.

The second major issue is the controversy over the use of corn for energy and the impact that it will have on the price of food, the supply chain and the large amount of land necessary to harvest it. With corn being used for ethanol fuel, more and more farmland must be devoted to it, which may have an impact on food prices globally. Requiring more land to be devoted to corn for ethanol may also accelerate deforestation, having a negative impact on rainforests that are already at risk. Moreover, the net carbon impact of production of biomass is also a concern. Overall this controversy is calling into question whether the use of corn for fuel is actually better or worse for the environment, especially in terms of the amount of fuel required to harvest it.[23]

New Technologies

Currently a majority of the ethanol or biofuel comes from corn and soy, but new technologies are being developed that will make it more cost-effective to convert abundant cellulosic biomass sources into liquid transportation fuels. The more abundant sources include crop and forestry residues, switch grass and sorghum and even municipal waste.

Technology is also being developed to find other sources of biofuels, such as genetically engineered photosynthetic micro-organisms that produce ethanol and diesel. Algae and seaweed are also being studied as potential producers of biofuel. A company in Leander, Texas is also looking to produce biofuels with a solar based technology that uses genetically engineered photosynthetic micro-organisms. This process would be more efficient than the algae based biofuels making it a possibility for consumer use. [24]

Future of Biomass Energy

Technological improvements will likely reduce some of the controversy surrounding biofuels as alternative sources are found to replace the heavy dependence on corn. The technology being developed will likely reduce the overall cost involved with biofuels and will make it more accessible to everyday consumers. On a large scale it is possible that industrial park tenants will be able to figure out a way to work with their neighbors on ways to use other's waste streams as an energy source. This type of cooperative environment is known as an eco-industrial park and involves a network of firms and organizations, working together to improve their environmental and economic performance. This could reduce the overall cost of doing business while at the same time reducing dependence on fossil fuels.

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[22] http://www1.eere.energy.gov/biomass/biomass_basics_faqs.html
[23] http://www.aboutmyplanet.com/alternative-energy/ethanol-fuel/
[24] http://buildaroo.com/news/article/new-biofuel-technology-using-sunlight-and-micro-organisms-could-change-the-industry/

These types of eco-industrial parks are already being developed through public, private and non-profit sector partnerships. For example, in Burlington, Vermont the Intervale Food Center is a 60,000 square foot facility that has 10,000 square feet of business space and 50,000 square feet of greenhouse space. The greenhouse buildings will utilize the wasted heat that is a by-product of burning wood chips at the McNeil brewery plant. The eco-park currently houses community gardens, citywide composting, wind power and a demonstration project that is using living plants to convert liquid organic waste from the food industry into marketable products such as fertilizer and fish food. [25]

Online Resources

- http://www1.eere.energy.gov/biomass/information_resources.html
- http://www.aboutmyplanet.com/alternative-energy/ethanol-fuel/
- http://www.eia.doe.gov/kids/energy.cfm?page=biomass_home-basics

Images:

http://www.nrel.gov/data/pix/searchpix.php

http://www.eere.energy.gov/basics/renewable_energy/biomass_resources.html

Conclusion

This white paper serves as a primer for the various types of alternative energy being used and developed today. It offers some options on how economic developers can better situate their community to harness the power of alternative energy and use it to their advantage when working towards economic development goals. It is Camoin Associates' intention that this paper help provide economic developers with a basic understanding of various alternative energy sources being deployed.

There are as many different communities in the United States as there are different ways to handle the increasing demand for and rising cost of energy. There is no right answer when it comes to which alternative energy source is best for all communities, which is why economic developers should take a proactive approach in identifying the local assets and potential for alternative energy as a way to set themselves apart from their competition, reduce the cost of doing business for existing and new businesses, and reduce dependence on fossil fuels.

[25] http://engineering.dartmouth.edu/~cushman/courses/engs37/EIPs.pdf last accessed March 25, 2011