Renewable Energy:

Resources, policies, and alternative technologies

INTRODUCTION

Over the last century, fossil fuel resources have increasingly become central to the U.S. energy economy. The U.S. relies primarily on fossil fuels to supply energy for industry, residential and commercial buildings and transportation technology. This trend continues despite the questionable future viability of fossil fuels as a safe, secure, and plentiful energy resource. However, advances in consumer advocacy, public policy and technological innovation promise increased investment and interest in renewable energy resources as an alternative to fossil fuel consumption. Solutions may be found in the expansion of renewable energy production and alternative energy technologies, including energy efficiency.

U.S. ENERGY CONSUMPTION

Energy is consumed in the U.S. for electricity generation, spacing heating in buildings, and transportation mainly through the burning of fossil fuels such as coal, petroleum and natural gas. According to the U.S. Department of Energy, fossil fuels provide 83% of the energy consumed in the U.S. Coal makes up over 20% of the energy in the U.S. while about 8% of energy was generated by renewable energy sources for that year (U.S. E.I.A.).

Fossil fuels are non-renewable resources (peak oil). Most energy experts predict that discovery of new petroleum reserves will peak within the next 20 years, while some believe this has already occurred (Malone 2006). Coal and natural gas resources are expected to peak within the next 40 to 70 years. Some experts argue that new extraction technologies will render peak oil a less imminent crisis, but combined with growing concern over climate change, economic security, and environmental degradation, the impending depletion of fossil fuels presents a monumental challenge for individuals and policymakers to manage energy needs.

Wind turbines convert wind energy into electricity. Turbines are often installed in groups called "windfarms" as shown to the left.
Source: http://www.skf.com

VIRGINIA ENERGY CHOICE AND ENERGY PRICE DEREGULATION

The consumer education program, Virginia Energy Choice (VEC), highlights several recent legislative changes that affect the way utility customers will purchase electricity and natural gas in the future. VEC is charged with informing interested consumers of their options, including renewable energy portfolios, when choosing an energy provider.

According to VEC, Virginia operates under a hybrid system of energy pricing. The State Corporation Commission (SCC) regulates utility rates of return, but permits utilities to request rate adjustments to cover the costs of environmental, energy-efficiency, and demand management programs, among others. This allows utilities to purchase electricity from renewable energy generators and charge the market premium. Prior to deregulation, utilities had no economic incentive to offer renewables to their customers. However, utilities are currently not required to include renewable sources in their energy portfolio in Virginia, limiting renewable energy options.

FOSSIL FUEL BASICS

When fossil fuels are burned, heat energy is produced, along with small particles that are released into the air from combustion. Heat energy is used for everything from directly heating water for industrial or residential uses to electricity generated by steam turbines to driving pistons in vehicles. Electricity is transmitted through a national distribution system, known as the "National Electricity Grid," to reach its commercial, residential and industrial users.

Particles released into the atmosphere through combustion of fossil fuels are referred to technically as emissions and commonly as pollution. Coal-fired power plants alone account for 60% of sulfur dioxide emissions and 40% of mercury emissions (Barcott 2004). Sulfur dioxide and mercury are toxic substances that pose serious threats to human and environmental health. Other fossil fuel emissions, such as carbon dioxide and methane are "greenhouse gases" that are known to contribute to the alteration of the earth's climate and weather patterns. Although vehicles that burn fossil fuels such as gasoline and

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diesel have become cleaner and more efficient in recent decades, increased miles traveled and total vehicles on the road have largely offset gains made in cleaner combustion technologies.

RENEWABLE ENERGY

Renewable energy is an energy source that is regenerative and inexhaustible. Renewable energy can be derived from natural sources such as wind currents, the sun, organic matter, flowing water, or heat from the Earth's core. Hydroelectric and biomass energy account for the overwhelming majority of renewable energy generation nationwide, while geothermal, wind, and solar energy lag far behind.

Some renewable energy technologies have greater environmental impact than others. In particular, large utility-scale hydroelectric power generating facilities have been found to have devastating effects on riparian and river ecosystems. The renewable sources described below are generally considered the cleanest, least environmentally destructive, and most technologically viable sources for future energy generation.

Solar photovoltaic panels use light-sensitive silicon cells to transfer energy from the sun directly into electricity.
Source: http://alternativesolar.com

Solar Energy

Energy is generated from the sun in many forms. While solar energy has a long history in directly and passively heating water and building space, a growing application is for generating electricity using photovoltaic panels.

Photovoltaic (PV) arrays convert light energy into direct current electricity, without moving parts, fuel, or resulting emissions. PVs are comprised of dense semiconductor material, usually either crystalline or thin film silicon.

Solar water heater on a residential roof
Source: www.superiorsolar.com.au

When the photons in sunlight strike a photovoltaic cell, electrons are dislodged, creating an electric current. Approximately 30% of the light energy that passes through modern photovoltaic cells is converted directly into electricity. Solar energy accounts for less than 1 % of U.S. energy generation.

Solar hot water heaters use the sun to heat water as it run through the solar collector. There are no emissions and in many climates solar hot water can provide up to 85% of hot water used in residential settings.

Nanosolar technology has the potential to revolutionize how solar power is integrated into homes and businesses. Nanosolar products are thinner, lighter, and more versatile that traditional PV arrays. Additionally, they are more cost-effective since they are easier to mass produce. The founding company launched nanosolar products in 2007.

A COMMERCIAL WIND PROJECT IN HIGHLAND COUNTY

In 2005, Highland New Wind Development LLC applied for permission to build a proposed twenty wind turbines in western Highland County, VA. The facility would be Virginia's first commercial wind project, producing more than 100 million kilowatt hours of electricity annually, or enough to power about 12,000 homes. Construction of the facility requires approvals from both the local Board of Supervisors as well as the State Corporation Commission (SCC). Citizens and conservation groups concerned with the impacts of the 400-foot turbines on birds, bats and the scenic quality of the area challenged the Supervisors' issuance of a conditional use permit in both district and state supreme court; both courts ruled in favor of the wind project.

In December of 2007, the SCC granted conditional approval for the project, requiring additional wildlife protection and mitigation measures and three years of monitoring by the Department of Game and Inland Fisheries. Highland New Wind will also be charged a penalty for each raptor killed by the turbines. The period for appeal of the SCC decision expired in January 2008, allowing Highland New Wind to move ahead with construction schedules and a search for financing (*Daily News Record*, 2008). Successful completion could help to encourage other renewable wind energy projects in Virginia.

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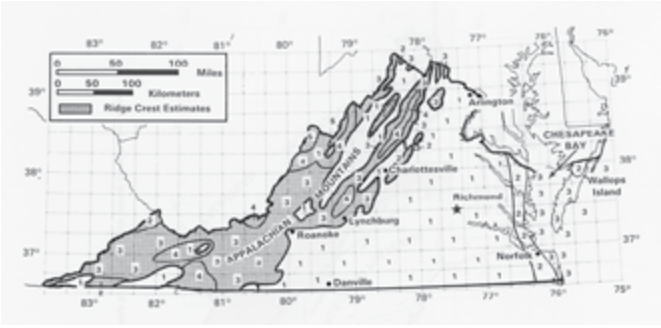
BENEFITS AND CHALLENGES OF WIND AND SOLAR

Benefits

- ***They're Clean*** Wind and solar energy generate no emissions or greenhouse gases.
- ***They Boost the Economy*** When states encourage wind and solar manufacturers to locate in-state, jobs are created, distribution costs are decreased, and a competitive market is created. Furthermore, wind turbines provide alternative income for landowners, farmers, and ranchers who may still manage their lands as before.
- ***They're Versatile*** Solar energy can be used for space heat, hot water, and electricity. Photovoltaics and wind turbines can be integrated into homes or commercial buildings or expanded into utility-scale power facilities.
- ***They're Growing*** Solar technology is improving and costs are decreasing. Photovoltaic panels have reduced in cost by 90% since the 1970s. Some experts predict that the market for photovoltaics to grow more than 30% each year through 2025 (REPP 2005). Meanwhile, wind energy is growing even faster at a rate of about 40% each year (AWEA 2004).

Challenges

- ***Limited Areas/Seasons*** Wind and solar are only viable in areas of sufficient wind and sunshine.
- ***High Costs*** High initial capital costs for solar energy make it difficult to compete with traditional methods, especially without the substantial tax breaks that the oil and gas industries receive each year.
- ***Environmental Impacts*** Photovoltaic panels contain heavy metals that must be disposed of at the end of the life cycle, typically 30 years. Wind turbines, if not sited carefully, can increase mortality of migratory birds and bats.



The map above shows wind power potential in Virginia. Shaded areas are generally suitable for wind energy generation.
Source: Virginia Wind Resources Map, NREL

Biomass materials range from corn to wood to animal waste.
Source: www.serbep.org

Wind Energy

Wind turbines harvest the kinetic (or motion) energy of wind and convert it to electrical energy. With a range of a dozen to several hundred grid connected turbines, wind farms are the most common producers of wind energy. Modern utility-scale wind turbines are equipped with three-bladed rotors 138 to 262 feet in diameter mounted on towers that are between 130 and 330 feet tall. A single turbine can generate anywhere from 600 kilowatts to 2 megawatts of electricity, a power supply sufficient for 600 homes. Smaller-scale turbines are popular in marine and remote applications.

With a nearly five-fold increase in consumption since 1990, wind energy is the fastest-growing renewable energy source in the U.S. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy estimated a total national wind energy capacity in the United States at more than 9,000 megawatts as of 2005, enough for about 2.3 million average American households.

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SOUTHEASTERN REGIONAL BIOMASS ENERGY PROGRAM: MARTIN FARM SWINE LAGOON PILOT PROJECT

An innovative biogas demonstration project in rural Southern Virginia harvests methane gas from a hog farm to produce electricity. Hog wastes are stored in a covered lagoon fitted with an anaerobic digester which converts liquid wastes into methane gas. The gas is burned for heat energy and electricity. The methane gas harvested from the lagoon provides enough energy to cover 80% of the Martin Farm's electricity needs.

The project was funded with a grant from the Southeasetern Regional Biomass Energy Partnership, which provides technical assistance for biomass energy projects throughout the southeast. Virginia Dept. of Mines, Minerals and Energy (DMME) and Virginia Tech were also partners in the project.

Biomass

According to the U.S. Department of Energy's Energy Efficiency and Renewable Energy Program (EERE), biomass has been the leading source of renewable energy in the United States since 2000. Biomass was the source for 53% of all renewable energy or 4% of the total energy produced in the United States in 2010 (EIA Monthly Energy Review). Biomass also provides the only renewable alternative for liquid transportation fuel, commonly produced from corn as ethanol.

Biomass is stored energy from the sun contained in plant matter and animal waste. It is considered renewable because it is replenished more quickly when compared to the millions of years required to replenish fossil fuels. Biomass is generally classified into three categories:

- **Untreated biomass** such as wood, straw, and grass;
- **Cultivated biomass** such as forestry crops, canary reed grass or switchgrass;
- **Residues and Waste-Derived Fuels (WDF)** such as organic waste from agriculture, industry, construction materials, or sewage sludge.

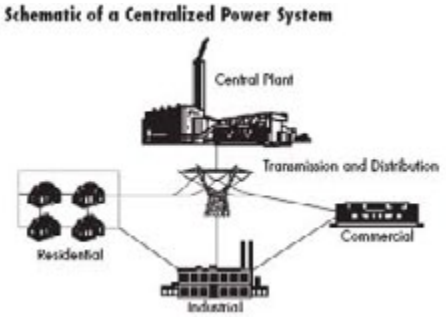
Biomass is considered highly beneficial for its net-neutral carbon emissions. Atmospheric carbon dioxide is absorbed by growing plants and subsequently released during the combustion phase of biomass energy generation. Biomass also strengthens rural economies, decreases America's dependence on imported oil, avoids use of highly toxic fuel additives and reduces air and water pollution. However, biomass burning is a source of greenhouse gases methane and nitrous oxide.

Geothermal

Geothermal energy is derived from heat beneath the Earth's surface, which can be accessed to heat and cool buildings, or drive power plants. While large geothermal reservoirs are only found in a small number of geographical areas around the country, it has been shown that small scale heating and cooling can be achieved in many places with proper precision. For this reason, geothermal reserves can be an integral part of smaller renewable energy strategy.

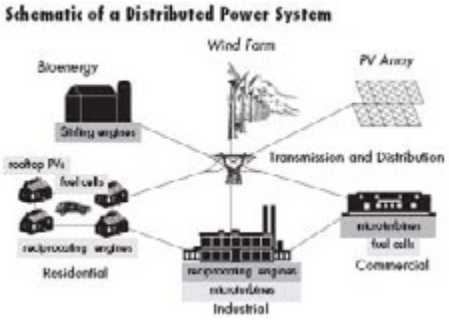
ALTERNATIVE ENERGY GENERATION

THEN



For the last century, our national energy system has relied on large, centralized power production facilities to generate electricity for residential, commercial, and industrial buildings.
Source: Dunn, 2001

NOW



Today, technological advances in production and changes in utility regulation create new opportunities for communities to generate their own power from local sources.
Source: Dunn, 2001

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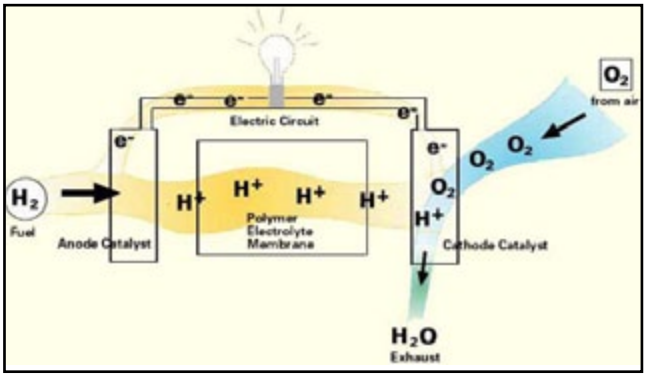
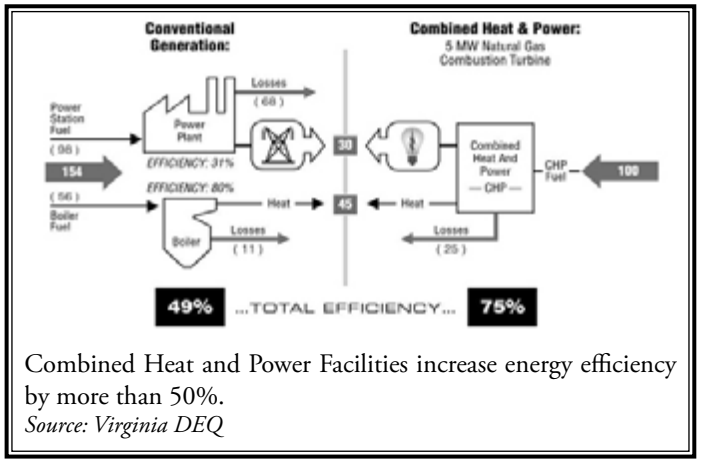
The image to the right is a 250-kilowatt fuel cell power plant, one of many experimental fuel cell installations in the U.S. Below is a schematic of the fuel cell process combining Hydrogen and Oxygen to create electricity, with water and heat as a byproduct.
Source: Fuel Cells 2000





Combined Heat and Power Facilities increase energy efficiency by more than 50%.
Source: Virginia DEQ

The development of new energy generation and distribution techniques that are more reliable, adaptable, cleaner, and potentially more economical than conventional methods is changing the way the U.S. thinks about energy. Many of these innovations increase efficiency and local control of energy generation.

Distributed Generation

The capital and environmental resources required to build and operate conventional coal-fired and natural gas power plants, combined with the inefficiency and unreliability of the national electricity grid, are a huge risk for utilities, their investors, and consumers. The alternative is a small, modular, decentralized, grid-connected or off-grid energy system located in or near the place where energy is used. Rather than consuming energy produced on an industrial scale and distributed on a large grid system, a network of smaller power producers can supply energy to meet the demand for a group of users, such as a business district or a local community.

Fuel Cells

Fuel cells use a chemical reaction to generate electricity. Fuel cells operate quietly, are two to three times as efficient as conventional power plants, produce almost no pollution, and are more reliable than the grid. Additional generating capacity can be added to or subtracted from fuel cells as needed. Fuel cells can also be used in cars or as a part of a distributed generation facility. Fuel cells have a wide applicability in small portable devices, personal automobiles and commercial vehicles, as well as stationary generators for industrial, office, residential and commercial buildings.

VIRGINIA'S NET METERING LAW

Virginia has one of the most generous net metering laws in the country: solar, wind, and hydroelectric systems are all eligible to benefit from net metering. The law applies to residential and non-residential systems with capacity of up to 10 kilowatts and 500 kilowatts, respectively. Net excess generation (NEG) of energy from one month carries over to the next month as a credit. However, NEG credits remaining at the end of the 12-month annual period is granted to the utility company. The program operates on a first come first serve basis until 0.1% of the utility's previous-year peak demand is generated by customer-owned systems.

Combined Heat and Power (CHP)

CHP systems use the waste heat from the conversion of fuel to electricity at a distributed generation facility to provide heating for households and commercial buildings served by the facility. More recent innovations use the waste heat from fuel cells. Energy can be circulated as super-heated water or steam.

RENEWABLE ENERGY PROGRAMS AND INCENTIVES

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The amount of energy produced by renewable sources is unlikely to grow significantly without private and public incentives. Tax credits, low-interest loans, grants, zoning ordinances that allow for solar or wind access, special utility rates, and technical assistance are all incentives that could help to enable and promote the use of renewable energy. In 2010, Virginia developed and published a statewide Energy Plan examining Virginia's energy resources and potential and outlining several innovative programs and incentives to both require and encourage energy generation using renewable sources (Energy Plan, 2010).

Net Metering

Net metering is an agreement between utility companies and electricity customers that allows a credit for electricity generated in excess of consumption. Utility companies generally buy customer-generated energy at wholesale prices rather than at utility rates, though it can still provide some revenue for the customer. Net metering is a low-cost, easily administered method of encouraging customer investment in renewable energy technologies. As of My 2010, only four states do not allow net metering.

Renewable Portfolio Standards (RPS)

A renewable portfolio standard is a state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. As of May 2009 32 states plus the District of Columbia have RPS policies in place, ranging from 2% of the electricity supply in Iowa to 40% in Maine U.S. DOE EERE).

2007 electric utility legistlation in Virginia includes a provision for voluntary RPS. Adoption of an RPS is allowed for any utility that shows reasonable expectation of meeting a goal to replace 12% of base year sales with renewables by 2022. Utilities who pursue the RPS can earn an increased rate of return by meeting the 2022 and other intermediate goals, and can also earn enhanced rates of return on construction of generation facilities for renewables.

Public Benefits Funds

Public Benefits Funds are state funds for renewable energy through a specific tax on public utility customers. These funds are often used for rebates on renewable energy systems, funding for renewable energy research and development, and development of renewable energy education programs.

Renewable Energy Credits (RECs)

RECs support the technology and environmental attributes of electricity produced by renewable sources. Because RECs can be sold separately from the actual unit of electricity produced, they increase the available markets for renewable energy. For example, a residential customer in an area not served by a provider of renewable energy can offset a percentage of their annual electricity use by purchasing certificates generated elsewhere.

Residential Renewable Energy Tax Credits

Energy Star, a program of the U.S. Department of Energy and the U.S. Environmental Protection Agency, provides energy efficiency standards for appliances, heating and cooling systems, water heaters, lighting, and electronics. Purchasing Energy Star products qualifies consumers for tax credits at 30% of the cost of certain products, including geothermal heat pumps, solar panels, and solar water heaters. These tax credits are designed to encourage homeowners to purchase energy efficient products.

CONCLUSION

The United States faces significant challenges in balancing the consumption of energy with a finite supply of resources and environmental quality. Wind, solar, biomass and geothermal energy technologies are emerging as four viable ways to generate electricity with resources that are locally available and renewable. Technological advances are making renewable energy production more efficient and economical. Changing utility regulations are beginning to favor smaller-scale energy production, while simultaneously creating more energy options for consumers.

Our future energy path is far from truly sustainable. However, by distributing energy generation systems throughout our communities and harnessing renewable energy resources, we can begin to tackle the problem of energy security while protecting our life-sustaining environment.

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Updated September 2011 by Melissa Keywood

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