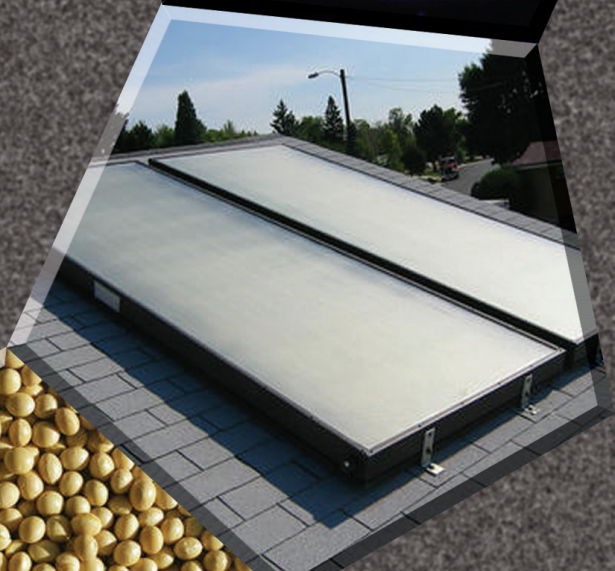
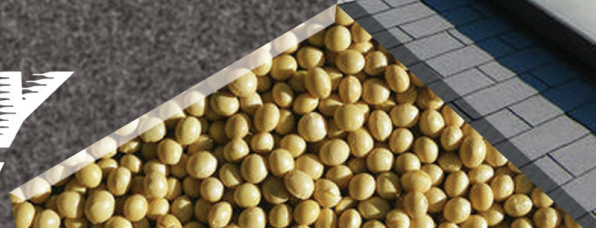
North Carolina

Economic Developer's

Spring 2005

Renewable Energy Industry Guide





State Energy Office
N.C. Department of Administration

State Energy Office
ENERGY
www.energync.net 1-800-662-7131
N.C. Department of Administration "Ensuring a sustainable energy future"

Cover: Images are courtesy of NREL; www.nrel.gov/data/pix

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Five hundred copies of this document were printed at a cost of $___ per copy.

Sections

photos: www.nrel.gov/data/pix

Executive Summary

The purpose of this industry guide is to provide economic developers with basic information about the renewable energy industries. Designed as a quick reference book, this document will be published periodically to reflect new industry developments. This document is designed for an audience with little or no knowledge of renewable energy. Contained within are pertinent facts about renewable energy industries in general, existing companies in North Carolina, and resources for further information.

Energy resources such as **wind power, solar power, crops, waste, and hydrogen** are the fastest growing sources of energy in the world. Making use of these energy sources requires a broad array of technology produced by industries ranging from semiconductors and advanced materials to biotechnology.

Development of these resources has created millions of jobs and billions of dollars in investment, often in rural communities. Local economies benefit from installation and operation of renewable energy technologies, as every dollar spent on using indigenous resources is a dollar that remains in the local economy.

As states in every region of the country and nations around the globe implement policies designed to increase energy independence, reduce pollution, and create jobs, the demand for renewable energy equipment grows stronger every day. As a result of this rapidly increasing demand, economic development efforts increasingly target renewable energy-related manufacturers.

Leveraging tax credits, low-interest loans, grants, renewable portfolio standards, and local natural resources, states are scrambling to establish dominance in renewable energy markets to ensure that the rapid growth in these industries translates to jobs and investment in their local communities.

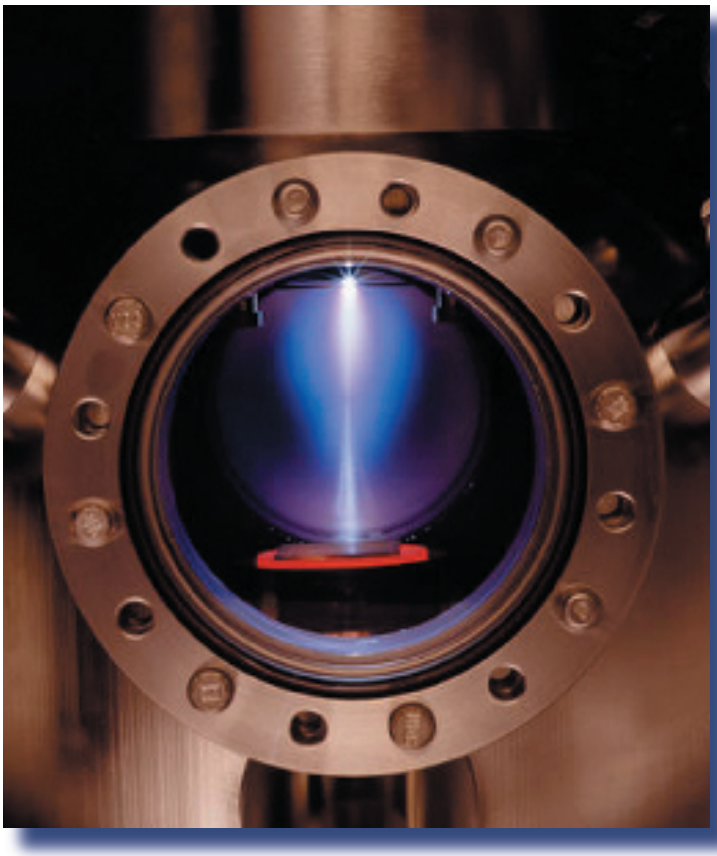


photo: www.nrel.gov/data/pix

The potential for North Carolina to capitalize on opportunities in renewable energy is enormous. Home to a vibrant agricultural economy, a rapidly growing biotechnology industry, the strongest wind-power resources in the southeast, and leading fuel cell component manufacturers, North Carolina is primed to harvest significant numbers of jobs and investment dollars from renewable energy across all sectors of the economy.

Already, North Carolina hosts several fuel cell research projects, a small-wind turbine testing site, multiple landfill gas-to-energy projects, public biodiesel pumps, a one-of-a-kind green power program, and many institutions dedicated to increasing the impact of renewable energy industries on the state's economy.

For more information about renewable energy and economic development visit the ASU Energy Center's web site at *www.energy.appstate.edu*

Markets, Drivers and Benefits

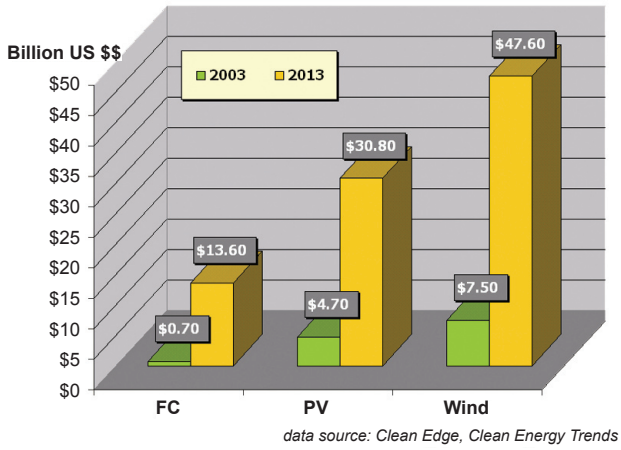
Market Size & Growth

Growth rates for renewable energy markets have reached record levels over the past decade with solar photovoltaics (PV), wind turbines and fuel cells combining today for a market value of about $13 billion, and are projected to reach a combined value of over $90 billion by 2013.

Projections for renewable energy growth in the upcoming decade show these industries combined having a 22% compound growth rate. Fuel cells are projected to grow at a compound rate of 35%, solar photovoltaics at a compound rate of 21%, and wind power at a compound rate of 20%.

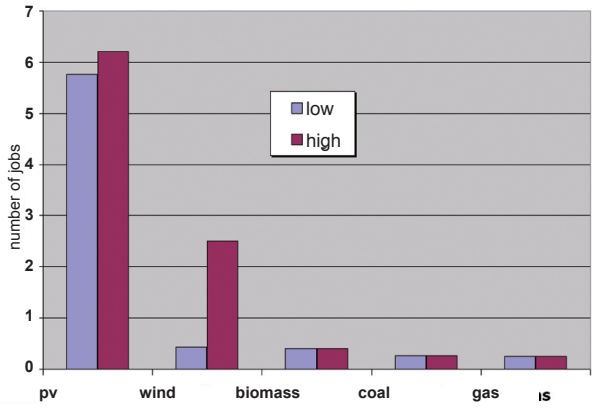
These high-growth industries are being driven primarily by rapidly decreasing costs. For example, the cost of both wind and solar PV have declined 80%-90% in the past two decades. Generally speaking, solar PV costs drop 18% with every doubling of manufacturing capacity, and wind power costs decline 10% with every doubling of installed capacity.[2]

Market Projections



data source: Clean Edge, Clean Energy Trends

Manufacturing Jobs per Megawatt



source: Megawatt U.C. Birkley "Putting Renewables to Work"

Benefits & Driving Forces

Renewable Energy is produced locally - allowing energy dollars to remain within the local economy and increasing the sustainability of local and regional economies.

Fossil fuel use creates air and water pollution that is responsible for health hazards such as smog and high mercury levels in fish, and their emissions places federal transportation money in jeopardy. On the other hand, renewable fuels and the crops grown to create them reduces our dependence on foreign nations for oil, provides cleaner-burning fuel, and supports the rural agricultural economy.

Policies that support renewable energy encourage job creation and investment in areas where local resources such as wind or sunshine are readily available. And, finally, renewables offer more jobs per megawatt in manufacturing and operation than fossil fuels.[3]

Policies and Incentives

Policy and incentive support is a vital economic development concern in the renewable energy industry. With favorable policy support, states such as Rhode Island and Pennsylvania have realized success in attracting direct foreign investment resulting in manufacturing jobs, increased local income, and healthier local economies.

Numerous states have enacted policies that create markets for renewable energy electricity, such as Renewable Portfolio Standards that require a state or locality to diversify its supply of energy sources, or Net Metering which enables small producers, including homes and businesses, to sell the excess power generated at their site back into the grid.

Other policies directly support the use and production of renewable power, these include property tax incentives, corporate and personal income tax incentives, and industrial recruitment incentives.

The Database of State Incentives for Renewable Energy (DSIRE) is a project managed for the Department of Energy by the N.C. Solar Center. DSIRE maintains current listings of renewable energy incentives nationwide. The site can be found at ***www.dsireusa.org***.

Alternative Fuels Incentives and Regulations are available from the Department of Energy at ***www.eere.energy.gov/afdc/laws/incen_laws.html***.

Energy Improvement Loan Program
§143-345.18

Amount: up to $500,000 loaned at 1% APR for renewable energy projects, and 3% for energy efficiency projects

Terms: Loan period of up to 10 years, available for industry, commercial, non-profit, or government projects

Corporate Tax Credit - § 105-129.16A

Amount: 35% of cost for construction, design, and installation of renewable energy equipment

Limit: $250,000, also varies by technology

Terms: Distributed over 5 years, may not exceed 50% of tax liability

N.C.'s Renewable Energy Equipment Manufacturer Incentive

N.C. Gen. Stat. § 105-130.28

Eligible Technologies: Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Photovoltaics, Wind, Biomass, Hydroelectric, Renewable Transportation Fuels

Amount: **25% of installation and equipment costs** of construction (construction costs offset by state, federal, or local grants may not be included in the total)

Limit: No maximum limit, although credit may not exceed 50% of tax liability for the years the credit is claimed

Terms: Credit must be taken in 5 equal installments, and can be carried forward 10 years. The credit may be used in conjunction with the federal corporate tax credit and accelerated depreciation allowances.

photo: www.nrel.gov/data/pix

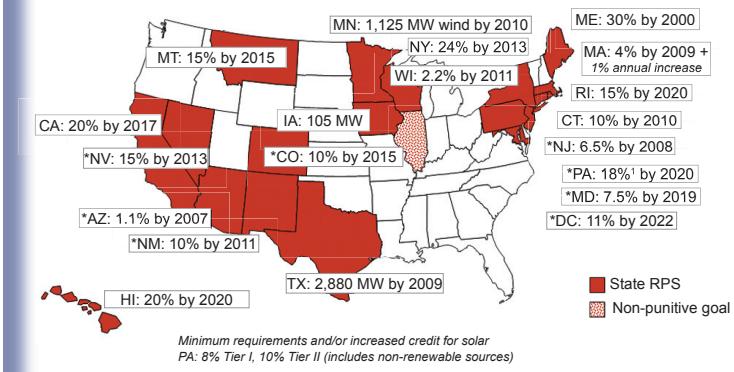
DSIRE: www.dslrueusa.org May 2005

State Generation Disclosure Rules

"Disclosure" typically refers to the requirement that utilities provide their customers with additional information about the energy they are supplying. This information often includes fuel mix percentages and emissions statistics. Fuel mix information, for example, can be presented as a pie chart on customers' monthly bills. Disclosure is designed to help consumers make informed decisions about the energy and supplier they choose. It is worth noting, though, that two states that have not moved ahead with restructuring--Florida and Colorado--have enacted disclosure provisions. Indeed, disclosure is often thought of as a good policy to help educate customers about electricity and thereby to prepare markets in advance of retail competition.

DSIRE: www.dslrueusa.org May 2005

Renewables Portfolio Standards

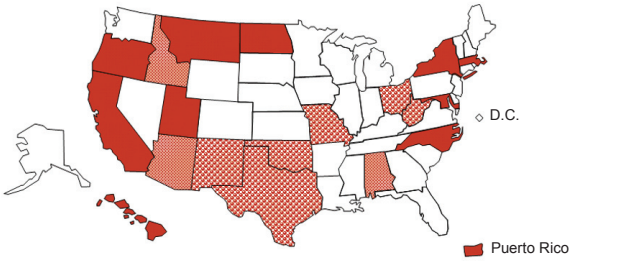


Minimum requirements and/or increased credit for solar
PA: 8% Tier I, 10% Tier II (includes non-renewable sources)

Renewables Portfolio Standards (RPS) require that a certain percentage of a utility's overall or new generating capacity or energy sales must be derived from renewable resources, i.e., 1% of electric sales must be from renewable energy in the year 200x. Portfolio Standards most commonly refer to electric sales measured in megawatt-hours (MWh), as opposed to electric capacity measured in megawatts(MW). The term "set asides" is frequently used to refer to programs where a utility is required to include a certain amount of renewables capacity in new installations.

DSIRE: www.dslrueusa.org May 2005

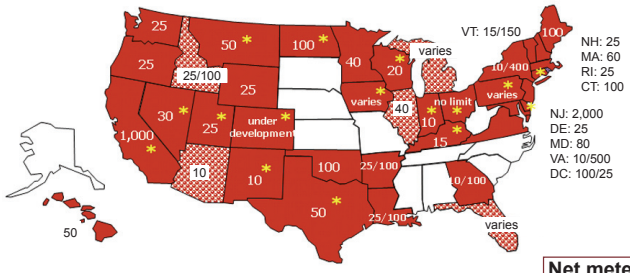
State Tax Creidts & Deductions for Renewables



Corporate tax incentives allow corporations to receive credits or deductions ranging from 10% to 35% against the cost of equipment or installation to promote renewable energy equipment. In some cases, the incentive decreases over time. Some states allow the tax credit only if a corporation has invested a certain dollar amount into a given renewable energy project. In most cases, there is no maximum limit imposed on the amount of the deductible or credit.

DSIRE: www.dslrueusa.org May 2005

Net Metering Rules



Net metering is available in 39 states + D.C.

#'s indicate system size limit (kW); in some cases limits are different for residential & commercial as shown

For those consumers who have their own electricity generating units, net metering allows for the flow of electricity both to and from the customer through a single, bi-directional meter. With net metering, during times when the customer's generation exceeds his or her use, electricity from the customer to the utility offsets electricity consumed at another time. In effect, the customer is using the excess generation to offset electricity that would have been purchased at the retail rate. Under most state rules, residential, commercial, and industrial customers are eligible for net metering, but some states restrict eligibility to particular customer classes.

Agricultural & Waste Gas

Biogas Basics

Renewable biogas is a combination of methane and carbon dioxide produced by decomposition of either municipal solid waste or animal by-product. There are multiple ways to employ biogas as a power-generation resource including fuel cells, microturbines, and conversion to alcohol-based fuels.

North Carolina has landfills, animal feeding operations, and wastewater treatment plants across the state that could be tapped to:

- provide local income and electricity
- support community development projects
- reduce pollution.

Biogas requires enzymatic reaction, as waste must decompose for gas to be created. The burgeoning biotechnology industry in the state could offer advanced solutions to waste control through the development of enzymes that rapidly process waste.

Industry Classification

Microturbines
336111 - Turbines and Generator Set Units Manufacturing

Microturbines are highly efficient small-scale turbines that operate like traditional steam turbines.

Fuel cells can also be used to provide electricity from small-scale gas projects *(see page 17 for Fuel Cell industry classifications).*

NC Manufacturers

Ingersoll-Rand Company
Mecklenburg 704.896.4000
Manufactures small-scale gas systems

photo: www.nrel.gov/data/pix

Anaerobic digester and biogas storage on Kawilihan Farm, Philippines. Photo courtesy of NREL & California Polytechnic State University.

EnergyXchange

The Yancey-Mitchell Landfill

The mission of EnergyXchange is to demonstrate the responsible use of landfill gas as an energy source for small enterprises in craft and horticulture, and to meet local energy needs.

Photo at left shows construction at the site of EnergyXchange, a landfill gas project supporting local crafts and community projects located in Western North Carolina.

www.energyXchange.org

Industry Facts

In October of 2002 there were 40 biogas recovery systems in operation in the U.S. Of these, nine are at swine farms and 29 are at dairy farms. Estimated total U.S. electricity production is about 4 MW per year.[4]

"Of the estimated 2,000 or so MSW landfills currently operating in the United States, approximately 340 have LFG utilization projects. We estimate that over 600 more MSW landfills could turn their gas into energy, producing enough electricity to power over 1 million homes."[5]

In 2003, 17.7 million metric tons of carbon equivalent emissions were prevented, or a reduction in pollution equal to removing 14.3 million cars from the road.[6]

photo: www.nrel.gov/data/pix

Resources

AgSTAR Program

www.epa.gov/agstar/

Voluntary effort to encourage methane recovery at animal feeding operations. Jointly sponsored by the E.P.A., Dept. of Agriculture, and the Dept. of Energy.

Landfill Methane Outreach Program (LMOP)

www.epa.gov/lmop/

A voluntary assistance and partnership program partnering with communities and businesses to reduce pollution and help build a sustainable future.

USDA Farm Bill Section 9006

www.rurdev.usda.gov/rbs/farmbill/

Methane Gas Sources

- landfills
- wastewater treatment plants
- animal waste storage facilities and feeding operations

Gas Reformer

The gas reformer scrubbs the methane to remove carbon dioxide and other pollutants. Scrubbing, or reforming, gas increases the efficiency of gas use.

System Components

Extraction system (includes piping, a low-pressure compressor, and gauges and controls)

Other equipment needed, depending on specific use, is power conversion and conditioning equipment, heat exchangers for CHP applications, and pressurization equipment if the gas is to feed the pipeline.

Project Considerations

Distance to power lines or gas transport site increases cost, and limits possible uses
Most methane must be controlled; flaring gas is often required as a minimum, and the cost of adding electricity or fuel generating equipment adds significant marginal value.

Technologies utilized in waste gas-to-energy capture:

- Fuel Cells (often solid oxide, or other CO_2 resistant types)
- Microturbines
- Other Combined Heat and Power technologies

Biodiesel

Biodiesel Basics

Biodiesel is diesel fuel made from natural oils, animal fats, and often processed waste oil from restaurants. Biodiesel can be used either by itself (known as B100), or in a blend with petroleum diesel. It can be used in regular diesel engines, and is biodegradeable and nontoxic. Biodiesel is made by separating glycerin from animal fats or vegetable oil. Fuel-grade diesel must meet specification ASTM D6751.

A 15-million gallon 'turn-key' biodiesel plant requires about $9.6 million in capital investment, and could be expected to directly employ about 15 people, as estimated by the Univ. of Georgia. The plant would require a 5,000-sq.ft. building with 60-ft. high ceilings on a 7-10 acre site. [7]

Biodiesel Use in NC

Retail Sites [9]

- **BP/Han-Dee Hugo's**
  919-779-3858
  401 Benson Rd. Garner, NC 27529
- **Exxon**
  919-471-6924
  4401 Roxoboro Rd Durham, NC 27704
- **BP Station**
  919-481-4493
  102 Gregson Dr. Cary, NC 27511

Other Users

Durham County Schools, Duke University, and the public pump in Durham are estimated to use 1 million gallons of a 20% biodiesel blend per year. The **Town of Chapel Hill** also largely powers its motor fleet with biodiesel. [10]

Sources for biodiesel production in N.C. include used cooking oil, animal fats from swine processing facilities, and crude plant oils such as soybean.

Industry Classification

311225- Fats and Oils Refining & Blending

311222 - Soybean Processing

311221 - Wet Corn Milling

311223 - Other Oilseed Processing

31161 - Animal Slaughtering and Processing

NC Manufacturers

Piedmont Biofuels
Chatham Co. 919.542.2900
www.biofuels.coop

***Filter Specialty Bioenergy, LLC**
Cumberland Co. 910.567.5474
www.filter-specialty.com

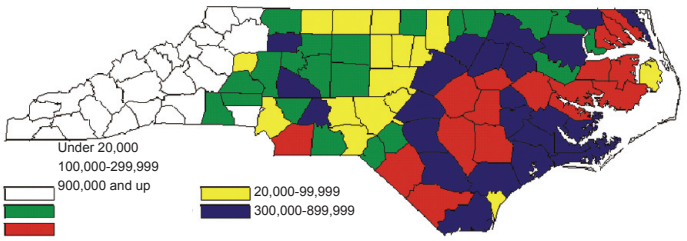
***Grain Growers Cooperative**
Wayne Co. 252.446.7100
www.graingrowersinc.com

***Blue Ridge Biofuels**
Buncombe Co. 828.253.1034
www.blueridgebiofuels.com

**proposed biodiesel plant*

NC Soybean Production in 2000 [8]

Total of 1,360,000 acres harvested and 44,880,000 bushles produced



Source: Robert M. Murphy
North Carolina Department of Agriculture and Consumer Science

Industry Facts

Currently, more than 1 billion gallons of diesel fuel are used in NC annually.[11] Supplying this use with a 5-percent blend of biodiesel (B5) would require 50 mil. gallons of pure biodiesel (B100).

Every energy unit of a fossil fuel required to produce biodiesel results in a gain of 3.2 energy units, in other words, "every gallon of biodiesel used has the potential to extend our petroleum reserves by four gallons."[12]

As of May 2004, there were over 400 major fleets using biodiesel, including all branches of the U.S. Military, Yellowstone Park, NASA, utilities, and over 50 school districts. There are over 1000 distributors nationwide, and over 200 retail fueling sites.[13]

Use of 100% biodiesel reduces emissions of carbon monoxide by 43% and particulate matter by 70%.

Fourteen ethanol-powered buses operate along regular routes in Peoria, Illinois. Photo form NREL PIX.

Processing Biodiesel

photo: www.nrel.gov/data/pix

Raw materials:

- Soybean, rapeseed, canola, corn, or other vegetable oils
- Waste fryer oil from restaurants
- Yellow fat from animals, such as hogs

Other Requirements:

- Storage facilities for blended fuel and reactants
- Nearness to transportation infrastructure such as a railroad for long-distance movement, or a highway for local sales

The fats or oil are mixed with the reactants in a blending machine, when mixture meets ASTM-D6751 it is ready for use as 100% biodiesel.

Co-Products:

- Soy meal
- Soy hulls
- Glycerol
- Soap stock

Reactants:

(methyl-ester process)

- Methanol
- Sodium or Potassium Hydroxide

photo: www.nrel.gov/data/pix

Resources

National Biodiesel Board (NBB)
www.biodiesel.org
The NBB is the national biodiesel trade association coordinating research and development efforts in the U.S.

U.S.D.A. Education Program
www.biodiesel.org/usda/

Triangle Clean Cities
www.trianglecleancities.org

Ethanol

Economic Value

Ethanol is an alcohol gasoline additive produced by fermenting and distilling simple sugars. Although there are large companies such as Archer Daniels Midland producing ethanol, farmer-owned facilities represent 32 of the 72 existing ethanol plants (40% of all production capacity), and 12 of the 15 ethanol plants under construction in 2004.[14]

Although corn is the primary feedstock for ethanol production, "Ethanol can be made from other products such as grain sorghum (milo), wheat, barley, sugar cane or beets, cheese whey, and potatoes. Cellulosic feedstocks such as municipal waste or recycled products, rice hulls, bagasse (fibrous residue from sugar cane), small diameter trees, wood chips, and switch grass may also be used to produce ethanol, but these products are not yet utilized on a commercial scale." [15]

The ethanol industry is expected to consume $4.6 billion of raw materials and other inputs while producing 3.5 billion gallons in 2004; the majority of this money flows into the economy of rural farming communities.

photo: www.nrel.gov/data/pix

Use of ethanol reduces vehicle emissions of carbon monoxide, particulate matter, nitrogen oxides, and other ozone-forming pollutants, and can assist municipalities in meeting E.P.A. air quality standards.

Industry Classification

Ethanol
325193 Ethyl alcohol manufacturing

3251930111 Fuel ethanol (fuel-grade ethyl alcohol), manufactured by the wet mill process

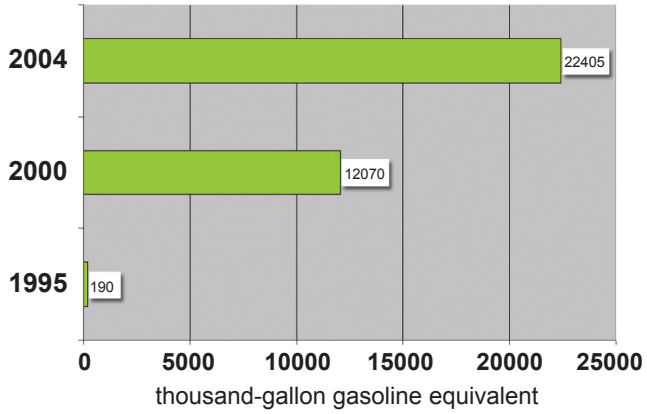
3251930311 Fuel ethanol, manufactured by other processes (dry mill-distillation)

Distilling Equipment
333298 All Other Industrial Machinery Manufacturing

NC Manufacturers

There are no NC manufacturers of Ethanol

E-85 Consumption Estimates



source: Energy Information Administration, Department of Energy

Ethanol can be produced from any cellulosic or starch plant matter, including crop residue and other waste material, using industrial enzymes

NC could generate $1.5 billion in new business if only 5% of our gasoline was displaced with locally produced ethanol

Alex Hobbs, Ph.D.
Director N.C. State University Solar Center[16]

Industry Facts[17]

The American Coalition for Ethanol reports:

Farmers who invest $20,000 in a local ethanol plant receive an average of 13.3% per year return on their investment over 10 years.

Ethanol use could cut the U.S. trade deficit by $34.1 billion through 2012.

Ethanol production in 2004 is estimated to be 3.5 bill. gallons, a 25% increase over 2003's 2.8 bill. gallons.

About 30% of all gasoline used in the U.S. in 2004 will be blended with ethanol, according to industry estimates.

Farmer-owned production represents 40% of domestic production capacity.

Resources

Renewable Fuels Association
www.ethanolrfa.org
National Trade Association for the ethanol industry.

American Coalition for Ethanol
www.ethanol.org
A national grassroots group that includes farmers, ethanol producers, rural electric cooperatives, and others.

Governor's Ethanol Coalition
www.ethanol-gec.org
A nationwide organization, N.C. has been a member since 1999, the coalition's goal is to reduce our need for foreign oil, improve the environment, and stimulate the economy by increasing the use and production of ethanol.

Ethanol Process


photo: www.nrel.gov/data/pix

Raw materials:
- Corn
- wheat
- barley
- potatoes
- sugar beets or cane

Experimental feedstocks:
- cellulosic agricultural residues
- wood chips
- switchgrass
- animal waste slurry

Starch is extracted via crushing and heating, and enzymes are added to turn the starch into sugars for fermentation. Following fermentation, is distillation, and then blending with gasoline.

Additives (dry-mill process)
- Enzymes
- Yeast

Co-products
Following ethanol production, dried distillers grain (DDG) remains. DDG is often sold for animal feed as a protein supplement.
The U.S.D.A.'s ARS is developing a process to extract the main corn protein, zien, from DDG; once affordable, zien can be used to replace a variety of synthetic plasticizers.[18]


photo: www.nrel.gov/data/pix

Process Equipment
- Crushing and liquefaction
- Fermentation tanks
- Distillation
- Evaporation tanks or centrifugal systems

Efficiency

Economic Value

Energy savings and renewable-based electricity/fuel production in a state like North Carolina that has no fossil fuel resources of its own mean that fewer dollars are exported from the state's economy. Energy savings mean higher levels of disposable income and affordable heating and transportation.

Efficiency often offers a quicker payback on an investment than other renewable energy sources because savings accrue immediately and continue indefinitely.

Low interest loans are offered to businesses by the State Energy Office for both renewable energy at 1% APR and energy efficiency at 3% APR.

Durant Road Middle School
saving the school system money

Wake County's school system saves about $21,000 annually from a single green-built middle school.

Utilizing daylighting, high-efficiency HVAC systems, and state-of-the-art sensors and control systems the school makes significant achievements in efficiency and was one of three schools worldwide highlighted at the 1998 International Green Building Challenge.

According to Principal Tom Benton, "The daylit classrooms have increased the well being of the students and teachers and are at least partly responsible for our record high attendance." [19]

Photos courtesy of Innovative Designs, Inc. and NREL PIX

Industry Classification

A large variety of manufactured products contribute to energy efficiency, including:

- insulation
- lighting equipment
- electronic sensor controls
- windows and coatings
- heat pumps

To find manufacturers of Energy Star products, visit the E.P.A.'s Energy Star program home at *www.energystar.gov*.

NC Manufacturers

NC is home to many manufacturers of Energy Star Products. Products manufactured in NC include windows, ceiling fans, insulation, and transformers. Some of the largest are

US Greenfiber, LLC
Chloride Systems, Inc
Eaton Corporation
Lowe's Home Improvement
Liquid Ceramic International, Inc
Thermal Swing Windows
ACME Electric Corporation, Transformer Division
Union Corrugating Company
Cyberlux
Crosley Corporation

Over 200 small businesses, 50 large businesses, and 130 builders in NC are Energy Star partners. [20]

Efficiency Facts

"A 2001 report shows that North Carolina would gain 38,900 jobs by 2020 by implementing more clean energy policies, especially energy efficiency policies." [21]

In 2002, greenhouse gas emission savings from the Energy Star program were equivalent to removal of 14 million vehicles from the highways.

The value of these pollution reductions was estimated at $7 billion, and represents the avoided electricity output of fifty 300-MegaWatt power plants. [22]

Efficiency savings programs play an important role in economic development efforts targeted at making local manufacturers more competitive, such as the programs in place in the City of Chicago.

Resources

EnergyStar
www.energystar.gov

NC Energy Star Homes
www.ncenergystar.org

NC State Energy Office
www.energync.net
Manages a variety of efficiency programs for homes, businesses, industry, and local governments. Also certifies energy service companies to perform energy efficiency audits.

American Council for an Energy Efficient Economy (ACEEE)
www.aceee.org
Nonprofit group promoting energy efficiency through economic prosperity and environmental protection.

Efficiency Programs in N.C.

Energy Management Program [23]
Operated out of N.C. State University's Industrial Extension Service with primary funding from the N.C. State Energy Office, the Energy Management Program helps N.C.'s industries grow and prosper by providing energy conservation, use, and management workshops. The average client reduces their annual energy costs by $50,000 using the program's state-of-the-art energy savings and facilities management techniques.

The program areas include: boiler efficiency, Utility Savings Initiative, advanced energy surveys and training, Industrial Assessment Center, the N.C. Industries of the Future, and a variety of energy- and facilities-related diplomas.

Energy for Buildings
Provides industrial companies with assistance in reducing emissions of air pollution such as carbon dioxide and other greenhouse gasses.

Energy Improvement Loan Program
A statewide program providing low-interest loans to commercial and industrial businesses, local governments, non-profits, and schools for implementing energy conservation and renewable energy projects.

During 2003, these programs provided 104 energy surveys and recommended $9.7 million in savings for N.C. clients.

www.energystar.gov.

Fuel Cells

Economic Value

Although not a source of renewable energy directly, fuel cells are highly efficient power production technology with nearly nonexistent emissions. Hydrogen, if generated from renewable sources like wind or solar power, is considered renewable.

Commercialization of fuel cell technology remains an obstacle. The potential market applications for fuel cells are broad, ranging from small portable electronics to automobiles and large megawatt-plus power plants. The first mass-market application for fuel cells were introduced near the end of 2004, and are direct-methanol fuel cells for use in portable electronics. [24]

Some uncertainty exists in estimating fuel cell markets as technological hurdles with both fuel cells themselves and their hydrogen fuel remain to be solved, however the Freedonia Group predicts the fuel cell market to grow to $1.1 billion in 2008.[25]

"Fumes-to-Fuel" at Ford[26]

In Ford's Dearborn Truck Plant the paint shop now provides 5 kWh of electricity. Ford's innovative system captures pollutants (volatile organic compounds, or VOCs) from the paint fumes and converts them into fuel for a solid-oxide fuel cell.

The system will be expanded later this year to generate more than 100 kW, enough to power over 20 average American homes.

Ford received a Clean Air Excellence Award from the E.P.A. for this system, and says that it will save them millions of dollars in fuel, reduce maintenance costs, and eliminate CO_2 emissions while allowing the company to use higher quality solvent-based paints.

Industry Classification

335999 - Fuel Cells
All Other Miscellaneous Electrical Equipment and Component Manufacturing

334413 - Solid State Fuel Cells
Semiconductor and Related Device Manufacturing

325120 - Hydrogen
Industrial Gas Manufacturing

NC Manufacturers

Povair
Henderson Co. 828-696-9854
Manufacture ceramics and stack plates used in fuel cells

Microcell
Wake Co. 919-858-8500
Manufacture and research novel micro-fiber fuel cell design

Scribner Associates
Moore Co. 910-695-8884
Manufacture testing equipment and software for fuel cells

DuPont
Bladen Co. 910-483-4681
Manufacture polymer-membrane material used in PEM fuel cells

Altom Fuel Cells
Buncombe Co. 828-350-0441
Research fuel cell components

INI Power
Wake Co.
Research DMFC fuel cell systems

This natural-gas powered fuel cell at N.C. A&T has logged over 7,000 cumulative operating hours, and produced almost 18 MWh of electricity. [27]

photo: www.nrel.gov/data/pix

Industry Facts

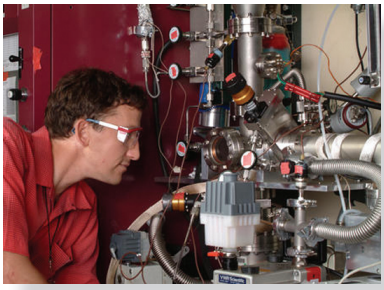
The fuel cell industry is not a mass-market industry yet, and remains research oriented. Over half of the 9,000 fuel cell-related patents filed since 1971 were filed after 2000.[28]

Nearly every major electronics company and vehicle manufacturer has invested in fuel cell research and development projects.

Research activities in fuel cells are targeted at reducing component cost and improving performance.

The military is the largest federal investor in fuel cell development programs.

Production, storage, and distribution of hydrogen remain major barriers to fuel cell development.



NREL Researcher working in a lab at NREL.

Photo curtosy of NREL, Jim Yost

Resources

NC Fuel Cell Alliance
www.energy.appstate.edu/fuelcells/
Public Fuel Cell Alliance
www.CleanEnergyStates.org
U.S. Fuel Cell Council
www.usfcc.com
FuelCells.org
Hydrogen Fuel Cell Investor
www.h2fc.org
World Fuel Cell Council
www.FuelCellWorld.org
Fuel Cell Today
www.FuelCellToday.com
Hydrogen & Fuel Cell Letter
www.HFCLetter.com

Fuel Cell Operation

Sources of Hydrogen

- reformed natural gas or methane
- electrolyzed water*
- other fossil fuels such as coal or oil

*electrolysis can be powered using wind or solar energy, resulting in a renewable source of hydrogen

Other system components

Hydrogen fuel storage - Often stored under pressure in tanks, many methods are competing to be the standard including, glass microspheres, borohydride solutions, and metal hydrides.

Distribution - Most fuel cells today are run off natural gas, but gasses are not feasible for all applications. An enabling technology will be a core hydrogen storage platform that can be adapted to nearly all applications.

Fuel Cell Components[29]

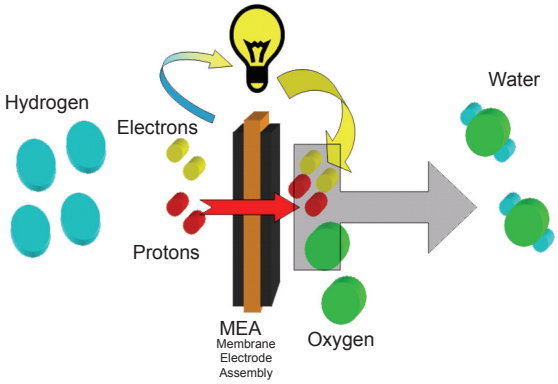
Stack Plates provide conductivity and stability. They can contain advanced materials such as nano-carbon and advanced ceramics.

Membrane Electrode Assembly

The MEA is often a sealed assembly containing, among other things, the anode and cathode electro-catalyst layers sandwiching the polymer electrolyte membrane.

Electrolyte and Catalyst

Hydrogen fuel is catalyzed at the anode, resulting in protons and electrons. The electrolyte separates the protons from the electrons, forcing electrons to travel an external circuit and provide electricity. The type of electrolyte differentiates the multiple types of fuel cells.



Solar Water Heating

Economic Value

Water heating typically represents 15% to 25% of a home's energy costs. Using solar water heaters reduces water heating costs 50% to 80%, and when amortized in a long-term mortgage provides even greater cash-flow benefits.

Solar water heating provides the greatest returns in high-volume applications like restaurants, process heat for manufacturing, or swimming pools.

Across the economic spectrum, from industry to residences, solar water heating provides energy savings that manifest in an economy as additional disposable income. These savings increase the efficiency and competitiveness of a region's economy.

Industry Classification

333414 - *Solar Heating Equipment* - Heating Equipment (except Warm Air Furnaces) Manufacturing

3334149136
Solar energy collectors (water or air)

NC Manufacturers

SunQuest
Catawba Co. 828.465.6805
Manufacture solar systems and sunroom kits

* A list of dealers and installers is available at the N.C. Solar Center's web site:
www.ncsc.ncsu.edu

NC's Loss is Chicago's Gain - Solargenix relocated [31,32]

Whether called the "City of the Big Shoulders," the "Hog Butcher for the World," or the "Windy City" Chicago is not known for its clean and green streets.

Images from the past are changing however, as the city leverages its power supply, pollution, and economic troubles into renewable energy development. With progressive policies that encourage developing renewable energy manufacturing facilities and research centers on old polluted industrial sites, or brownfields, and large purchases of green power equipment by the city Chicago has created new jobs and new investment.

Some of those new jobs come from North Carolina. Although Solargenix remains headquartered in N.C., they manufacture their solar thermal equipment in Chicago. As an incentive to Solargenix Chicago loaned $1.7 million over five years, but what sealed the deal was the $5 million worth of solar collectors the city agreed to buy over the next three years.

Chicago is outfitting all municipal buildings with solar, and a specification in the RFP was that manufacturing be done in Chicago, adding to the city's job and tax base. Chicago, one of the top three commercial centers in the U.S. has set a goal to purchase 20% of its power from renewable sources, and expects to hit that target two years ahead of schedule. Spire Solar, a manufacturer of turn-key PV manufacturing systems, has also taken advantage of Chicago's sustainable policies and located their manufacturing facilities within the city at brownfield sites.

Chicago is expanding to include wind power in a similar program, and anticipates jobs and investment from both manufacturing wind turbines and components, and installation and operation of turbines within the city. As additional support to businesses within the city, Chicago targets one industry a year to reduce its energy use and pollution, partly by offering free energy and pollution audits for manufacturers within the industry.

Industry Facts

China has recently become the largest user of solar thermal technology in the world. [33]

The vast majority of solar collector systems in the U.S. are used in high-volume applications such as pool heating.

In 2002, 10 companies produced 98% of all solar thermal shipments in the U.S. [34]

Solar thermal products accounted for 90% of all revenue for 19 of 27 companies in the U.S. in 2002.[34]

This $33.3 million market employed 356 people across the U.S. in 2002.[34]

Resources

Solar Energy Industries Association
www.seia.org
National trade association, includes dealers, installers, and manufacturers.

Florida Solar Energy Center
www.fsec.ucf.edu
Provide research, testing, training, and certification for the solar thermal industry.

N.C. Solar Center
www.ncsc.ncsu.edu
Conduct research, installer training, and public awareness campaigns. N.C.'s leading source of information for solar energy, and home to the alternative fuels garage.

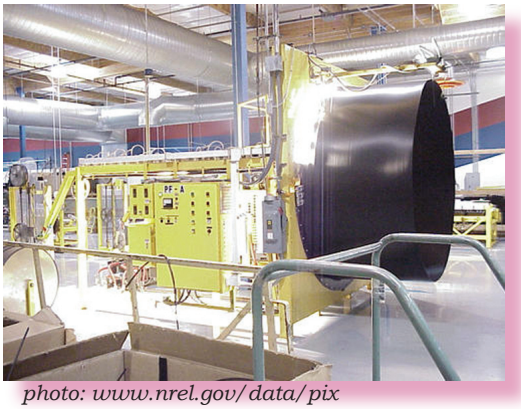
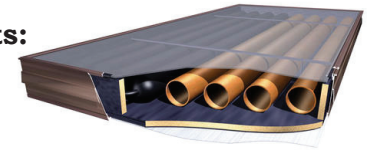


photo: www.nrel.gov/data/pix

Solar Water Heating Systems [35]

Solar heating systems use an insulated box to capture sunlight and transfer heat to pipes that flow from the box to a larger storage tank.



The basic components:
- tubing
- collector box
- box lining
- glazed glass or plastic to cover the box and prevent heat loss

Active systems use a pump to create flow through heater.

Passive systems use variations in heat to provide the system's flow.

Direct systems heat water as it flows through the collector.

Indirect systems heat a glycol (sugar solution) in the collector, which then heats water in the tank.

Other system components include:
- pump
- insulated storage tank
- insulated plumbing pipe
- pressure release valves (to prevent burst pipes because of freezing)
- heat exchanger (for indirect systems)

Installation often can be performed by plumbers, although systems are increasingly being designed into a building's structure.

photo: www.nrel.gov/data/pix

FAFCO, a manufacturer of solar pool heating collectors, uses this "panel former" in its manufacturing process. Extruded polymer tubing is continuously fused into 4-ft. widths that are then cut into panels of proper length. These panels then become part of the finished solar pool heating collector.

Photovoltaic Cells

Economic Value

New York explored a state-issued half-million-dollar revenue bond for the purchase of solar panels and found that the purchase and installation of 69MW of solar panels would create almost 2,500 year-long jobs. The bond effort would create at least 783 local jobs even without local manufacturing facilities. [36]

The majority of photovoltaic cells manufactured in the U.S. are for export, and the manufacturing capacity within the U.S. continues to grow rapidly with new or expanding facilities announcements arriving nearly weekly.

Research continues to play a major role in the development of photovoltaics, as solar cell researchers are striving for spray-on application and other 'designer' features. North Carolina's experience in the semiconductor industry and other high-technology areas, coupled with the research capability within the university system should prove to provide fertile ground for photovoltaic manufacturers.

photo: www.nrel.gov/data/pix

Central Carolina Bank: 2.75 kWe, produces electricity and heats building. Installed in Bessemer City at Central Carolina Bank.

Industry Classification

334413 - Photovoltaic cells (PV)
Semiconductor and Related Device Manufacturing

333295 - PV manufacturing equipment
Semiconductor Machinery Manufacturing

NC Manufacturers

SBM Solar, LLC
Cabarrus Co. 704.788.2881
Assemble solar cells into custom-designed modules

Torpedo Specialty Wire
Nash Co. 252.977.3900 x3003
Manufacture specialty photovoltaic interconnection wire

Panels at N.C. State's solar research annex, part of the solar house. Photo: NREL PIX.

photo: www.nrel.gov/data/pix

Northern Vance High School: Electric vehicle charging station, 2.6 kWdc, manufactured by BP

Industry Facts

In 2002 the industry market segment became the largest PV market segment, replacing the consumer segment.

Within the U.S. PV manufacturing accounted for almost 2,700 person-years of employment in 2002, up from about 1,300 person-years in 1996.[37]

PV still retain a positive net trade balance, despite a severe reduction in PV imports by Japan as they increase their own manufacturing capacity. [37]

Half of all U.S. PV exports were purchased by Germany in 2002.[37]

Cell Preparation

Solar cell plants for crystalline silicon typically require a capital investment of $1 million per megawatt of capacity. When based on well-proven technology a manufacturing plant can be operational in under two years from approval, and a 50MW fully operational plant could create 300 jobs.

Resources

American Solar Energy Society
www.ases.org

Solar Electric Power Association
www.solarelectricpower.org

Solarbuzz
www.solarbuzz.com

International Solar Energy Society
www.ises.org

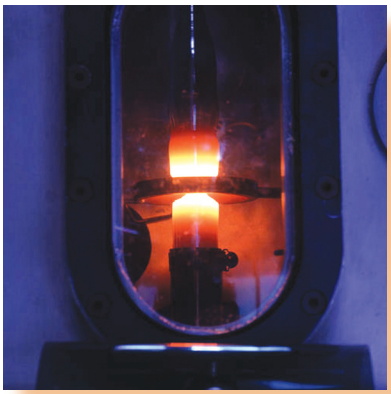
N.C. Solar Center
www.ncsc.ncsu.edu

Solar Cell Manufacturing[38]

Growing Silicon Crystals

Polycrystalline silicon processing is performed at about 1600 degrees celsius, often near the solar cell manufacturing plant. Growing crystals requires an abundant, reliable, and cheap supply of electricity.

Once grown, the crystals are prepared for integration into modules with a series of etching, diffusion, and screen printing in the solar cell plant.

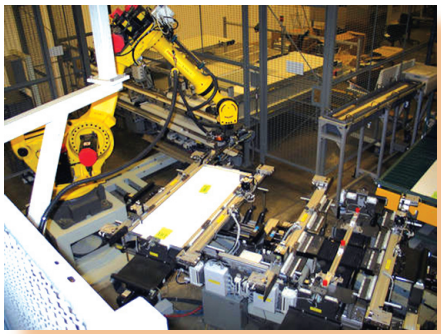


A silicon crystal takes shape using the float-zone refining method. photo: NREL PIX and Jim Yost Photography

Module Assembly

Cells are soldered together and laminated between layers of glass and a polymer backing. Module assembly plants can be either highly automated, or rely mostly on manual labor.

Shell Solar manufacturing robots framing the laminate of cells. photo: NREL PIX and Shell Solar



System Assembly

The final stage, system assembly is often the most labor-intensive, as the cells must be integrated into the building's existing structure and electrical conduits. This stage requires certified electricians, preferably with experience in interconnection.

Wind Turbines

Economic Value

Wind is the world's fastest growing energy source with an average annual rate of 32% between 1998 and 2002.

North Carolina is home to the nation's most southern wind resources. In the mountains and at the coast the potential for large-scale wind power is significant

The U.S. Department of Energy estimates N.C. could produce about 2% of its electricity using large-scale wind turbines. [39]

Producing 2% of N.C.'s electricity from wind would result in the creation of over 1,700 jobs during the construction period with over $187 million in economic output. During operation, nearly 300 annual jobs with earnings over $8 million would be provided from the 462 turbines required. [40]

Industry Classification

333611
Turbine and Turbine Generator Set Units Manufacturing

3336110856 Wind turbines

3336110766 Parts and accessories for wind turbines (sold separately)

NC Manufacturers

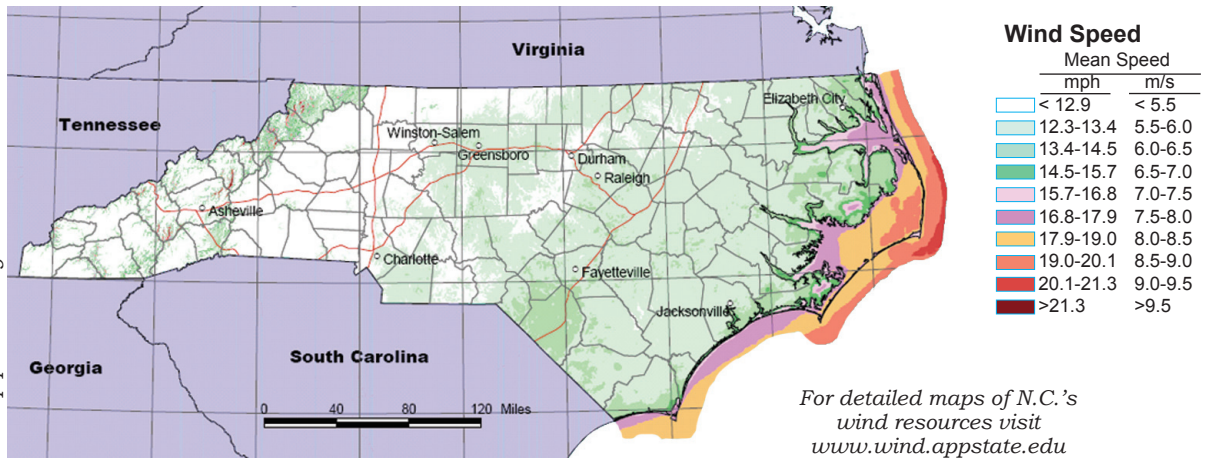
Precision Fabric Group
Guilford Co. 336.510.8079
Manufacture woven fabric used in making composite wind turbine blades

PPG
Cleveland Co. 704.434.2261

3Tex
Wake Co. 919.481.2500

BGF Industries
Guilford Co. 336-545-0011

N.C. Wind Speed at 100 meters



Map provided by TrueWind Solutions

For detailed maps of N.C.'s wind resources visit www.wind.appstate.edu

NC Small Wind Initiative
A State Energy Office-funded program based at Appalachian State conducts training and educational workshops for landowners with identified wind resources. The Initiative also conducts tests on a variety of small turbines ranging in output from hundreds of watts up to multiple kilowatts. *www.wind.appstate.edu/*

The Renewable Energy Policy Project recently released the location of component and subcomponent manufacturers for wind turbines in the U.S. **N.C. ranks 13th in potential for wind turbine manufacturing.** For more information: *www.repp.org/*

Industry Facts

Global wind power investment in 2003 is estimated at $9 billion, up from $7 billion in 2002.[41]

Farmers benefit from wind power, as the average $3,000-per-turbine lease can increase a farmer's return on land by 30%-100%.[42]

School districts in Texas reap large financial rewards from wind farms, in 2002, almost $11.7 million was paid to school districts by wind farms. [43]

Kittitas County, Washington expects benefits of over 185 jobs and over $10 million in wages during the construction phase of a 390 megawatt wind farm, and over 53 long-term jobs with annual income of $4 million. [44]

Southwest windpower H40 on an 80 foot tilt-up tower at the North Carolina small wind research and demonstration site on Beech Moutnatin, NC. Photo curtosy of NREL PIX and Appalachain State University's Dennis Scanlin.

Wind Turbine Components[45]

photo: www.nrel.gov/data/pix

Structural Components

Wind speeds are higher at higher elevations, so turbines are often raised hundreds of feet on steel towers. Towers are often constructed from tubular steel or steel lattice, and frequently rest on a large concrete foundation.

Wind Turbine Components

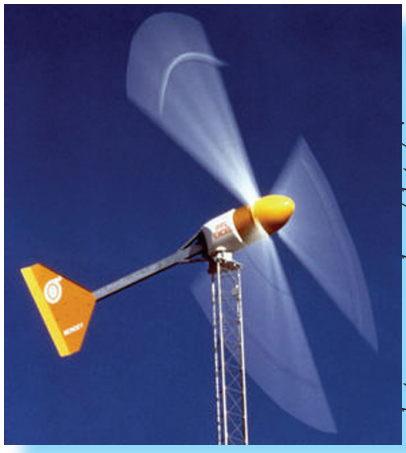


photo: www.nrel.gov/data/pix

Rotor & Blades: capture the wind and turn the low-speed drive. Weight and strength are factors in blade design, and reinforced plastics are standard blade material.

Nacelle: houses the electromechanical apparatus. Within the nacelle is the generator, brakes, and controller. Nacelles can be large enough to stand in. The generator is run by a high-speed shaft that is turned by gears via the low-speed shaft. The controller measures wind speed and turns the generator on between wind speeds of 8 and 65 m.p.h. Brakes are used to stop the spinning blades for repairs.

Resources

American Wind Energy Association
www.awea.org

Windustry
www.windustry.com

National Wind Coordinating Committee
www.nationalwind.org

N.C. Wind Working Group
www.wind.appstate.edu

N.C. Small Wind Initiative
www.wind.appstate.edu/swi/swi.php

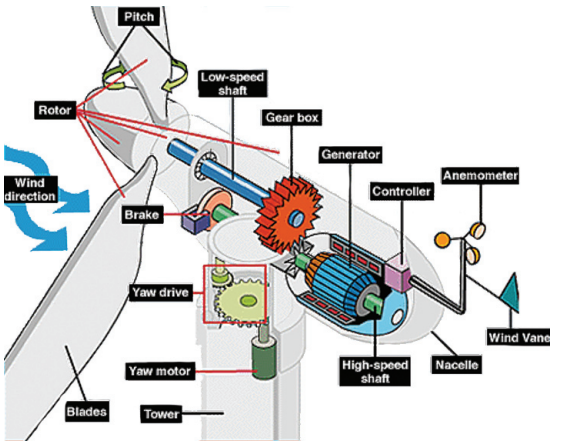


image source: Department of Energy

References

1, 41 Makower, Joel, Ron Pernick and Clint Wilder. “Clean Energy Trends 2004” Clean Edge 3/2004

2, 15 ibid

3 Kammen, Daniel M. ,et al. “Putting Renewables to Work: How Many Jobs can the Clean Energy Industry Generate.” U.C. Berkeley

4 http://www.epa.gov/agstar/operational.html

5 http://www.epa.gov/lmop/benefits.htm

6 http://www.epa.gov/lmop/accomplish.htm

7 http://www.agecon.uga.edu/%7Ecaed/biodieselrpt.pdf

8 Robert M. Murphy, North Carolina Department of Agriculture and Consumer Services

9 http://www.biodiesel.org

10 http://www.triangletechjournal.com/news/article.html?item_id=651

11 Dr. Jeff Ramsdell, ASU Energy Center

12 http://nbb.org/markets/gen/

13 http://nbb.org/pdf_files/backgrounder.PDF

14 http://www.ethanol.org/production.html

16 Dr. Alex Hobbs, N.C. Solar Center, Biomass to Biofuels Conference presentation

17 http://www.ethanol.org

18 U.S.D.A. Agricultural Research Service

19 National Renewable Energy Laboratory Photographic Information Exchange (PIX) http://www.nrel.gov/data/pix/

20 http://www.energystar.gov

21 Tellus Institute, MREG & Associates. www.eere.energy.gov/state_energy/ efficiency.cfm?state=NC

22 “Energy Star - The Power to Protect the Environment Through Energy Efficiency”

23 http://www.ies.ncsu.edu/energy/

24 http://www.mtimicrofuelcells.com/news/article.asp?id=163

25 http://www.freedoniagroup.com/Fuel-Cells.html

26 http://www.ford.com/en/company/about/corporateCitizenship/report/articlesPaintFumes.htm

27 http://www.dodfuelcell.com/res/site_summary.php4?location_id=8

28 Fuel Cell Today Market Survey: Patents www.fuelcelltoday.com/FuelCellToday/ FCTFiles/FCTArticleFiles/Article_757_patentsurvey0204.pdf

29 H2FC Fuel Cell Investor

30 N.C. Solar Center

31 Synergy Brings Solargenix to Chicago - chiefengineer.org

32 Chicago, Green Kind of Town. Renewable Energy World. Feb. 2004

33 Renewable Energy World

34 DOEForm 63-B

35 ASU Department of Technology, Dr. Jeff Tiller

36 Job Creation from Solar Energy in New York

37 EIA Form 63B “Annual Photovoltaic Module/Cell Manufcaturers Survey”

38 http://www.solarbuzz.com/plants.htm

39, 45 http://www.eere.energy.gov/windandhydro/wind_technologies.html

40 ASU Wind Energy Center, JEDI model study

42 Union of Concerned Scientists

43 “Wind energy for Rural Economic Development.” http://www.nrel.gov/docs/fy04osti/33590.pdf

44 “Wind Power Opportunities in Washington” http://www.energy.cted.wa.gov