NORTH CAROLINA

Economic Developer's

Guide to the Renewable Energy Industries

VOLUME 2
WINTER 2008

CLIMATE, SECURITY, ECONOMY

drive Renewable Industry

NEW JOBS

IN North Carolina *from* *Renewable Energy*

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Introduction

Renewable energy manufacturing has become big business in North Carolina. The number of companies in our database of North Carolina renewable energy manufacturers is currently over 100, up from only 28 in early 2005, when the first volume of the *North Carolina Economic Developer's Guide to the Renewable Energy Industries* was published. The increase is largely due to an increase in the number of companies entering energy-related markets, but also due to the increased visibility of companies serving the energy sector.

The diversification and security of our energy supplies, increased efficiency of our energy use, and mounting concern over the impact of energy-related emissions are issues of undisputed importance in the modern economy, and may well be the guideposts to a fundamental economic transition. As we navigate the morass of options that could be tomorrow's energy solution on the national and state levels, it is important to note that there are many ways local communities can benefit from this transition today from new jobs, higher standards of living, increased use of local resources, and the establishment of knowledge centers.

This year's Guide is focused on an area of green energy closely related to economic development - the manufacture and development of the equipment and technologies that make using green energy resources possible.

The *North Carolina Economic Developer's Guide to the Renewable Energy Industries* is designed primarily as a tool to provide economic developers with information about the industries in the renewable energy and energy efficiency fields so that they are able to identify growth opportunities appropriate for their area. Volume 2 of the Guide offers even more detailed information about the supply chain and technology development of green energy technologies than Volume 1, plus it offers additional information about markets, policies, technologies and trends affecting these industries.

Much information is available about the use of renewable energy and energy efficiency technologies and the benefits they provide. The Guide, however, is focused on an area of green energy closely related to economic development - the manufacture and development of the equipment and technologies that make using green energy resources possible. Aside from its focus on manufacturing, the Guide briefly examines roles local energy sources can fulfill in regional economies and provides a framework for evaluating opportunities.

On the cover

This edition's cover features Microcell Corporation, North Carolina's newest renewable energy technology manufacturer. In October 2007, Microcell Corp.'s production facility opened its doors in Robersonville, NC. This facility is expected to employ over 100 local people in high-technology polymer manufacturing jobs as the company seeks to commercialize its revolutionary fuel cell technology.

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Photo Source: NREL PIX

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About

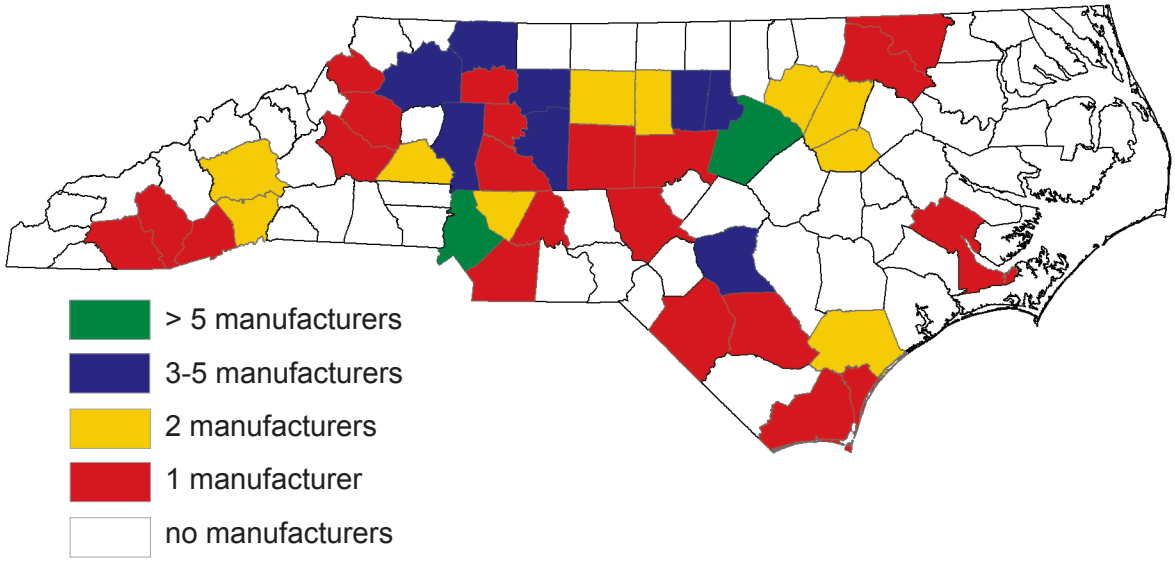
The *North Carolina Economic Developer's Guide to the Renewable Energy Industries* is produced by Appalachian State University Energy Center with funding from the NC State Energy Office. This effort is sponsored by the State Energy Office, North Carolina Department of Administration and the U.S. Department of Energy, with State Energy Program funds, in cooperation with Appalachian State University. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author and do not necessarily reflect the view of the U.S. Department of Energy or the State Energy Office. This public document was printed at a cost of $3,680.00 for 5,000 copies at $0.736 per copy.

Green Energy Manufacturing in NC

Summary results: Biodiesel breakout, solar emerging, fuel cell growth

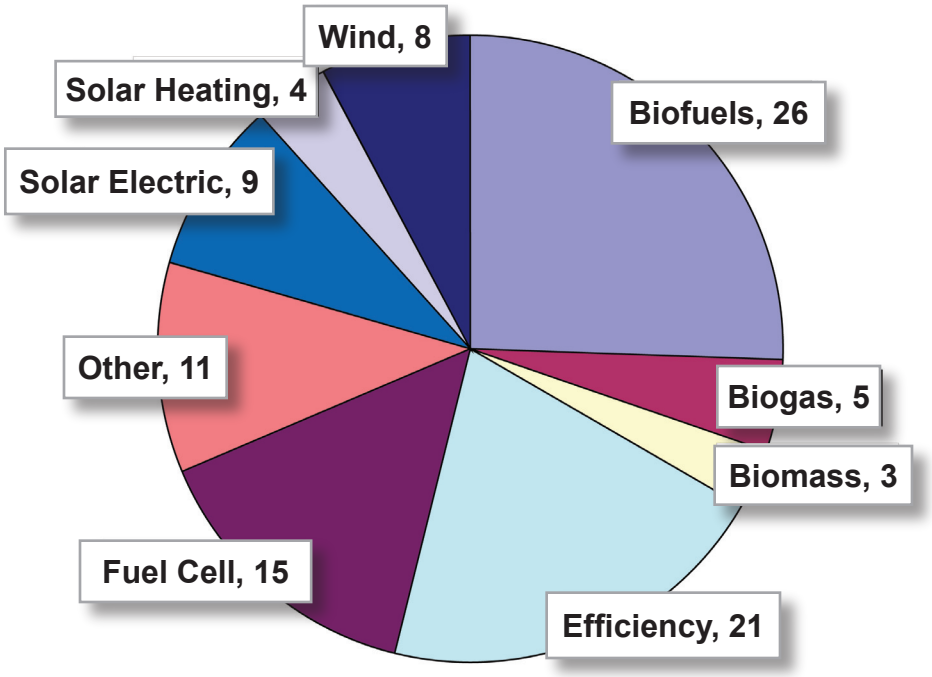
North Carolina is home to over 100 companies involved in either manufacturing or developing green energy technology. These companies range in size from small-business start-ups to multinational giants, and specialize in technologies ranging from polymers and composites to solid-state lighting and semiconductor materials, and from biotechnology to nanotechnology.

Location of Renewable Energy Equipment Manufacturers



Map Source: Appalachian State University Energy Center 2007

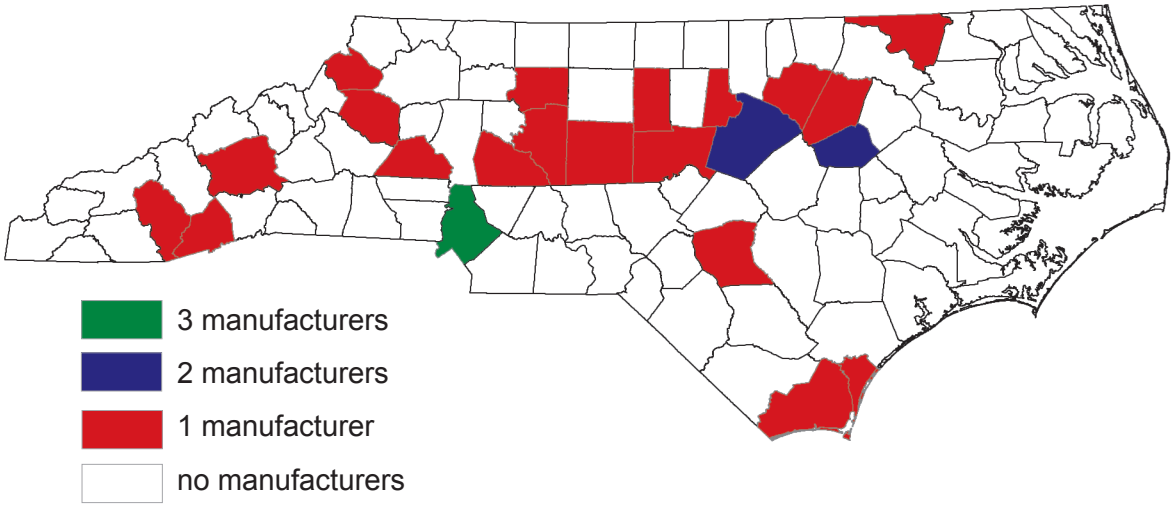
Manufacturers by Energy Area



Biodiesel is by far the most vibrant green energy industry within the state today. North Carolina has a rapidly developing producer base made up mostly of local cooperatives and community-based ventures producing less than 10 million gallons per year serving the local area. As of May 2007, we were able to identify 23 companies active in biodiesel production. The Department of Energy's Alternative Fuels Data Center shows North Carolina has more biodiesel stations than any other state with 50 stations offering biodiesel fuel, and 10 of those stations offer pure biodiesel in concentrations of 99%-100%.

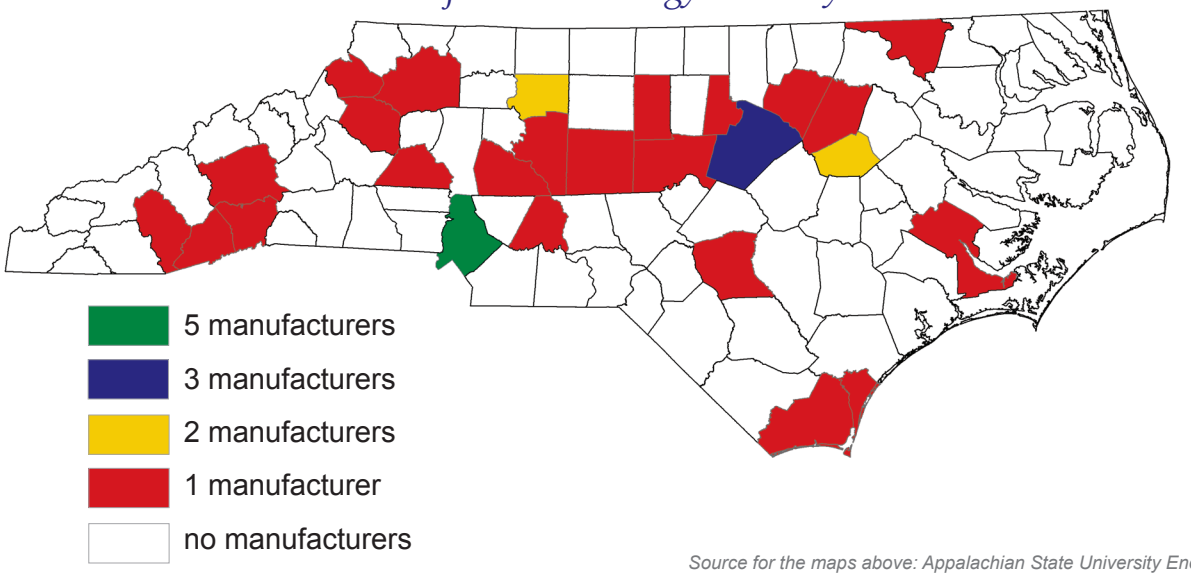
Ethanol producers have had much less success establishing facilities in the state despite continuous efforts to support development. The primary industrial ethanol company in the state is Novozymes, a biotech company and leading researcher into the development of enzymes that can break down fibrous materials such as corn stalks and wood chips – a key technology in cellulose ethanol. The distribution of ethanol blends of 85% (E85) is limited with only 9 stations offering the product, not many, but more than 32 other states.

Location of Biofuels Industry



Biomass energy applications have progressed at a more subdued pace than the other bio-energy industries. This group uses methane from landfills, wastewater treatment plants, and animal waste as an energy source. Other common sources of biomass energy are fuel crops that can be used to supplement coal.

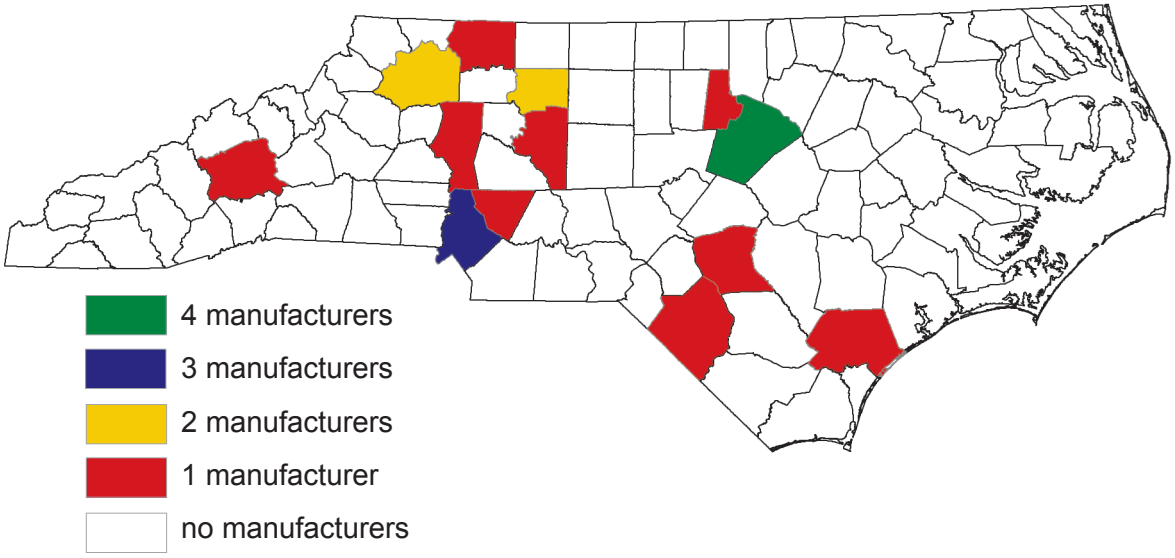
Location of Biomass Energy Industry



Source for the maps above: Appalachian State University Energy Center 2007

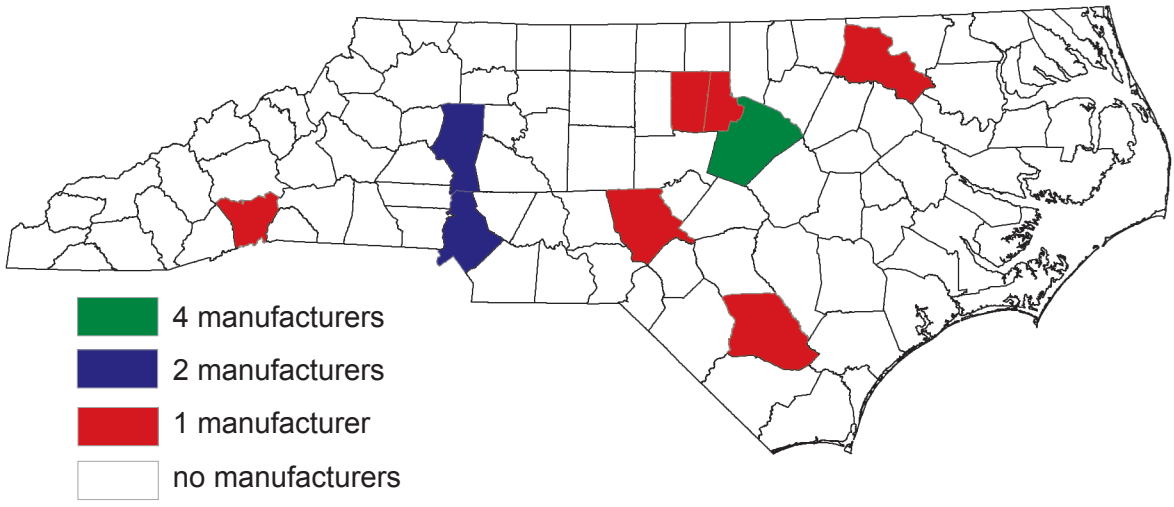
Energy Efficiency is as much a manufactured product as it is a design concept. The number of ENERGY STAR manufacturers and other producers of energy efficient products have remained relatively constant over the past several years with 19 companies producing products for energy efficiency markets today. These products range from high-tech solid-state semiconductors for efficient lighting to highly efficient ceiling fans and transformers for the electric industry.

Location of Efficiency Product Manufacturers



The fuel cell and hydrogen company count has consistently increased, and currently stands at 16. Recent additions to the database include a recent arrival from Europe and several companies with sales representatives in the state. The state's fuel cell industry is involved in development of fuel cell technologies for applications including portable electronics, transportation and utility vehicles, and several instances of innovative components that have potential to leapfrog over several of today's technical barriers to fuel cell development. More established companies provide testing equipment and other components, including the DuPont facility that produces the bulk of the membrane material.

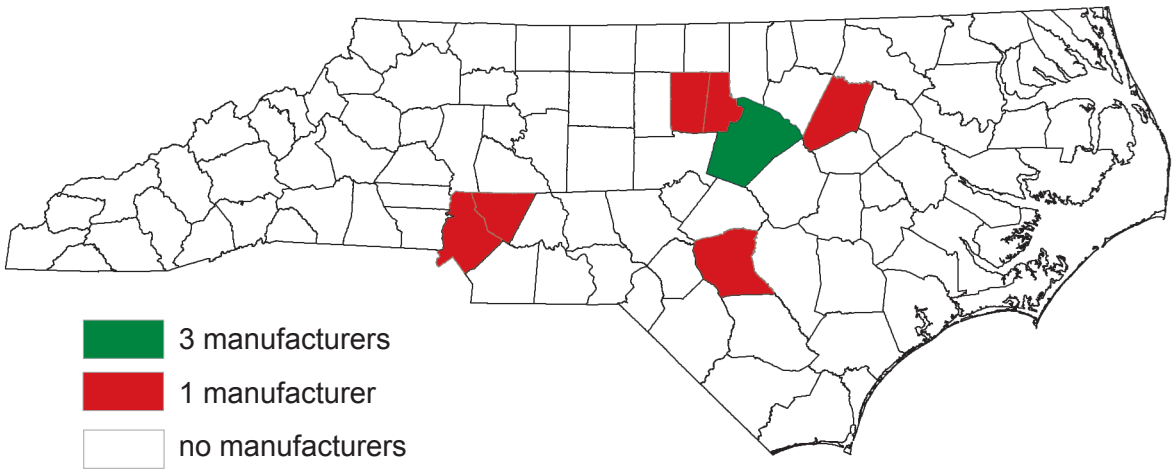
Location of Fuel Cell & Hydrogen Equipment Manufacturers



Source for the maps above: Appalachian State University Energy Center 2007

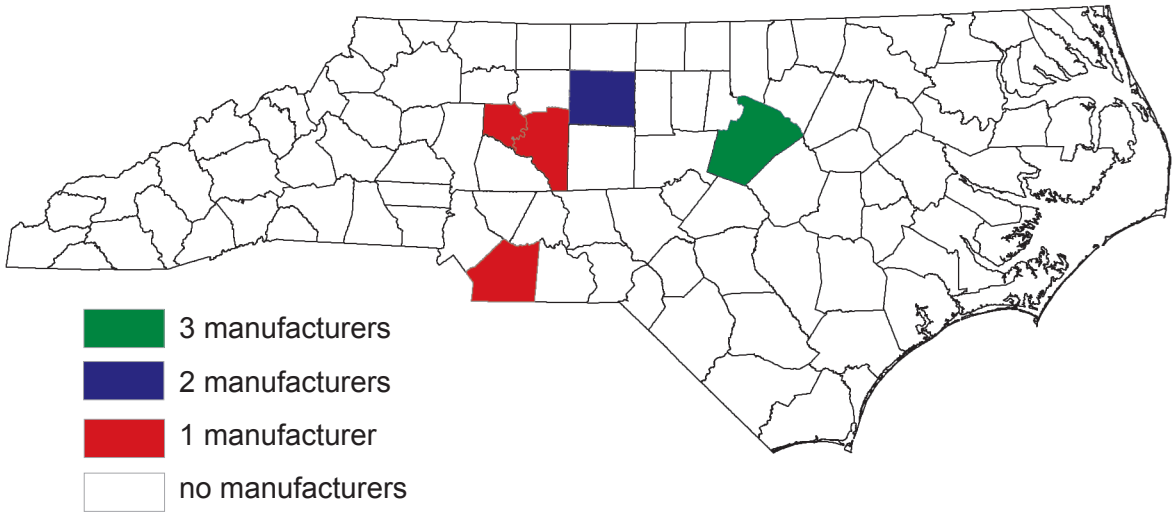
Solar electricity companies have increased their numbers substantially as well, with nine identified. A couple of the state's earliest solar market-entrants, Solargenix (formerly Duke Solar) and Torpedo Specialty Wire, continue to be active in the growing market, although the former has located their manufacturing outside the state to better serve the market. Most of the new entrants are involved in semiconductor-related technology development and commercialization, although a few are targeting technologies that concentrate sunlight and generate electricity using collected heat.

Location of Solar Electricity Equipment Manufacturers



Wind industry companies total eight. The bulk of these companies provide some type of advanced fiber for use in wind turbine blade construction. Other companies are involved in activities such as the production of ball bearings and other basic components of a turbine.

Location of Wind Energy Equipment Manufacturers



Source for the maps above: Appalachian State University Energy Center 2007

Manufacturing Potential

11,000 new jobs in existing industry

North Carolina is a leading state with potential to manufacture renewable energy equipment. If the state does not reap its projected share of 11,000 manufacturing jobs from a projected 74,000MW of new capacity from renewable energy and energy efficiency it will be because another state has successfully gained market share in these industries.

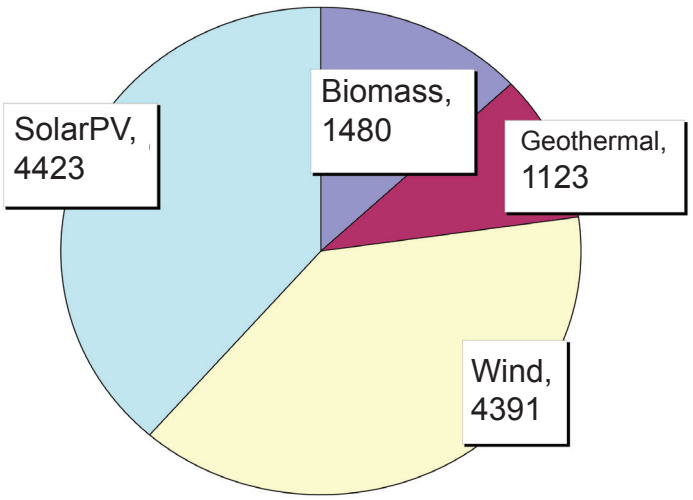
While there are few producers of complete renewable energy systems, **North Carolina alone is home to over 900 companies that operate within the supply chain of renewable energy equipment** - these manufacturers only need to be made aware of and connected with the emerging energy technology markets.

A renewable energy supply chain study performed by the Renewable Energy Policy Project (REPP) examined the industries that produce component parts for renewable energy equipment and then classified states based on their existing industry. The thousands of component parts in renewable energy equipment are common items such as wire, reinforcement woven textiles, polymers and electronics technology - all areas of expertise for the Tarheel state.

Simply maintaining our market share in existing industries will bring the state over 11,000 jobs and over $2 billion in capital investment - a veritable economic boom. If national demand for renewable energy were to increase at twice the expected rate, a possible outcome of carbon regulations, North Carolina could benefit even more. With 185,000 MW (equivalent to about 185 Shearon Harris Nuclear Plants) nationwide, North Carolina has the potential to add nearly 30,000 new manufacturing jobs just from existing industry. This potential is magnified by the possibility of new technology development as state researchers innovate and commercialize new technological developments.

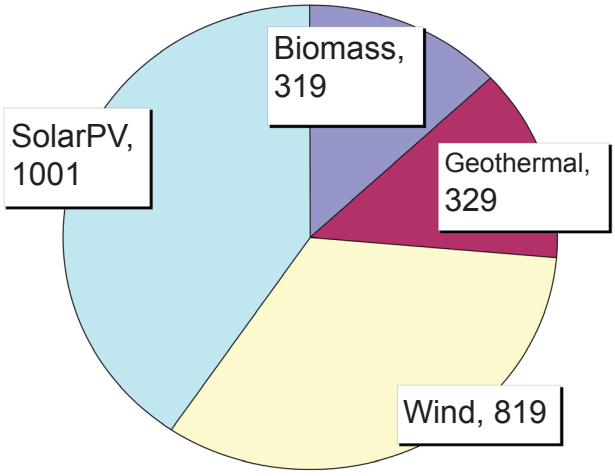
Potential Manufacturing Jobs (FTE)

74,000 MW Renewable Capacity in the U.S.

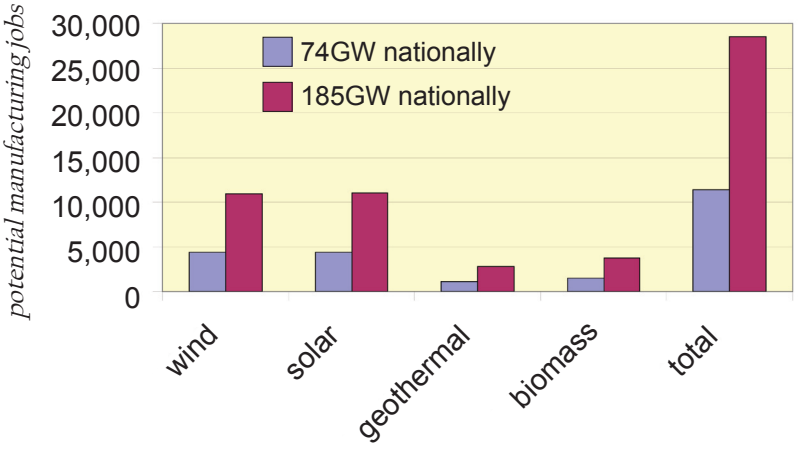


Potential Manufacturing Investment ($mill)

74,000 MW Renewable Capacity in the U.S.



NC Job Potential - 74GW vs.185GW



74,000 MW (74GW) represents industry roadmap targets, and 185,000 MW (185GW) represents an estimate of renewable energy required to stabilize the climate, according to the REPP reports.

Data source for the 3 charts above: Renewable Energy Policy Project, Location of Manufacturing Activity report series, available at www.repp.org

Our Green Energy Future

Renewables & efficiency a priority for NC

Renewable Energy and Energy Efficiency Mean Big Business in North Carolina.

North Carolina's energy outlook is changing rapidly. As we go to press with this issue the North Carolina General Assembly passed a Renewable Energy & Efficiency Standards Portfolio for North Carolina. Duke Energy Carolinas, Progress Energy and Piedmont Natural Gas have all begun implementing energy efficiency programs.

Renewable & Efficiency Portfolio Standard Requirements*

Year	Utilities	EMC-Muni	Solar	Swine Waste	Poultry Waste
2010			0.02%		
2012	3%	3%	0.07%	0.07%	170,000 MWh
2015	6%	6%	0.14%	0.14%	900,000 MWh
2018	10%	10%	0.20%	0.20%	900,000 MWh
2021	12.50%	10%	0.20%	0.20%	900,000 MWh
2025	12.50%	10%	0.20%	0.20%	900,000 MWh

** Requirements in GS 62-133.7*

Going Green Will Lower Energy Bills

A recent North Carolina Utilities Commission study by LaCapra & Associates concluded that increased use of renewable energy and energy efficiency in North Carolina will lower energy bills. According to the study, obtaining 10% of our state's electricity from renewable energy and energy efficiency would not only reduce average electricity bills but also add 50,000 new jobs to the state's economy.

LaCapra & Associates Study Results

Inclusion of energy efficiency would enable the State to achieve a 10% RPS and would reduce consumers' overall electricity bill

Current Capacity, MW

2,000

Technical Potential, MW

12,000

Practical Potential, MW

3,400

NC Electric Providers Issue RFPs

Following the enactment of the portfolio standards legislation, the state's investor-owned utilities and the NC Electric Membership Corporation (NCEMC) issued RFPs for renewable energy. Duke Energy Carolinas led the way, issuing an RFP prior to the legislation's passage. Duke called for 2,100 MW of new renewable energy capacity in service by 2012, preferably located in the Triad area of the state. The NCEMC issued an RFP for 200 MW of renewable capacity, with a preference to NC-based installations. Progress Energy Carolinas issued an RFP in November calling for 1,000,000 MWh of renewable energy by 2012, with preference given to projects in service by 2010. Dominion Power also issued an RFP in November seeking ownership shares in renewable energy generation projects, with a preference for NC-based projects using swine and poultry waste or solar energy resources.

Efficiency Measures in the Pipeline

The cheapest energy, according to U.S. Energy Secretary Samuel Bodman, is the energy we could save. Requirements for increases in energy efficiency have yet to accompany those for renewable energy. Duke Energy has filed a proposal with the N.C. Utilities Commission to allocate 1% of its revenue to efficiency programs that would reduce future capacity needs for both peaking and baseload generators. Progress Energy has filed a proposal in late 2007, and the state's rural electric cooperatives are working to provide their customers with these benefits as well. Natural gas companies have also filed their own plans to increase efficiency.

Resources

NC Utilities Commission: *www.ncuc.net*

Senate Bill 3, 2007 Session *www.ncleg.net*

Green Energy in the News

Microcell Corp. Opens Manufacturing Facility

Martin County recently became home to the state's newest fuel cell manufacturing facility. Microcell Corp. celebrated the opening of an 80,000 sq.ft. manufacturing facility expected to employ over 100 people from the local area.

This October 2007 milestone follows on the heels of the company's January announcement that the company has delivered its first 'automotive fuel cell core' developed with their novel microfiber architecture for fuel cells.

- Fuel Cells Bulletin

Strategic Plan for Biofuels Leadership

The N.C. Biotechnology Center released its "Strategic Plan for Biofuels Leadership in North Carolina" in April 2007. The plan calls for development of new biofuel production capacity of 500 million gallons over the next decade as part of their nine-piece strategy to produce 10% of the state's fuel locally.

- NC Biotech Center Report

PPG-Devold

The February 2007 signing of a new joint venture between PPG and Devold AMT in Shelby, NC expanded a glass-fiber manufacturing facility to produce stitched glass-fiber reinforcement for use in wind turbine blades.

Reinforcement glass fibers are a major component of wind turbine blades and about 46,000 sq.ft. of the plant will be dedicated to their production. The expansion will create about 50 new jobs at the facility in Cleveland County.

- Charlotte Business Journal

DuPont $50 mill. Solar Manufacturing Expansion

Fayetteville recently became home to a $50 million DuPont facility producing solar cell components. The facility expansion will create 15 jobs paying an average of $874 per week, nearly double Bladen County's average weekly wage. This expansion was made possible in part by a $50,000 investment from the One North Carolina Fund.

- Raleigh News & Observer

Catawba Eco-Complex

Catawba County is developing an ecologically minded industrial park where companies will use each other's production wastes and byproducts to fuel their operations.

Planners believe the Catawba County Eco-Complex has the potential to attract $105 million in investment and create as many as 350 jobs over the next five years.

Built around using methane gas from the landfill, a high-tech sawmill, pallet maker, a hydroponics greenhouse operation supplying Dole Food's planned $54 million facility, and possibly a specialty brick maker may locate here.

- Charlotte Business Journal

Recent Clean Energy Manufacturing Expansion

# of jobs	County	Description
100	Martin County	Microcell fuel cell manufacturing facility
50	Cleveland County	PPG-Devold glass fibers for wind turbine
15	Bladen County	DuPont film for solar panels
350	Catawba County	Eco-Complex using landfill methane
15	Orange County	MegaWatt Solar developing solar power
8	Wake County	INI Power fuel cell development
50	possibly in NC	Sencera, PV manufacturing technology
15	Robeson County	Ethanol plant fuel with landfill methane

GoldenLEAF Biomass Energy Grants

GoldenLEAF has awarded $2.25 million in grants for cellulosic ethanol and biodiesel industry assistance programs. These grants will support greater use of crops in local fuel production.

The Foundation has previously awarded energy-related grants totaling over $1.4 million supporting programs for energy crops and an ethanol plant that plans to use landfill gas.

- Triad Business Journal

MegaWatt Solar Tests Solar Power Design

Hillsborough-based solar start-up MegaWatt solar received $17 million investment from Norway-based clean energy company Scatec. The 15-person company has devleoped a solar power device that tracks the sun across the sky and uses a dozen 8-foot by 4-foot mirrors to concentrate the sun's rays.

- Raleigh News & Observer

Photovoltaics & Poultry Produced Power

Renewable portfolio policies are likely to be shaped as much by business opportunities as they are environmental concerns. Two prominent opportunities are a poultry litter-fueled power plant and interest from solar cell manufacturers.

Fibrowatt turns poultry waste into electricity, and is considering a dozen North Carolina sites for a new 55 MW plant. The $202 million plant is expected to employ about 30 people and create demand for poultry waste.

PowerLight Corp., a California-based solar cell maker, is considering an investment in North Carolina. The major barrier today is that there is no market for solar power in the state. Mandated use of solar being considered by the legislature would go a long way towards attracting distributors, sales, and service businesses, and eventually manufacturers.

- Charlotte Business Journal

Sencera Develops Solar

Charlotte-based solar startup Sencera received $1.5 million to complete development of a high-speed solar panel production technology. When completed, their product will be licensed for about $53 million over the next 10 years.

The company is also considering its own $30 million manufacturing plant that would employ about 50 people. Locations are being scouted near Charlotte as well as overseas and in other states. Although the company expressed a desire to stay in the state, the Southeast is a backwater for the solar industry.

- Charlotte Business Journal

Carbon-to-Liquids Development Center in RTP

Southern Research Institute will open its Carbon-to-Liquids (C2L) Development Center in Research Triangle Park. This fuel and energy research facility will focus on commercializing biomass resources into high value products such as jet fuel, methanol, ethanol, and electric power.

Agricultural wastes, energy crops, waste biomass, animal and human waste will be used as feedstocks for fuel and reduce greenhouse gas emissions. The 28-acre site has a 30,000 sq.ft. space for constructing pilot plants.

- PR Newswire

INI Power Secures $4 mill. in Funding

INI Power of Morrisville announced in May 2007 that the company had secured an additional $4 million in a second round of financing. The fuel cell developer's first venture financing round, received in 2004, was valued at $3 million.

- Triangle Business Journal

Wake Forest Univ. Achieves Solar Power Milestone

Wake Forest University researchers have doubled the efficiency of plastic solar panels, achieving 6% efficiency in their lab. Researchers in the university's Center for Nanotechnology and Molecular Materials hope to achieve 10% during 2008.

Plastic solar cells are lightweight, inexpensive to manufacture, and can be applied in a variety of ways to almost any product because of their flexibility. Higher efficiencies have been achieved by the group by mimicking the design of veins in a tree's leaves.

- RenewableEnergyAccess

Market Growth, Innovation = $$$, Jobs

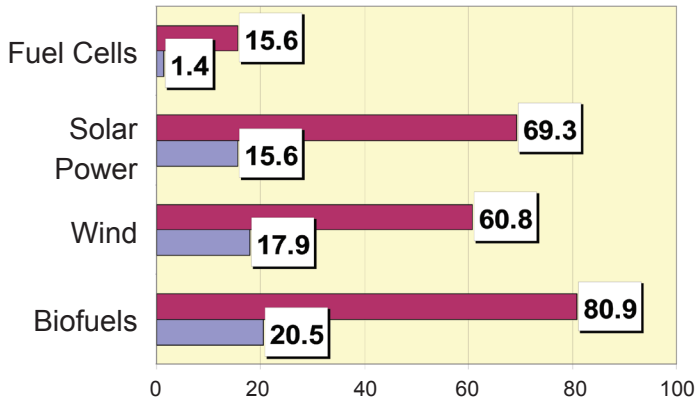
supply risks, fuel inflation, carbon, & air quality drive markets

Market Projections

The 2006 market for green energy technology was estimated at over $55 billion. These markets are expected to grow to over $226 billion in a decade – an increase of $171 billion, or three times today's estimated size. The largest of these projected markets will remain biofuels, estimated at $80 billion in 2016.

Solar power is expected to eclipse wind as the second most valuable renewable energy technology market with estimated values of $69 billion and $60 billion, respectively. And, at the head of the growth-rate line are fuel cells, whose imminent commercialization in limited applications is highly anticipated. Fuel cells are expected to grow from today's market size of $1.4 billion to over $15 billion by 2016.

Clean Energy Projected Growth 2006-2016 (US$bil)



Source: Clean Edge, Clean Energy Trends 2007

These projections reflect expectations assuming nothing changes, but in reality everything about today's energy systems is changing. The full economic costs of today's energy is only beginning to be reflected in prices via incentives for greater use of local sources of energy and, eventually, carbon limits. An entire portfolio of change is poised to impact green energy markets in a significant way.

Energy's New Face

Clean energy technology growth rates in excess of 20% per year have been both projected and sustained over the past five years. This growth has been driven by a number of factors that have served to reveal weaknesses in our current energy systems. Everything from natural disasters and terrorism to fuel price inflation and increasing concern over emissions has played a part in the establishment of national renewable fuel standards and mandates by nearly half the states that a portion of electricity sold be generated using renewable resources.

The technologies of renewable energy are continually benefitting from innovation that improves performance and reduces cost, yet several technologies such as wind and landfill gas are already competitive with traditional power sources, in many cases without accounting for the value of carbon reductions, local economic development, or credits for green power. Renewable energy and energy efficiency also contribute to more economical electricity generation because 1) their cost of power is not tied to the market value of fossil fuels, 2) deployment of these technologies reduces the need for expensive peak generation facilities, and 3) renewable energy portfolio standards have been shown to actually reduce the price of natural gas, making the existing electricity generation infrastructure more economical.

U.S. EPA Top Green Power Partners 2007

Name	MWh	% of Power	Industry
PepsiCo	1105045	100%	Food/Beverage
Wells Fargo	550000	42%	Financial Svcs.
Whole Foods	463128	100%	Retail
US Air Force	457500	4%	US Military
Johnson & Johnson	400703	39%	Health Care
US EPA	329880	100%	US Government
Starbucks	185000	20%	Food Svcs.
DuPont	180000	4%	Chemicals

Source: U.S. EPA Green Power Partners

While states often pursue renewable energy as a means of driving economic development, cleaner air, efficient use of local resources, and increasing energy system security, a sure sign of these technologies' entry into the American mainstream is their acceptance by Fortune 500 corporations, the military, and major U.S.-based non-governmental organizations, as shown above.

Growth

Green is Gold for the Tarheel State

Renewable energy and energy efficiency technologies offer North Carolina new jobs in nearly every economic sector, a more secure and sustainable economic structure, and the opportunity to leverage the state's research and innovation leadership to create technologies that increase the use of local resources.

New Manufacturing Jobs

Existing state mandates for the use of renewable energy, called Renewables Portfolio Standards (RPS), will result in an estimated 90 GW of renewable capacity by 2025. As the 9th ranked state for job creation potential from renewable energy manufacturing, North Carolina's existing manufacturers will have to add 12,000 new jobs just to maintain their current market share. A doubling of projected capacity to 185 GW is expected to create over 30,000 new manufacturing jobs in the state's existing industries. The state's expected share of job gains could increase as well if existing research institutions and universities continue to produce innovations, as these knowledge assets will attract technology companies like metal to a magnet.

Reduce Emissions Risk

The fossil fuels we use to travel to work and light our homes are the largest source of air-pollutant emissions today. Emissions from fuels used in both transportation and electricity contribute greatly to the creation of acid rain, smog, and particulate matter in our air as well as deposits of heavy metals, such as mercury, in our water supply.

With the exception of viewshed-driven tourist industries, air pollution has not traditionally been considered to materially affect economic growth because the impacts were only marginally relevant to companies evaluating a state with the quality of life and business advantages North Carolina offers. However, all the competitive advantage in the world won't help a company get an air permit for a new facility.

This situation is exemplified by Toyota's recent decision to locate its new facility in Mississippi, partly due to air quality risks from non-attainment classification in several NC counties. An isolated instance is no cause for alarm, but if this trend sustains itself over several years, air quality could become a major barrier to economic development in some NC counties.

Whether air permits are denied or not is largely irrelevant, because even the possibility of not being able to secure an air permit or of having future production limited by emission regulations is enough to create a substantial financial risk. Local competitive advantages may be sufficient to justify a company assuming that risk, but when competing candidate sites have no risk from air quality permitting their competitive position is much stronger.

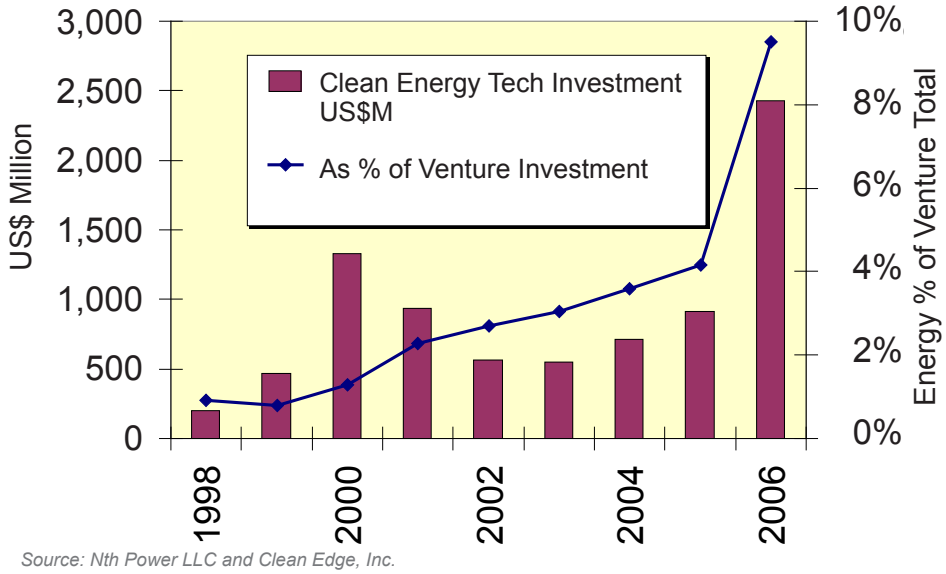
Synergy in Economic Assets

Growth in renewable energy markets will require substantial investment in manufacturing facilities, technology development companies, and generation projects.

As the home of one of the world's leading financial industry clusters, North Carolina's finance industry has the capability to tap this potential demand and become a leader in the mainstreaming of renewable energy and energy efficiency technologies.

Venture capital activity in the clean energy sector has been increasing rapidly. A shift 'en masse' has occurred during the past year with clean energy technologies receiving almost 10% of total venture investments in 2006, up from less than 5% in 2005.

Private Equity Investment Trends
US Clean Energy Companies



Source: Nth Power LLC and Clean Edge, Inc.

The Carbon Crunch

The largest wildcard in the future of green energy technologies is the impending limitations on greenhouse gas emissions. Fossil fuels used for energy are the largest source of greenhouse gas emissions, so stabilizing the climate will likely destabilize the energy industry to some extent. Unfortunately, if widely expected climate change impacts do occur the economic destabilization will encompass all industries.

A recent study performed by several university professors in North Carolina reveals examples of the likely costs to our state's economy from the effects of climate change.

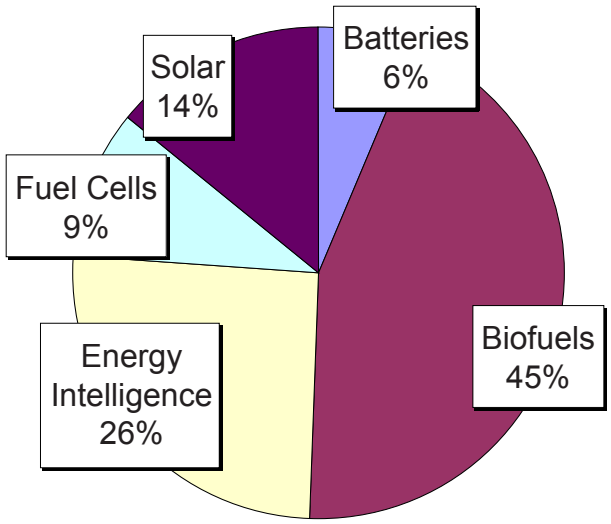
Increased severity of hurricanes is expected to cost the four counties examined an additional $1 billion per storm event.

Nearly $7 billion in property value will be lost - as in under the ocean - in just four coastal counties.

Tourism along the coast will grind to a near halt, dropping at a rate of 16% per year by 2030 and 48% per year by 2080. An estimated $3.9 billion will be lost from disappearing beaches over the next 75 years. In fact, only three of our existing 17 recreational beaches will even exist by 2080 (one of which will hardly be usable as it is expected to only be about 3 feet wide) if climate change is not stopped.

Increased severity of hurricanes is expected to cost the four counties examined an additional $1 billion per storm event.

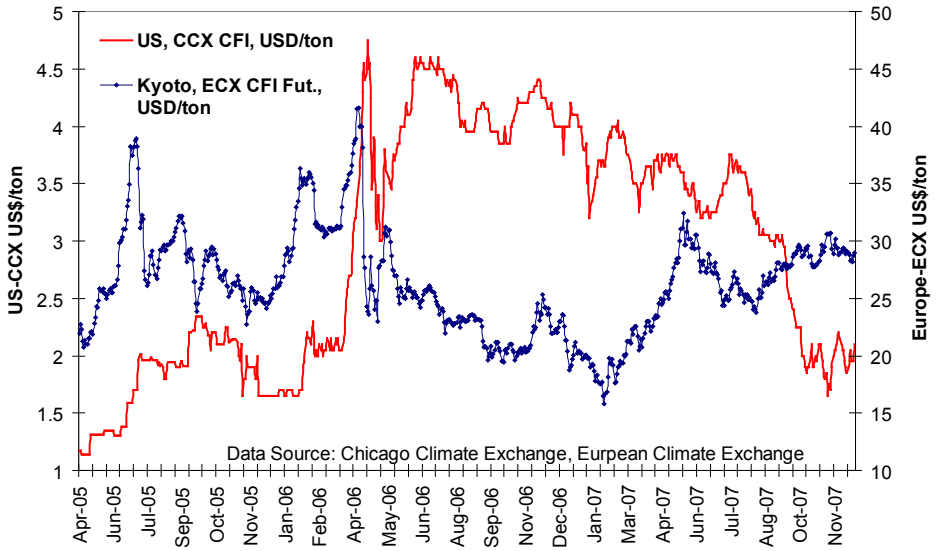
US Clean Energy Venture Activity 2006



Source: Nth Power LLC and Clean Edge, Inc.

In 2005, the U.S. was the world's largest emitter of greenhouse gases with over 6.4 billion metric tons emitted, 90% of which is directly attributable to combustion of fossil fuels for energy. So, the obvious answer is to either stop altogether or drastically reduce our use of fossil fuels - a task much easier said than done, however.

U.S. & European Carbon Market Prices



Source: Chicago Climate Exchange and European Climate Exchange

The cost, or value, of carbon emissions is best measured by market exchanges set up to facilitate the transfer of value from entities requiring carbon emission reductions to projects that reduce carbon emissions. In the U.S. voluntary but legally binding carbon market, Chicago Climate Exchange, a ton of greenhouse gas emissions has traded between $1.50 and $4.50. But, in the European Exchange set up to facilitate Kyoto Protocol compliance, a ton of greenhouse gas emissions has been valued between $20 and $30.

Energy Equipment Manufacturing for a Carbon Constrained Economy

Robots in a Shell Solar Industries photovoltaic manufacturing plant
Photo Source: NREL PIX

Because renewable energy resources and energy efficiency technologies offset and reduce greenhouse gas emissions, these technologies are likely to have a significant role in a carbon-constrained future - a future that remains uncertain, however, and one that is not typically calculated in market growth projections.

What is known, however, is that any substantial increase in the market for renewable energy technology from carbon limits will require significant growth in the production capability of certain components.

Recent supply chain bottlenecks identified by the Renewable Energy Policy Project identify component production capacity increases necessary to achieve 185 GW of installed renewable generating capacity.

As shown in the tables below, the largest capacity increase will be needed in some highly specialized components unique to wind turbines, but overall, the most growth will be required to meet the projected demand for solar power equipment.

Resources

Renewable Energy Policy Project
www.repp.org

Chicago Climate Exchange
www.chicagoclimatex.com

CleanTech Venture Network
www.cleantechventure.com

Manufacturing Capacity Constraints in Renewable Energy

Solar Cell Manufacturing

NAICS Industry	Incremental Demand	Available Production Capacity	Incremental Demand as % of Available Production Capacity
Top surface	$479,950	$50,904	942.86%
Wiring	$241,550	$57,176	422.47%
Blocking Diode	$93,327	$75,510	123.59%
Solar cells	$2,691,123	$1,282,194	209.88%
Electrical Connections	$400,388	$103,055	388.52%
Charge Controller	$477,569	$50,056	954.07%
Inverter	$643,392	$171,306	375.58%

Wind Turbine Manufacturing

NAICS Industry	Incremental Demand	Available Production Capacity	Incremental Demand as % of Available Production Capacity
Nacelle Case	$132,643	$55,931	237.15%
Rotor Blade	$1,133,332	$477,888	237.15%
Towers	$1,476,550	$381,607	386.93%
Generator	$551,900	$99,554	554.37%
Gear Box	$942,025	$14,593	6455.34%
Power Electronics	$447,150	$191,626	233.34%

Source: Renewable Energy Policy Project, www.repp.org

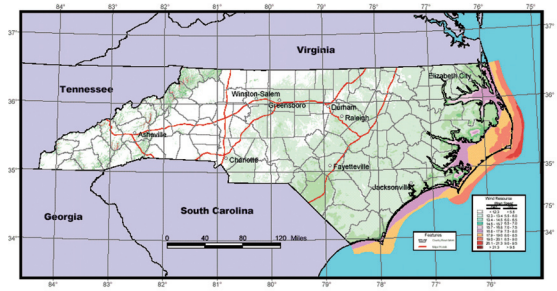
Economic Development Approaches

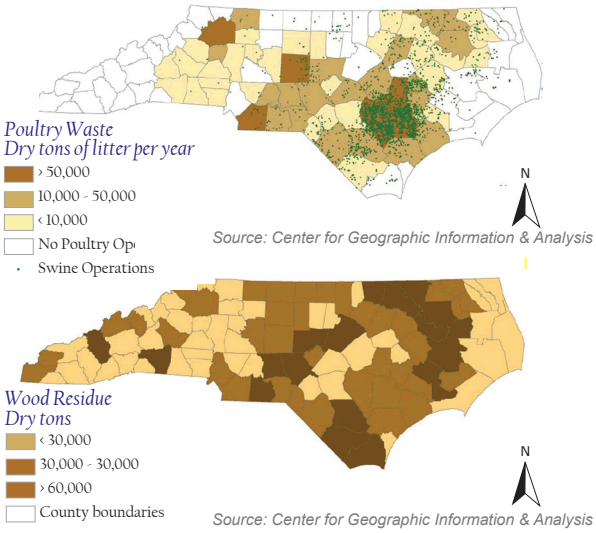
Two Approaches for Every Economy: Creating Demand & Stimulating Supply

Economic development approaches to the renewable energy and energy efficiency industries target either equipment manufacturing or energy supply projects. On the one hand, using renewable resources to produce energy provides local jobs and income from ongoing operations as well as construction. On the other hand, global and national growth in demand for renewable energy technology can drive manufacturing job creation and, in turn, drive wealth creation in local economies.

Using renewable energy resources in North Carolina will add considerable value to the rural economy of the state, provide farmers with new sources of value from existing operations, reduce the $15 billion annually the state currently spends to import fossil fuels, and alleviate several significant waste management problems from human, poultry, and swine waste.

While demand-side efforts to use renewable energy resources bring local jobs, primarily in construction, plumbing, and electrical trades, manufacturing these technologies can be performed anywhere. However, manufacturing renewable energy and energy efficiency technologies and other supply-side activities can provide economic growth beyond that immediately supported by existing local resource development.





Scientific Roles in Green Energy

Nanotechnology: offer new highly efficient materials, and greater potential applications for existing materials

Biotechnology: will make every bit of plant matter tomorrow's oil reserve, including everything from wood chips to corn stover and switchgrass

Electronics: integrating renewable energy equipment into the grid and engineering applications that replace batteries requires expertise in electronics technology

Advanced textiles: reduce weight and increase strength of materials, increasing their inherent energy efficiency

Polymers: provide new applications of all sorts and new technologies are making the polymer structure functional as well by adding electrical conductivity and photovoltaic capabilities

The Role of Technology

Because the green energy industries are only now emerging in a substantial way with some long-term certainty about market potential, technology development is rapid and innovative. North Carolina is economically strong in many areas that are commonly believed to hold the key to making clean energy technologies far surpass their fossil fuel ancestors in performance, cost and reliability.

Wind turbines have emerged as one of the largest sources of demand for fiber-reinforced plastics as each turbine has several blades that can be as long as a football field. Advances in semiconductor technologies are striving to develop solar cells in striking designs that include super-efficient cells, flexible fabric-like materials, and even spray-on coatings similar to paint in their application. The fuel of tomorrow is almost certainly going to be increasingly bio-based, and as a leader in biotechnology, North Carolina may well be home to the innovative companies that bring biofuels into the mainstream of our our transportation economy.

The state's knowledge of these research areas could effectively be tapped as a means to make our existing local energy resources more competitive and useful.

Regional Energy Clusters

Current economic development approaches have evolved from sectoral-based and supply chain-gap strategies. They generally consist of efforts to establish an attractive business environment that creates competitive advantage through specialization of both core manufacturers and supporting infrastructure. This development approach, called cluster development, consists of strategies to emulate the observed characteristics of highly competitive regions.

The three broad cluster types of regional economies as identified by Harvard Business School's Institute for Strategy and Competitiveness are traded clusters, local clusters, and natural resource-driven clusters. As a framework for examining green energy's potential impacts on a regional economy, these broad cluster types offer insight into specific methods green energy can be leveraged to create competitiveness.

Energy & Economic Clusters

Local Clusters

Local clusters include things found in nearly every locale such as grocery stores and gas stations as well as the contruction trades essential to using renewable resources;

Often a primary source of local employment, these industries serve the needs of the local economy, but rarely drive growth or wealth on their own;

Clean energy offers opportunity to decrease operating costs, primarily through energy efficiency measures, and can help maintain an economical but high standard of living. And many new jobs can be added in a local economy from the installation and maintenance of renewable energy and energy efficiency equipment.

Traded Clusters

Traded clusters are the primary driver of wealth in regional economies and typically manufacture products for export and sale elsewhere;

Clean energy technologies developed and manufactured in a region fall in this category, and the variety of products and involved industries means than nearly every region has some aspect of its industrial economy suited to serving these markets. Manufacturing can also be boosted from innovation in technologies that make greater use of locally available natural resources, establishing synergistic linkages between local resources, knowledge assets, and technology development and commercialization.

Natural Resource-Driven Clusters

Once the backbone of many endowed regions such as Gulf coast oil, and Appalachian coal, these opportunities were generally considered fixed as there was little a region could do to benefit from these industries without a natural endowment.

Today, though, energy resources are abundant. Windy plains, mountaintops or ocean area can produce electricity at times for less than the cheapest coal-fired plant. The hot bright desert is rapidly becoming an energy reserve for western states that is highly reliable and cannot be depleted.

North Carolina's extensive geographic diversity means that now the state can count its own energy resources as developable, and the state's historically strong agriculture industries have opportunities to convert everything from crops to field residue to animal effluent into sources of fuel.

Biomass: Our Greatest Resource

Biofuels, Gasification, and waste are the state's largest energy reserves

What is Bio-Energy?

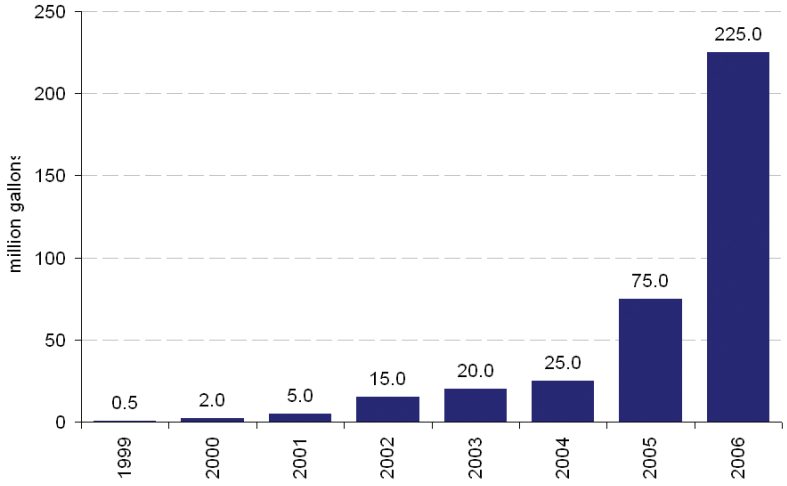
Biomass sources of energy are the most abundant local energy supplies in North Carolina and in many cases are found in the waste streams of existing farms and facilities. Biomass energy products include ethanol, biodiesel, methane gas, and other fuels. Using biomass for energy adds value to agricultural products and processing by-products, generates lower emissions than fossil fuel sources, and increases energy security by increasing the portion of energy sources available from a vertically integrated local energy industry.

Triple biofuels dispenser at Baca Street Biofuels Stations Photo Source: NREL PIX

Biodiesel

Biodiesel is a cleaner alternative to diesel fuel that is produced from plant oils, animal fats, or waste oil from restaurants. Pure biodiesel (called B100) can be used in any modern diesel engine with minimal modifications, and lower-concentration blends such as B20, a 20% biodiesel blend, can be used with existing equipment.

U.S. Biodiesel Production



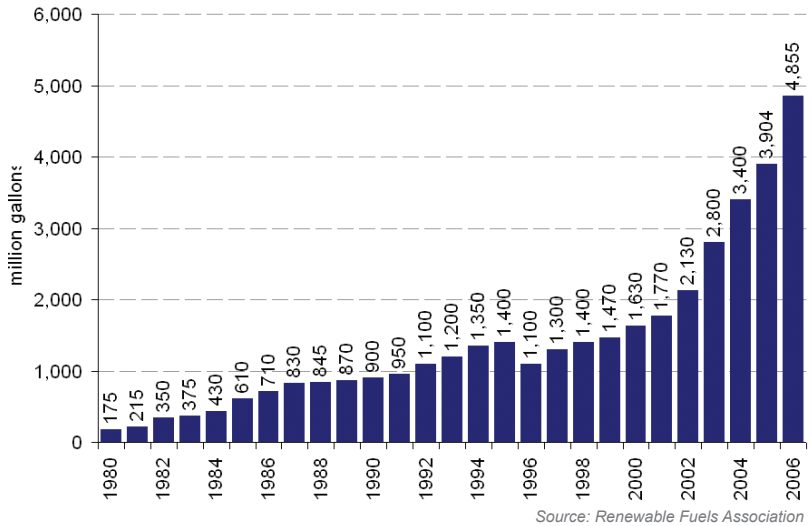
Source: National Biodiesel Board

Biodiesel is becoming widely accepted as a viable fuel for reducing our petroleum dependence, decreasing emissions rates and buffering rural agricultural economies. Many engine manufacturers now specifically state that using blends of biodiesel up to 20% will not void their parts and workmanship warranties. Other companies, such as John Deere, have gone a step further and ship all new vehicles with a full tank of biodiesel-blended fuel.

Ethanol

Ethanol is a form of alcohol used as a gasoline fuel additive. Ethanol can be used by any gasoline-fueled vehicle in small concentrations, and in blends with concentrations of 85%, called E85, in the tens of millions of specially manufactured 'flex fuel' vehicles.

U.S. Ethanol Production



Source: Renewable Fuels Association

Ethanol's use as a component of gasoline has waxed and waned through the decades, mostly in response to the availability and price of oil. In addition to increased demand driven by high oil prices and uncertainty about long-term oil supplies, strong demand for ethanol is also being driven by its use replacing MTBE, an oxygenate known to contaminate water supplies in every state, a political push for decreased energy dependence, and requirements for decreased emissions of greenhouse gases and a variety of regulated air pollutants.

Waste & Other Biomass

Biomass-to-energy opportunities aside from renewable fuels include: agricultural waste combustion, biomass co-firing, waste methane gas, and gasification. Biomass fuel of these types is exceptionally valuable, because otherwise these resources would be wasted. Biomass fuel of these types is exceptionally valuable because without these materials would be wasted.

These biomass resources constitute the bulk of the state's natural energy reserves – with the added benefit of replenishing themselves as long as the state is growing crops and raising animals. Plant material is closest in use to coal, and can reduce the millions of tons of coal North Carolina imports each month for electricity generation while simultaneously supporting local farmers by adding additional value to their crop waste. Many readily available complementary or substitute fuels for natural gas are available from landfills, wastewater treatment facilities, and animal feeding operations. Use of these local sources provides a local component to the fuel supply, adds value to tasks such as manure management that were previously only expenses, insulates local areas from supply disruptions and, in the big picture, contributes to lower long-term natural gas and energy prices.

Economic Impact

Ethanol - The economic benefits of ethanol manufacturing can be significant with a 41-million gallon per year plant employing about 35 people at an average wage of over $42,000 – a total annual payroll of nearly $1.5 million. This plant will also use over 15 million bushels of corn and consume about $6.5 million in electricity and natural gas. The broader economic impact of the plant is impressive as well with over 100 indirect and induced jobs paying a total of $2.7 million annually in wages, and total value added for the project is $11.8 million, according to estimates by Iowa State University.

Biodiesel - University of Georgia estimates show that a 15-million gallon per year biodiesel manufacturing facility will require about $9.6 million in investment and will employ about 15 people. This facility would require a 5,000 sq.-foot building on a 7-10 acre site.

Biogas - Methane gas from landfills, animal waste, and wastewater treatment plants has been successfully used to drive economic development by providing a low-cost substitute fuel as an incentive for recruiting companies, serving as a resource around which incubator programs are developed, and by reducing the costs of compliance and waste management to farmers, county governments, and cities alike.

Industry in NC

Biodiesel producers are showing up across the state in the form of locally driven cooperatives. These small-scale producers serve their local areas, some with publicly accessible pumps, with fuel made from processed restaurant fryer oil. A few larger-scale entities capable of producing millions of gallons per year are also appearing, although at a slower rate than local cooperatives. The larger producers typically use virgin oil from any number of oil-bearing plant seeds and research is underway to determine the most productive feedstocks.

The state's appetite for biodiesel is evidenced by North Carolina having the second-most biodiesel gas stations of any state. While North Carolina currently does not produce sufficient oil crops for a biodiesel industry of large-scale producers, in many cases these crops could be rotated into existing growing cycles and result in increased productivity for farmland. The state's animal producers could also benefit by providing waste animal fat as a feedstock for biodiesel production.

Ethanol and North Carolina have had a rocky relationship defined by big promises from industry but no shovels in the ground. Since 2000, at least five major ethanol production facilities, estimated to provide over 1,300 jobs, were proposed in-state, yet none have materialized. Although there are several projects currently slated to begin production in 2007, as of November 2008, no construction had begun. This industry is not absent for lack of supportive effort from the Department of Commerce, Department of Agriculture, State Energy Office, and grants from the GoldenLEAF Foundation.

Ethanol production has failed in the state largely because of market factors. Traditional ethanol production uses corn as a feedstock and requires low-cost heat, often from natural gas – major factors that work against the viability of an industry in North Carolina. Emerging technologies for the production of ethanol use biotechnology to produce ethanol from currently unusable plant fibers. Cellulosic ethanol uses biotechnology-derived enzymes to make ethanol from corn stover, switchgrass, and woody biomass at a much lower cost than traditional ethanol production.

Biofuels Production

North Carolina's Strategic Plan for Biofuels Leadership

"Of the 5.6 billion gallons of fuel consumed in North Carolina annually, not a single gallon contributes to the agricultural, forestry, or production economy of North Carolina."

- NC Strategic Plan for Biofuels Leadership

Ethanol Production

Production of ethanol begins with crops high in starch. Corn ethanol is most common in the U.S., sugar cane is the feedstock of choice in the world's leading ethanol producing country, Brazil, but other high-starch crops can be used, including sweet potatoes and sugar beets.

These crops are then fermented, a process which requires substantial energy for heat. Once fermented, the product is distilled and denatured then mixed in blends of 5%-85% with gasoline.

Transporting ethanol has recently been a barrier to rapid development. Ethanol cannot be transported through pipelines like most fuel products because it is water soluble, and once it reaches its destination the ethanol must be stored in a specially prepared tank.

Biodiesel Production

Biodiesel is made through the transesterification of fats. Animal fat, crude vegetable oil, and even used fryer oil from restaurants can be converted into biodiesel.

These fats are collected, cleaned of foreign matter, and then processed. Processing fats into biodiesel requires reacting the fats with methanol and sodium hydroxide - not unlike soap manufacturing. The biodiesel is complete and ready for use as a 100% concentration or in other blends with petroleum diesel once it meets the ASTM fuel standards.

***Switchgrass** is one of the most promising energy crops in the southern United States of America (USA). Once switchgrass blanketed the prairies, protecting the soil, cleansing the wetlands, and providing shelter and food to wildlife. Now that gasification is being developed to turn feedstocks like switchgrass into electricity, farmers have the option to plant these hardy grasses to restore eroded land and gain flexibility in crop planning and rotation. Photo Source: NREL PIX*

Biofuels Vision

"North Carolina is well-advised to gain internal capability for production of a measurable percentage of its biofuels consumption. Doing so reflects increasingly strong national and federal mandates, and is also mirrored by other states - many of which are targeting biofuels development far more aggressively and measurably than North Carolina. More importantly, gaining increased internal biofuels capability is eminently feasible in this state in coming decades. North Carolina is remarkably well-positioned to shape science, biotechnology, agricultural and biomass resources, smart participants, and policies into an internally strong biofuels sector."

View the Strategic Plan for Biofuels Leadership

www.ncbiotech.org

Golden LEAF Funds Biofuels

North Carolina State University received $1.5 million to design, construct and commission a pilot plant for developing technology to convert biomass easily grown in North Carolina into ethanol. Crops initially targeted for this project include sweet potatoes, switchgrass, and loblolly pine.

Appalachian State University received $750,000 to construct and operate a modular biodiesel testing facility that will provide valuable feedstock, fuel quality, and emissions data to the growing biodiesel industry in the state. This grant will expand the university's existing biofuels and biomass initiative to serve the needs of mid-sized biodiesel producers in North Carolina and further develop a decentralized fuel production model that relies heavily on local feedstocks and fuel markets.

- NC Biotechnology Center

Efficiency: Save Power, Save Money

"The cheapest energy is the energy we waste" - US Energy Secretary

What is energy efficiency?

Energy efficiency is a key component of any strategy to provide a cleaner, sustainable, secure and reliable energy system. Opportunities to increase efficiency can be found everywhere from light bulbs to industrial boilers.

Increased efficiency reduces operating costs, serves as a hedge against rising and volatile fossil fuel prices, and improves the state's economy by reducing our imports of fuels. And, because efficiency measures have so long been neglected in North Carolina due to our state's lower-than-average price of electricity, studies commissioned by the Utilities Commission report that the state could save $1.8 billion between today and 2017 (over 25,000 billion kilowatt-hours) by implementing efficiency measures that cost $0.05/kWh or less.

Analysis of the thermal performance of Tierra I home
Photo Source: NREL PIX

Economic Potential

Efficiency saves money by saving energy. Over the next decade, studies for the North Carolina Utilities Commission report that NC could implement energy efficiency measures costing less than $0.05/kWh that would save:

25,132,000,000 kWh over 10 years, equal to nearly 14% of expected demand in 2017

Industrial Measures

Some recommended industrial efficiency measures include: installing sensors and controls, using advanced lubricants, improving air compressor equipment, motor management, and using advanced motor designs.

Source: Report to the NC Utilities Commission by GDS Associates, Inc.

Industry in North Carolina

Energy efficiency is perhaps the broadest of the technologies in the area of green energy because it includes the use of anything that allows us to accomplish the same goal while using less energy. The obvious first source of efficient products is those that have earned the Energy Star label. Aside from efficient products, a large number of buildings are increasingly becoming energy efficient. Building efficiency is attained partly from use of highly efficient HVAC systems and other equipment, but also from proper design, specially coated windows and the incorporation of solar energy. Educational programs that encourage workers to act efficiently by turning off lights and generally being aware of energy-use reduction opportunities are also increasing.

North Carolina is home to several of the country's leading energy management companies who conduct energy audits and will assist building owners (including local governments) financing energy efficiency improvements with resulting cost savings. Often many of these services begin by simply installing monitors to quantify the amount of energy used and checking billing records for accuracy. Our state is also home to many other opportunities for technology that will enable energy efficiency in all areas of our society. For more information on existing efficiency programs and approved Energy Service Companies, contact the State Energy Office.

Resources

State Energy Office
www.energync.net

Energy Star
www.energystar.gov

Advanced Energy
www.advancedenergy.org

Home Energy Saver
http://hes.lbl.gov

Energy Savers
www.energysavers.gov

American Council for an Energy Efficient Economy
www.aceee.org

American Society of Heating, Refrigerating, and Air-Conditioning Engineers
www.ashrae.org

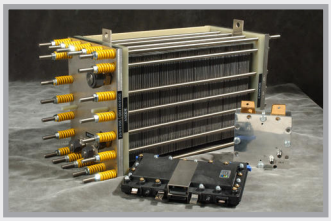
Fuel Cells: The 21st Century Engine

Hydrogen-powered fuel cells may power every device we use in the future

What are fuel cells and hydrogen technologies?

Fuel cells are an electrochemical conversion technology that operate like batteries, with the main difference being that they produce electricity as long as hydrogen fuel is provided. Fuel cells are highly efficient technologies and have been used to power everything from vehicles to buildings to wireless cameras.

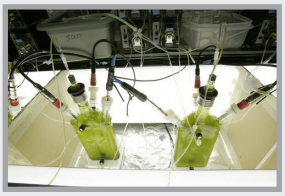
Commercialization and deployment of fuel cells is widely thought to be a long-term necessity for ensuring a secure future powered by clean energy. As an intermittent target for commercialization since their use in the Apollo space missions, both the fuel cell itself and the required infrastructure systems for hydrogen production and delivery will benefit from considerable innovation before penetrating mass markets significantly. Yet, these technologies are currently being applied in specialized markets where they hold unique performance or cost advantages over existing technology.



A collection of fuel stacks with power output from 5 watts to 5 kilowatts
Photo Source: NREL PIX

Industry in NC

Fuel cells have a unique place in our state's economy – they are a natural extension of the state's industrial and technical knowledge assets. Fuel cells are made of plastics, specialized metal coatings, and other engineered materials. This emission-free and highly efficient technology is touted as the all-in-one replacement for turbines, engines and batteries, capable of operating in nearly every niche from large utility-scale power plants to vehicle engines and small electronic devices.



Laboratory production of pure hydrogen from water using green algae
Photo Source: NREL PIX

This industry has been thriving in the state, despite the fact that fuel cell and hydrogen technology is only beginning to emerge as a competitive technology in many markets. Several companies have moved to North Carolina to take advantage of the state's extensive knowledge assets in areas related to fuel cells, and others that have been born and nurtured in-state are growing successfully. Scribner & Associates and INI Power have both moved to the state within the past several years, partly because of our wealth of knowledge in electronics. Other companies such as Microcell and Liquidia Technology have developed novel polymer technologies that could revolutionize the entire fuel cell industry.

Fuel Cell Manufacturing

Fuel cells are full of high-tech materials. Although there are several types of fuel cells, they all require system components such as gas storage tanks, tubing, inverters and other electronic equipment to operate.

Fuel cells generate electric current via a reaction in the membrane. Membrane materials vary depending on the type of fuel cell. The most common membrane is a solid polymer with special properties that block electrons from passing through, providing current.

Materials found in other fuel cell types are often metal-ceramic composites capable of withstanding high temperatures and to varying degrees, impurities in the fuel supply.

Nano- and materials-technology advances hold considerable promise for fuel cell technology. Advances in these areas will decrease production costs, increase fuel cell operating efficiency and bring this emission-free technology into mainstream markets.

Solar: Energy Shines Everywhere

Solar energy can be used for heating buildings, hot water, or for light

What is solar heating and lighting?

Using the sun as a source of heat is an ancient concept employed by the most primitive of societies. In modern times, the sun's energy is used directly to heat and cool buildings, provide indoor lighting, and heat water.

Solar energy is the cheapest form of heat and light available today. When used in buildings, solar heating technologies often feature energy-absorbing materials and appropriate architectural designs. Solar lighting, called daylighting, technologies include efficient windows, skylights, and highly reflective tubes that transfer sunlight to a building's interior. Solar heat is also valuable and efficient for heating water and, while cost-effective for household use, this technology can be highly profitable for commercial and industrial facilities that require large volumes of hot water.

Industry Facts

Market growth in solar water heating is expected to reach 50% between 2006 and 2007.

New solar heating equipment certifications are driving new entrants to the market with the Solar Rating and Certification Corporation receiving 22 applications from new applicants - a 25% increase over last year.

The top 5 solar thermal companies shipped 92% of all solar collectors in 2005.

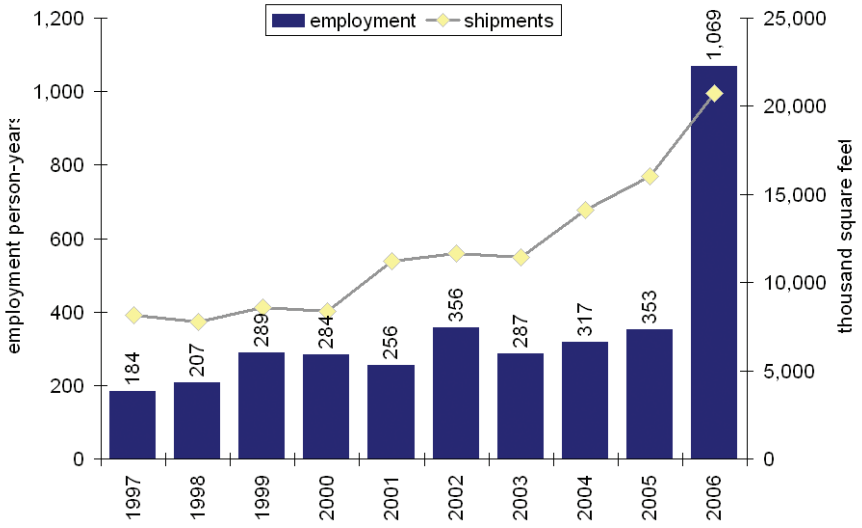
Total shipments in 2005 were valued at nearly $46 million.

Industry in NC

Manufacturing solar heating equipment is concentrated in locations with high solar exposure and strong market demand, such as Arizona and Florida.

In North Carolina, the industry is largely limited to local installers who can determine the optimal location and provide estimates as to the amount of heating available. These installers are often skilled in both plumbing and general building science.

U.S. Solar Thermal Industry, Employment and Shipments



Source: Energy Information Administration, US Dept. of Energy

Solar Heating Equipment

Water Tanks, Heat Exchangers & Plumbing

Solar water heating systems require a specifically designed hot water tank with an integrated heat exchanger equipment that transfers heat from the collector to the water in the tank. The rest of the system is mostly pumps and plumbing - except that this plumbing goes up to the roof.

The collector is the critical component of solar heating systems. Today's collector is much improved over old designs that were basically a box filled with serpentine copper tubes. Today, solar collectors are made of advanced composite plastics prized for their heat absorption capability, feature light-capturing coatings, and are made with automated processes such as extrusion.

Solar Electric: Peak Power via Silicon

"Venture capital is flooding into clean tech and PV companies with promise of third-generation and nanotechnologies." -Solar Energy Industries Association "2006 Year-In-Review"

What is solar electricity?

Solar energy can also be converted into electricity using one of several commercially available technologies. Photovoltaic cells, or solar cells, use semiconductor material imbued or coated with light-absorbing chemicals that convert 'particles' of light into electrons, or electricity. Increasingly common are concentrated solar collectors that focus sunlight onto a small area and use the resulting heat to power a turbine or generator.

Photovoltaic system on the EPA's Research Triangle Park (RTP) facility
Photo Source: NREX PIX

Solar electricity often receives a special mandate in state policies requiring renewable energy use because these technologies' peak electricity production coincides with times of peak demand. Solar electricity technologies are also improving rapidly with increases in efficiency, decreasing costs, and a variety of integrated design options ranging from flexible solar cells for hybrid cars to solar cells camouflaged as roof shingles and other building-integrated products.

Industry in NC

North Carolina is the headquarters of one of the country's leading solar electricity companies – Solargenix LLC (formerly Duke Solar) – but strong incentives, including guaranteed purchases by the local government, supporting growth of solar power markets enticed the company to locate its manufacturing facility in Chicago. Currently, hundreds of DuPont workers research and produce products for solar electricity in the state. Several start-ups are also active with MegaWatt Solar researching a technology similar to that of Solargenix, and research and development company Sencera having secured another round of funding for development of a high-speed manufacturing process for solar cells that the company says could lead to a manufacturing facility. Other opportunities abound for companies serving more mundane component markets, such as wire manufacturing, as exemplified by the successful solar-market entry of Torpedo Specialty Wire of Rocky Mount a few years back.

Economic Potential

Solar photovoltaic installations grew more than 20% in 2006 while manufacturers continued to expand production lines both at home and abroad. The president of NC-based solar energy-startup Sencera told the Charlotte Business Journal that our state is a backwater for the solar industry and, although Sencera would like to stay in North Carolina, the $30 million investment and 50 jobs from their planned production facility are far from a sure thing for the state. The executive director of California-based solar company PowerLight Corp. predicts that the state could reap considerable investment and new jobs from the solar industry – but only if clean energy policies create a local market and utility companies remove barriers to interconnecting solar power with the grid.

In addition to these companies, several other solar start-ups are active in the state developing and refining their technology. These efforts benefit

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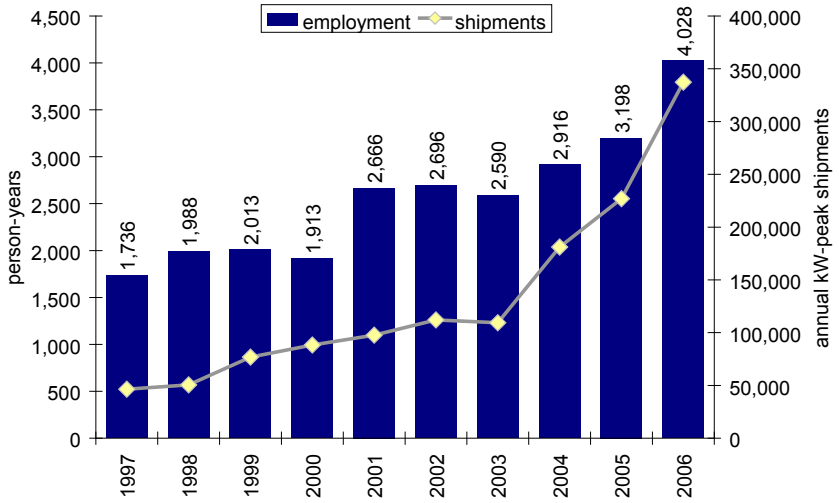
U.S. Photovoltaics Industry, Employment and Shipments



Source: Energy Information Administration, US Dept. of Energy

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from the state's extensive expertise in materials research. For example, researchers at Wake Forest University have been breaking records for efficiency in a new type of solar cell – one made of plastic. Plastic solar cells could revolutionize the solar power industry by providing inexpensive and lightweight solar cells that could be used as a replacement for roof tiles or home siding, integrated into automobiles, airplanes or spacecraft.

Resources

Solar Energy Industries Association
www.seia.org

Solar Electric Power Association
www.solarelectricpower.org

NREL Photovoltaic Research
www.nrel.gov/pv

North Carolina Solar Center
www.ncsc.ncsu.edu

Florida Solar Energy Center
www.fsec.ucf.edu

Industry Facts

US solar electricity installations grew at rate of over 20% in 2006 to 120 MW.

Over 22,000 jobs nationwide and billions in manufacturing investment will come from a growing solar industry.

Solar power relies heavily on building trades such as electricians, roofers, designers and engineers.

There is no national standard for interconnecting solar equipment.

Solar power supply chains remain tight with demand for polysilicon – solar's primary raw material – breaking record highs, and has spurred with new capacity dedicated to the solar industry.

Capital markets are increasingly financing the solar manufacturing expansion through IPOs and secondary equity offerings, and new technologies such as nanotech-based solar are receiving substantial venture investments.

Solar Cell Manufacturing

Balance of System Components

Component	NAICS	NAICS Description
Batteries	335911	Storage Batteries
Blocking Diode	334413	Semiconductors
Charge Controller	335999	Electronic Equipment and Components, NEC
Circuit Breaker	335313	Switchgear and Switchboard Apparatus Man
Inverter	335999	Electronic Equipment and Components, NEC
Meter	334515	Instrument Manufacturing for Measuring and Test
Switch Gear	335313	Switchgear and Switchboard Apparatus Man
Wiring	331422	Copper Wire (Except Mechanical) Drawing

Solar Cell Module

Component	NAICS	NAICS Description
Complete Module	334413	Semiconductors and Related Devices
Solar Cell	334413	Semiconductors and Related Devices
Top Surface	327211	Flat Glass
Encapsulant	325211	Plastic Material and Resin Mfg.
Rear Layer	326113	Unlaminated Plastics Film and Sheet Manufacturing
Electrical Connections	335931	Current-Carrying Wiring Device Manufacturing
Frame	332322	Sheet Metal Work Manufacturing

10 kW PV system installed at Intek Corporation's Aberdeen, N.C. facility
Photo Source: NREL PIX

Wind Turbines: $$$ Blowing Bye

"The U.S. and global wind energy markets are facing wind turbine shortage as demand for wind power continues to increase." - American Wind Energy Association, Wind Power Outlook 2007

What is wind power?

Electricity-generating windmills can provide electricity cheaper than even coal plants in locations with sufficient wind resources. A single modern windmill produces 2,500 kilowatts (kW) of electricity on land and over 3,500 kW offshore – enough to serve the electric needs of 750 average homes. Groupings of turbines, called wind farms, can provide as much electricity as a baseload coal-fired power plant.

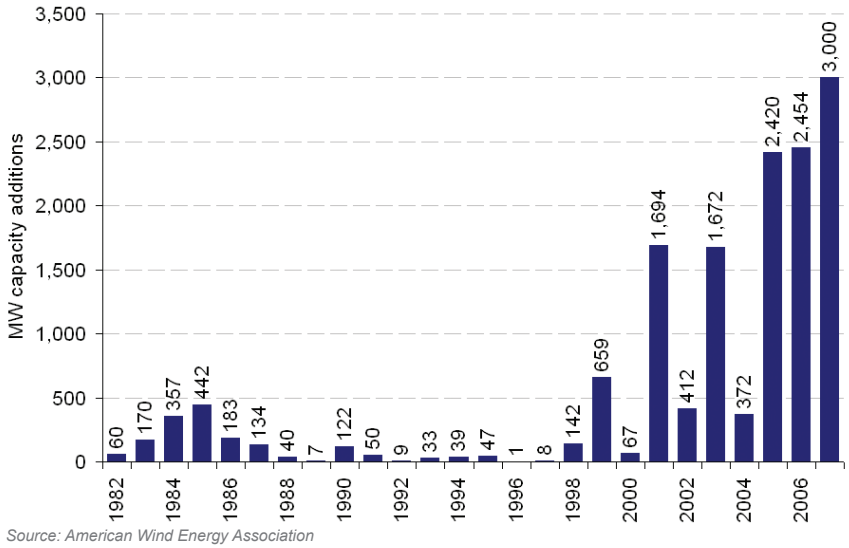
Windmills are simple machines at their core, primarily composed of turbine-generators with extensive gearing and long blades made of reinforced plastics raised on a large steel tower. Wind power has benefited greatly from advances in electronics technology, increasingly detailed information about wind speeds and consistency, as well as from innovations in textile and polymer materials.

Industry in NC

Manufacturing for wind turbines could be a major component of our state's industrial economy. While the turbines and blades are often assembled in their final form at facilities near their end-use site, the production of components and raw materials occurs across the nation.

Wind turbine blades are made of reinforced polymers to maximize their strength and flexibility while minimizing their weight. Several NC-based textile makers serve the wind turbine market, and a new facility was recently announced in Shelby to produce glass fibers for wind turbine blades. Other facilities in the state produce polymers for use in turbine production; and electrical and mechanical components for the turbine assembly are also an obvious fit for the state's economy.

U.S. Annual Wind Generation Capacity Additions



Source: American Wind Energy Association

Economic Potential

Home to the nation's southern-most large-scale wind resources, North Carolina could generate up to 6% of its electricity from wind power – not including potential offshore turbines. Generating power from wind provides emission-free and reliable energy at a price that is not affected by the inflation or market volatility that have plagued fossil fuels of late. Economical wind power offers farmers additional income, county governments increased property taxes, emission-free power, and North Carolinians new jobs.

While the potential to produce electricity from wind is substantial in the state, the broadest potential benefits are found in manufacturing the component parts of wind turbines. **The Renewable Energy Policy Project (REPP) reports that our state could reap nearly 4,900 jobs and $1.55 billion in investment from production of wind turbine components.**

Aside from the blades which are largely made of composite materials, the bulk of the wind turbine is mechanical equipment such as speed changers, motors and generators, roller bearings, circuits, and related power equipment – all areas that are strong in the state's economy. In fact, according to REPP there are currently over 30,000 workers employed in industries that are technically suited to serve the wind industry, determined by NAICS classification.

Resources

Appalachian Small Wind Initiative - *www.wind.appstate.edu*
American Wind Energy Association - *www.awea.org*
World Wind Energy Association - *www.wwindea.org*
National Wind Coordinating Collaborative - *www.nationalwind.org*

The BWC EXCEL is a 10 kilowatt wind turbine designed to supply most of the electricity for an average total electric home in areas with an average wind speed of 12 mph. In remote locations, it can charge batteries for stand-alone applications or pump water electrically without the need for batteries. Simple and rugged, the BWC EXCEL is designed for high reliability, low maintenance, and automatic operation in adverse weather conditions.

Photo Source: NREL PIX

Industry Facts

25% growth in 2007 wind installations to 3,000 MW is projected by AWEA.

About 31 billion kilowatt-hours (kWh) will be generated by wind power in the U.S. in 2007, enough electricity to power the equivalent of nearly 3 million average homes.

Wind turbines cause less than 1 in 10,000 bird fatalities while buildings/windows cause over 5,000 of every 10,000 human-caused bird fatalities.

Wind manufacturing facilities, each employing hundreds of workers now span from Pennsylvania to Iowa and from North Dakota to Louisiana.

GE Energy has facilities in nearby Salem, VA and Greenville, SC.

Wind Turbine Manufacturing

Rotor & Nacelle Components

Component	NAICS	NAICS Description
Blade	326199	All Other Plastics Product Manufacturing
Blade Extender	331511	Iron Foundries
Hub	331511	Iron Foundries
Pitch Drive	335312	Motor and Generator Manufacturing
Anemometer	334519	Other Measuring and Controlling Device Manufacturing
Brakes	333613	Mechanical Power Transmission Equipment Manufacturing
Controller	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
Cooling Fan	333412	Industrial and Commercial Fan and Blower Manufacturing
Nacelle Case	326199	All Other Plastics Product Manufacturing
Nacelle Frame	331511	Iron Foundries
Sensors	334519	Other Measuring and Controlling Device Manufacturing
Yaw Drive	335312	Motor and Generator Manufacturing

Gearbox, Generator & Tower Components

Component	NAICS	NAICS Description
Bearings	332991	Ball and Roller Bearing Manufacturing
Coupling	333613	Mechanical Power Transmission Equipment Manufacturing
Gearbox	333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
High-Low speed shafts	333613	Mechanical Power Transmission Equipment Manufacturing
Generator	333611	Turbine and Turbine Generator Set Units Manufacturing
Power Electronics	335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
Tower	332312	Fabricated Structural Metal Manufacturing
Tower Flange	331511	Iron Foundries

The Renewable Energy 100

A listing of manufacturers serving renewable energy and energy efficiency markets in North Carolina

Biomass & Biofuels Technology

Company Name	Technology	Description	Contact	County
Agri-Ethanol Products, LLC.	Biofuels	Ethanol	www.aepnc.com	Wake
American Distillation, Inc.	Biofuels	Biodiesel	www.americandistillation.net	Brunswick
Biotech Industries, LLC	Biofuels	Biodiesel	704-462-0075	Catawba
Blue Ridge Biofuels	Biofuels	Biodiesel	www.blueridgebiofuels.com	Buncombe
Brevard Biodiesel	Biofuels	Biodiesel	www.brevardbiodiesel.com	Transylvania
Burlington Biodiesel Coop	Biofuels	Biodiesel	www.burlingtonbiodiesel.org	Alamance
Cape Fear Biofuels Coop	Biofuels	Biodiesel	www.capefearbiofuels.com	New Hanover
Carolina Biodiesel	Biofuels	Biodiesel	www.carolinabiodiesel.org	Durham
CF Alternative Energy	Biofuels	Biodiesel	unknown	Forsyth
Cummins Atlantic Inc	Biofuels	Biodiesel	www.cumminsatlantic.com	Wilson
Evans Environmental Energies, Inc.	Biofuels	Biodiesel	www.evansbiodiesel.com	Wilson
Filter Specialty Bioenergy	Biofuels	Biodiesel	www.filter-specialty.com	Cumberland
Foothills Bio-Energies	Biofuels	Biodiesel	www.foothillsbio-energies.com	Caldwell
Gortman Biofuel, LLC	Biofuels	Biodiesel	336-731-2599	Davidson
High Country Biofuels	Biofuels	Biodiesel	highcountrybiofuels.googlepages.com	Watauga
Nature Fuels, LLC	Biofuels	Biodiesel	704-414-6604	Mecklenburg
NC Zoo	Biofuels	Biodiesel	www.nczoo.org/biofuels/index.cfm	Randolph
NewGen Technologies	Biofuels	Biodiesel	www.newgenholdings.com	Mecklenburg
North Carolina Biofuels, LLC	Biofuels	Biodiesel	252-589-8280	Northampton
Novozymes	Biofuels	Ethanol	www.novozymes.com	Franklin
Piedmont Biofuels Industrial, LLC	Biofuels	Biodiesel	www.biofuels.coop	Chatham
Smoky Mountain Biofuels	Biofuels	Biodiesel	www.smokymountainbiofuels.com	Jackson
Southeast Biodiesel	Biofuels	Biodiesel	sebd.biz/index.html	Mecklenburg
Triangle Biofuel Industries, Inc.	Biofuels	Biodiesel	www.trianglebiofuels.com	Wake
Woodleaf Biodiesel	Biofuels	Biodiesel	www.woodleafbiodiesel.com	Rowan
Xethanol	Biofuels	Ethanol	www.xethanol.com	Nash
BioEnergy Conversion, LLC	Biogas	Waste conversion	www.bioenergyconversion.com	Stanly
DTE Biomass	Biogas	Landfill Gas	www.dtebe.com	Forsyth
Duke Engineering Services	Biogas	Anaerobic Digesters	www.dukeengineering.com	Mecklenburg
Ingersoll-Rand Co	Biogas	Anaerobic Digesters	www.energy.ingersollrand.com	Mecklenburg
Orbit Energy Inc.	Biogas	High-solids anaerobic digestion	www.orbitenergyinc.com	Wake
Decker Industries (Craven Wood)	Biomass	Wood waste combustion	www.ccwe.net	Craven
Fibrowatt	Biomass	Poultry waste combustion	www.fibrowattusa.com	Wilkes
Grain BioEnergy Systems Inc.	Biomass	Crop residue combustion	www.grainbioenergy.com	Henderson

Efficiency Technology

Company Name	Technology	Description	Contact	County
A&H Windows and Doors	Efficiency	ENERGYSTAR manufacturing partner	www.ahwindows.com	Wilkes
Acme Electric Corp.	Efficiency	ENERGYSTAR manufacturing partner	www.acmeelec.com	Robeson
Advanced Energy Corp.	Efficiency	Efficiency research, programs	www.advancedenergy.org	Wake
Aldo Products Co.	Efficiency	ENERGYSTAR manufacturing partner	www.aldoproducts.com	Cabarrus
Atrium Windows & Doors	Efficiency	ENERGYSTAR manufacturing partner	www.atrium.com	Davidson
Chloride Systems	Efficiency	ENERGYSTAR manufacturing partner	www.chloridesys.com	Pender
Cree	Efficiency	Solid-state lighting	www.cree.com	Durham
Crosley Corporation	Efficiency	ENERGYSTAR manufacturing partner	www.crosley.com	Forsyth
Eaton Corp	Efficiency	ENERGYSTAR manufacturing partner	www.eaton.com	Wake
EverGlow Inc.	Efficiency	ENERGYSTAR manufacturing partner	www.everglow.com	Iredell
Jobbers	Efficiency	ENERGYSTAR manufacturing partner		Forsyth
Lenovo Corp.	Efficiency	ENERGYSTAR manufacturing partner	www.lenovo.com	Wake
Lowe's	Efficiency	ENERGYSTAR manufacturing partner	www.lowes.com	Wilkes
Moss Supply Co.	Efficiency	ENERGYSTAR manufacturing partner	www.mosssupply.com	Mecklenburg
NC Foam Industries	Efficiency	ENERGYSTAR manufacturing partner	www.ncfi.com	Surry
Sci-Cool	Efficiency	ENERGYSTAR manufacturing partner	www.scicool.com	Buncombe
Stock Building Supply	Efficiency	ENERGYSTAR manufacturing partner	www.stockbuildingsupply.com	Wake
Sunlife Systems International, Inc.	Efficiency	ENERGYSTAR manufacturing partner	www.sunlifesystems.com	Mecklenburg
Union Corrugating Co.	Efficiency	ENERGYSTAR manufacturing partner	www.unioncorrugating.com	Cumberland
US Greenfiber, Inc.	Efficiency	ENERGYSTAR manufacturing partner	www.us-gf.com	Mecklenburg

Electric Component Technology

Company Name	Technology	Description	Contact	County
Command Mobility	Electric	Electric vehicles and components	www.commandmobility.com	Macon
Douglas Battery	Electric	Batteries	www.douglasbattery.com	Forsyth
Energy Control Systems Co	Electric	Electric controls	www.energycontrolsystems.com	Wake
Majorpower Corp	Electric	Inverters	www.majorpower.com/corp	Alamance
Progressive Technologies	Electric	Batteries	www.protechnologies.com	Surry
Saft America	Electric	Batteries	www.saftbatteries.com	Burke
Wilmore Electronics Co Inc	Electric	Inverters	www.wilmoreelectronics.com	Orange

Fuel Cell Technology

Company Name	Technology	Description	Contact	County
AVRNC, Inc.	Fuel Cell	Vehicular testing and development	www.avrnc.com	Haliax
C3 International	Fuel Cell	Nano-scale coatings	www.cccintl.com	Iredell
DuPont Fuel Cells	Fuel Cell	Polymer membrane	www.fuelcells.dupont.com	Bladen
IdaTech	Fuel Cell	Fuel cell systems, sales rep. in state	www.idatech.com	
INI Power	Fuel Cell	Fuel cell systems,electronics	www.inipower.com	Wake
Jadoo Power	Fuel Cell	Fuel cell systems, electronics	www.jadoopower.com	Wake
JMC, Inc.	Fuel Cell	Metal hydrides	www.jmcusa.com	Durham
John Deere	Fuel Cell	Fuel cell systems, utility vehicles	www.johndeere.com	Mecklenburg
Lambda Technologies	Fuel Cell	Polymer membrane	www.microcure.com	Iredell
Lift-One	Fuel Cell	Fuel cell-powered forklifts	www.carolinacat.cat.com	Mecklenburg
Liquidia Technologies	Fuel Cell	Polymer membrane	www.liquidia.com	Orange
Microcell Corp	Fuel Cell	Polymer membrane	www.microcellcorp.com	Wake
NTDA Energia	Fuel Cell	Research, application development	www.ntdaenergia.com	Wake
Porvair Fuel Cell Systems	Fuel Cell	Composite backing plates	www.porvairfuelcells.com	Henderson
Scribner Associates Inc	Fuel Cell	Testing equipment and software	www.scribner.com	Moore

Solar Electric & Heating Technology

Company Name	Technology	Description	Contact	County
Delta Group	Solar Electric	Research	www.delta-corp.com	Wake
DuPont Tedlar	Solar Electric	Photovoltaic panels	www2.dupont.com/Photovoltaics/en_US	Cumberland
Kyma Technologies	Solar Electric	Research semiconductor substrates	www.kymatech.com	Wake
MegaWatt Solar	Solar Electric	Concentrated solar power	www.megawattsolar.com	Orange
SBM Solar	Solar Electric	Solar module assembly	www.sbmsolar.com	Cabarrus
Sempruis	Solar Electric	Flexible electronics	www.semprius.com	Durham
Sencera	Solar Electric	Processing research	www.sencera.com	Mecklenburg
SolarGenix, LLC	Solar Electric	Concentrated solar power	www.solargenix.com	Wake
Torpedo Specialty Wire	Solar Electric	Wire for PV modules	www.torpedowire.com	Nash
Enertia Building Systems Inc	Solar Heating	Integrated passive solar buildings	www.enertia.com	Franklin
SolarH2Ot	Solar Heating	Manufacturer	www.solarh2ot.com	Wake
SolarHero.com	Solar Heating	Manufacturer, Installer	www.solarhero.com	Surry
SunQest Inc	Solar Heating	Manufacturer, Installer	www.sunquest.com	Catawba

Wind Technology

Company Name	Technology	Description	Contact	County
3Tex	Wind	Textiles for turbine blade manufacture	www.3tex.com	Wake
ABB, Inc.	Wind	Wind components	www.abb.com	Wake
Alleghany Technology (ATI)	Wind	Iron castings	www.alleghenytechnologies.com	Union
American Superconductor	Wind	Turbine generator electronics	www.amsuper.com	Wake
BGF Industries	Wind	Textiles for turbine blade manufacture	www.bgf.com	Guilford
Keydon Bearings	Wind	Bearings	www.kaydonbearings.com	Davie
PPG	Wind	Glass fiber reinforcement for turbine blades	www.ppg.com	Davidson
Precision Fabrics	Wind	Textiles for turbine blade manufacture	www.precisionfabrics.com	Guilford

Other

Company Name	Technology	Description	Contact	County
Carolina Solar Energy	Other	Utility-scale installation	919-489-1656	Wake
ec systems	Other	Carbon nanotubes	unknown	Pender
NanoTechLabs, Inc.	Other	Nano-scale conductors	www.nanotechlabs.com	Yadkin
Research Triangle Institute	Other	Research	www.rti.org	Wake
Southern Research Institute	Other	Research, incl. carbon-2-liquids	www.southernresearch.org	Durham
EPRI	Other	Electric power research	www.epri.com	Mecklenburg

Solid Biomass (wood) chips can be converted to a dark brown viscous liquid (shown here) by a process known as pyrolysis. In this process heat is applied to the biomass very rapidly in the total absence of oxygen. This is typically carried out in fluidized beds with an inert gas used as the fluidizing medium. Liquid yields of up to 70 wt% have been demonstrated under optimum process conditions. The bio-oil liquid can be used in fuel applications in addition to extracting useful chemical compounds.
Photo Source: NREL PIX

Economic Development Tools

Renewable Energy Equipment Manufacturer's Tax Credit

Manufacturers of renewable energy equipment may claim a tax credit equal to 25% of the construction and equipment cost for a facility that produces renewable energy equipment. Credit has no maximum limit, and may be carried forward for up to 5 years.

expired

Clean Fuel Advanced Technology (CFAT)

Provides grants of up to $150,000 in 2007 for projects that reduce mobile air emissions. Eligible projects include alternative fuel vehicles, renewable fuel infrastructure, idle reduction technologies, and hybrid buses. This 3-year grant program is managed by the NC Solar Center and offers more information at www.ncmobilecare.org.

Biodiesel Production Tax Credit

Starting January 1, 2008, biodiesel producers making over 100,000 gallons per year are eligible to claim a tax credit equal to the per gallon excise tax the producer paid on the biodiesel portion of fuel blends not to exceed $500,000.

Alternative Fuel Production Tax Credit

A tax credit may be claimed by producers of biodiesel or ethanol (70% ethanol blend or greater) for 25% of the construction and equipment cost of the facility. Or, a 35% credit may be claimed by producers with 3 processing facilities, a total investment of at least $400 million, and be in service before January 1, 2011.

Alternative Fuel Refueling Infrastructure Tax Credit

Qualified refueling facilities providing biodiesel or ethanol blends of at least 70% ethanol may claim a tax credit equal to 15% of the construction and equipment cost of equipment used directly and exclusively for biofuels distribution. Credit must be claimed in 3 equal annual installments on facilities placed in service before January 1, 2011.

Alternative Fuel Tax Exemption

The retail sale, use, storage or consumption of alternative fuels is exempt from the state retail sales and use tax.

Biodiesel Requirement for School Buses

Every school bus that is capable of operating on diesel fuel must be capable of operating on diesel fuel with a minimum content of 20% biodiesel (B20). Furthermore, at least 2% of the total volume of fuel purchased annually by local school districts statewide for use in diesel school buses must be a minimum of B20, to the extent that biodiesel blends are available and compatible with the technology of the vehicles and the equipment used.

Active Solar Heating and Cooling Systems Exemption

Limits property tax valuation of solar heating systems to that of a comparable conventional system. Applies to residential, commercial and industrial sectors.

Energy Improvement Loan Program

Low-interest loans in amounts up to $500,000 are available through the State Energy Office to commercial, industrial, nonprofit, schools, and local government sectors for energy efficiency improvements (3% APR) or installation of renewable energy equipment (1% APR).

NC Green Power Production Incentive

Program offers payment per-kWh to producers of electricity generated from renewable sources. Program receives voluntary payments from consumers and pays a premium to producers of green energy.

Renewable Energy Tax Credit - Corporate

Commercial and Industrial facilities can claim a tax credit for the construction of a renewable energy facility equal to 35% of the installed cost. Taken in 5 annual installments (annual limit of 50% of taxpayer liability) with a maximum value of $2.5 million per installation.

Steam Trap Rebate Program

The Steam Trap Survey Rebate Program provides steam trap survey services to facilities that use steam for heating or processing. Participants receive funding per steam trap enrolled with a maximum incentive of $6,500.

For more incentive information

Database of State Incentives for Renewable Energy (DSIRE)
www.dsireusa.org
US DOE Alternative Fuels Data Center
www.eere.energy.gov/afdc

Where to go for more information...

North Carolina Resources

NC State Energy Office
www.energync.net

NC Solar Center
www.ncsc.ncsu.edu

NC A&T CERT
cert.ncat.edu

Appalachian State Energy Center
www.energy.appstate.edu

Duke University School of the Environment
www.nicholas.duke.edu

UNC-Chapel Hill Institute for the Environment
www.ie.unc.edu

NC State Animal and Poultry Waste Management Center
www.cals.ncsu.edu

Central Carolina Community College, Biofuels Curriculum
www.cccc.edu

Cape Fear Community College
energy.cfcc.edu

NC Small Wind Initiative
www.wind.appstate.edu

Triangle J Clean Cities Coalition
www.trianglecleancities.org

Centralina Clean Fuels Coalition
www.4cleanfuels.com

NC Biotechnology Center
www.ncbiotech.org

NC Green Power
www.ncgreenpower.org

National Resources

US Dept. of Energy, Energy Efficiency & Renewable Energy
www.eere.energy.gov
National Renewable Energy Laboratory
www.nrel.gov
Renewable Energy Policy Project
www.repp.org
American Wind Energy Association
www.awea.org
Solar Energy Industries Association
www.seia.org

US Fuel Cell Council
www.usfcc.com
American Council for an Energy Efficient Economy
www.aceee.org
National Biodiesel Board
www.biodiesel.org
Renewable Fuels Association
www.ethanolrfa.org
Chicago Climate Exchange
www.chicagoclimatex.com

Appalachian State University Energy Center
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Boone, NC 28608-2131

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