# Tennessee's Advanced Energy Asset Inventory

## Edition 1
## Energy Efficiency, Renewable Energy And Energy Management

Tennessee Advanced Energy Business Council
in partnership with the Tennessee Energy Education Initiative

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Tennessee Advanced Energy Business Council

TENNESSEE ENERGY EDUCATION INITIATIVE
*Power. Positive. Progress.*

Pathway Lending

# Acknowledgements and Disclaimers

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# Foreword

**Tom Ballard**, *President, Tennessee Advanced Energy Business Council*

Tennessee's Advanced Energy Asset Inventory is the first document of its kind dedicated to promoting the use of advanced energy technologies and assisting the development of Tennessee businesses in the emerging advanced energy sector. Produced by the Tennessee Advanced Energy Business Council, the inventory is a product for the Tennessee Energy Education Initiative's online resource center, a public-private partnership that includes the Tennessee Department of Environment and Conservation, Pathway Lending and the U.S. Department of Energy. We are grateful for the Tennessee Energy Education Initiative's support of this project.

The Tennessee Advanced Energy Business Council was created to champion advanced energy technologies and, through the adoption of these technologies, contribute to the growth of the state's economy. The Council does not endorse specific technologies. Rather, through efforts to educate public officials and business leaders about a growing volume of Tennessee's advanced energy assets, the Council seeks to lay the foundation for partnerships that link these assets with opportunities to incorporate an array of new technologies, lower energy costs, and in the process generate new companies and new jobs for the state's advanced energy sector.

The Tennessee Advanced Energy Asset Inventory is a snapshot of assets that by their nature can change rapidly in response to innovations and market forces. This first edition focuses upon assets related to Energy Efficiency, Renewable Energy and Energy Management. The inventory contains an extensive, but not exhaustive, overview of advanced energy assets that together reflect an economic sector that has witnessed substantial growth in Tennessee over the last decade. In addition to established companies, these assets include cutting-edge research and development that, when linked with a variety of entities dedicated to helping entrepreneurs turn innovations into companies, offer what promises to be an exciting future for Tennessee's advanced energy economy.

In much the same way that today's energy economy would have been difficult to envision a decade ago, we are limited in our ability to predict the road that lies ahead. New technologies such as battery storage and carbon fiber are but two of the advanced energy technologies that lie just over the horizon with the potential to play a lasting role in the State's economic development. With these and other technologies in mind, we hope that this asset inventory will be only the first of more to come.

# About Us

## About the Tennessee Energy Education Initiative

The Tennessee Energy Education Initiative provides training, tools, and local events to help organizations in Tennessee take control of their energy usage. By connecting Tennesseans with the right resources, expertise, peer experience, and potential funding options, the Tennessee Energy Education Initiative provides a roadmap to successfully navigate the energy landscape.

The Tennessee Energy Education Initiative is sponsored by the Tennessee Department of Environment and Conservation's Office of Energy Programs, Pathway Lending, and other statewide energy resource providers. Funding is provided by the U.S. Department of Energy through the American Reinvestment and Recovery Act.

For more information visit: **tnenergy.org**.

## About the Tennessee Advanced Energy Business Council (TAEBC)

The Tennessee Advanced Energy Business Council champions advanced energy as a job creation and economic development strategy. No other entity in the State concentrates specifically on this robust sector.

TAEBC educates public officials and business leaders about Tennessee's advanced energy assets, establishes strategic partnerships to connect assets with opportunities, and informs policy that expands and strengthens the industry.

We ultimately seek to translate corporate interest in sustainability into Tennessee jobs.

Rather than favoring specific technologies, advanced energy is inclusive in nature and characterized by the benefits it provides in the field and in the marketplace. Electric and plug-in hybrid cars, lightweight composites for the automotive industry, natural gas fueled trucks, pollution control equipment, bio energy, high-performance buildings, more efficient industrial processes, power reliability and the latest wind, solar, and nuclear technologies—all are advanced energy, using energy more productively, diversifying energy sources, and reducing health and environmental costs. For more information visit: **tnadvancedenergy.com**.

# Introduction

The Tennessee Advanced Energy Asset Inventory is designed to provide information about the State's advanced energy industry. The report highlights the growing sector of Tennessee's economy characterized by the manufacture, research, installation, service and use of new advanced energy technologies.

Developed in partnership with the Tennessee Energy Education Initiative for its online resource center, the first edition of the Tennessee Advanced Energy Asset Inventory examines the State's traditional clean energy assets of renewable energy, energy management and energy efficiency. Future editions will examine other aspects of Tennessee's advanced energy sector, including opportunities to leverage the State's assets in support of economic growth.

This document includes an overview of research institutions, economic development organizations, and programs in Tennessee that together represent the State's inventory of energy-related assets. The assets listed represent a compilation derived from a variety of publically available sources, including State and federal government reports, energy-related organizations and trade associations, and media coverage of energy programs. Due to the entry each year of new companies and new programs, the lists are not exhaustive. They do, however, form the foundation for continued growth of the design, manufacture, installation and service of advanced energy technologies.

As a complement to energy generation assets, Tennessee's energy inventory also includes a growing effort to reduce energy consumption. The desire by the residential, industrial, commercial and public sectors to achieve greater energy efficiency is motivated by both cost and concerns about the State's air quality. Strategies to reduce energy use include a combination of tax incentives, the adoption of renewable energy alternatives, the alignment of existing technologies to address energy needs, and the process of moving a number of innovative technologies from the laboratory to the market.

The report's inventory of assets for energy generation and efficiency is accompanied by a sampling of innovations at the State's research institutions with potential to transform the advanced energy sector. These innovations hold promise for increasing energy efficiency, reducing carbon emissions, and expanding Tennessee's manufacturing sector. A variety of organizations dedicated to promoting both the State's energy economy and assisting entrepreneurs in the creation of new energy-related companies are included in the inventory.

# Tennessee's Advanced Energy Industry

The advanced energy industry includes the manufacture, distribution, installation and service of products designed to diversify energy sources, mitigate pollution, and reduce greenhouse gas emissions. This report focuses on the renewable energy, energy efficiency and energy management sectors. In Tennessee the industry also includes a substantial research and development sector dedicated to enhancing the potential to expand the integration of advanced energy into the State's economy. Using this definition of "advanced energy technology," the industry represents a diverse workforce that includes scientists exploring new techniques to produce biofuels, workers manufacturing electric car batteries, and technicians installing solar panels. (In this report, the terms used by separate studies for "green jobs" and "clean jobs" are considered interchangeable.)

The absence of a universally accepted definition of clean or advanced energy jobs presents a challenge to efforts to measure the industry in every state, including Tennessee. Two surveys, for example, conducted in 2010 by the Brookings Institute[i] and the Tennessee Department of Labor and Workforce Development[ii] estimated the number of "clean jobs" in Tennessee at 76,000 and 44,000, respectively. Additionally, the presence of advanced energy technology jobs in existing industries and supply chains is not always captured by data surveys. Both factors contribute to the lack of a comprehensive central data source to receive and distribute data on the advanced energy industry. Despite these limitations, the following tables represent a combination of studies that together provide a reasonable estimate of the advanced energy technology jobs in Tennessee.

**Table 1: Tennessee Department of Labor Green Jobs Estimates, 2010[iii]**

| Green Jobs Category | Number of Jobs | Percent of All Green Jobs |
|---|---|---|
| Energy Efficiency | 8,966 | 20% |
| Sustainable Transportation | 5,839 | 13% |
| Green Manufacturing | 5,446 | 12% |
| Recycling & Waste Reduction | 5,174 | 12% |
| Environmental Protection | 4,798 | 11% |
| Green Construction | 4,106 | 9% |
| Renewable Energy | 3,539 | 8% |
| Research & Development | 3,136 | 7% |
| Agriculture and Forestry | 1,651 | 4% |
| Governmental and Regulatory Administration | 1,149 | 3% |
| **Total** | **43,804** | **100%** |

The Brookings Institution's 2010 study entitled Sizing the Clean Economy contained a broad definition of a clean technology job, including all employment in "the sector of the economy that produces goods and services with an environmental benefit." Using this broad definition, Brookings estimated the presence in Tennessee of approximately 76,000 clean technology jobs. At 2.8 percent of the statewide workforce, the total was the sixth-highest concentration of clean technology jobs in the country.

In Table 2, a closer look at Tennessee's advanced energy technology jobs indicates that 44 percent are found in Greenhouse Gas Reduction, Environmental Management, and Recycling, a category that includes waste collection and recycling and—unique among most states—a multi-billion dollar environmental remediation project in Oak Ridge funded by the Department of Energy to remove legacy wastes generated at nuclear facilities during the Manhattan Project and the Cold War. While the decontamination and demolition efforts in Oak Ridge have a clear environmental benefit, much of the work, including security and other support personnel, would not fall within more conventional definitions of "advanced energy technology jobs."

In the Brookings study, Tennessee's second-largest clean technology category is Energy and Resource Efficiency, containing approximately 25,800 jobs. The segments with the most jobs in this category were Professional Energy Services (8,400), HVAC and Building Control Systems (6,800), Appliances (3,500) and Energy-saving Building Materials (3,100).

The Renewable Energy category comprised approximately 3,600 jobs, found primarily in the Hydropower (2,200) and Solar Photovoltaic (1,000) categories.

Additional segments that often fall within the category of "advanced energy technology" were generally small but growing in Tennessee. The Electric Vehicle Technologies segment increased from no jobs in 2003 to 184 jobs in 2010. Wind increased from none to 209, and Biofuels/Biomass increased from 15 to 70 during the same period.

**Table 2: Brookings Clean Jobs Estimates, 2010[iv]**

| Category | Number of Jobs | Percent of TN Advanced Energy Economy |
|---|---|---|
| Greenhouse Gas Reduction, Environmental Management, and Recycling | 33,411 | 20% |
| Energy and Resource Efficiency | 25,794 | 13% |
| Education and Compliance | 7,700 | 12% |
| Agricultural and Natural Resources Conservation | 5,544 | 12% |
| Renewable Energy | 3,582 | 11% |
| **Total** | **76,031** | **100%** |

The most dramatic job growth in clean jobs occurred in the categories of professional energy services and regulatory compliance.

| Table 3: Tennessee's Fastest Growing Clean Energy Sectors, 2003-2010[v] | | |
|---|---|---|
| **Segment** | **Jobs 2010** | **Job Change 2003-2010** |
| Professional Energy Services | 8,415 | 8,123 |
| Biofuels/Biomass | 70 | 55 |
| Green Architecture and Construction | 416 | 312 |
| Regulation & Compliance | 7,699 | 5,277 |
| Air and Water Purification Technologies | 216 | 145 |
| **Total** | **76,031** | **100%** |

# A Growing Renewable Sector

A steady expansion of renewable jobs is a discernible trend in Tennessee's advanced energy technology industry.

## Solar Energy

Tennessee's potential for solar power generation is roughly 80 percent that of states such as Arizona and Nevada, providing the potential for expansion of the solar industry.[vi] Tennessee's current solar energy industry was not fully represented in the 2010 data. Indeed, since 2009 the solar industry's growth in Tennessee is to a large extent the product of focused efforts by the State of Tennessee, the Tennessee Valley Authority, Oak Ridge National Laboratory and the University of Tennessee to cultivate the solar industry as a means of both reducing fossil emissions and creating the foundation for long term growth of the solar sector in the advanced energy technology industry.

According to the 2012 National Solar Jobs Census released in November of 2012, Tennessee is home to 125 businesses in the solar manufacturing, installation, sales and distribution, project development and "other" sectors.[vii] The largest sectors in Tennessee's solar supply chain are installation companies (57) and manufacturers (31), according to the census.

Despite the success of Tennessee's solar value chain, the production of polysilicon used for the manufacture of solar panels has been vulnerable—as in many states—to global forces that on occasion have provided unanticipated challenges. While dozens of solar companies have been started in Tennessee over the last decade, two major investments have been put on hold pending the stabilization of world markets for polysilicon. Meanwhile, severe fluctuations in European demand and Chinese supply of polysilicon have been balanced to some extent by a parallel decline in the cost of solar equipment and installation, leading to an increase in consumer demand for the solar industry in Tennessee. Signal Energy of Chattanooga has expanded from a startup in 2005 to a business with 125 employees and annual revenues of more than $100 million.[viii] Similarly, since the company's founding in 1996 Shoals Technologies Group of Portland has become one of the State's largest companies to provide balance of system components for the solar industry.[ix]

As of June 2013, Tennessee had 47 megawatts of solar capacity either in operation or committed for construction at approximately 1,400 locations.[x] The State of Tennessee has promoted renewable technologies through the Volunteer State Solar Initiative, funded by the U.S. Department of Energy. The 5 megawatt West Tennessee Solar Farm in Haywood County, one of the Southeast's largest

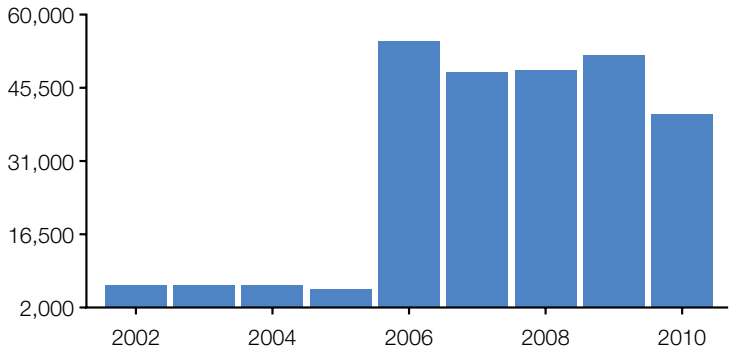
solar installations,[xi] is a demonstration and education project that distributes power through TVA and the Chickasaw Electric Cooperative, and is operated by the University of Tennessee. A second program, the Tennessee Solar Institute, funded the installation of more than seven megawatts of solar power to more than 150 businesses and supported the development of the State's solar business supply chain.[xii]

## Wind Energy

A relatively small amount of wind power is generated in Tennessee. TVA's existing wind power site is located on Buffalo Mountain near Oak Ridge, with 15 large turbines and three smaller ones. Owned by Invenergy, the wind farm has a capacity of 29 megawatts, enough to power approximately 3,800 homes.[xiii]

As of July 2013, TVA had nine contracts to import 1,515 megawatts of wind power from the Midwest.[xiv] Pending the outcome of discussions about additional purchases, wind power's relative position in Tennessee's energy portfolio could increase over the next decade. Whether and how much Tennesseans increase their consumption of wind power will depend upon a number of policy decisions, some to be resolved by TVA and others by external stakeholders who will evaluate the construction of power lines needed to transport wind power to Tennessee.

**Electricity Generation in Tennessee from Wind 2002 – 2010[xv]**
(million kWh)




Clean Line Partners of Houston, Texas, has entered a memorandum of understanding with TVA to deliver wind power from Kansas, Oklahoma and Texas to Tennessee. Prior to completing what would be America's largest power transmission line, the $2 billion proposal must receive an environmental impact evaluation from the U.S. Department of Energy as well as right of way approval through Arkansas. The project's first phase is proposed to deliver 3,500 megawatts, comparable to the energy consumption of one million homes. How much of this power would eventually come to Tennessee, and at what cost, are decisions yet to be determined by TVA. Clean Line estimates the project would provide more than 5,000 construction jobs and 500 permanent jobs maintaining and operating the wind farms and the transmission line.[xvi]

## Bioeconomy

A study conducted by the University of Tennessee concluded the State has the potential

to produce more than a billion gallons of ethanol on an annual basis, a volume capable of replacing 30 percent of the State's current petroleum consumption.[xvii] A combination of efforts by the Department of Energy, the State of Tennessee, the Memphis BioWorks Foundation and private industry has laid the foundation for the development of biofuels as a significant sector in Tennessee's clean energy economy.

Many of the components are in place to sustain a biofuels industry in Tennessee. In 2007, the state legislature appropriated $70.5 million for the University of Tennessee Biofuels Initiative. The approach has been comprehensive. Multi-year contracts with farmers helped establish a dedicated energy crop with 5,000 acres of switchgrass, a product that can produce 6-8 tons per acre on marginal land. The goal is to develop and commercialize cellulosic biofuels, which researchers view as a viable way to produce affordable alternatives to fossil fuels without raising food or feed costs. A partnership with Oak Ridge National Laboratory is dedicated to improving technologies used to create cellulosic ethanol and reduce the costs of biofuels production.[xviii]

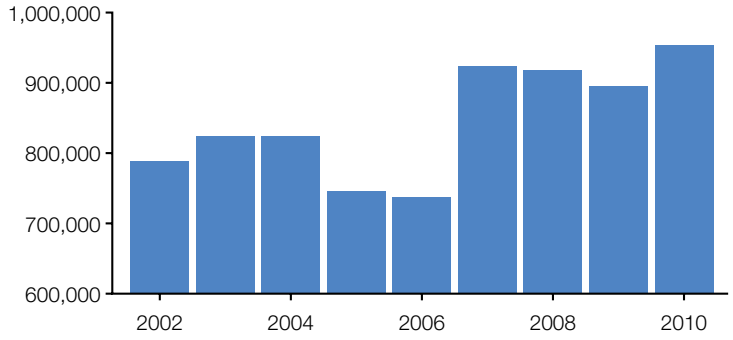
After the Biofuels Initiative funds expired in June 2012, two companies were formed to carry on the initiative's vision. Genera Energy provides integrated, commercial biomass supply solutions for the advanced biofuels, biopower, and biobased products industries,[xix] while TennEra provides general research and development focused on technologies and processes for biomass fractionation, or separating cellulosic biomass components and commercial application of biorefinery co-products.[xx]

One of Tennessee's most valuable biofuel assets is the Biomass Innovation Park research campus, located in Vonore, Tennessee. Genera designed and built the Biomass Innovation Park to be the country's leading research and development facility for demonstrating and optimizing the feedstock supply chain.[xxi] In operation since 2011, and operated exclusively by Genera Energy, the Biomass Innovation Park is the only commercial facility operating today that can perform all the processes and steps necessary to bridge the farm gate and the biorefinery gate, ranging from biomass receiving and inventory management to size reduction and characterization.

A second major biofuels asset is the BioEnergy Science Center, located at Oak Ridge National Laboratory and funded by the Department of Energy. Established in 2007 with a research budget of $25 million annually, the Center works closely with the University of Tennessee and is dedicated to accelerating research toward the development by 2017 of advanced biofuels that can be produced at $3.00 per gallon. Breakthroughs in "cellulosic recalcitrance," or the ability of cells to resist the creation of sugars used in making biofuels, would greatly reduce the cost of biofuels production and likely lead to a sharp rise in consumer demand for biofuels.[xxii]

Also supporting the Tennessee bioeconomy is the Southeast SunGrant Center located at the University of Tennessee and funded by the U.S. departments of Agriculture, Energy and Transportation. The SunGrant Initiative's mission is to revitalize rural communities with land-grant university research, education, and extension programs that focus on renewable energy and biobased, non-food industries.

**Electricity Generation in Tennessee from Biomass 2002 – 2010**[xxiii]
(million kWh)




Memphis Bioworks Foundation, through its focus on bioscience commercialization, has been a major catalyst for business led approaches to commercializing advanced biofuels, biomass feedstocks, and biobased products across Tennessee and the Mid-South region.

## These activities include:

**A partnership with Northwest Tennessee Entrepreneur Center** to establish the NextFarm Agricultural Innovation Accelerator focuses on commercializing early stage agricultural companies including those related to advanced biofuels, biomass feedstocks and biobased products. NextFarm leverages the resources and support of the University of Tennessee at Martin. The program includes mentorship from companies such as Monsanto's bioenergy group and Abengoa Bioenergy.

**Development of Ag Innovation Development Group, Inc.,** a private company focused on commercializing early stage research including biofuels and industrial biotechnology. Partnership with farmers and private industry in the establishment of other startup companies that are commercializing new biomass feedstocks for biofuels and biobased products. These include:

- **BioDimensions Renewable Oils, LLC**, based in Ripley, is introducing new varieties of winter oilseeds as feedstocks for advanced biofuels and biobased products. The company is coordinating farm scale production plots in West Tennessee, as well as pursuing breeding program development for new varieties that are tailored for the region.

- **Delta BioRenewables LLC**, based at Agricenter International, is commercializing sweet sorghum and energy beets as feedstocks for producing advanced biofuels and chemicals. The company operates the nation's only pilot scale processing facility and the largest producer of sweet sorghum. Delta BioRenewables is coordinating testing of new varieties in partnership with international seed companies for deployment in the U.S. and Brazil.

In addition to cellulosic ethanol, Tennessee is home to both corn ethanol and biodiesel plants. Two commercial plants produce corn ethanol. Green Plains Renewable Energy operates a 120 million gallon ethanol plant in Obion County.[xxiv] Tate & Lyle operate a 105 million gallon ethanol plant in Loudon.[xxv] Biodiesel firms include Green Gallon Solutions in Cookeville and Sullens Biodiesel in

Morrison. Each company produces approximately two million gallons of biodiesel fuel annually.

As of May 2013, there are 34 E85 ethanol pumps and 23 B20 biodiesel pumps open to the public in Tennessee that give citizens and travelers renewable fuel options across the state.[xxvi] The Tennessee Department of Transportation maintains a map of publically accessible E85 and B20 stations.

Tennessee is also building infrastructure to support natural gas as an alternative transportation fuel. The Tennessee NGV Task Force was formed to enable this transition and maintains a map of fueling stations and other resources about compressed natural gas (CNG) and natural gas vehicles on its website.[xxvii] Two companies that are building natural gas fueling stations in Tennessee include PBG Energy and Clean Energy Fuels.

### Waste and Biomass to Energy

An expanding number of Tennessee's companies and municipalities are using advanced energy technology to generate power with renewable, cost effective solutions that replace traditional fossil fuels. The clean conversion of recycled waste produces fuel for kilns, boilers or electrical generation. In Covington, PHG Energy of Nashville has installed a downdraft gasification system that uses waste to generate power and save a substantial amount on annual utility bills.

An abundance of biomass in Tennessee also presents opportunities for the adoption of advanced energy technologies. ARiES Energy of Lenoir City employs technologies capable of using almost any cellulosic material to generate power. Using a combination of solar energy and a 500 kilowatt biomass to energy gasification system, Wampler's Farm Sausage of Loudon County became a net-zero user of energy with no greenhouse gas emissions.

### Electric Vehicles

Another area of anticipated growth not captured by the 2010 Brookings study is the manufacturing of electric vehicles and electric batteries. In the fall of 2012 Nissan's manufacturing complex in Smyrna began producing 600-pound lithium-ion battery packs that fit into the bodies of the company's new electric car at the nearby vehicle assembly plant. The Smyrna battery plant is the largest lithium-ion auto battery factory in North America, employing 300 workers who produced battery packs for 2,000 cars a month. Should future sales meet Nissan's projection, the plant will expand employment to produce 200,000 battery packs annually. [xxviii]

Nissan began U.S. commercial production of the LEAF electric vehicle in January 2013 at its Smyrna, Tennessee manufacturing facility. This plant was modified with a $1.4 billion loan granted by the U.S. Department of Energy to allow the manufacturing plant to produce the Nissan LEAF and its advanced batteries.[xxix] The Smyrna plant is expected to produce up to 150,000 vehicles annually.[xxx]

Tennessee is among the leaders in developing the infrastructure needed for charging electric vehicles. As of September 2013, the U.S. Department of Energy reported that 307 electric vehicle charging locations are available to the public in Tennessee. Of these locations, 17 have installed DC "Fast Chargers." A map of electric vehicle charging station locations in Tennessee can be found at the U.S. Department of Energy website.[xxxi] This map is based upon data that is gathered and verified by the National Renewable Energy Laboratory (NREL). Differences between the

U.S. Department of Energy website and databases maintained by other organizations are due to differences in methodologies and inclusion criteria.[xxxii]

### Energy Storage

In Tennessee the expansion of the advanced energy industry, especially in the sectors of solar energy, wind energy and electric vehicles, is supported by efforts to identify new technologies that will enhance the capacity to store energy. The challenge involves the development of new materials with more capacity to store power, a slower rate of degradation, and reduced weight. The Department of Energy funds research on energy storage at Oak Ridge National Laboratory, using the Spallation Neutron Source, the Center for Nanophase Materials and the Laboratory's supercomputer to explore alternatives to the use of silicon or graphene in batteries. The nation's largest open access research facility enables collaboration with industry while protecting intellectual property. The laboratory is attracting battery manufacturers, chemical and materials suppliers, system integrators and original equipment manufacturers.

A new research facility at the University of Tennessee's Cherokee Farm, the Joint Institute for Advanced Materials, will open in 2014. The Institute will partner with the Laboratory on the development of materials related to energy storage. The partnership includes the recipient of a Governor's Chair hired specifically for energy storage research.

### Energy Efficiency

The most significant progress in energy efficiency and demand response in Tennessee has been led by TVA. In 2007 the TVA board adopted a plan to emphasize the promotion of energy efficiency and the reduction of consumer demand. The goal was renewed in 2010 with a commitment to become the South's leader in energy efficiency. To meet this ambitious goal, TVA established the "EnergyRight Solutions" program to encourage the residential, business and industrial sectors to help TVA meet annual targets for efficiency and demand response. The program was implemented through a combination of rebates, incentives, finance options, energy audits, technical assistance and access to qualified and trained contractors.

In 2012, TVA achieved 560 gigawatt hours of energy savings through the EnergyRight Solutions program. Since the launch of the EnergyRight Solution program in 2008, more than 3,000 homeowners and 150 businesses have participated in the program. Approximately 1,600 gigawatt hours of energy needs have been avoided in the Tennessee Valley—the equivalent of a 900 megawatt power plant.[xxxiii]

Tennessee's advanced energy economy is supported by the state chapter of The Energy Services Coalition, a nonprofit organization composed of experts from a wide range of organizations working to increase energy efficiency, energy management and building infrastructure through energy savings performance contracting. Energy savings performance contracting (ESPC) enables building owners to reduce capital expenditures by using future energy savings to pay for up-front costs of energy efficiency projects.[xxxiv]

ESPC's are frequently a tool to upgrade or replace aging infrastructure with clean, efficient technologies that reduce the full life cycle cost of products such as HVAC systems. State and local governments, the industrial and commercial sectors, and the State's system of colleges and

universities have successfully executed ESPC's.

The Coalition's website includes examples of energy reductions, cost savings, and infrastructure improvements completed at Tennessee facilities using energy savings performance contracts. The University of Memphis saved more than $1.1 million dollars annually over the 12-year contract by installing improved lighting, variable refrigerant systems, advanced steam trap and de-aerators, ultraviolet lighting, the treatment of cooling tower water, and boiler control upgrades.[xxxv]

In the medical sector, Mountain State Health Alliance realized savings of more than $5 million through ESPC by installing energy management control and mechanical upgrades, lighting retrofits, cooling tower bypass piping, and the replacement of the incinerator and kitchen heaters.[xxxvi]

The Coalition makes available engineers to identify and evaluate energy-saving opportunities, develop engineering designs and specifications, arrange financing, manage the project to installation, and train staff for ongoing maintenance services.

### Grid Technologies

An emerging area in the energy efficiency sector is the effort to develop new technologies needed to improve America's aging power grid. A large portion of the existing grid was designed for a much smaller population and an economy far less dependent upon the ability to move massive amounts of energy quickly through constrained spaces.

Tennessee's advanced energy inventory contains assets dedicated to technologies that can produce a safer and more efficient grid network. TVA, the Electric Power Research Institute (EPRI) and local power companies are evaluating technologies designed for a more dynamic transmission system. The "smart grid" includes a two-way communication system that enables customers to know how much power is being used and shift power consumption from peak periods. TVA hosts a demonstration of Smart Wire Grid, Inc., a monitoring technology designed to provide congestion relief by shifting overloads to underused portions of the network.

The University of Tennessee is a partner in CURENT, a consortium of universities funded by the National Science Foundation and the Department of Energy that uses the University's assets in the College of Engineering to address the areas of monitoring, modeling, control, and security of the grid system. In cooperation with Oak Ridge National Laboratory, the University hired a Governor's Chair to focus on grid technologies.

The University's research is complemented at the Laboratory, where the Power Line Conductor Accelerated Testing facility tests overhead power lines at high temperatures and currents. Grid reliability technologies include development of superhydrophobic coatings for exposed high voltage insulators and power lines to reduce the loss of power due to icing, corrosion, and deterioration. The Laboratory is also developing new technologies, tested under the streets of New York, for superconducting cables capable of transmitting enormous amounts of data through much smaller spaces.

# Advanced Energy Technology Innovation

One feature that distinguishes Tennessee's inventory of advanced energy assets is access to some of the world's preeminent energy research. The ability to develop new technologies and move them to the commercial sector will play a crucial role in efforts to expand the State's clean energy economy. The State also has a number of programs in the university system and in the private sector that promote the use of advanced energy technologies and examine the impact of these technologies on the environment.

## Oak Ridge National Laboratory

Foremost among Tennessee's advanced energy research assets is the Oak Ridge National Laboratory. Managed by the Department of Energy, the Laboratory is the largest energy research facility in the world, with some 4,500 employees and a budget of more than $1.5 billion. The Laboratory is home to the Spallation Neutron Source, the world's leading center for the study of materials, and Titan, one of the world's most powerful supercomputers capable of 17 thousand trillion calculations per second. The combined resources of these two research tools have enabled Oak Ridge National Laboratory to tackle what the Department of Energy calls "grand scientific challenges."

Among these grand challenges directly related to advanced energy technologies are:

### Biofuels

The BioEnergy Science Center was established by the Department of Energy in 2007 to accelerate research toward the development of cost-effective advanced biofuels made from biomass such as switchgrass and wood chips. In partnership with the University of Tennessee's biorefinery, the Center is reducing the time and cost for manufacturing biofuels by developing microbes that convert plant biomass into biofuels in a single step.

Contact: Paul Gilna, **gilnap@ornl.gov**

Website: **bioenergycenter.org/besc**

### Carbon Fiber

One of Tennessee's newest clean energy assets, the $35 million Carbon Fiber Technology Facility funded by the Department of Energy, demonstrates low-cost manufacturing processes for lightweight carbon fiber. Made from the waste product of biofuels production, the technology has enormous potential to improve fuel efficiency for the automotive and aeronautics industries.

Contact: Lee McGetrick, **mcgetricklb@ornl.gov**

Website: **ornl.gov/manufacturing**

### Energy Efficiency

The Buildings Technology Research & Integration Center is among the premier U.S. research facilities devoted to the development of technologies that improve the energy efficiency of residential and commercial buildings. Partnering with TVA, the Center has developed Habitat for Humanity homes that combine technologies for items such as roofing shingles and water heaters to produce more energy than they consume.

Contact: Patrick Hughes, **hughespj1@ornl.gov**

Website: **ornl.gov/sci/ees/etsd/btric**

### Clean Manufacturing

The Manufacturing Demonstration Facility is devoted to developing new technologies for the production of clean energy products such as wind turbines, solar panels, energy efficient appliances, light bulbs, vehicles and automotive components. The innovative technologies are designed to reduce life-cycle energy and greenhouse gas emissions, and lower production costs.

Contact: Tom Rogers, **rogerstc@ornl.gov**

Website: **ornl.gov/manufacturing**

### Energy Storage

Electric and hybrid electric vehicles, as well as a rising demand for solar panels, are driving the market to produce high performance batteries that are smaller, lighter, cheaper, longer-lasting, and safer for the consumer. The Laboratory's multi-disciplinary research program in electrical energy storage focuses on discovery of new materials that will enable more practical electrical energy storage for vehicles, solar panels and wind turbines.

Contact: Claus Daniel, **danielc@ornl.gov**

Website: **ornl.gov/sci/physical_sciences_directorate/esr/**

### Grid Management

The Powerline Conductor Accelerated Testing facility is a unique testing center that conducts research on issues associated with electricity transmission reliability and security. The center develops consumer and commercial technologies to balance power capacity with load demand.

Contact: Timothy McIntyre, **mcintyretj@ornl.gov**

Website: **ornl.gov/sci/ees/mssed**

### Transportation

The National Transportation Center explores barriers to effective use of bio-based products and natural gas. Vehicle efficiency is being advanced through research and development of lightweight materials including low-cost carbon fiber, as well as systems integration of electric propulsion/power electronics and internal combustion engines.

Contact: Ron Graves, **gravesrl@ornl.gov**

Website: **ntrc.gov**

### Nanotechnology

The Center for Nanophase Materials Sciences integrates energy applications at the nanoscale with neutron science, synthesis science, and theory, modeling, and simulation.

Contact: Sean Smith, **smithsc@ornl.gov**
Website: **ornl.gov/user-facilities/cnms**

### Spallation Neutron Source

Completed in 2006 at a cost of $1.4 billion, the Spallation Neutron Source is the world's foremost center for the study of materials. The facility hosts more than 1,000 visiting scientists each year from around the world.

Contact: Kelly Beierschmitt, **beierschmitt@ornl.gov**
Website: **neutrons.ornl.gov/facilities/SNS**

### High Performance Computing

ORNL's Leadership Computing Facility is home to the most powerful supercomputer in America, capable of 17,000 trillion calculations per second. The machine is used to model a broad variety of "grand challenges" in energy research, including biofuels, advanced materials, and performance of nuclear fuels.

Contact: Jeff Nichols, **nicholsja2@ornl.gov**
Website: **olcf.ornl.gov**

## University of Tennessee, Knoxville

Teaming with Battelle Memorial Institute, the University of Tennessee assumed the management of Oak Ridge National Laboratory in 2000. The University has since joined with the Laboratory to expand a number of energy-related research programs.

## Joint Research Programs

### Bredesen Institute

Established in 2010, the Bredesen Institute is a highly competitive graduate program in energy studies that emphasizes student research at Oak Ridge National Laboratory.

Contact: Lee Riedinger, **lrieding@utk.edu**
Website: **bredesencenter.utk.edu**

### Governor's Chairs

Recipients of the joint appointments divide their time between the University and the Laboratory. Areas of clean energy focus include environmental biotechnology, electrical power production, environmental microbiology, and energy storage.

Contact: David Milhorn, **millhorn@tennessee.edu**
Website: **utk.edu/govchairs**

### Science Alliance

Also comprised of joint appointments with the Laboratory, clean energy research areas in the Science Alliance include power plant emissions, lithium-ion batteries, and fuel cells.

Contact: Craig Barnes, **cebarnes@utk.edu**
Website: **scialli.utk.edu**

### Joint Institute for Advanced Materials

Located in the University's Cherokee Farm research park, researchers explore electronic, magnetic, and optical materials that are smaller and more energy efficient. The institute is operated in partnership with Oak Ridge National Laboratory.

Contact: George Pharr, **pharr@utk.edu**

Website: **jiam.utk.edu**

## Other University of Tennessee Energy-Related Programs

### Baker Center for Public Policy

The Howard H. Baker Jr. Center for Public Policy is a nonpartisan institute devoted to education and research concerning public policy and civic engagement. A significant focus of the Center is policy related to energy and the environment.

Contact: Matt Murray, **mmurray1@utk.edu**

Website: **bakercenter.utk.edu**

### SunGrant Center

The SunGrant Initiative seeks to revitalize rural communities through research, education, and extension programs on renewable energy and biobased, non-food industries.

Contact: Timothy Rials, **trials@utk.edu**

Website: **sungrant.tennessee.edu**

### CURENT

A National Science Foundation Engineering Research Center, CURENT conducts grid research to maximize efficiency, reliability, and cost. The program seeks to accommodate renewable energy resources and responsive load with power transmission technologies.

Contact: Brad Trento, **btrento@utk.edu**

Website: **curent.utk.edu**

### Center for Clean Projects

The Center develops and evaluates clean products and clean technologies that minimize pollution at the source and contribute to long-term sustainable development. Research focuses on the earliest stages of pollution prevention, including product design and manufacturing.

Contact: Catherine Wilt, **catwilt@utk.edu**

Website: **isse.utk.edu/ccp**

### Center for Materials Processing

Located in the College of Engineering, research includes innovative materials for advanced energy systems.

Contact: Claudia Rawn, **crawn@utk.edu**

Website: **engr.utk.edu/cmp**

### Center for Renewable Carbon

Located in the College of Agriculture, the Center for Renewable Carbon is dedicated to supporting Tennessee's biobased economy through advances in bioenergy and biofuel production as well as

the development of new chemicals and materials from renewable carbon sources.

Contact: Timothy Rials, **trials@utk.edu**

Website: **renewablecarbon.org**

### UT Zero

Located in the College of Architecture, UT Zero is a multidisciplinary program that identifies new technologies for zero energy buildings and zero emissions at the University of Tennessee and in State government.

Contact: Edgar Stach, **utzero@utk.edu**

Website: **utzero.utk.edu**

### West Tennessee Solar Farm

Located approximately 50 miles east of Memphis, the farm uses 21,000 solar panels to produce annually 5 megawatts of DC power that is sold to TVA and distributed by Chickasaw Electric Cooperative.

Website: **solarfarm.tennessee.edu**

### China

US Center for Ecosystem and Environmental Change: Occupying research facilities at UT, ORNL and the Chinese Academy of Sciences, the Center addresses the combined effects of climate change and human activities on regional and global ecosystems and explores technologies for restoration of degraded environments.

Contact: Gary Sayler, **sayler@utk.edu**

Website: **jrceec.utk.edu**

### SunShot Initiative Rooftop Solar Challenge

The UT team sought to reduce non-hardware costs of installing solar energy using four metropolitan areas across the state as model communities. Projects included mapping permit processes, updating planning and zoning codes and improving standards for connecting to the electric grid.

Website: **sites.google.com/site/sunshottn/home**

## University of Tennessee, Chattanooga

### SIM Center

Energy-related research at the SIM Center for Computational Engineering includes design of next generation fuel cells and lithium batteries.

Contact: T.W. Swafford, **Tim-Swafford@utc.edu**

Website: **utc.edu/college-engineering-computer-science/research-centers/simcenter**

### Center for Energy, Transportation and Environment

The Center's program of applied research focuses on the deployment of advanced technologies that utilize clean and secure energy sources, particularly in the utilities and transportation sectors.

Contact: Ronald Bailey, **Ronald-Bailey@utc.edu**

Website: **utc.edu/Research/CETE**

## University of Memphis

### Center for Biofuel Energy and Sustainable Technologies

The Center for Biofuel Energy and Sustainable Technologies is a data resource for the environmental impact of the biofuels supply chain and biodiesel production.

Contact: John Hochstein, **jhochste@memphis.edu**

Website: **best.memphis.edu/coreteam.HTM**

### Center for Sustainable Design

Located within the College of Architecture, the Center incorporates a variety of energy efficiency technologies into the design of residential and commercial buildings.

Contact: Michael Chisamore, **mkchsmre.memphis.edu**

Website: **architecture.memphis.edu**

## Tennessee Technological University (Cookeville)

### Center for Manufacturing Research

The Center's mission focuses on advanced engineering in the manufacturing sector through fundamental research and technology transfer activities. Research includes a variety of energy-related technologies.

Contact: Kenneth R. Currie, **kencurrie@charter.net**

Website: **tntech.edu/cmr/home**

## David Lipscomb University (Nashville)

### Institute for Sustainable Practice

The Institute offers undergraduate and graduate training in sustainability management and technologies.

Contact: Dodd Galbreath, **Dodd.Galbreath@lipscomb.edu**

Website: **lipscomb.edu/sustainability**

## Vanderbilt University (Nashville)

### Institute for Energy and Environment

Basic and applied research examines the impacts of energy production and use on the environment and health through links with climate, water quality, economics, and natural resources.

Contact: George Homberger, **george.m.hornberger@vanderbilt.edu**

Website: **vanderbilt.edu/viee**

### Institute of Nanoscale Science and Engineering

The Institute's energy-related research focuses on new technologies, including energy conversion devices, based on nanoscale materials.

Contact: Sandra Rosenthal, **sandra.j.rosenthal@vanderbilt.edu**

Website: **vanderbilt.edu/vinse**

## University Consortium

### TN-SCORE

Funded by the National Science Foundation, TN-SCORE is a consortium of Tennessee's university community, TVA and a number of the State's leading industries. Areas of research focus include energy storage devices, energy efficiency at the nanoscale, and advanced solar conversion.

Contact: John Hopkins, **jhop@tennessee.edu**

Website: **tnepscor.org**

## Tennessee Valley Authority

TVA has identified three signature technologies for special emphasis. The technology sectors are small modular nuclear reactors, energy utilization (including energy efficiency, demand response and electric vehicle transportation infrastructure) and grid modernization. Investments in TVA's research portfolio are highly leveraged through partnership and collaboration with the Electric Power Research Institute, the U.S. Department of Energy, national laboratories, federal agencies, academic institutions, the Center for Energy Advancements through Technological Innovation, the National Rural Electric Cooperative Association and other research consortiums.

Website: **tva.com/environment/technology/about.htm**

## Electric Power Research Institute (Knoxville)

EPRI conducts research and development relating to the generation, delivery and use of electricity. An independent, nonprofit organization, EPRI's members include electric utilities that represent approximately 90 percent of the electricity generated and delivered in the United States.

Website: **epri.com**

## Biomass Innovation Park (Vonore)

In operation since 2011 and operated exclusively by Genera, the Biomass Innovation Park (BIP) is the only commercial facility operating today that can perform all the processes and steps necessary to bridge the farm gate and the biorefinery gate. BIP is designed to handle a wide range of biomass feedstocks, currently processing switchgrass, corn stover, biomass sorghum, sugar cane bagasse, and wood.

Contact: Kelly Tiller, **info@generaenergy.com**

Website: **generaenergy.com/about/facilities**

# Economic Development and Trade Organizations

A number of not-for-profit organizations actively support the use of advanced energy technologies and the development of advanced energy companies. Additionally, State government departments direct various programs that benefit advanced energy.

### Energy Technology and Environmental Business Association

A trade association representing more than 200 small, large and mid-sized companies that provide environmental, technology, energy, engineering, construction and related services to government and commercial clients.

Contact: Sherry Peske, Executive Director, **speske@eteba.org**

Website: **eteba.org**

### Tennessee Energy Education Initiative

Provides training and tools, and hosts local events to help organizations in Tennessee take control of their energy usage.

Website: **tnenergy.org**

### Tennessee Energy Services Coalition

Promotes energy efficiency and building upgrades through energy savings performance contracting. Online member listing includes contact information for energy service companies in Tennessee.

Contact: Deb Faust, **deb.faust@energyservicescoalition.org**

Website: **energyservicescoalition.org/chapters/TN**

### Tennessee Advanced Energy Business Council

Promotes advanced energy as a job creation and economic development strategy by educating public officials and business leaders about Tennessee's advanced energy assets, establishing strategic partnerships to connect assets and opportunities, and making available industry expertise to policymakers.

Contact: Cortney Piper

Website: **tnadvancedenergy.com**

### Memphis Bioworks Foundation

MBF Leads a collaboration of public, private, academic and government entities to accelerate growth of the biosciences in the Memphis region. AgBioworks is an initiative of the foundation dedicated to developing new agricultural technologies and processing that support a bioeconomy in the Mississippi Delta.

Contact: Steve Bares, President, **sbares@memphisbioworks.org**

Website: **memphisbioworks.org**

### Tennessee Solar Institute (TSI)

An initiative of the University of Tennessee and Oak Ridge National Lab, the institute brought together scientists, engineers and technical experts to provide technical assistance and workforce development to solar industry firms, assist in technology commercialization, and improve manufacturing processes that helped grow the solar industry in Tennessee. TSI assisted in installing 7.2 megawatts of solar photovoltaic energy across Tennessee. The website includes reports on Tennessee's solar industry and a listing of solar installers and companies in Tennessee's solar value chain.

Website: **solar.tennessee.edu**

### US Green Building Council

Promotes green building as an economically and environmentally viable solution to transform the way buildings and communities are designed, built and operated. The organization provides support to 188,000 LEED (Leadership in Energy and Environmental Design) professionals. Tennessee is home to three chapters of the US Green Building Council. (usgbc.org)

**East Tennessee Green Building Council**
Contact: **EastTnUSGBC@gmail.com**
Website: **etnusgbc.org**

**Middle Tennessee Green Building Council**
Contact: Erik Daugherty, Chair, **info@usgbcmidtn.com**
Website: **usgbcmidtn.com**

**Memphis Regional Green Building Council**
Contact: Gay Taylor, Chair, **info@usgbcmem.org**
Website: **umrc.memberclicks.net**

### Association of Energy Engineers (AEE)

Founded in 1977, the nonprofit professional society serves 16,000 members in 89 countries. AEE's mission "promotes the scientific and educational interests of those engaged in the energy industry and to foster action for sustainable development." Tennessee is home to three chapters of the Association of Energy Engineers. Website: aeecenter.org

**AEE East Tennessee Chapter**
Contact: James Warren, President, **jmwarren@spectratechinc.com**
Website: **etcaee.org**

**AEE Middle Tennessee Chapter**
Contact: Debra Faust, President, **deb@hvacdigital.com**
Website: **aee-mtchapter.com**

**AEE Mid-South Chapter**
Contact: Michael Vernon, **mvernon@mlgw.org**

### East Tennessee Clean Fuels Coalition

A program of the U.S. Department of Energy, promotes air quality improvement through the use of advanced technology vehicles, alternatives to gasoline and diesel fuel and the building of local alternative fuel refueling infrastructure.

Contact: Jonathan Overly, Executive Director, **Jonathan@etcleanfuels.org**

Website: **eerc.ra.utk.edu/etcfc**

### Middle Tennessee Clean Fuels Coalition

A program of the U.S. Department of Energy, promotes air quality improvement through the use of advanced technology vehicles, alternatives to gasoline and diesel fuel and the building of local alternative fuel refueling infrastructure.

Contact: Atha Comiskey, Coordinator, **mtcf@comcast.net**

Website: **middletncleanfuels.org**

### West Tennessee Clean Cities Coalition

A program of the U.S. Department of Energy, promotes air quality improvement through the use of advanced technology vehicles, alternatives to gasoline and diesel fuel and the building of local alternative fuel refueling infrastructure.

Contact: Paul Rice, Coordinator, **mrpfrice@aeneas.com**

Website: **cfwt.tn.org**

### Industrial Energy Efficiency Network

The Industrial Energy Efficiency Network is a Southeastern focused collaborative that unites energy professional from industry to identify best practices, promote energy efficiency opportunities, and link industry with financial and technical resources.

Contact: Rick Marsh, Program Director, **info@industrialee.org**

Website: **industrialee.org**

### Industrial Assessment Center

The Tennessee 3-Star Industrial Assessment Center provides no-cost studies of manufacturing plants across Tennessee. Engineering & technology students under the direction of faculty from Tennessee Technological University, East Tennessee State University, and University of Memphis perform studies analyzing a plant's energy and waste.

Contact: Michelle Davis, **mdavis@tntech.edu**

Website: **tntech.edu/iac/home**

### Tennessee Renewable Energy & Economic Development Council

A network of 92 city and county mayors and 28 colleges focused on identifying economic development opportunities of renewable energy for rural economic development.

Contact: Warren Nevad, **warren.nevad@tennessee.edu**

Website: **treedc.us**

### Tennessee Solar Energy Industries Association

The state chapter for the national Solar Energy Industries Association is a business association representing the State's solar industry. It promotes solar energy as a mainstream energy source with a goal of expanding consumer and commercial use of solar power.

Contact: Gil Melear-Hough, President, **info@tenneseiasolar.com**

Website: **tenneseiasolar.com**

### Tennessee Solar Energy Association

A charter member of the American Solar Energy Society, the organization is dedicated to educating Tennesseans about the many unique benefits of using solar energy.

Contact: Stephen Levy, Technical Director, **info@tnsolarenergy.org**

Website: **tnsolarenergy.org**

### Innovation Valley

Regional economic development partnership in greater Knoxville whose target businesses include bioeconomy, materials science and renewable energy.

Contact: Doug Lawyer, **dlawyer@knoxvillechamber.com**

Website: **innovationvalleyinc.com**

### Enterprise Center

Promotes high-tech economic development in the Chattanooga community to create jobs and build wealth. Core initiatives are alternative energy, advanced transportation, technology development and transfer, and community revitalization.

Contact: Wayne Cropp, President, **EnterpriseCenter@theenterprisectr.org**

Website: **theenterprisectr.org**

### East Tennessee Economic Council

Based in Oak Ridge, works with federal and State officials to support investments in energy research at Department of Energy facilities in Tennessee.

Contact: Jim Campbell, President, **info@eteconline.org**

Website: **eteconline.org**

### Tech 2020

Works to create knowledge-based enterprises in the greater Knoxville region by providing counseling and incubator space to start-up companies.

Contact: John Morris, President, **morrisj@tech2020.org**

Website: **tech2020.org**

### Tennessee Department of Economic and Community Development

Coordinates the State's economic development strategy with six clusters areas, including manufacturing and energy technologies.

Contact: Ted Townsend, Assistant Commissioner, Strategy, **Ted.Townsend@tn.gov**

Contact: Kingsley Brock, Senior Advisor, Business Development, **Kingsley.Brock@tn.gov**

Website: **tn.gov/ecd**

### Tennessee Department of Environment and Conservation

Through their grant, loan, education, and outreach programs the Office of Energy Programs and the Office of Sustainable Practices support the Department's mission to enhance the quality of life for citizens of Tennessee and to be stewards of our natural environment.

Contact: Molly Cripps, Director, Office of Energy Programs, **molly.cripps@tn.gov**

Website: **tn.gov/environment/energy.shtml**

Contact: Lori Munkeboe, Director, Office of Sustainable Practices, **lori.munkeboe@tn.gov**

Website: **tn.gov/environment/sustainable-practices.shtml**

### Tennessee Valley Authority

Owned by the U.S. government and funded by ratepayer revenues, the utility provides electricity for nine million people in parts of seven southeastern states, including most of Tennessee. TVA has committed to an energy portfolio that will increase the utility's use of nuclear power and energy efficiency and reduce the energy production from coal-fired plants.

Website: **tva.com/renewable**

# Entrepreneurial Assets

An important aspect of growing Tennessee's advanced energy economy is making available the resources needed to assist entrepreneurs wishing to establish companies that specialize in clean technologies and services. A number of Tennessee organizations specialize in providing entrepreneurs services that include legal, accounting, marketing, and—on occasion—the venture capital required to stand up a new company and to accelerate the commercialization of energy technologies.

### Launch Tennessee

Funded in part by the State of Tennessee, the public-private partnership supports the development of high-growth companies with four initiatives that include oversight of nine regional business accelerators located across the State. Commercialization services aid in the development of business plans centered on emerging technologies from research institutions. Outreach events provide opportunities for entrepreneurs to meet investors from venture capital firms both inside and outside Tennessee.

Contact: Charlie Brock, President, **info@launchtn.org**
Website: **launchtn.org**

Regional business accelerators under the oversight of Launch Tennessee:

### AccelNow-Johnson City

Contact: Dave Lawrence, Director, **dave@accelnow.com**

### ETRAC-Knoxville

Contact: **inquiries@etrac.org**
Website: **etrac.org**

### CO.LAB-Chattanooga

Contact: Sheldon Grizzle, Director, **sheldon@colab.is**
Website: **colab.is**

### UC Success Now-Crossville

Contact: Jeff Brown, Director, **jeff@uceftn.com**
Website: **ucsuccessnow.com**

### Entrepreneur Center-Nashville

Contact: Michael Burcham, Director, **michael.burcham@entrepreneurcenter.com**
Website: **entrepreneurcenter.com**

### Southern Middle Tennessee Entrepreneur Center-Murfreesboro

Contact: Dan Marcum, Director, **dan@smtec.com**

Website: **smtec.com**

### Connect and Grow-Martin

Contact: Carol Reed, Director

Website: **ntecconnect.com**

### StartUp-Jackson

Contact: Linda Garrard, Director, **lgarrard@startupedc.com**

Website: **startupedc.com**

### Start Co.-Memphis

Contact: **info@launchmemphis.com**

### Great Memphis Accelerator Consortium-Memphis

Contact: Allan Daisley, Director, **allan@memphisbioworks.org**

Website: **memphisaccelerators.com**

### East Tennessee State University, Innovation Lab (Johnson City)

Partners with entrepreneurs and investors to affect the successful establishment of technology-based start-up and spin-off companies. The Lab counts Renewable Algal Energy, a bio-fuels company, as a member.

Contact: Dr. Audrey Depelteau, Director, **depelteau@etsu.edu**

Website: **etsuilab.org**

### NextFarm Agricultural Innovation Accelerator

A venture of Northwest Tennessee Entrepreneur Center and Memphis Bioworks Foundation, the initiative seeks to commercialize companies that are engaged in new feedstock development, biofuels and bioenergy.

Website: **ntecconnect.com/ag-tech2.html**

### Lamp Post Group

Located in Chattanooga, the venture incubator assists aspiring entrepreneurs in taking their ideas from the planning stages to commercialization through financial investment and business guidance.

Contact: Jack Studer

Website: **lamppostgroup.com/contact**

### Knoxville Entrepreneurial Center

A downtown business accelerator that offers various resources to budding entrepreneurs, including training and mentoring. A key focus is alternative and renewable energy technologies.

Contact: Mike Carroll

Website: **knoxec.com**

### Battelle Ventures

With its affiliate fund, Innovation Valley Partners, BV manages a combined $255 million to accelerate the development of early-stage technology companies with breakthrough solutions to key market problems. The fund enjoys a close relationship with the technology transfer offices of Oak Ridge National Laboratory.

Contact: Rick Sacks, **rick@smartpr.net**

### Seed Hatchery

The business model supports emerging technology entrepreneurs in the Memphis region with $15,000 in capital, mentors, and a host of other support services. Seed Hatchery receives a 6% ownership stake in the company.

Contact: Andre K. Fowlkes, Co-President, **info@seedhatchery.com**

Website: **seedhatchery.com**

### Tech 2020

Based in Oak Ridge, Tech 2020 is a not for profit organization whose goal is to accelerate the development of high-growth potential companies. The organization's Center for Entrepreneurial Growth provides a variety of support services critical to first-time entrepreneurs.

Contact: John Morris, President, **morrisj@tech2020.org**

Website: **tech2020.org**

### TNInvestco

TNInvestco was created by the Tennessee Small Business Investment Company Credit Act. The act offers $120 million in gross premiums tax credits to insurance companies that invest in companies certified by the State of Tennessee as "TNInvestcos." For a small business to qualify to receive investment funds from TNInvestco, the business must be independently owned and operated, employ no more than 100 employees, be headquartered in Tennessee and have at least 60 percent of its employees located in Tennessee.

Contact: Lamont Price, Director, **Lamont.Price@tn.gov**

Website: **tennessee.gov/ecd/tninvestco**

### Venture Incite

Formed by the partners of Nashville-based venture firm Solidus, Venture Incite has offices in Nashville and Oak Ridge. The company's focus is on accelerating the commercialization of technologies from the region's major research institutions, including Oak Ridge National Laboratory and the University of Tennessee.

Contact: Vic Gotto

Website: **ventureincite.com**

### University of Tennessee Research Foundation

Located on the Knoxville campus, the business incubator utilizes faculty and other experts to provide entrepreneurs with strategies for building a technology-based business.

Contact: David Washburn, **utrf@tennessee.edu**

Website: **utrf.tennessee.edu/techtransfer**

# Advanced Energy Workforce Training

The ability to accelerate the integration of clean energy depends increasingly on the availability of workers trained to install and maintain state-of-the-art clean energy technologies. A number of Tennessee institutions offer specific training for energy technologies.

### Austin Peay State University (Clarksville)

The Chemical Engineering Technology program prepares students to enter the workforce as a chemical technician or process operator in the fields of bioenergy and solar energy.

Contact: Chester Little, Director, **fraleym@apsu.edu**

Website: **apsu.edu/chemical-engineering-technology**

### Chattanooga State Community College

Solar Energy Technology program trains students in the design and installation of solar systems, components, and equipment subsystems, including connecting a photovoltaic system to the electrical grid.

Website: **chattanoogastate.edu/engineering-technology/solar-energy.html**

### Wacker Institute at Chattanooga State Community College

A unique collaboration with WACKER POLYSILICON North America, the program provides four principle areas of study: Process Technician (Chemical Operator); Chemical Laboratory Technician (Analytics); Mechanical Systems Technician and Electronics & Instrumentation Technician.

Contact: Amanda Bennett, **wackerinstitute@chattanoogastate.edu**

Website: **chattanoogastate.edu/engineering-technology/partnerships/wacker-institute**

### Columbia State Community College

The Solar Power Professional program teaches the fundamentals of photovoltaic solar powered energy systems, training students for careers as a dealer, installer, or maintenance technician with photovoltaic companies.

Contact: Ronald Beck, Director, **workforcedevelopment@columbiastate.edu**

Website: **columbiastate.edu/workforcedevelopment**

### Middle Tennessee State University (Murfreesboro)

The Engineering Technology program emphasizes hands-on training and developing technologies for solar-powered competitions.

Contact: Walter Boles, Chairman, **etdept@mtsu.edu**

Website: **mtsu.edu/et**

### Mid-South Community College (Memphis)

The Mid-South Renewable Energy Center has a specific focus on biofuel, including a biofuel production laboratory (ethanol, biodiesel, jet fuel), and an engine testing facility to evaluate the effects of biofuels and biolubricants on engine performance and durability.

Contact: Glen Fenter, President

Website: **midsouthcc.edu**

## Roane State Community College, Advanced Materials Training and Education Center (Oak Ridge)

### Solar Energy

A training program for solar technicians includes solar photovoltaic applications and solar installations.

Contact: **amtec@roanestate.edu**

Website: **roanestate.edu/?7006-Advanced-Materials-Training-and-Education-Center**

### Carbon Fiber

A one-year program offers a Composite Materials Certificate, focusing on the carbon fiber technology being developed at Oak Ridge National Laboratory.

Contact: Nicholas Forrester, **forresternw@roanestate.edu**

Website: **roanestate.edu/?8726-Composite-Materials-Certificate**

### Southern Energy Training Consortium (Memphis)

Established by the Memphis Bioworks Foundation as a network of training providers serving 21 counties in West Tennessee. Training programs target specific renewable energy/energy efficiency careers. The network includes four community colleges and the National Electrical Contractors Association.

Contact: Susan Wilson, **scwilson@southwest.tn.edu**

Website: **plansys.southwest.tn.edu/SETC**

### University of Tennessee Center for Industrial Services

The Center provides on-site energy efficiency training for business, industry and government; NABCEP certification training for photovoltaic professionals; safety and emergency responder training for photovoltaic installations; and comprehensive sustainability training that integrate energy efficiency with environmental, productivity and other waste reduction initiatives.

Contact: Paul Jennings, Executive Director, **tmep@tennessee.edu**

Website: **cis.tennessee.edu**

### Walters State Community College (Morristown)

Clean Energy Technology program offers an associate of applied science degree program designed to train students who wish to enter the job market in selected areas of the clean energy field.

Contact: Andrew Aarons, Coordinator, **andrew.aarons@ws.edu**

Website: **ws.edu/academics/technical-ed/clean-energy**

### Tennessee Colleges of Applied Technology

Under the governance of the Tennessee Board of Regents, the Tennessee Colleges of Applied Technology's Workforce Development includes 27 colleges and enables Tennessee residents to obtain the technical skills and professional training necessary for advancement in today's competitive job market.

Contact: Carol Tomlinson, **Carol.Tomlinson@tbr.edu**

Website: **tbr.edu/offices/tennesseetechnologycenters.aspx?id=2444**

# Advanced Energy Incentives

A number of initiatives coordinated by TVA, the State of Tennessee and private lenders promote investments in clean energy as a way of reducing energy consumption and saving money for business, residential consumers and local government agencies.

The Database for State Incentives for Renewables and Efficiencies serves as a central repository for much of this information and includes local programs and incentives available in Tennessee.
Website: **dsireusa.org/incentives?re=1&ee=1&spv=0&st=0&srp=1&state=TN**

The State of Tennessee maintains tax guides on the Department of Revenue's website that includes "green" tax credits, incentives and more information.

Website: **tennessee.gov/revenue/taxguides**

The following programs are tax credits and energy-related incentives managed by the State of Tennessee.

### Emerging Clean Industry Tax Credit

A taxpayer that establishes a qualified facility to support an emerging industry is eligible for a sales and use tax credit of all Tennessee state sales or use taxes paid (except .5%) with respect to the purchase or use of qualified tangible personal property, which is defined to be building materials, machinery, equipment, furniture and fixtures used exclusively in a facility that supports an emerging industry. For purposes of the credit, an emerging industry includes an industry that promotes clean energy technology, including clean energy technology research and development and installation and can include those primarily engaged in manufacturing clean energy technology. For the purposes of the credit, clean energy technology means technology resulting in energy efficiency, technology used to generate energy from biomass, geothermal, hydrogen, hydropower, landfill gas, nuclear, solar and wind sources, and technology that is designed to result in the development of advanced coal through carbon capture and sequestration or otherwise any other manner that significantly reduces carbon dioxide emissions per unit of energy generated. To qualify for the credit, the taxpayer must make a minimum investment in the facility of at least one hundred million dollars ($100,000,000) and create not fewer than fifty (50) full-time employee positions, created primarily for the support of the operations at the qualified facility during the investment period, that pay at least one hundred fifty percent (150%) of Tennessee's average occupational wage. The effect of the credit is to allow the taxpayer to purchase qualified property free of state sales tax except .5%. The local option tax of up to 2.75% continues to apply to such purchases.

Website: **tn.gov/ecd/BD_tax_incentives.html**

### Green Energy Tax Credit

Tennessee offers a Green Energy Tax Credit, to be applied to the taxpayer's Tennessee franchise and excise tax liability, to certified green energy supply chain manufacturers and campus affiliates, integrated customers and integrated suppliers of a certified green energy supply chain manufacturers. A "certified green energy supply chain manufacturer" is defined as any manufacturer that has made, during the investment period, a required capital investment in excess of $250 million in a facility certified by the Commissioner of Revenue, the Commissioner of Economic and Community Development and the Commissioner of Environment and Conservation, in their sole discretion, to be a facility engaged in manufacturing a product that is necessary for the production of green energy. The credit is designed to offset charges for electricity consumed by the taxpayer, to the extent to charges exceed the "maximum certified rate" as set forth in a ruling issued to the taxpayer by the Commissioner of Revenue, and approved by the Commissioner of Economic and Community Development and the Commissioner of Finance and Administration, thereby providing a taxpayer a predictable rate for electricity used in manufacturing a product necessary for the production of green energy.

Website: **tn.gov/ecd/BD_business_tax_credit.html**

### Sales Tax Credit

A sales tax a credit of 100% of the sales and use tax paid with respect to machinery and equipment used to produce electricity in a "certified green energy production facility" which generally is defined to be (i) a facility that produces electricity for use and consumption off the premises using clean energy technology, (ii) an alternative motor vehicle fueling station that utilizes natural gas in compressed or liquid form for the purpose of fueling motor vehicles and (iii) a facility which utilizes natural gas in a combined heat and power configuration (CHP) for production of heat and electricity for consumption onsite. Clean energy technology means technology used to generate energy from geothermal, hydrogen, solar, and wind sources. Instead of taking the credit the taxpayer may apply to the Commissioner of Revenue for a refund of the taxes paid or for authority to make purchases exempt from sales tax.

Website: **tn.gov/ecd/BD_tax_incentives.html**

### Property Tax Credit

Property used to produce power from a wind source is valued initially at one-third of its total installed costs and property used to generate power from a solar source is valued initially at twelve and one-half percent of its total installed cost. Property that is used to engage in the fueling of natural gas vehicles and that is a certified alternative fueling site is initially valued at thirty percent of its total installed costs.

Website: **tn.gov/sos/acts/108/pub/pc0297.pdf**

### Franchise Tax Exclusion

Machinery and equipment used to produce electricity in a certified green energy production facility is not included in the alternate measure of the franchise tax base (the value of property used in Tennessee) provided the taxpayer obtains the required certification.

Website: **tn.gov/ecd/BD_tax_incentives.htm**

### Energy Standards

Tennessee law requires that office equipment, appliances, lighting, and heating and cooling products and systems purchased by and for State agencies to be Energy Star qualified when available. The law stipulates that contracts not offering Energy Star products not be renewed

and all future contracts with the State should offer Energy Star products.

Website: **state.tn.us/sos/acts/106/pub/pc0529.pdf**

Updated: **state.tn.us/sos/acts/108/pub/pc0403.pdf**

### Solar Easements

Tennessee law authorizes the creation of easements for the purpose of ensuring access to direct sunlight for solar energy systems. The statute states that the "encouragement and protection of solar energy systems is a valid objective which counties and municipalities may consider in promulgating zoning regulations." When land is sold, easements pass with the property as recorded with the register of deeds in the county in which the land is situated. Written easements may contain descriptions of property affected, angles at which an easement extends, and conditions of compensation or termination.

Website: **dsireusa.org/documents/Incentives/TN01R.htm**

### Energy Efficient Schools

The Energy Efficient Schools Initiative (EESI) was established by the Tennessee General Assembly in 2008 with $90 million. Over $87 million has been approved for projects to improve the energy efficiency in Tennessee's public K-12 schools. Purposes of the Energy Efficient Schools Council, also created by this legislation, include providing grants and loans for capital outlay projects and establish and support energy management programs. The enabling legislation also created a twelve member council to approve guidelines, award grants and loans, verify energy efficiencies, and establish and support energy management programs.

Website: **tn.gov/eesi/about_us.shtml**

### State Vehicles

The Tennessee Department of General Services must ensure that at least 25% of newly purchased passenger motor vehicles procured for use in areas designated as ozone nonattainment areas are hybrid electric vehicles, flexible fuel vehicles, or natural gas vehicles. State statute requires that "every effort should be made to achieve a target goal that one hundred percent (100%) of newly purchased passenger motor vehicles be energy-efficient or alternative fuel motor vehicles."

Website: **tn.gov/sos/acts/108/pub/pc0423.pdf**

### Clean Tennessee Energy Grant Program

The purpose of the Clean Tennessee Energy Grant Program is to select and fund projects that best result in a reduction of emissions and pollutants. The Program provides financial assistance to municipal government, county government, utility districts, and other entities created by statute (e.g. airport authority) in Tennessee to purchase, install, and construct energy projects that fit into the following categories: cleaner alternative energy, energy conservation, air quality improvement.

Website: **tn.gov/environment/grants_energy.shtml**

### Qualified Energy Conservation Bonds (QECBs)

May be issued by state and local governments to finance up to 30% of qualified energy conservation projects. Qualified projects are defined broadly as energy efficiency capital expenditures in public buildings, green communities, renewable energy production, various research and development, efficiency and energy reduction measures for mass transit, and energy efficiency education campaigns. The Department of Environment and Conservation's Office of Energy Programs serves as the administrator of the State's QECB program in partnership with the Tennessee Local Development Authority.

Website: **tn.gov/environment/energy_qualified-energy-conservation-bonds.shtml**

The following programs are energy-related incentives managed by the Tennessee Valley Authority.

### Green Power Providers

TVA and participating power distributors offer a performance-based incentive program to homeowners and businesses for the installation of renewable generation systems of solar, wind, hydropower, and biomass. The energy generated from these renewable generation systems applies toward TVA's green power pricing program, Green Power Switch.

Website: **tva.com/greenpowerswitch/providers/participant.htm**

### Green Power Switch

Supports regional renewable energy in the Tennessee Valley. Each $4 block of Green Power Switch purchased is added to monthly electric bills and ensures 150 kilowatt-hours of electricity is generated by a renewable resource such as wind, solar or biomass.

Website: **tva.com/greenpowerswitch**

### Renewable Standard Offer

Developers of new small to mid-size renewable energy projects in the TVA power service area can participate in TVA's Renewable Standard Offer program. The program offers pre-set prices and terms and conditions for power generated by selected, commercially available renewable energy technologies. Projects must be greater than 50 kW and less than or equal to 20 megawatts.

Website: **tva.com/renewablestandardoffer**

### EnergyRight Solutions

TVA program, in cooperation with local power distributors and directly served customers, to help homeowners, businesses and industrial sectors save energy and money. The program promotes energy efficiency, demand response and renewable energy and helps users identify contractors to complete retrofits and installations as well as finance options.

Website: **energyright.com**

### TVA Unsolicited Proposals

TVA encourages unsolicited proposals from qualified suppliers of capacity and/or energy from Renewable Energy and/or Clean Energy Resources. The program's scope falls outside of the Generations Partner standard offer of projects less than 1 megawatt. TVA is interested in term proposals for such power supply of 1 to 20 years in duration.

Website: **tva.com/power/submit_proposal.htm**

The following program is a private sector incentive for energy efficiency and renewable energy.

### Energy Loans

Pathway Lending's Tennessee Energy Efficiency Loan program provides Tennessee business and non-profit entities with below-market rate loans for energy efficiency and renewable energy improvements. This program is funded through collaboration between the State of Tennessee, TVA, Pinnacle Financial Partners and Pathway Lending.

Website: **pathwaylending.org**

# Appendix I

Company and institution contact information (in order of appearance)

**Tennessee Valley Authority**
A: 400 West Summit Hill Drive
Knoxville, TN 37902
W: **tva.gov**
P: 865-632-2101

**Oak Ridge National Lab**
A: 1 Bethel Valley Road
Oak Ridge, TN 37831
W: **ornl.gov**
P: 865-576-7658

**University of Tennessee**
A: Knoxville, Chattanooga, Martin
W: **tennessee.edu**
P: 865-974-1000

**Signal Energy**
A: 2034 Hamilton Place Blvd., 4th Floor
Chattanooga, TN 37421
W: **signal-energy.com**
P: 423-443-4190

**Shoals Technologies Group**
A: 1400 Shoals Way
Portland, TN 37148
W: **shoals.com**
P: 615-451-1400

**Clean Line Partners**
A: 1001 McKinney Street, Suite 700
Houston, TX 77002
W: **cleanlineenergy.com**
P: 832-319-6310

**Genera Energy**
A: 167 Tellico Port Road
Vonore, TN 37885
W: **generaenergy.com**
P: 423-884-4110

**Tennera Energy, LLC**
A: 2450 E.J. Chapman Drive, Suite 216
Knoxville, TN 37996
W: **tennera.net**
P: 865-974-8258

**Monsanto Company**
A: 800 N. Lindbergh Blvd
St. Louis, MO 63187
W: **monsanto.com/Pages/default.aspx**
P: 314-694-1000

**Abengoa Bioenergy**
A: 16150 Main Circle Drive, Suite 300
Chesterfield, MO 63017
W: **abengoabioenergy.com/web/en/acerca_de**
P: 636-728-0508

**BioDimensions**
A: 5173 North Racquet Club Place
Memphis, TN 38117
W: **biodimensions.net**
P: 901-866-1800

**Delta BioRenewables**
A: 7430 Smythe Farm Road
Memphis, TN 38120
W: **deltabiorenewables.com**
P: 901-866-1800

**Tennessee Department of Transportation**
A: 505 Deaderick Street
Nashville, TN 37243
W: **tdot.state.tn.us**
P: 615-741-2848

**Agbioworks**
A: 20 South Dudley, Suite 802
Memphis, TN 38103
W: **agbioworks.org**
P: 901-866-1801

### Green Plains Renewable Energy
A: 2098 McDonald Road
Rives, TN 38253
W: gpreinc.com
P: 731-536-1286

### Tate & Lyle
A: 196 Blair Bend Road
Loudon, TN 37774
W: tateandlyle.com/Pages
P: 865-458-5681

### Green Gallon Solutions
A: 1816 Browns Mill Road
Cookeville, TN 38506
W: greengallonsolutions.com
P: 239-284-1391

### Sullens Biodiesel
A: 100 Hennessee Avenue
Morrison, TN 37357
P: 931-815-9892

### Tennessee NGV Task Force
W: eerc.ra.utk.edu/etcfc/tn-team-for-ngvs.html
P: 731-855-1441

### PBG Energy
A: PO Box 23185
Knoxville, TN 37933
W: pbgenergyinc.com
P: 865-405-0963

### Clean Energy Fuels
A: 4675 MacArthur Court, Suite 800
Newport Beach, CA 92660
W: cleanenergyfuels.com
P: 770-823-2854

### PHG Energy
A: 3048 Owen Drive
Nashville, TN 37013
W: phgenergy.com
P: 615-471-9299

### ARiES Energy
A: 487 Sam Rayburn Parkway
Lenoir City, TN 37771
W: ariesenergy.com
P: 865-309-4674

### Wampler's Farm Sausage
A: 781 Highway 70 West
Lenoir City, TN 37771
W: wamplersfarm.com
P: 865-986-2056

### Nissan
A: 983 Nissan Drive
Smyrna, TN 37167
W: nissanusa.com
P: 615-459-1400

### The University of Memphis
A: 920 Madison Avenue
Memphis, TN 38163
W: memphis.edu
P: 901-448-5500

### Mountain State Health Alliance
A: 400 N State of Franklin Road
Johnson City, TN 37604
W: msha.com
P: 423-431-6111

### Renewable Algal Energy
A: 2109 West Market Street, Suite 159
Johnson City, TN 37604
W: rae-energy.com
P: 423-979-8008

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