

Advanced Energy Influence & Impact

Report

Developed by



Contents

Acronyms Used Throughout	i
Executive Summary.....	2
Introduction	8
Methodology.....	9
Overview of Advanced Energy’s Actions.....	9
Five Areas of Impact.....	10
The Impact Curve	11
Impact and Influence Framework	14
Gathering Insights	15
Quantifying Impacts	17
Advanced Energy’s Influence and Impact.....	21
Overview	21
Motors and Drives.....	22
Promoting Motor Efficiency Across the US with Pentair	25
Residential Housing.....	27
Helping North Carolina Families through SystemVision	29
Commercial and Industrial	31
Helping Daimler Achieve ISO 50001 Certification at 8 Facilities.....	34
Transportation.....	34
Promoting Emission-Free Driving with Plug-in NC.....	37
Renewable Energy.....	39
Promoting Safe Reliable Renewables with Duke Energy Interconnection Commissioning.....	41
Helping Schools with Solar and STEM Education.....	41
Advanced Energy’s Future	43



Acronyms Used Throughout

AHRI — Air Conditioning, Heating and Refrigeration Institute

ANSI — American National Standards Institute

C&I — Commercial and Industrial

CO₂e — Carbon Dioxide Equivalent

DER — Distributed Energy Resource

DOE — U.S. Department of Energy

DTNA — Daimler Trucks North America

EASA — Electrical Apparatus Service Association

EFL — Environments for Living

EIA — Energy Information Administration

EISA — Energy Independence and Security Act

EPA — U.S. Environmental Protection Agency

EPAct — Energy Policy Act

EV — Electric Vehicle

MEPS — Motor Efficiency Performance Standards

NCHFA — North Carolina Housing Finance Agency

NIST — National Institute of Standards and Technology

NOM — NORMA Oficial Mexican

NREL — National Renewable Energy Laboratory

PEV — Proven Efficiency Verification

PV — Photovoltaic

SCE — Southern California Edison

SEM — Strategic Energy Management

STEM — Science, Technology, Engineering, Math



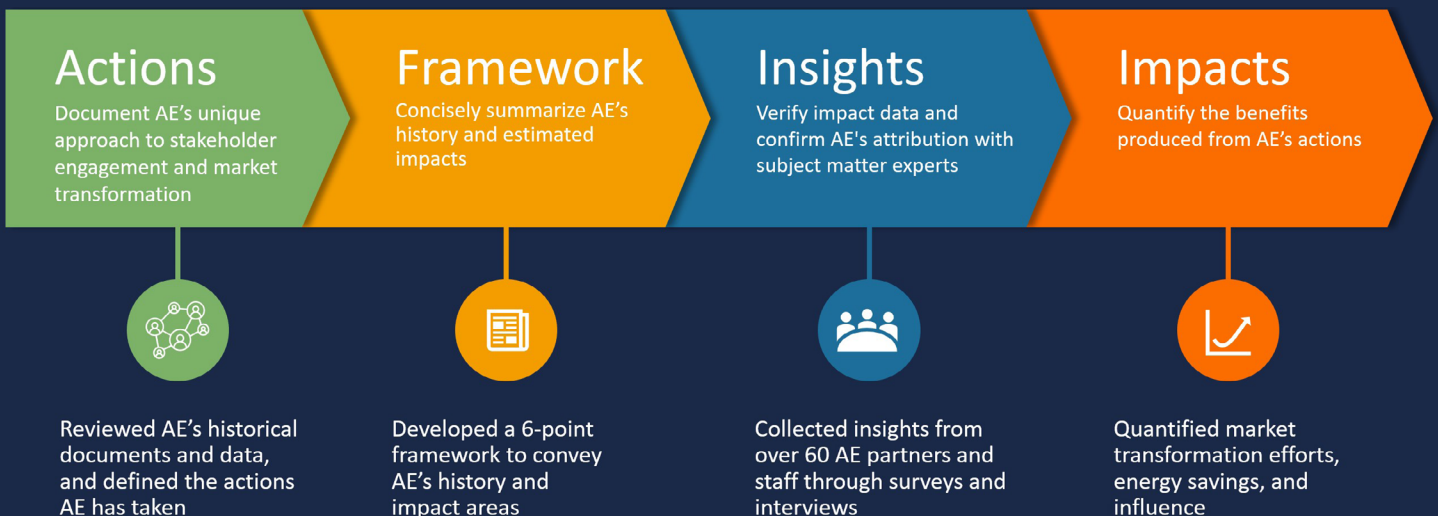
TIERRA™ Executive Summary

In April 2020, Advanced Energy celebrated 40 years of working to ensure energy is clean, affordable, reliable, efficient, and safe for all people. To recognize this milestone, Advanced Energy's leadership team retained Tierra Resource Consultants to document its four decades of achievements and quantify its cumulative impacts in North Carolina and throughout North America.

Tierra is a California-based resource management consulting firm specializing in leading-edge strategies for energy management and carbon reduction, as well as an independent third-party evaluator of energy efficiency programs for utilities and state utility commissions. For over 30 years, Tierra staff have consulted on energy-related projects for federal and state governments, utilities, and businesses.

Advanced Energy tasked Tierra with reviewing and verifying its historic efforts; tracing the most significant initiatives associated with each; quantifying the estimated energy impacts; and attributing its influence on the outcomes and effects occurring in five market sectors that Advanced Energy serves: residential, commercial and industrial, motors and drives, electric transportation, and renewables.

Research Methodology



To accomplish the project, Tierra fielded an influence and impact assessment survey and facilitated group and individual discussions to gather insights from more than 60 subject matter experts and market actors who worked with Advanced Energy on key initiatives. This team of experts helped Tierra assess Advanced Energy's influence and relative impacts in each sector.

This executive summary discusses Advanced Energy's unique approach to market transformation and presents highlights of Tierra's research findings. It concludes with a brief forward-looking prospectus to provide insight into how Advanced Energy is positioned to generate new and sustained impacts over the next 40 years.

Advanced Energy's Approach to Market Transformation

Turns Bold Ideas into Big Impacts

Advanced Energy identifies opportunities to magnify incremental energy savings through collaboration with key market actors. To do this, they deploy a process-oriented approach to research, testing, education, and collaboration that is designed to transform the way energy is produced and consumed in North Carolina and beyond.



Program Services



Consulting



Training & Education



Testing & Evaluation



Investigative Research

Impact

Time



How AE Turns Bold Ideas into Big Impacts



Bold Ideas

Motors & Drives

Making small incremental improvements in motor and drive efficiency and labeling them can transform the market and generate sustainable energy savings

Residential Housing

Increase energy performance, durability, and safety in single-family, multi-family, and affordable housing by using applied building science to improve construction practices, set standards, and train building tradespeople

Commercial & Industrial

Help businesses deliver more product per unit of energy by systematically reducing energy waste through improved processes, equipment efficiencies, employee behaviors, and energy management techniques

Research

Develops testing methodologies for U.S. Department of Energy and other clients

Aligns written codes and standards with real-world installation practices and building design failures

Industrial Electrotechnology Laboratory serves as problem-solving center to provide technical assistance and technology demonstrations

Testing & Standards

Supports development of new motor standards, regulations, and policies for the U.S. Department of Energy, the Energy Independence and Security Act, and manufacturers

Tests building performance and helps develop Engineered for Life, Environments for Living, ENERGY STAR, and SystemVision certification standards

Tests electrotechnologies for processes, including infrared drying, infrared powder coat curing, radio frequency drying, and food service equipment

Training

Educates motor industry professionals on quality standards and best practices

Trains developers, builders, framers, insulators, HVAC contractors, utilities, product representatives, and code officials

Delivers workshops and webinars to train C&I customers as well as regional and national organizations on new technologies and techniques, such as cogeneration and strategic energy management

Consulting

Conducts motor and drive testing for manufacturers, trade groups, distributors, utilities, government agencies, and users; helps create first NVLAP lab in South Korea

Helps develop ENERGY STAR construction specifications, Engineered for Life energy guarantee program, National Renewable Energy Laboratory Standard Work Specifications

Conducts C&I process assessments to evaluate energy use and find energy efficiency opportunities in facilities and production processes

Programs

Launches Proven Efficiency Verification motor repair quality assurance program; is recognized by U.S. Department of Energy as a national certification program; partners with Pentair on energy-efficient pool pump program with Southern California Edison and other utilities

Develops and enhances the most influential national residential building performance programs

Guides facilities through ISO 50001, 50001 Ready™, and Superior Energy Performance 50001™ programs





Electric Transportation

Renewables: PV Interconnection

Renewables: NC GreenPower

Bold Ideas

Collaborate with industry leaders and influencers to speed EV adoption in North Carolina through research, testing, planning, and educational campaigns

To ensure safety, reliability, and power quality, new customer-sited, utility-scale PV installations need formal commissioning and inspection by qualified third parties

Collaborate with industry leaders and influencers to develop easy ways for residents and businesses to support renewable energy generation and carbon offsets by working with North Carolina utilities to collect funding via monthly electric bills

Research

Researches EV driving patterns, charging habits, operating costs, utility load impacts, economic impacts, and emissions

Researches and aligns written codes and standards with real-world installation practices

Investigates options for establishing a green power pricing program for North Carolina

Testing & Standards

Tests EV potential of personal cars, fleet vehicles, and school buses

Develops formal process for commissioning and inspecting new PV installations at customer sites

Collaborates to define green energy for North Carolina; informs North Carolina legislature to support passage of the North Carolina Renewable Energy and Energy Efficiency Portfolio Standard

Training

Develops and delivers workshops and webinars, educational materials, and marketing collateral to promote EVs in North Carolina and throughout the U.S.

Trains solar developers, contractors, and utility personnel in the field and in the classroom

Promotes renewable generation and carbon offsets and provides grants to schools for PV installations and education programs

Consulting

Collaborates with Clean Cities Coalitions and other stakeholders on EV roadmaps, Volkswagen Settlement working group; advises NC Department of Transportation on Zero Emission Vehicle Plan; consults with nonprofits and co-ops

Helps developers, contractors, and utility personnel with technical questions regarding integration of renewable equipment

Helps businesses understand how renewable energy credits and carbon offsets can meet their goals

Programs

Leads formation of and operates Plug-in NC

Leads and manages commissioning of medium voltage PV for utilities in North and South Carolina

Leads creation of NC GreenPower

Advanced Energy's Big Impacts

Summary

Over the past 40 years, Advanced Energy's actions and influence have generated **250,000 GWh** of energy savings and **1,059 GWh** of clean energy production. This is the equivalent of...

- **Powering 775,000 NC households for 25 years,**
- **Mitigating 101 million metric tons of CO₂e, and**
- **Saving \$17.8 billion in utility energy costs.**



Motors & Drives

Advanced Energy's contributions to national motor efficiency performance standards and efficient motor rewind practices amount to over **214,000 GWh** saved, **86 million metric tons** of avoided CO₂e, and over **\$14 billion** in utility cost savings.

Additional impacts include...

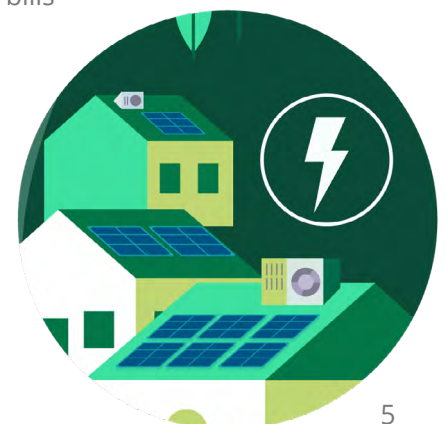
- **About 50 businesses participate in motor management workshops each year**
- **4,000 motors tested in total, representing ~70% of national motor manufacturers**
- **25 motor service centers certified through Proven Efficiency Verification program**
- **24 national, state, and international industry standards supported**
- **22% of EASA accredited repair centers audited**

Residential Housing

Advanced Energy's role in developing and implementing residential housing programs has generated **34,627 GWh** in energy savings, avoided **14 million metric tons** of CO₂e, and will save homeowners more than **\$3.5 billion** on their utility bills nationwide and **\$48 million** within the state.

Additional impacts include...

- **Over 1 million high-performance homes built through programs developed and influenced by Advanced Energy research, testing, and implementation**
- **Nearly 6,000 high-performing, affordable homes constructed in North Carolina through SystemVision program**
- **More than 5,000 people have attended trainings developed by Advanced Energy**



Commercial & Industrial

Energy and process assessments conducted by Advanced Energy and its utility partners have generated **1,010 GWh** of energy savings, **\$67 million** in utility cost savings, and **357 thousand metric tons** of CO₂e reductions for C&I customers. Additional impacts include...

- **Approximately 1800 people attend Advanced Energy trainings on C&I systems and strategic energy management each year**
- **1,600 assessments provided to C&I customers**
- **More than 20 ISO 50001 trainings and webinars conducted since 2019**



Electric Transportation

Advanced Energy has educated thousands of people

and supports EVs through researching technical factors, strategic planning, and familiarizing North Carolinians with the benefits of the technology. Additional impacts include...

- **5 North Carolina EV Roadmaps**
- **More than 1,000 people attending 20+ events/workshops annually**
- **104 Plug-in NC members maintaining 332 charging stations and 238 electric fleet vehicles**



Renewables

Advanced Energy contributed to **1,059 GWh** of clean energy production through its role in establishing NC GreenPower and commissioned **872 MW** of utility-scale solar interconnected to utility grids. Additional impacts include...

- **56 North Carolina schools awarded solar arrays and 43,000 students receiving STEM education through NC GreenPower Solar+ Schools program**
- **Approximately 100 industry personnel trained annually on solar commissioning practices**
- **107 thousand metric tons of greenhouse gas emissions mitigated through NC GreenPower offsets and projects**



Subject Matter Experts Consulted

The Tierra team thanks the Advanced Energy Board and the following industry experts who assisted Tierra in assessing Advanced Energy's influence and impacts

Renewables	Transportation	C&I	Motors & Drives	Residential
<p>Duke Energy Kevin Chen W. Roger Paules, Jr. Randolph EMC Dale Lambert Solar Operations Solutions Adam Foodman Strata Solar John Gajda NC Utilities Commission Sam Watson Pritchard Engineering Ewan Pritchard* NCSEA Ward Lenz* Baylor University Emmanuel Agamloh* Quanta Technology Carl Wilkins* Advanced Energy/NC GreenPower Cyrus Dastur Shawn Fitzpatrick Staci Haggis Nathan Holder Katie Lebrato Bob Goodson Vicky McCann Bob Koger</p>	<p>Randolph EMC Michael Trent Town of Cary Katie Drye* NCSEA Ward Lenz* Pritchard Engineering Ewan Pritchard* NC Clean Energy Technology Center Lisa Poger* Advanced Energy Jacob Bolin Kristi Brodd Alexis Giannattasio</p>	<p>Electric Power Research Institute Perry Stephens (Duke Energy) Duke Energy W. Roger Paules, Jr. Daimler Trucks North America Sandra Carter Nidec Motor Corporation Rob Boteler Pritchard Engineering Ewan Pritchard* Baylor University Emmanuel Agamloh* Welch Energy Services Dan Welch* Advanced Energy Mike Stowe Charlie Martin Kitt Butler Nathan Holder</p>	<p>Nidec Motor Corporation Rob Boteler NEMA Kirk Anderson (UL) NEMA/SEW-Eurodrive Tim Schumann JMAL Consulting John Malinowski (ABB/Baldor - Reliance) Franklin Electric Dan Delaney Electrical Apparatus Service Association Tom Bishop WorldWide Electric Rick Simmons Pritchard Engineering Ewan Pritchard* Baylor University Emmanuel Agamloh* Blue Ridge CC Bob Zickefoose* Welch Energy Services Dan Welch* Advanced Energy Kitt Butler Michael Lyda Jonathan Coulter</p>	<p>Davenport Consulting, LLC Rick Davenport (Louisiana-Pacific/MASCO) BASF Brad Townsend John Tooley, LLC John Tooley* NCSEA Kristi Matthews* Ward Lenz* Housing 2.0 Sam Rashkin (U.S. EPA) Building Performance Association Keith Aldridge* Retired Arnie Katz* Advanced Energy Brian Coble Lisa Manuel Jonathan Coulter Maria Mauceri</p>
		*Former Advanced Energy employee		

Tomorrow's Bold Ideas

This research confirms that Advanced Energy is uniquely situated as a trusted, non-biased, technically savvy nonprofit that brings together utilities, customers, government agencies, and other energy industry stakeholders. This positioning results in collaborative, iterative, and sustained initiatives that transform markets and generate outsized impacts within North Carolina and across North America.

Advanced Energy is looking forward with a focus on Bold Ideas to drive a clean energy future, including:

- Researching new technologies and energy management strategies to help reduce peak kW demand and shift electric loads to off-peak hours.
- Expanding its strategic energy management activities and focusing on carbon emissions to help businesses, utilities, and North Carolina achieve their climate action goals.
- Making motor-driven systems more efficient and reliable while evaluating how motors and drives interact with advanced grid management techniques, like voltage reduction and self-healing.
- Helping the transportation industry transition to electricity as a new fuel source by addressing challenges ranging from infrastructure and interoperability to education.
- Supporting the addition of flexible renewables onto the grid and working with utilities, developers, and stakeholders to ensure renewables and energy storage assets are integrated in a safe, reliable manner that preserves high power quality.

Introduction

On April 11, 2020, Advanced Energy celebrated 40 years of working to ensure that energy is clean, affordable, reliable, efficient, and safe for all people. To commemorate the milestone, Advanced Energy's leadership team retained Tierra Resource Consultants (Tierra) to help document its four decades of achievements and quantify its cumulative impacts in North Carolina and throughout North America.

Tierra is a resource management consulting firm based in Walnut Creek, California, that specializes in leading-edge strategies for carbon reduction, distributed energy resources (DERs), and electric load management, as well as third-party evaluation of energy efficiency and demand-side management programs for utilities and state utility commissions. For more than 30 years, Tierra's principals and senior staff have been consulting on energy-related projects on behalf of federal and state governments and agencies, utilities, and publicly held and private companies. Throughout that time, Tierra's team members have interacted with Advanced Energy on multiple projects. The potential insights afforded by that long-term familiarity added to the value that Tierra would bring to the project.

Advanced Energy tasked Tierra with using its extensive evaluation experience to review Advanced Energy's historic efforts; trace the most significant initiatives associated with each; quantify the estimated energy impacts; and attribute its influence on the outcomes and effects occurring in five market sectors that Advanced Energy serves: motors and drives, residential, commercial and industrial, electric transportation, and renewables.

To accomplish the project, Tierra applied its experience in survey design and meeting facilitation to gather insights from subject matter experts and market actors who worked with Advanced Energy on key initiatives. Tierra conducted in-depth interviews and led Delphi panel¹ discussions to garner a deeper understanding of Advanced Energy's efforts, its key collaborators, and the historic context in which those efforts took place. The Delphi panels also included iterative debates regarding Advanced Energy's influence and relative impacts in each market sector. Upon completing this consensus process, Tierra used resulting numbers to calculate energy impacts and attribution.

As Tierra conducted research for this project, it was clear throughout each of the market sectors studied that Advanced Energy's unique role as a trusted nonbiased technical resource was instrumental in driving collaboration among diverse partners to create sustained market transformation. And from the very beginning, championed by North Carolina Governor Hunt in 1979, Advanced Energy has turned bold ideas into big impacts by taking early actions to advance emerging energy technologies and efficiency practices.

This report further explains Tierra's methodology, discusses Advanced Energy's unique approach to market transformation, and details the research findings. It concludes with a forward-looking prospectus to provide insight into how Advanced Energy is positioned to use its bold ideas to generate big and sustained impacts over the next 40 years.

¹ The Delphi method gathers input from a panel of experts using multiple rounds of questions. After each round the responses are aggregated and shared with the group until consensus is reached.



Methodology

Tierra employed the four-step process depicted in Figure 1. to complete the research project and document Advanced Energy’s market transformation actions, the influence of those actions, and the resulting impacts, outcomes, and benefits.

Figure 1. Research Project Overview



First, Tierra reviewed Advanced Energy’s historical documents and data to qualitatively characterize its approach to market transformation. Next, Tierra developed a framework to concisely identify and describe Advanced Energy’s influential actions in five areas of impact. Finally, Tierra employed a modified Delphi panel procedure², consisting of an online survey, in-depth group interviews, and follow-up emails, to gather both qualitative and quantitative insights from over 60 subject matter experts, partners, and staff. The insights and data collected were used to quantify Advanced Energy’s market transformation efforts, its influence, and the resulting energy savings, greenhouse gas reductions, and cost savings. The following sections discuss each step in greater detail.

Overview of Advanced Energy’s Actions

At the start of the project, Tierra submitted a data request to Advanced Energy to provide files detailing the organizations wide-ranging efforts over the years and supporting data to document its historic

² The Delphi method builds consensus around an estimate by having experts provide answers and discuss their reasoning for those answers over multiple rounds. The range of answers narrows over each successive round until a final estimate or range is achieved.

impacts. Upon completing the data analysis, Tierra worked with Advanced Energy staff members to better understand how company policies, procedures, and strategic approaches had evolved over time. This initial research revealed an interesting and consistent pattern across each sector that spanned from the genesis of an idea through its execution and ultimate outcomes in the field and marketplace. Throughout the entire process, Advanced Energy collaborates with stakeholders and market actors to identify needs and emerging opportunities to drive clean energy impacts. Tierra found Advanced Energy to be uniquely positioned to act on these opportunities before other organizations and develop expertise that it is willing to share, unlike many private firms looking to protect proprietary information. This reinforces AEs position as a trusted third-party actor who helps build alignment around issues by bringing trusted and accurate information to all players.

Five Areas of Impact

For this research, Tierra structured its approach and applied the research framework presented above around the following five areas of impact and the services that Advanced Energy provides.

- ▶ [Motors and Drives](#) — Advanced Energy’s team of motor and drive system engineers strive to make motors and drives as energy efficient and reliable as possible. Using its internationally accredited test lab, Advanced Energy provides independent and unbiased testing, certification, training, and research services to governments, original equipment manufacturers, motor and drive manufacturers, distributors, motor service centers, utilities, and others.
- ▶ [Residential Housing](#) — Advanced Energy’s residential team works to ensure that new and existing homes are healthy, safe, affordable, comfortable, durable, energy-efficient, and environmentally responsible. Advanced Energy partners with electric utilities, program implementers, regional energy efficiency organizations, building product manufacturers and others on the design, development, and delivery of energy efficiency programs and trainings addressing market-rate and affordable housing.
- ▶ [Commercial and Industrial](#) — Advanced Energy’s commercial and industrial (C&I) team helps manufacturers and building owners save energy and money by making their facilities and production processes more efficient. Advanced Energy achieves this through trainings and workshops, energy and process assessments, and strategic energy management support services, such as ISO 50001 consulting.
- ▶ [Transportation](#) — Advanced Energy has helped shape the electric transportation industry since 1989 and it applies its expertise to encourage smart electric vehicle (EV) adoption. Advanced Energy administers [Plug-in NC](#), a statewide program in North Carolina that increases education and awareness around EVs, and partners with utilities, builders, governments, businesses, and schools to assist with their EV efforts.
- ▶ [Renewables](#) — Advanced Energy offers independent engineering services for commercial and utility-scale projects to ensure that renewable energy and battery storage facilities are installed to quality standards, provide optimal performance, and can be maintained for safe and reliable operation. Advanced Energy also led the development of the first independent, statewide, multi-utility green power pricing program — [NC GreenPower](#) — which collects voluntary contributions to support renewable energy and clean air. NC GreenPower also provides grants to schools for solar arrays and science, technology, engineering, and math (STEM) curricula for schools.



The Impact Curve

Advanced Energy works across these five areas using a process-oriented approach to research, education, and collaboration that is designed to transform the way energy is produced and consumed in North Carolina and beyond. This market transformation perspective follows an impact curve (Figure 2) which serves as the foundation for how Advanced Energy conducts business and creates results.

Figure 2. Advanced Energy's Impact Curve



The impact curve consists of the phases listed below. Advanced Energy creates impacts by building on the successes of each step. While the curve implies that the steps happen individually and sequentially, actual implementation is fluid and iterative. In other words, implementation of program services may uncover new problems or opportunities that require investigative research or additional training. For example, the advent of storage in utility-scale solar projects has necessitated new investigative research and the enhancement of contractor and developer trainings. In this way, the impact curve is a continual process that positions Advanced Energy to sustainably create impact for years to come. The five stages of Advanced Energy's market transformation impact curve are as follows:

- ▶ **Investigative Research** focuses on defining the underlying data necessary to solve a problem or identify an opportunity for improving efficiency within a given sector.
- ▶ **Testing and Evaluation** collects performance data; distinguishes high-quality, efficient products from those that are not; and supports certification programs.
- ▶ **Training and Education** for customers, trade allies, product manufacturers, utilities, and many other stakeholders promotes energy efficiency and clean energy and supports the delivery of high-performing products and services.

- ▶ **Consulting Services** provide strategic planning and other services for investor-owned and municipal utilities, electric cooperatives, industry organizations, government agencies, and others to support sustainable business models for high-performing products.
- ▶ **Program Services** directly deliver high-performing products and services.

The phases of the impact curve are defined by the actions Advanced Energy takes. These actions – listed below – represent the underpinnings of Advanced Energy’s unique approach to market transformation. The Delphi panel participants repeatedly discussed examples of the organization demonstrating the following actions in real, meaningful ways across all five areas of impact.

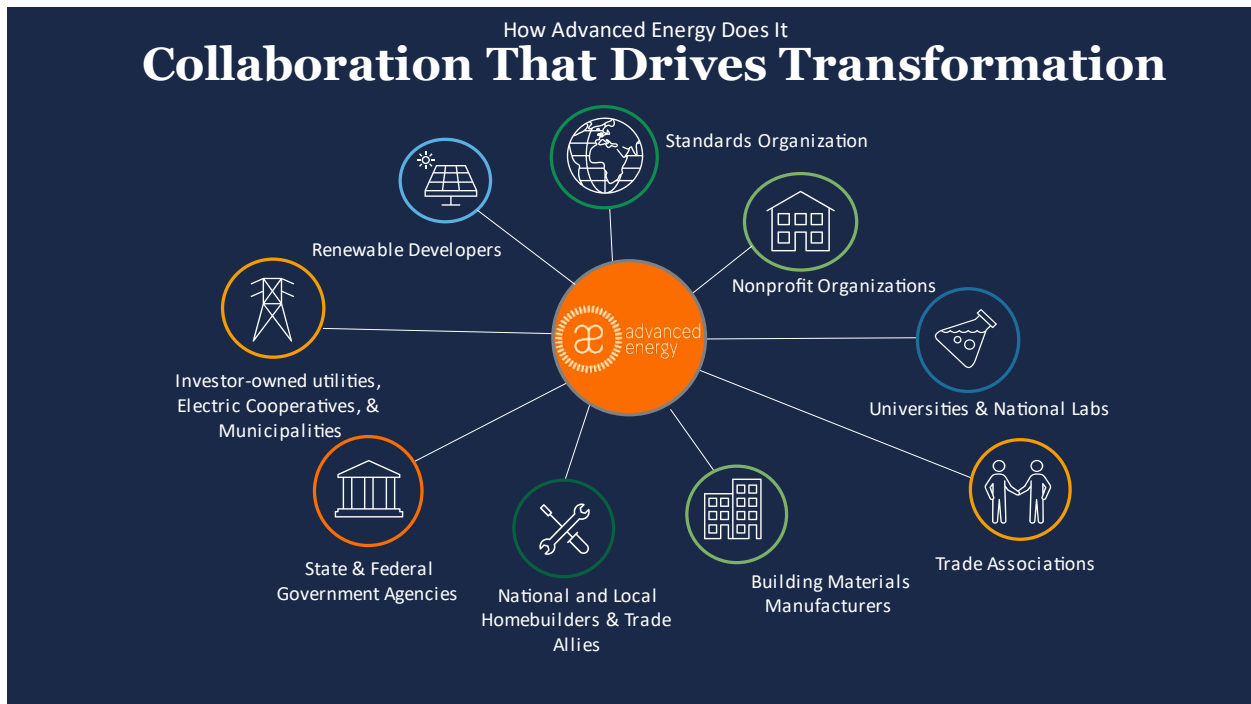
- ▶ **Taking Early Action with Cutting-Edge Ideas and Innovative Thinking** – Advanced Energy works with industry to understand issues and conduct the necessary investigative research and testing to formulate and act on bold ideas. While many businesses lack the resources to fully research issues and act on emerging bold ideas, Advanced Energy has the capability and direction to do so. For example, Advanced Energy recognized that motors convert 50% of the world’s electricity and saw how small incremental improvements in efficiency could save large amounts of energy. In response, Advanced Energy used its laboratory research and testing resources to support the development of national motor efficiency performance standards, which have since created significant energy-saving impacts.
- ▶ **Establishing Industry Standards and Performance Certifications** – Advanced Energy works with industry professionals to understand how efficiency standards and certifications make businesses more sustainable and profitable while also saving energy. While other organizations formally establish standards and set policy, Advanced Energy conducts investigative research and testing to support the development of those standards and to build understanding through workforce training. For example, the motors and drives team supported U.S. Department of Energy (DOE) performance standards created through the Energy Policy Act (EPAct) and Energy Independence and Security Act (EISA) by actively participating on committees and providing test data collected at Advanced Energy’s lab.
- ▶ **Defining Energy Technology Applications and Installation Best Practices** – Similar to standards and certifications, Advanced Energy identifies improvements through research and testing and supports workforce development initiatives that make efficient applications and installation practices the industry standard. Advanced Energy’s engagement with residential builders and industry professionals through events such as the Residential Energy Forum ultimately led to the development of performance standards and the thermal bypass checklist that served as the basis for approximately 750,000 homes built to ENERGY STAR Version 3 specifications to date. This effort redefined the way builders construct, insulate, and seal homes and achieved energy savings of about 12% compared to standard construction practices.
- ▶ **Collaborating with Partners** – Advanced Energy collaborates with stakeholder groups across all phases of the impact curve to build a shared understanding of how to advance efficiency within a sector, why it is important, and how it creates sustainable business models. Advanced Energy frequently partners with investor-owned utilities, electric cooperatives, federal, state, and local government agencies, trade associations, nonprofits, manufacturers, and others (Figure 3).
- ▶ **Serving Customers from Large C&I to Residential Limited Income** – Advanced Energy’s research, testing, training, and program services span all sectors and customer segments, ranging from large, international industrial manufacturers like Daimler Trucks North America pursuing energy



management goals to nonprofit organizations such as Habitat for Humanity that build affordable housing for limited-income populations.

- ▶ Driving Scope/Scale to Transform Markets – Advanced Energy’s actions create impacts and benefits for communities and businesses at the local, regional, national, and international levels. Advanced Energy provides direct program and consulting services within North Carolina (e.g., SystemVision, NC GreenPower, Plug-in NC) and in the Southeast (e.g., interconnection commissioning, C&I assessments). Moreover, Advanced Energy’s investigative research, testing, and workforce development have also created impacts at the national level (e.g., motor efficiency performance standards, ENERGY STAR Homes and Environments for Living, ISO 50001), and in some cases at an international level (e.g., NORMA Oficial Mexicana).
- ▶ Nurturing Small Homegrown Successes and Creating Economic Development Opportunities for North Carolina Businesses – Advanced Energy works with local businesses to support economic development, create jobs, and make energy use cleaner and more efficient across all steps of the impact curve. For example, Advanced Energy worked with North Carolina-based Pentair to gain funding to develop efficient variable speed pool pumps and deliver them via utility (e.g., Southern California Edison, Arizona Public Service) energy efficiency programs. The pool pumps reduce consumption by up to 90% and have resulted in state and national codes and standards being updated to require the technology.

Figure 3. Advanced Energy Collaborators Over the Past 40 Years



Impact and Influence Framework

Building on Tierra's understanding of Advanced Energy's position in the market, the Tierra team developed a six-point framework to capture and organize the important actions, ideas, collaborators, and impacts that make up Advanced Energy's 40-year history. The framework consisted of six key questions to guide the research and to trace the organization's history in a concise and consistent manner.

- ▶ What is the bold idea behind Advanced Energy's approach? Advanced Energy creates impacts from a bold idea that drives the research, testing, training, and programs that make up its impact curve. Advanced Energy is uniquely positioned to act on those bold ideas as part of its corporate purpose to "promote or fund...the efficient uses of electric power." Tierra developed draft statements describing the bold ideas for each of Advanced Energy's five areas of impact and refined those statements through the interviews with subject matter experts.
- ▶ What is the context? Advanced Energy's bold ideas emerged from discussions, interactions, and collaborations with industry associations, utilities, government agencies, and other organizations as Advanced Energy and its respective partners sought to identify gaps, needs, and priorities related to the efficient use of energy across a range of sectors. This research question focused on the key milestones and context within each sector that prompted the bold idea behind Advanced Energy's approach. For example, a lack of consistent standards for the commissioning of utility-scale solar led to less-than-optimal operation of some large photovoltaic (PV) systems. Advanced Energy then filled this niche by working with the industry to develop protocols for the interconnection commissioning of utility-scale PV.
- ▶ What is Advanced Energy's approach for each sector? Advanced Energy customizes its approach to the market transformation impact curve for each individual sector based on addressing the unique needs of those customers. This research question included documenting how the organization's actions align with each step along the impact curve - research, testing, training, consulting, and program services - to act on the bold idea. For instance, in the case of motors and drives, this meant using a nationally accredited lab to conduct testing and certification and applying those learnings to inform national efficiency performance standards. In residential housing, this meant testing and inspecting blower doors, duct systems, and envelope construction in actual homes to develop best practices that served as the foundation for national programs, like ENERGY STAR homes.
- ▶ What are the key actions? Advanced Energy achieved key milestones over its 40-year history that highlight its advancements in creating impacts from its bold ideas. Rather than replicating Advanced Energy's previous efforts to document its history, for this research question Tierra examined existing documentation and convened Delphi panel discussions to establish historical context and identify the most important and influential actions taken by Advanced Energy as it established trust within the industry in the process of transforming each market sector.
- ▶ Who are the key actors? Advanced Energy's local, national, and international achievements are built on trusted relationships with hundreds of organizations and thousands of people. Organizations include investor-owned and municipal utilities, electric cooperatives, federal, state, and local government agencies; industry associations; nonprofits; national manufacturers; schools and universities; and North Carolina-based businesses. Tierra documented organizations and collaborators within and outside of Advanced Energy during the Gathering Insights phase of the project.



- ▶ **What are the impacts?** Advanced Energy’s actions create energy, environmental, economic, health, and safety benefits for individuals, organizations, and communities within North Carolina, across the country, and around the world. For the purposes of this research, Tierra defined the quantifiable impacts as energy savings, greenhouse gas reductions, and energy cost savings that result from and are attributable to Advanced Energy’s actions. Tierra estimated impacts using data collected through surveys, interviews, and secondary research that quantified the number of tangible units (homes, motors, etc.) influenced by Advanced Energy’s actions, the amount of energy those units saved, and an influence factor that accounts for Advanced Energy’s contributions to achieving those energy savings. These are discussed more in the Quantifying Impacts section below.

Gathering Insights

Once Tierra established the research framework, clarified Advanced Energy’s impact curve, and identified the organization’s typical collaborators, the Tierra team next identified key partners and industry subject matter experts who were familiar with the organization’s efforts and recruited them to participate in a multi-phase, modified Delphi panel to build the qualitative and quantitative components of the research framework. The Delphi method gathers input from a panel of experts using multiple rounds of questions. After each round the responses are aggregated and shared with the group until consensus is reached.

The Delphi panel phases included an online survey sent to all participants to gather initial data to understand influence and quantify impacts. The survey was followed by six group discussion panels to refine the survey data and learn more about the most relevant contextual factors, people, and actions associated with each area of impact. In addition, Tierra conducted six individual interviews with collaborators who were unable to attend the group interviews or who were used to provide additional independent verifications. Upon completion of the data collection phase, the Tierra team sent follow-up emails, one to verify the impacts and one to verify the information presented in the Advanced Energy’s Influence and Impact section below. This process allowed Tierra to gather a range of insights and refine the findings through continual engagement with Advanced Energy’s collaborators.

In all, Tierra gathered insights through surveys and interviews from more than 60 subject matter experts representing over 25 different organizations (Figure 4). Several individuals who had worked at Advanced Energy in the past indicated that their experiences enabled them to share Advanced Energy’s market transformation process to their current roles at other nonprofits, universities, government agencies, and additional organizations.



Figure 4. Survey and Interview Contributors

Renewables	Transportation	C&I	Motors & Drives	Residential
<p>Duke Energy Kevin Chen W. Roger Paules, Jr. Randolph EMC Dale Lambert Solar Operations Solutions Adam Foodman Strata Solar John Gajda NC Utilities Commission Sam Watson Pritchard Engineering Ewan Pritchard* NCSEA Ward Lenz* Baylor University Emmanuel Agamloh* Quanta Technology Carl Wilkins* Advanced Energy/NC GreenPower Cyrus Dastur Shawn Fitzpatrick Staci Haggis Nathan Holder Katie Lebrato Bob Goodson Vicky McCann Bob Koger</p>	<p>Randolph EMC Michael Trent Town of Cary Katie Drye* NCSEA Ward Lenz* Pritchard Engineering Ewan Pritchard* NC Clean Energy Technology Center Lisa Poger* Advanced Energy Jacob Bolin Kristi Brodd Alexis Giannattasio</p>	<p>Electric Power Research Institute Perry Stephens (Duke Energy) Duke Energy W. Roger Paules, Jr. Daimler Trucks North America Sandra Carter Nidec Motor Corporation Rob Boteler Pritchard Engineering Ewan Pritchard* Baylor University Emmanuel Agamloh* Welch Energy Services Dan Welch* Advanced Energy Mike Stowe Charlie Martin Kitt Butler Nathan Holder</p>	<p>Nidec Motor Corporation Rob Boteler NEMA Kirk Anderson (UL) NEMA/SEW Eurodrive Tim Schumann JMAL Consulting John Malinowski (ABB/Baldor - Reliance) Franklin Electric Dan Delaney Electrical Apparatus Service Association Tom Bishop WorldWide Electric Rick Simmons Pritchard Engineering Ewan Pritchard* Baylor University Emmanuel Agamloh* Blue Ridge CC Bob Zickefoose* Welch Energy Services Dan Welch* Advanced Energy Kitt Butler Michael Lyda Jonathan Coulter</p>	<p>Davenport Consulting, LLC Rick Davenport (Louisiana-Pacific/MASCO) BASF Brad Townsend John Tooley, LLC John Tooley* NCSEA Kristi Matthews* Ward Lenz* Housing 2.0 Sam Rashkin (U.S. EPA) Building Performance Association Keith Aldridge* Retired Arnie Katz* Advanced Energy Brian Coble Lisa Manuel Jonathan Coulter Maria Mauzeri</p>

*Former Advanced Energy employee

The initial survey was conducted as a broad data-gathering exercise to identify the actions, programs, and topics that would later serve as the areas of focus for the interviews. Tierra obtained more than 40 survey responses across the 18 topic areas presented in Figure 5. These included questions that asked respondents to provide qualitative insights into which of Advanced Energy’s actions they believed were most impactful and to estimate values that would later be used to derive the impacts, including:

- ▶ Tangible Units - The number of “units” of participation (e.g., motors, homes, facilities) impacted by a program, standard, etc.
- ▶ Savings – The reduction (or percent reduction) in energy consumption due to a program, standard, etc. (e.g., SystemVision, C&I process assessments)
- ▶ Influence – The portion of energy savings attributable to Advanced Energy’s contributions

Figure 5. Survey Topics

C&I	Motors & Drives	Renewables	Residential Housing	Transportation
<ul style="list-style-type: none"> • Training • Energy Assessments* • Strategic Energy Management 	<ul style="list-style-type: none"> • Motor Efficiency Performance Standards* • Motor Efficiency Testing and Certification • Motor Management Training • Proven Efficiency Verification (PEV) Program* 	<ul style="list-style-type: none"> • NC GreenPower • PV Interconnection Commissioning 	<ul style="list-style-type: none"> • Residential Consulting (Advanced Energy at Home) • Environments for Living* • ENERGY STAR Homes* • SystemVision* • Closed Crawlspace* 	<ul style="list-style-type: none"> • Plug-In NC • Plug-In Electric Vehicle Consumer Usage Study • NC EV Roadmaps • Co-op Electric Vehicle Planning

*Denotes topics with quantified energy savings.

Prior to each group and individual interview, Tierra developed a draft response for each question of the six-point framework based on data from discussions with Advanced Energy, review of existing documentation, and insights from the survey. Tierra then used those drafts to guide the interview discussion.

In the first portion of the interview, participants were asked to:

- ▶ Verify and refine initial drafts of the bold idea.
- ▶ Provide context regarding key issues and opportunities that led to the development of the bold idea and why it was necessary.
- ▶ Identify specific actions Advanced Energy took to advance the bold idea.
- ▶ Verify the key organizations and people that Advanced Energy collaborated with.

The second portion of the interview focused on discussing and refining the three impact-related inputs shown above. For this, we presented the estimates obtained from the survey, led a group discussion about the values the panelists felt to be most accurate, and then polled the panelists to arrive at a final answer. The iterative discussion format afforded participants an opportunity to provide examples of how Advanced Energy contributed to the collective achievements within a given sector.

Based on the results of the interviews, Tierra developed initial drafts summarizing Advanced Energy's approach, influence, and impacts within each sector. These were then distributed to the panelists for review. This step allowed the panelists to see how their specific answers resulted in the final numbers to be reported. For example, Table 1 shows how factors and impacts for motor efficiency performance standards changed with each step of the process from the survey, interview, and verification emails, thereby highlighting the importance of the ongoing engagement with Advanced Energy's subject matter experts. The calculations to develop these impacts are discussed in the next section.

Table 1. Refinement of Impacts from Surveys, Interviews, and Emails

	Initial Survey	Interview	Follow-up Email Refinement
Percent Energy Savings	5%	2.5%	2.5%
Number of Motors	1,792,533	6,714,286	3,071,429
Influence Factor	65%	50%	20%
Impacts (GWh)	2,696	3,884	711

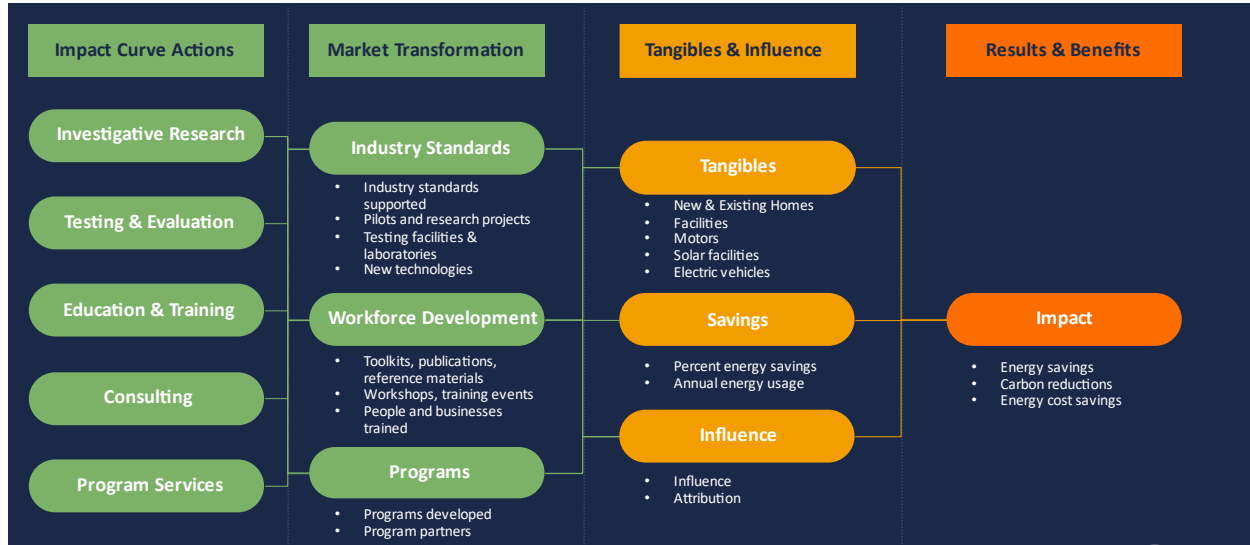
Quantifying Impacts

In the final phase of the research methodology, Tierra quantified the impacts of Advanced Energy's actions based on the insights gathered from the subject matter experts. The diagram presented in Figure 6. demonstrates how Advanced Energy's five-step process (e.g., Impact Curve Actions) transforms markets through industry standards, workforce development initiatives, and programs (e.g., Market Transformation) to influence the production of efficient products (e.g., Tangibles and Influence) and ultimately create energy and cost savings, carbon reductions, and health, safety, and economic benefits for people, businesses, and communities (e.g., Results and Benefits). This segmented approach to



quantification facilitated Tierra's analysis by enabling it to trace how Advanced Energy transforms a given market and to understand the influences that actions have on the creation of high efficiency products, and ultimately the energy and non-energy benefits that people enjoy as a result.

Figure 6. Impact Quantification Framework



The market transformation outcomes of Advanced Energy's actions include products, research, services, and programs that demonstrate to market actors the differentiators that make up an efficient product. These generally fit within three categories: Industry Standards, Workforce Development, and Programs, and are listed as bullet points under each category in Figure 6.

- ▶ **Industry Standards** includes the research projects, testing services, and pilot demonstrations that support the development of industry standards. This includes the motor efficiency performance standards (MEPS) and the building performance standards that serve as the foundation for national residential new construction programs. The nearly 4,000 motors tested by Advanced Energy through its nationally accredited lab is one example of a quantification metric in this category.
- ▶ **Workforce Development** includes the trainings, workshops, and reference materials that support the adoption of efficient practices and products within a sector. Advanced Energy provides dozens of workshops, trainings, and presentations each year to thousands of industry professionals across all sectors. In 2020, even with the limitations of precautionary measures due to COVID-19, Advanced Energy led and participated in over 60 webinars, trainings, and presentations that reached close to 3,000 industry professionals. This category also includes reference materials – such as the [Standard Work Specifications](#) for the residential retrofit market – that Advanced Energy contributed to.
- ▶ **Programs** includes the strategic program planning and implementation services that Advanced Energy provides. Examples include the five strategic EV roadmaps developed for the state of North Carolina, and the formation and operation of [Plug-in NC](#), [SystemVision](#) and [NC GreenPower](#).

Advanced Energy has produced or contributed to many standards, workforce development materials, and programs. In place of quantifying impacts for every market transformation product or service, Tierra worked with Advanced Energy to identify the most representative and impactful energy savings initiatives for each sector. These topics are bolded and denoted with an asterisk in Figure 5 above. Tierra also collected data regarding the amount of clean energy installed and produced for NC GreenPower, interconnection commissioning, and the quantity of EVs and charging stations for Plug-in NC, to convey the quantitative impacts for these initiatives.

For each topic, Tierra calculated energy savings, and the related impacts of greenhouse gas reductions and utility cost savings, based on three primary metrics: Tangibles, Savings, and Influence, which are defined below.

- ▶ **Tangibles** refers to the physical “units” that result from the market transformation products and services. This includes the actual homes, facilities, motors, solar PV systems, or EVs that result in saving energy or producing clean energy. Tierra developed counts of these units from various sources, including program records maintained by Advanced Energy and their partners, publicly available data sources, interviews, and follow-up discussions with subject matter experts.
- ▶ **Savings** refers to the energy saved due to a program or standard (e.g., SystemVision, C&I process assessments) that Advanced Energy helped create. Tierra derived savings from estimates of the energy consumed by a “unit” over its useful lifetime and the percent energy saved from a program. Values for these metrics were obtained from publicly available measurement studies and confirmed with subject matter experts through interviews and follow-up discussions.
- ▶ **Influence** refers to the percent of energy savings attributable to Advanced Energy’s contributions (i.e., the influence factor) among those of its collaborators. The impacts resulting from these programs and services would not have been possible without contributions from every organization and person involved. However, given that the purpose of this research is to quantify Advanced Energy’s impact specifically, this metric apportions a percentage of the overall impact as directly attributable to Advanced Energy. Tierra built consensus around this metric and the resulting impact numbers through surveys, interviews, and follow-up emails with subject matter experts.

Multiplying these three metrics and the lifetime for each “unit” together results in the cumulative impact from Advanced Energy’s contribution. As an example, the following equation shows how Tierra calculated cumulative energy savings for motor efficiency performance standards:

Equation 1. Calculation of Cumulative Energy Savings for Motor Efficiency Performance Standards

$$92,142,857 \text{ motors} \times 1,157 \text{ kWh/year for each motor} \times 10 \text{ years} \times 20\% \text{ influence factor} \times 10^{-6} \text{ GWh/kWh} = 213,196 \text{ GWh}$$

These energy impacts are converted to greenhouse gas reductions and utility cost savings based on the following assumptions:

- ▶ Carbon Equivalent Intensity Factor – North Carolina: 779.5 lbs/MWh³

³ [eGRID2019 Summary Tables – Table 3.](#)



- ▶ Carbon Intensity Factor – United States: 889.2 lbs/MWh⁴
- ▶ Average Industrial Cost of Electricity: \$0.067/kWh⁵
- ▶ Average Residential Cost of Electricity: \$0.10/kWh⁶

Details on the values and sources used for each input can be found in the supporting spreadsheet – “Appendix – Quantification Analysis.”

⁴ Ibid.

⁵ <https://www.statista.com/statistics/190680/us-industrial-consumer-price-estimates-for-retail-electricity-since-1970/>

⁶ <https://www.statista.com/statistics/183700/us-average-retail-electricity-price-since-1990/>



Advanced Energy's Influence and Impact

Overview

As noted above, Tierra's research methodology yielded an abundance of factual data, calculations, and expert insights that were then distilled into the findings discussed below. Because the scope of this project spanned a 40-year timeframe, the distillation process necessitated a high degree of summation, condensation, and truncation to convey the most essential activities undertaken by Advanced Energy and the cumulative impacts of its prolonged efforts while remaining within the confines of a readable and easily digestible report.

In the subsections below, we discuss the five primary areas of Advanced Energy's impact individually, but each subsection shares the same format to enable readers to understand how Advanced Energy follows the same essential approach from an originating bold idea through each of the steps along its impact curve. Each of the five subsections begins with a discussion of the bold idea or guiding principle driving Advanced Energy's efforts in that sector. This is followed by an overview to establish historic context for the activities over time. Next comes a summation of the most important initiatives, major milestones and seminal outcomes achieved by Advanced Energy and its collaborative partners. Each subsection ends with an impact section that discusses the tangible effects and subtle influences that led to the final results and the ultimate benefits enjoyed by the people of North Carolina and beyond.

Table 2 summarizes the impact and influence metrics quantified by Tierra and the corresponding energy savings for seven market transformation standards, services, and programs in the motors and drives, commercial and industrial, and residential housing sectors, where energy savings are the primary impact. NC GreenPower, PV Interconnection Commissioning, and Plug-in NC are not included in the table because they primarily facilitate the production and use of clean power instead of saving energy. Impacts for these programs, including clean energy produced or EV infrastructure installed, were sourced directly from program tracking records provided by Advanced Energy and can be found in the impact and influence discussions in the subsections below.



Table 2. Impact and Influence Summary⁷

Area of Impact	Market Transformation Initiatives	Tangibles (# of units)	Savings (kWh per year)	Influence Factor (%)	Lifetime of Unit (years)	Cumulative Energy Savings (GWh)
Motors & Drives	Motor Efficiency Performance Standards	92,142,857	1,157	20%	10	213,196
	Proven Efficiency Verification Program	721,951	231	50%	10	835
C&I	C&I Energy and Process Assessments	1,600	126,214	50%	10	1,010
Residential Housing	Environments for Living	300,000	2,130	89%	25	14,176
	ENERGY STAR Version 3	750,000	1,704	63%	25	19,967
	SystemVision	5,346	1,942	84%	25	218
	Closed Crawl Spaces	10,000	1,295	82%	25	265

Motors and Drives

Bold Idea

At a time when few people were thinking about motor efficiency, Advanced Energy recognized that motors represent approximately 50% of all electricity use worldwide - so consistent incremental improvements in motor efficiency could yield dramatic cumulative energy savings. To realize those savings, consumers needed a way to tell the difference between efficient and inefficient motors. Advanced Energy set out to provide both; and in pursuit of this bold idea, Advanced Energy has become one of the most internationally recognized and influential motor testing laboratories in the world.

Overview

Although many market transformation efforts arise in response to government regulations, Advanced Energy began advocating for motor system efficiency and testing three years before the federal government enacted the Energy Policy Act of 1992 that set goals, issued mandates, and changed utility laws to increase clean energy use and improve energy efficiency in the United States. Advanced Energy staff started educating customers and government representatives about the importance of motor efficiency in 1989. The following year, the organization established a motor testing lab in Raleigh, North

⁷ The “Tangibles” column accounts for the cumulative number of units impacted by AE’s actions. For example, the 92.1 million value represents the number of motors sold over the 30-year time frame for the standard.



Carolina, to fill the void for accredited third-party motor testing. A wide range of additional activities followed, including a burgeoning motor testing consultancy, advisory services on the creation of motor efficiency standards, and a host of certification and training programs to educate industry and government and to expand the number of qualified motor repair facilities. From 1990 to 2021, Advanced Energy has tested nearly 4,000 motors and drives in its internationally accredited lab, and provided trainings and consulting to governments, businesses, and utilities. This work has contributed to the development of worldwide motor efficiency standards and laid the groundwork for the testing of variable frequency drives to meet performance standards.

Approach

When new technologies are developed, early prototypes must be tested to assess their performance under real-world conditions and determine their safety, efficacy, and efficiency before they can be released to the general market. Likewise, new standards must be developed to ensure that motors and drives sold and operating in the marketplace comply with federal and state regulations. Advanced Energy's motors and drives team plays an important role in both these activities.

Advanced Energy's efforts in the policy and standards arena kicked off in the early 1990s by aligning with regulators, industry groups, and energy efficiency organizations to develop the U.S. Department of Energy's (DOE) minimum energy performance standards for electric motors that have now guided motor efficiency levels for more than 30 years. Advanced Energy's experts continue to work on a variety of research grants supported by the DOE, state agencies, utilities, and industry as they help to develop new testing methods and define new motor efficiency standards and regulations.

As efficiency regulations expand to additional motor types and motor-driven systems, Advanced Energy ensures they can be tested accurately and then investigates the motors' performance to assess energy efficiency and reliability. The number and style of motors that Advanced Energy is accredited and certified to test has grown steadily over the last three decades. In its early years, Advanced Energy's Industrial Electrotechnology Laboratory tested dozens of motors to help industrial customers increase productivity with improved efficiencies. Then in 1997, Advanced Energy's testing efforts expanded appreciably after its lab became the first in the world to be accredited through the National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program. While many manufacturer labs have since been accredited through the same program, Advanced Energy remains the only independent lab with such recognition in North America, making it uniquely qualified to evaluate and validate motors, drives and related products. Several other prominent accreditations and certifications followed, including:

- ▶ NORMA Oficial Mexicana (NOM) – Since 2012 Advanced Energy has served as the only independent motor efficiency testing lab outside of Mexico to perform electric motor testing for NORMA Oficial Mexicana (NOM) standards to assist motor manufacturers with motor efficiency compliance requirements in Mexico.
- ▶ Air-Conditioning, Heating, & Refrigeration Institute (AHRI) 1210/1211 – Advanced Energy serves as the only lab in the world authorized to perform testing to AHRI 1210/1211, a voluntary standard for variable frequency drive manufacturers in the HVAC industry. Since 2013, Advanced Energy has partnered with UL and AHRI to test VFDs for the AHRI Certified® program. Each year, VFDs are pulled from manufacturers' inventory by UL and sent to Advanced Energy's lab to be tested to the standard.



- ▶ ANSI ISO/IEC 17065 — In 2018, the American National Standards Institute (ANSI) recognized Advanced Energy as a Certification Body to ISO/IEC 17065 for energy efficiency verification of electric motors and generators.
- ▶ ISO/IEC 17025 — Since 1997, Advanced Energy has maintained confidence in its independent testing by delivering valid results and demonstrating high quality and competence to ensure ongoing annual accreditation of its test lab to ISO/IEC 17025.

These formal accreditations enable Advanced Energy to evaluate a wide variety of motors and drives from throughout the world. They also serve as the foundation for Advanced Energy to provide independent and unbiased services to governments, utilities, motor and drive manufacturers, original equipment manufacturers, distributors, and motor repair facilities. Among these services, Advanced Energy additionally helps its clients develop their own in-house motor testing capabilities.

Because technologies and standards constantly evolve, Advanced Energy also has a long history of conducting training activities. These efforts include hundreds of virtual and in-person workshops that provide classroom and hands-on learning for motor and drive users, manufacturers, purchasing managers, trade associations, utility account representatives, motor service centers, government contractors, professional engineers, technicians, and others. Topics include quality and performance standards, safety, and best practices for motor operation, management, troubleshooting, repair, and maintenance.

In addition to providing live instruction, Advanced Energy has distributed its Horsepower Bulletin since 1991. The Horsepower Bulletin assists motor users in managing their equipment by helping them to understand motor policy, make wise purchasing decisions, design energy management plans, operate motor-driven systems effectively, and repair them appropriately to ensure continued reliability and efficiency. Advanced Energy also helps businesses decide whether to repair or replace their motors via its motor survey. This survey empowers customers to conduct an inventory to track the history of their motors and make more-informed motor management decisions.

In many cases, it makes more economic sense to repair a motor than to replace it. For this reason, Advanced Energy developed a first-of-its-kind third-party quality assurance program for motor repair called Proven Efficiency Verification (PEV). PEV mutually benefits motor repair purchasers and providers by certifying that qualifying motor service centers consistently conduct repairs that perform at top efficiency. Once a motor service center completes the program requirements, it is entitled to use Advanced Energy's certification trademark. In 2014, the Electrical Apparatus Service Association (EASA) created its own motor repair accreditation program and chose Advanced Energy to be a third-party auditor. In this capacity, Advanced Energy is able to help more motor service centers follow quality assurance procedures that restore motor efficiency during the repair process.

Most recently in 2020, Advanced Energy achieved recognition from the DOE as a nationally recognized certification program for electric and small electric motors, giving motor manufacturers seeking compliance with DOE regulations a new source for motor efficiency certification.

In these multiple ways, Advanced Energy's decades of activities in the realm of motors and drives are helping to realize sizeable energy savings in real-world settings as shown in the Impacts and Influence section below.



Impacts and Influence

With the prevalence of motors and drives in most every building and industrial process in the U.S. and the fact that motors convert 50% of the world's electricity to mechanical energy, Advanced Energy's motors and drives team has achieved impacts that are greater in both scale and magnitude compared to the other sectors presented in this report. The residential housing sector, which has the next largest impacts, provides a good example for comparison. With respect to scale, over 3 million motors are sold each year in the U.S., compared to the almost 1 million new homes constructed in 2019⁸, only a portion of which are built to above-code efficiency standards. With respect to magnitude, the average motor consumes 46,000 kWh⁹ per year, which is three-and-a-half times the 13,000 kWh¹⁰ used by an average home in North Carolina annually. Advanced Energy's motor reach also impacts housing efficiency, as the average home has 30 to 45 motors in it.

For the purposes of this research, Tierra estimated energy savings impacts for two of the most impactful motors and drives initiatives: motor efficiency performance standards and the PEV program. As discussed above, Advanced Energy's motors and drives team supports more than these two initiatives, and the impacts presented here should be considered conservative estimates of Advanced Energy's total impact in the sector. The combined impacts of these two initiatives before factoring in Advanced Energy attribution amount to over 1 million cumulative GWh. This accounts for an average increase of 2.5% in motor efficiency from performance standards for the over 3 million¹¹ motors sold each year in the U.S.,

Promoting Motor Efficiency Across the US with Pentair

Among the 5 million U.S. homes that feature in-ground swimming pools, pool pumps represent one of the top three energy-using appliances. Recognizing this in 2005, AE approached Sanford, North Carolina-based Pentair with the idea of applying for an innovation grant that Southern California Edison (SCE) was offering for new energy-saving technologies. Their joint winning proposal resulted in a residential energy efficiency pilot program for SCE to promote and test Pentair's innovative new variable speed pool pumps.

Unlike single-speed pool pumps that run constantly or at preset and unnecessary intervals, this technology monitored pool conditions and adjusted system pumping automatically. As a result, the improved drive motor and impeller design reduced electricity use by up to 90% over conventional pumps.

Over the three-year pilot test period, the technology and the utility program design proved to be successful and eventually established a new industry standard. In fact, these early successes were so promising that before the pilot was even over, the technology and utility program design were adopted by two other California utilities, Pacific Gas and Electric and San Diego Gas and Electric. Within a few years, they were embraced by dozens of electric utilities, including Duke Energy, as well as by tens of thousands of swimming pool owners.

In 2013, Pentair received EPA's ENERGY STAR Partner of the Year Award for its high efficiency pool pumps. According to Pentair¹², its ENERGY STAR-rated pool pumps have saved U.S. pool owners \$2.4 billion in operating costs and 22 billion kWh of energy¹³ since 2005. These energy savings helped cut 17.1 million tons of carbon dioxide emissions, which is the equivalent of 38.6 billion car-driven miles.¹⁴

⁸ <https://www.statista.com/statistics/184842/single-family-house-starts-in-the-united-states-since-2000/>

⁹ Department of Energy. Table 1-3. "[PREMIUM EFFICIENCY MOTOR SELECTION AND APPLICATION GUIDE](#)".

¹⁰ Energy Information Administration – [2019 Average Monthly Bill – Residential](#).

¹¹ Based on input from AE subject matter experts

¹² Pentair, <https://investors.pentair.com/investor-relations/news-releases/news-release-details/2020/Pentair-Earns-2020-ENERGY-STAR-Partner-of-the-Year--Sustained-Excellence-Award/default.aspx>

¹³ Savings are based on a weighted average annual kWh savings from the Consortium for Energy Efficiency (CEE) at \$0.11 / kWh. Individual Weighted Energy Factor (WEF) scores and savings may vary by model.

¹⁴ Source: EPA Greenhouse Gas Equivalencies Calculator: <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>



and the 0.5% efficiency improvement for the over 36,000¹⁵ motors repaired by EASA-accredited businesses each year. Based on the Delphi panel discussions, Advanced Energy influences approximately 20% and 50% of savings from motor efficiency standards and efficient motor repairs, respectively. Adjusting the total impacts amounts to more than 214,000 cumulative GWh. Those impacts equal over 86 million metric tons of avoided CO₂e, over \$14 billion in electricity cost savings and are the equivalent of powering 660,000 North Carolina homes for 25 years. The following impact statements summarize the achievements and impacts of Advanced Energy's motors and drives team.

Motor Management Training

- ▶ Advanced Energy's motors and drives team has trained thousands of people and hundreds of businesses in proper motor management. Each year, approximately 100 people representing 50 businesses participate in the 3-4 motor management workshops conducted by Advanced Energy.

Motor Efficiency Testing

- ▶ Advanced Energy's motors and drives team has tested nearly 4,000 motors for approximately 70% of national motor manufacturers through its nationally accredited lab.

Motor Efficiency Performance Standards

- ▶ Advanced Energy supported the development of 10 national and international motor efficiency and testing standards. Efficiency standards save 711 GWh each year and are forecasted to save 213,196 GWh over the 30-year time frame for motor performance standards.

Efficient Motor Rewind Practices/PEV Program

- ▶ Since 2000, Advanced Energy has certified approximately 20 businesses through the PEV program. PEV influenced the EASA accreditation program, where Advanced Energy directly audits 33 business representing 22% of national EASA Accredited repair centers and approximately 2% of total service centers. Advanced Energy's contributions to expand the use of efficient motor rewind practices save approximately 4 GWh each year and 835 GWh cumulatively, with room to grow.

Overall Impacts

- ▶ 715 GWh saved each year attributed to Advanced Energy's motors and drives influence and actions
- ▶ 214,031 GWh saved cumulatively attributed to Advanced Energy's motors and drives influence and actions
- ▶ 288,316 metric tons of CO₂e avoided annually attributed to Advanced Energy's motors and drives influence and actions
- ▶ \$47,607,647 in annual electricity cost savings attributed to Advanced Energy's motors and drives influence and actions
- ▶ 86,326,257 metric tons of CO₂e cumulatively avoided attributed to Advanced Energy's motors and drives influence and actions

¹⁵ Ibid.



- ▶ \$14,254,481,654 in cumulative electricity cost savings for consumers attributed to Advanced Energy's motors and drives influence and actions

Residential Housing

Bold Idea

When Advanced Energy began its efforts in residential energy efficiency, building science remained a nascent field and the construction industry lacked cohesion. Advanced Energy staff helped focus the industry by promoting two key ideas. First, that a house is a holistic collection of interrelated systems; and second, that establishing and applying a consistent set of standards and practices across the industry would yield better home performance and occupant comfort in both market rate and affordable housing. As Advanced Energy pursued these concepts, it helped to transform a market segment that represents 26% of energy use in North Carolina and 21%¹⁶ throughout the U.S.

Overview

Among Advanced Energy's greatest strengths is its ability to bring together diverse groups of stakeholders, even those with widely divergent, even opposing, viewpoints, and to facilitate highly effective collaborative processes. Perhaps nowhere is this better illustrated than in Advanced Energy's residential practice. Advanced Energy's first major effort in this regard occurred in the 1980s, when it hosted a multiday forum with dozens of experts to establish the hallmark attributes of a high-performance home. The event launched Advanced Energy on a decades-long path of partnerships with building scientists, state and federal agencies, utilities, industry associations, academics, and other stakeholder groups. It also gave rise to Advanced Energy's guiding residential credo of promoting energy efficient, comfortable, affordable, healthy, safe, durable, and environmentally responsible homes.

This credo and Advanced Energy's multitude of alliances led to new federal standards for home performance, nationally standardized minimum specifications for energy efficiency upgrades in residential housing, and an ever-expanding set of scientifically backed, but still practical, best practices for the construction trades. They also resulted in novel concepts such as home performance guarantees, paradigm-changing approaches to building systems integration, and market transformation efforts that established the closed crawl space industry in North Carolina and across the county.

Approach

Advanced Energy's activities in the residential arena began with a series of outreach efforts developed in conjunction with local stakeholders and utilities to educate and inform people about energy efficiency, weatherization, and alternative energy sources. At the same time, Advanced Energy's early research efforts explored energy-efficient technologies, residential load control strategies, and a software program to estimate energy consumption in individual public housing units.

These parallel efforts converged in 1989, when Advanced Energy convened a seminal three-day Residential Energy Forum that gathered representatives from 21 organizations, including governmental agencies, utilities, trade associations and universities to define the characteristics of a high-performance home. The next year, Advanced Energy launched a five-home new construction pilot to demonstrate these characteristics and followed up with a practical field guide for builders. This in turn gave way to

¹⁶ <https://rpsec.energy.gov/energy-data-facts>



Advanced Energy's Energy-Efficient Home Program with the National Association of Home Builders that encouraged voluntary standards for builders and promoted the financial advantages of low energy bills to mortgage lenders.

As Advanced Energy's reputation grew, they teamed up with building science leaders, including Louisiana-Pacific and the Masco Corporation, to develop the Engineered for Life and Environments for Living new home guarantee programs. These programs ensured high-quality products and installations in new home construction and provided homebuyers with assurances regarding comfort and energy usage. The achievements prompted the U.S. Environmental Protection Agency (EPA) to contract with Advanced Energy to evaluate the performance standards of its ENERGY STAR® for New Homes program and compare them to the standards set by Environments for Living and to traditional code-built homes. Field research in Phoenix, Arizona, and Houston, Texas, indicated that ENERGY STAR homes performed similarly to code-built homes, and underperformed the Environments for Living homes. Consequently, the EPA updated its program specifications to more rigorous standards for ENERGY STAR Version 3.

Near this time, Advanced Energy also actively pursued energy efficiency improvements in the retrofit market by working with other industry experts under the auspices of the National Renewable Energy Laboratory (NREL) to set Standard Work Specifications that define minimal acceptable outcomes for energy efficiency upgrades installed on all types of residential housing and to establish best practices for people participating in the construction trades and other aspects of the home performance industry.

Of course, standards are one thing, but real-world adherence to them is another. For this reason, Advanced Energy stepped up its own education and outreach activities, as well as those provided in conjunction with utilities and other strategic partners. It sought to ensure that the tradespeople involved in a construction project understood not only best practices but also the building science and advantages associated with those practices. This ranged from framers who needed to perform the initial task, to plumbers and electricians who might alter the framing with holes for pipes and wires, to salespeople who educate homebuyers, to business executives who appreciated the financial savings associated with quality installs and minimal callbacks arising from homebuyers who were dissatisfied with their homes' performance.

These comprehensive efforts ensured that everyone involved in the process no longer viewed a home as an ad hoc collection of systems but rather as a unified whole that must operate optimally to provide maximum benefits. This proved to be a radical notion that increased home energy efficiency and also transformed the residential construction market.

Another highly effective market transformation initiative began in the mid-2000s when Advanced Energy received a federal grant to research crawl spaces without vents to the outside, known as closed crawl spaces. The energy efficiency and moisture control advantages established through this research led Advanced Energy to work with the NC Building Code Council to incorporate them into North Carolina building codes. Thanks to Advanced Energy's efforts to educate people about closed crawl spaces, a new industry has arisen in the state. Moreover, other states also now include this home component as an above-code option.

Advanced Energy also pioneered an effort to apply its credo to the affordable housing market. Building on its earlier efforts to develop energy efficiency guidelines for Habitat for Humanity and manufactured housing and on its home guarantees in Engineered for Life, Advanced Energy partnered with the North Carolina Community Development Initiative and later the North Carolina Housing Finance Agency to start the SystemVision program. As the only affordable housing guarantee program in the U.S., SystemVision works with developers and building tradespeople to ensure homes are healthy, safe,



comfortable, durable, energy efficient and affordable. When it launched in 2001, the program focused on new construction, but in 2015 it expanded to include existing homes as well. To date it has certified nearly 6,000 homes in North Carolina, and in 2018 it won the Health and Energy Linked Programs Award for Innovation from the American Council for an Energy-Efficient Economy.

Advanced Energy continued its low-income advocacy in 2017 when it contracted with NREL to host a series of Solution Summits on the DOE's Weatherization Assistance Program. The meetings convened experts and stakeholders from across the country to recommend ways to improve the efficiency and effectiveness of the program on a national scale. The outcomes resulting from the effort continue within the program to the present day.

Throughout its 40-year history, Advanced Energy has also maintained a focus on educating North Carolinians about how to save energy and enjoy greater comfort in their homes. These efforts span a wide spectrum of customers, housing types, and delivery methods, including conducting do-it-yourself home energy conservation workshops; creating a 13-part public television series targeted at homeowners; sponsoring energy projects for children through North Carolina's 4-H chapters; running a program to help senior citizens; and creating Advanced Energy at Home, an online resource that provides free homeowner guidance on energy efficiency, crawl spaces, moisture, and indoor air quality.

Through these many efforts and others, Advanced Energy has consistently sought to advance and transform the residential market as evidenced in the Impacts and Influence section below.

Impacts and Influence

Advanced Energy's actions in the residential housing sector have had, and continue to have, long-lasting impact and influence. The early investigative research informed building specifications that served as the foundation for local and national efficiency programs, and ultimately led to national building codes adopting similar standards. Advanced Energy also developed resources and trainings – with an average of over 125 people attending each year (a total of more than 3,750 trained over the past 30 years) – that facilitated the implementation of these new standards and created the impacts presented in this section.

For the purposes of this research, Tierra estimated impacts for four programs to which Advanced Energy's influence could be directly tied – these programs benefited from Advanced Energy's research, testing, training, and implementation. The analysis does not include impacts indirectly resulting from

Helping North Carolina Families through SystemVision

Thanks to a close relationship with the North Carolina Housing Finance Agency (NCHFA) and a tremendous network of affiliates, builders, raters, tradespeople and invested partners, SystemVision has improved the lives of thousands of North Carolina families over its 20-year history.

NCHFA provides funding for financial incentives to encourage participation by housing developers that range from local governments to Habitat for Humanity chapters to community development corporations and nonprofits, while Advanced Energy administers the program and provides the necessary training and technical support. Advanced Energy also establishes the program's above-energy code standards and provides the home guarantees. The standards require builders to take additional steps and install enhanced measures that increase the home's energy efficiency and durability as well as occupant comfort, health, and safety. Between these standards and the program's rigorous requirements and processes that builders must adhere to, Advanced Energy can confidently guarantee the home will be both comfortable and affordable to operate.

Most importantly, the benefits of SystemVision are enjoyed by North Carolinians on a daily and annual basis. In celebration of the program's 20th anniversary, Advanced Energy conducted interviews with current SystemVision homeowners. During one interview, Elliot of Raleigh explained how he now feels more comfortable in his home and has lower, more consistent energy bills that make it easier to budget. Moreover, SystemVision taught him how to keep his monthly electricity costs down in the future. SystemVision changed Caroline's life as well. Before participating in the program, she could barely afford her rent, but now, like Elliot, she now lives more comfortably in a well-built home in a neighborhood



Advanced Energy’s actions, such as the inclusion of building practices in national codes. Therefore, these values are conservative estimates of the total impact of Advanced Energy’s actions in the residential sector.

- ▶ [Environments for Living](#) (EFL) – Since 2001, EFL has delivered turnkey services for builders to apply building science and energy-efficient construction practices in the field and has offered limited guarantees to homeowners on heating and cooling energy use and comfort. The 300,000 homes built through EFL are approximately 20% more efficient than code homes. Subject matter experts estimate that 89% of the savings generated by EFL homes were influenced by Advanced Energy’s actions. This is equivalent to 567 GWh each year and 14,176 GWh over the lifetime of all EFL homes.
- ▶ ENERGY STAR - ENERGY STAR certified homes and apartments are at least 10% more efficient than homes built to code and achieve a 20% improvement on average¹⁷. Homes and apartments achieve this level of performance through a complete package of building science measures, including comprehensive air sealing, insulation, windows, a high efficiency HVAC system, energy-efficient lighting and appliances, and water management systems. Subject matter experts estimate that 62.5% of the savings generated by the approximate 750,000¹⁸ homes built through ENERGY STAR Version 3 were influenced by Advanced Energy’s actions, which is equivalent to 799 GWh each year and 19,976 GWh over the lifetime of all ENERGY STAR Version 3 homes.
- ▶ [SystemVision](#) - SystemVision provides the training and technical support that leads to improved health, safety, durability, comfort, and energy efficiency of affordable homes in North Carolina. 116 organizations contribute to and participate in SystemVision, and the nearly 6,000¹⁹ homes built through the program are approximately 15% more efficient than code homes. Subject matter experts estimate that 84% of the savings generated by SystemVision homes were influenced by Advanced Energy’s actions, which is equivalent to 9 GWh each year and 218 GWh over the lifetime of all SystemVision homes.
- ▶ [Closed Crawl Spaces](#) – Advanced Energy conducted research that showed that closed crawl spaces provide greater health, safety, energy, and durability benefits compared to vented crawl spaces. Homes with closed crawl spaces use approximately 10% less energy on average than those with vented crawl spaces. Subject matter experts estimate that 82% of the savings generated from homes with closed crawl spaces were influenced by Advanced Energy’s research and training, which is equivalent to 11 GWh each year and 265 GWh over the lifetime of a home.

Over 1 million homes benefiting from these four programs will generate 48,500 GWh in energy savings over their lifetimes and are the result of decades of collaboration, research, testing, training, and program implementation across dozens of organizations and thousands of people. Based on input from subject matter experts, Advanced Energy’s actions influenced approximately 71% of these cumulative savings, or 34,627 GWh, which is enough to power two-thirds of North Carolina’s households for one

¹⁷ https://www.energystar.gov/partner_resources/residential_new/about

¹⁸ https://www.energystar.gov/newhomes/energy_star_certified_new_homes_market_share. Assumes 2020 market share for EnergyStar homes over 10 years.

¹⁹ Based on best available data at the time of this report.



year²⁰. These savings avoided 14 million metric tons of CO₂e and will save homeowners more than \$3.5 billion on their utility bills nationwide and \$48 million within North Carolina.

Commercial and Industrial

Bold Idea

While businesses have always sought to find more effective ways of creating and delivering their products, energy efficiency was a newly developing field when Advanced Energy began serving commercial and industrial (C&I) customers. Moreover, when customers undertook efficiency upgrades, they were often done on a piecemeal basis with a focus on a single end use, such as lighting or an individual piece of equipment. Early on, Advanced Energy staff recognized that greater energy savings could be achieved when a business's energy use is considered as a whole, including not only increasing equipment efficiencies but also establishing companywide energy policies, improving processes, and training and educating employees. Advanced Energy's efforts to promote a systematic approach to strategic energy management have helped North Carolina businesses to save millions of dollars in utility costs and to eliminate hundreds of millions of pounds of CO₂e.

Overview

Although Advanced Energy's efforts in the C&I sector span its 40-year history and the full impact curve, from research to programs, its big impacts accelerated when Advanced Energy began offering engineering expertise to fill an unmet need among C&I customers who did not have internal staff members to pursue energy efficiency. Recognizing this gap, Advanced Energy stepped up to help North Carolina businesses deliver more product per unit of energy by systematically managing energy use and reducing energy waste through company commitments to improve equipment efficiencies, streamline processes, and alter employee behaviors. This led Advanced Energy to offer energy assessments and process analyses to identify opportunities for energy savings — known as energy conservation measures — and to develop programs to educate customers and promote strategic energy management (SEM) practices. As a result, North Carolina businesses are realizing sizable savings on their utility bills as well as non-energy benefits, such as improved operations, better working conditions, and reduced carbon emissions.

Approach

Because C&I customers account for nearly half²¹ of all annual energy consumption in the United States, Advanced Energy began helping them to reduce and manage their energy use soon after the nonprofit was formed in 1980. Early efforts included examining new technologies, conducting feasibility studies for energy efficiency, load management, and renewables, developing comprehensive energy audit procedures, weatherizing hundreds of churches across the state, and facilitating energy efficiency workshops for businesses and governments.

²⁰ Based on the average NC home consuming 12,948 kWh each year ([Energy Information Administration](#)), and 3,965,482 households in NC ([US Census Bureau](#)).

²¹ <https://www.eia.gov/energyexplained/us-energy-facts/>



In 1991, Advanced Energy launched the Industrial Electrotechnology Laboratory, enabling it to broaden its educational outreach to C&I customers to include demonstrations and problem-solving. For instance, the lab enabled visiting customers to try out new motors and other technologies, such as infrared drying, infrared powder-coat curing and radio frequency drying. Beyond the lab, some of Advanced Energy's in-the-field efforts explored higher-efficiency lighting for poultry houses, introduced an innovative produce-cooling system, and improved glass fabrication operations.

As Advanced Energy's C&I service line matured, the organization began to coalesce around two primary activities: assessments and education. For both, Advanced Energy partnered with utilities to identify customers in need of assistance and to support training efforts. Each year, Advanced Energy employees conduct energy and process analysis assessments at dozens of facilities that span many industries. Energy assessments examine a facility's overall energy use to identify areas for improvement. Process analysis assessments dig deeper to identify energy efficiency opportunities across a company's entire production process, from the raw materials arriving on the receiving dock to finished goods departing from the shipping dock.

Not only do both types of assessments help companies to save energy, but they also produce non-energy benefits, like enhanced workflow, productivity and product quality, and reduced emissions. Advanced Energy also delivers trainings and webinars so customers stay abreast of new technologies and energy management practices that can lower operational costs and increase economic competitiveness.

These conjoined efforts find their fullest expression through Advanced Energy's support of Strategic Energy Management (SEM), which is the practice of establishing continual improvement processes to reduce a company's energy intensity, or the amount of energy consumed per square foot of a facility or per unit of production. SEM starts with the customer developing a corporate energy policy, followed by an energy assessment, process analysis, or both. Equipment upgrades, process changes, staff training, and other activities are frequently pursued as the company implements the requisite measures to accomplish their goals. SEM can be conducted with varying degrees of rigor, and Advanced Energy aids customers with the full range of options.

After establishing an energy management foundation, a next step is often to pursue certification in energy management programs, such as the DOE's 50001 Ready™, ISO 50001, and Superior Energy Performance 50001™ programs. Advanced Energy is accredited to help businesses with each. For example, Advanced Energy is one of four national ISO 50001 experts recognized by the DOE, meaning it can work with companies to establish and/or maintain an energy management system that meets the requirements of ISO 50001.

To help businesses become 50001 Ready, the least rigorous of the three above named energy management programs, Advanced Energy leads cohorts of companies through a 6–12-month process of monthly group training webinars, virtual one-on-one coaching sessions, on-demand guidance, and peer-to-peer learning opportunities. This enables facilities to realize most of the benefits of ISO 50001 without the costs associated with formal certification. If certification is the goal, Advanced Energy also helps companies take the next steps to prepare with practice certification audits. Advanced Energy may even be in attendance when the formal audit takes place. For companies eager to go even further with SEM, Advanced Energy can assist them through the steps necessary to obtain the DOE's Superior Energy



Performance 50001 certification, the highest level of recognition, achieved by a limited number of highly dedicated companies.

Although Advanced Energy excels at helping businesses to develop SEM practices and become experts at operating and managing their own energy management systems, it also recognizes that many companies, schools, and local governments are not prepared to devote the time and resources to do so. For these, Advanced Energy has developed other consulting services over the years ranging from conducting ASHRAE level 1 and 2 audits to identify savings opportunities, to advising on new equipment acquisitions or energy performance contracting, to embedding an Advanced Energy expert as a dedicated staff member at a business in need of energy services.

While Advanced Energy's client roster is too extensive to list here, a few well-known examples include Caterpillar, Ingersoll Rand, Weyerhaeuser, Lance Crackers, Perdue Farms, Charlotte Pipe, Thyssenkrupp, Daimler, IBM, and Fort Bragg, as well as scores of private businesses, local governments, and colleges. Moreover, Advanced Energy's reach extends beyond North Carolina, since many companies that receive assessments on their in-state facilities apply the information gleaned from Advanced Energy to similar facilities elsewhere around the country.

The Impacts and Influence section below illustrates the tangible results arising from these and numerous other efforts conducted during Advanced Energy's four decades of serving North Carolina businesses and other C&I customers.

Impacts and Influence

Advanced Energy's impacts and influence in the C&I sector result from ongoing engagement with customers to identify efficiency improvements in industrial processes and building systems. This engagement includes continual trainings for utility account representatives and building energy managers, comprehensive SEM services, including consulting on 50001 Ready, ISO 50001, and Superior Energy Performance 50001, and direct-to-customer energy and process assessments.

Since 1985, approximately 35,000 people have attended Advanced Energy C&I trainings and webinars that cover fundamental concepts and efficient technologies. In recent years, attendance has grown to include about 1,800 professionals annually. Topics include chilled water, commercial HVAC, compressed air, and pumping systems, as well as efficiency improvements and new approaches to industrial and agricultural processes. Since 2019, Advanced Energy has expanded to include 50001 Ready trainings that have been delivered to 7 cohorts across 65 sites, including NASA with 16 sites, the U.S. Department of Justice with five sites, the Fort Bragg military base in North Carolina, and 26 North Carolina-based organizations with 34 sites.

Over its 40-year history, Advanced Energy has conducted assessments for approximately 1,600 C&I facilities that reduce energy, waste, emissions, and operational costs while enhancing productivity, product quality, and safety. These assessments have generated 2,020 GWh in energy savings prior to Advanced Energy attribution, based on subject matter experts' input that the typical assessment results in 3% of energy savings²² on average for each facility. Advanced Energy's actions influenced 50% of

²² This is based on subject matter experts estimates that each assessment identifies efficiency improvements that amount to 20% energy savings and 15% of those recommendations are implemented.



these savings, or 1,010 GWh, which saved C&I customers \$67 million in utility cost savings and delivered 357,000 metric tons of CO₂e reductions.

Helping Daimler Achieve ISO 50001 Certification at 8 Facilities

In late 2019, Daimler Trucks North America (DTNA) contacted Advanced Energy about ISO 50001 consulting. DTNA had previously earned ISO 50001 certification and Superior Energy Performance 50001™ certification at its Mount Holly truck assembly plant, and it was now looking to achieve ISO 50001 certification at all eight of its North American plants to meet a corporate goal.

A key objective for DTNA was to find a consultant who aligned with its existing vision and culture. Because the company did not want to have to reinvent its processes, it found Advanced Energy's flexible approach appealing. DTNA requested a proposal from the organization to provide ISO 50001 certification consulting for the eight sites, including four based in North Carolina. A combined funding program was established with support from both DTNA and Duke Energy, which readily assisted one of its larger industrial customers in the pursuit of energy management.

The joint effort was a win-win for all involved. Advanced Energy provided consulting services in line with DTNA's needs; Duke Energy played a crucial role in supporting an industrial customer; and DTNA built a culture of continual energy improvement at all of its North American plants.

"ISO 50001 certification at all of our North American truck sites is a great achievement, and I am proud of our team," said DTNA's Sandra Carter, corporate environmental manager. "We now have a continual energy management system that provides the information we need to reduce our energy usage per truck produced. ISO 50001 helps us meet our corporate environmental and sustainability goals on a daily basis. We are thankful for the support of partner Duke Energy and consultant Advanced Energy."

Transportation

Bold Idea

When Advanced Energy began working on electric vehicles more than 30 years ago, the technology remained in its infancy, and alternative fueled vehicles faced many roadblocks before they could reach maturity. Nonetheless, Advanced Energy staff recognized their potential and began to take bold steps to collaborate with industry leaders, utilities, local governments, and other stakeholders to assess the technology, plan and prepare for charging requirements, and execute educational campaigns. In the ensuing decades, Advanced Energy helped shape the electric transportation industry and assist utilities in developing the infrastructure necessary to support growing numbers of EVs and the increased electric loads they require.

Overview

Advanced Energy's support of EVs started with early research to understand how the then state-of-the-art technology performed in real-world conditions and how real-world use cases would impact vehicle adoption. As EV technologies advanced, the organization expanded its focus to helping utilities, businesses, and governments by investigating EV driving and charging patterns, determining the most effective ways to prepare the requisite charging infrastructure, and conducting education and outreach activities to encourage EV adoption. Thanks to these efforts and those of the many stakeholders Advanced Energy has collaborated with, it is no longer a question of how to best design an EV or what needs to be done to develop charging infrastructure, but rather a question of when EVs will constitute the majority of vehicles on North Carolina roads.



Approach

Electric vehicles began to solidify a place in the transportation market in 2010, with the release of the Nissan Leaf and Chevrolet Volt. Yet Advanced Energy's interest in EVs began 21 years earlier, when they invested in and tested an electric van to assess its potential application in commercial fleets. Soon after, in 1991, Advanced Energy converted a Pontiac Fiero to run on batteries and evaluated its promise for daily commuting in North Carolina. A decade later, in 2002, Advanced Energy began the formation of a partnership with more than a dozen school districts across the U.S. and school bus manufacturers on a U.S. Department of Education grant to develop and study plug-in hybrid electric school buses. The team assessed operating costs, emissions, fuel economy, and other benefits and limitations of the technology. While the test vehicles needed refining in each of the cases above, Advanced Energy's persistent step-by-step research efforts helped to improve the technology and prepare the market for the modern EVs we know today.

Beginning in 2012, Advanced Energy joined with business and government partners on a two-year DOE grant to study EV driving and charging patterns. Direct impacts from the study include displacement of 30,000 gallons of gasoline, avoiding 1,600 barrels of crude oil, and savings of \$82,000 over the two-year study. Further, the data collected in this study was used to identify potential impacts to the electric grid and to reduce barriers to widespread EV adoption. The study's results helped Advanced Energy's partners understand what they could do to encourage EV adoption through siting and installation of civic and private charging stations. Advanced Energy conducted a follow-up study in 2015 on public Level 2 charging stations and developed educational materials about charger installation at workplace and multifamily locations. Advanced Energy was next commissioned to prepare a modeling study to analyze the impacts of EVs on North Carolina's economy. Then, in 2019, Advanced Energy supported Duke Energy's EV Charging Infrastructure Project by assisting with charger installation at selected sites.

Many collaborative efforts were conducted under the auspices of the North Carolina Plug-in Electric Vehicle (NC PEV) Taskforce that was formed in 2011 as a statewide program focused on reducing barriers to EV adoption through research, education, and consulting services. The NC PEV Taskforce was rebranded as Plug-in NC in 2016 when its mission was expanded to embrace opportunities for more organizations and individuals to join the effort to integrate EVs into local communities. One early example of these efforts includes Advanced Energy's 2011 collaboration with the Centralina Council of Governments and other partners on a U.S. Department of Energy Mountains to Sea grant to create five North Carolina Plug-in Electric Vehicle Roadmaps (one each for North Carolina statewide, the Charlotte region, the Asheville region, the Triangle region, and Piedmont-Triad region). Advanced Energy led the education and outreach working group that developed training and marketing recommendations to increase awareness of EVs and identify the organizations best suited to support those market transformation efforts.

In 2019, Advanced Energy participated in collaborative stakeholder meetings to support the development of the North Carolina Department of Transportation's Zero Emission Vehicle Plan in response to Governor Cooper's Executive Order 80. Similar engagements around that same time helped shape North Carolina's share of the Volkswagen Settlement and assisted local organizations, businesses, and municipalities with benefiting from it. While in 2020, Advanced Energy worked with the North Carolina's Clean Cities Coalitions to host a three-part webinar series on medium-and heavy-duty vehicle electrification.



With Plug-in NC, Advanced Energy concentrates on events and activities that engage the public, utility staff and workplaces throughout North Carolina. Ongoing efforts include creating outreach and educational materials and newsletters, implementing communications campaigns, and planning and hosting events, webinars, and workshops that cover everything from electric transportation basics to the benefits of electric fleet vehicles to how to begin an EV program at a utility.

Advanced Energy's strategic planning consulting services for electric cooperatives provide an example of this approach. To help electric cooperatives encourage and prepare for electric transportation, Advanced Energy developed a step-by-step strategic planning process and guide in 2017. The process included analyzing the EV market in cooperatives' territories, conducting stakeholder education, and identifying strategies to support electric transportation. Advanced Energy presented its work to the staff and boards of directors of cooperatives across North Carolina and helped host awareness events so members could learn about EVs and experience them in person. The strategic planning guide has remained an important tool for cooperatives. Advanced Energy's clients have shared that they keep it handy and that it continues to be beneficial in their EV planning efforts. Examples of initiatives and programs developed include educational campaigns, charging station incentives, EV time-of-use rates and EV fleet adoption.

Advanced Energy later expanded its EV strategic planning beyond North Carolina. For instance, it partnered with Virginia's Old Dominion Electric Cooperative to facilitate a meeting for the cooperative to discuss the challenges, opportunities, and benefits associated with EVs and the factors impacting the EV market in its territory. To build interest and support for EVs among cooperative employees, Advanced Energy wrapped up the project with a ride-and-drive event at the Richmond Raceway. Then, to broaden its scope even further, Advanced Energy collaborated with Touchstone Energy Cooperatives to create handouts on a variety of EV topics to educate cooperatives nationwide.

Lastly, it is important to note that, in addition to traditional road vehicles, Advanced Energy's electric transportation efforts extend to other forms of electrification as well. For instance, in recent years, Advanced Energy has worked with Duke Energy, Dominion Energy and North Carolina's Electric Cooperatives to develop handouts and tools focused on the benefits of electric forklifts and electric transport refrigeration units for tractor trailers.

Impacts and Influence

As discussed above, Advanced Energy has supported EVs through researching technical factors, strategic planning, and familiarizing North Carolinians with clean and efficient driving. Unlike Advanced Energy's other service areas, Advanced Energy's impacts in transportation cannot be quantified in energy savings. In fact, EVs add to North Carolina's electricity demand. However, unlike traditional vehicles with internal combustion engines that burn gasoline and diesel fuel and emit greenhouse gases that contribute to climate change, EVs can use electricity derived from renewable power, thereby making them emissions-free both when being driven and charged.

The maps in Figure 7. show the significant growth in EV registrations and geographic distribution of public charging stations in North Carolina over the past decade. New EV registrations increased 400% from 283 in 2011 to 32,257 in 2021²³, reducing transportation related emissions by 110,000 metric tons

²³ Registrations for Plug-in Hybrid and All-Electric Vehicles sourced from North Carolina Department of Transportation



of CO₂e²⁴ each year. Accessibility to public charging has also grown beyond the major interstates and population centers, with 2,325²⁵ public charging stations located in most counties across the state. While it would be inappropriate and difficult to attribute Advanced Energy's influence on EV adoption throughout North Carolina, Advanced Energy's role was undoubtedly significant in the big picture.

Quantification became easier when Tierra focused on the impacts of Plug-in NC. Since the program launched in 2011, over 1,000 people representing the public, utility staff, and businesses have attended the more than 20 workshops and events held by Plug-in NC each year. Further, since rebranding in 2016, Plug-in NC has seen its membership²⁶ grow to 104 members, 332 charging stations and 238 fleet vehicles across North Carolina.

Promoting Emission-Free Driving with Plug-in NC

In 2011, Advanced Energy launched the North Carolina Plug-in Electric Vehicle (NC PEV) Taskforce, laying the groundwork for a statewide effort in support of electric transportation. The taskforce began as a collaborative of key stakeholders from private industry, academia, the nonprofit sector, and local and state governments. The taskforce worked together to promote EV readiness throughout the state by developing detailed roadmaps, hosting public events, and training key stakeholders, such as first responders and utility staff.

In 2016, the NC PEV Taskforce rebranded as Plug-in NC, and the original group of stakeholders evolved to include local businesses and EV owners. Through this expanded network, the program was able to greatly increase its reach to communities across North Carolina. Plug-in NC staff and partners have attended hundreds of events and have engaged thousands of people to increase awareness around driving electric. A concentration on collaboration has also remained over the years, with numerous working groups formed to address barriers to EV adoption. These have included workplace charging, multifamily charging, DC fast charging, fleet vehicles, ADA considerations, residential new construction, and more.

For over a decade, Plug-in NC has served an important role of bringing stakeholders together to work toward a common goal of making North Carolina a leader in electric transportation. Through specialized trainings, focused committees, outreach to the public, and resource development, it has truly helped shape the EV market in North Carolina.

²⁴ https://afdc.energy.gov/vehicles/electric_emissions.html

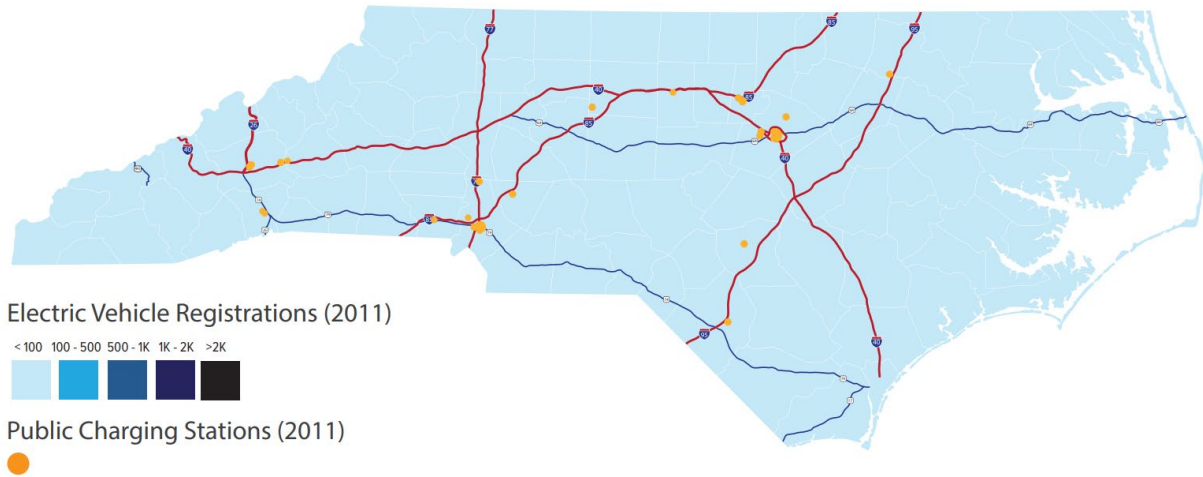
²⁵ <https://afdc.energy.gov/stations/states>

²⁶ Membership is open to local businesses, schools, communities, and organizations that are supporting EVs.)

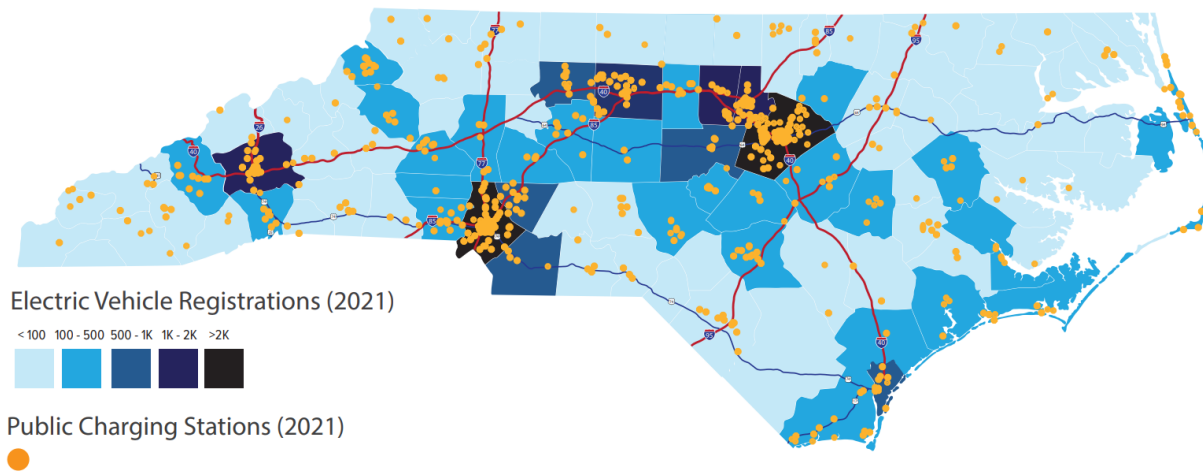


Figure 7. EVs and Public Charging Stations in North Carolina 2011, 2021²⁷

North Carolina Electric Vehicles & Charging Stations: 2011



North Carolina Electric Vehicles & Charging Stations: 2021



²⁷ <https://pluginnc.com/wp-content/uploads/2021/09/NC-Electric-Vehicles-and-Charging-Maps.pdf>

Renewable Energy

Bold Idea

In the early 1980s, the U.S. electric grid remained heavily dependent on fossil fuels for electric power generation. While the promise of solar power was widely recognized, technical constraints and high costs limited its potential. Nonetheless, Advanced Energy staff understood the value of clean, sustainable energy and took the first steps in a decades-long journey to promote renewable generation. Advanced Energy's initiatives spanned the impact curve from research and testing through policy and standards to practical programs in a concerted effort to promote the safe installation and operation of solar and other renewables, establish funding mechanisms, and further public interest. As a result, thanks to Advanced Energy and its collaborators, renewable energy represents up to 16% of North Carolina's energy mix today, and that percentage grows each year.

Overview

Advanced Energy has supported renewable power since the organization's founding. While succinctly summarizing 40 years of initiatives necessitates truncation and brevity, top mentions of marquee efforts include leading the creation of NC GreenPower, a—first in the U.S.—statewide program that uses voluntary contributions to support electricity generated from renewable sources and to mitigate greenhouse gases; contributing to the establishment of North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard; and collaborating with utilities to develop PV interconnection standards and commissioning processes to ensure safety and reliability. These and numerous other efforts have helped North Carolinians to enjoy cleaner air and an increasingly sustainable power supply.

Approach

Advanced Energy's original name was the North Carolina Alternative Energy Corporation, and true to its namesake, the organization began exploring solar power and other forms of renewable generation shortly after it received its charter. Advanced Energy's first foray was in 1981 when it developed an active and passive solar system monitoring program to improve understanding of PV design, specifications, installation, and performance. That same year, Advanced Energy started researching thermal energy storage systems for schools, evaluated small hydroelectric facilities on streams in western North Carolina, and partnered with Duke Energy on a battery demonstration project. These research efforts and others like them — including investigations of solar-powered domestic hot water systems, induction cogeneration, and power production using wave energy off the North Carolina coast — continued throughout the 1980s and 1990s.

At the same time, Advanced Energy jump-started its education and outreach in an early partnership with the North Carolina State Energy Division on the Governor's Showcase of Solar Homes that encouraged more than 20,000 people to tour 100 solar homes across the state. Advanced Energy also ran initiatives to promote energy education in high schools, vocational schools, and universities, as well as at science fairs and festivals.

The experience and credibility that Advanced Energy garnered with these activities prompted the North Carolina Utilities Commission to ask the organization to form NC GreenPower in 2003. As a subsidiary of Advanced Energy, NC GreenPower is currently tasked with improving North Carolina's environment by supporting renewable energy, carbon offsets, and solar installations at K-12 schools. However, the



original mandate called for Advanced Energy to design a first-of-its-kind independent, statewide, multi-utility green power pricing program. To accomplish this, Advanced Energy convened meetings with utility representatives, industry leaders, and other stakeholders to define green power and design mechanisms to solicit funding from electric customers and distribute it to green power producers throughout the state. The program Advanced Energy created empowers all the state's electric utilities to use customer bills to collect voluntary contributions to support renewables and cleaner air. It then pays power producers for green energy added to the North Carolina grid and pays carbon offset providers for tons of greenhouse gases mitigated. Funding also goes to public outreach to educate residents, businesses, and local governments about green energy and to promote residential rooftop solar and solar installations for schools.

The school PV projects started in 2015 with the launch of Solar Schools, a pilot program that provided grants to North Carolina schools for small solar PV arrays (3-5 kilowatts). In 2019, the North Carolina Utilities Commission approved an updated Solar+ Schools initiative as a full-scale program. Qualified contractors install the PV systems and NC GreenPower staff manage the projects. Schools also receive age-appropriate STEM curricula that include lesson plans for educators and hands-on solar experience for students.

While these school PV projects and numerous residential rooftop solar projects were gathering momentum, so were larger PV facilities from solar developers. The rapid development of these utility-scale PV projects raised concerns over safety, power quality, poor performance, and premature failure. So Advanced Energy was tapped to help improve the situation, this time by Duke Energy who retained Advanced Energy's services to establish a standardized commissioning program and to develop and maintain a PV commissioning service for medium-voltage installations. Since starting with Duke Energy in North Carolina and South Carolina, Advanced Energy now acts as an independent third-party partner for other utilities and cooperatives in the Southeast as well, providing onsite inspections and interconnection commissioning to confirm that new projects are built to quality standards and are properly connected to the utility grid in order to ensure safety, reliability, and power quality.

Advanced Energy also consults with utilities on preliminary research, distributed energy resource (DER) standards, compliance, systems troubleshooting, and program design. For instance, Advanced Energy created a reference guide for rural utility solar standards and worked with Dominion Energy to research grid-integrated water heaters. Advanced Energy is currently working with Duke Energy to assess the use of battery storage to reduce peak coincident demand and is conducting a multiyear project to assess how the proliferation of grid connected DER affects its power networks.

Advanced Energy provides consulting services to businesses as well, including solar feasibility studies to evaluate the viability of pursuing a project and sustainability consulting to determine the best options for local renewable energy certificates or carbon offsets to help meet corporate sustainability goals. On the educational front, Advanced Energy hosts dozens of workshops and webinars to train industry personnel on interconnection requirements, commissioning practices, and quality standards.

In these and additional ways, Advanced Energy and its many partners have helped to reduce North Carolina's dependence on fossil fuel-fired electric generation and begun to transform the market for renewable energy and other DERs.



Impacts and Influence

Advanced Energy's impacts and influence in the renewable energy sector are the result of ongoing collaboration with North Carolina utilities and cooperatives, solar technology developers and installers, schools, advocacy groups, government agencies, consumers, and more. While Advanced Energy's impacts and influence span multiple initiatives across almost four decades, those presented in this section are specific to the organization's role with NC GreenPower and with interconnection commissioning services. These impacts include the people trained and educated; the number, size, and clean energy production of renewable energy projects; and the associated greenhouse gas emissions reductions accompanying those projects.

The impacts reported have not been adjusted for attribution. For this analysis, we equate impacts created by NC GreenPower with the impacts created by Advanced Energy since the former is a subsidiary of the latter. For Advanced Energy's suite of PV engineering services, the organization directly inspected and commissioned each MW reported. Tierra recognizes that the projects themselves are the result of the collective efforts of Advanced Energy, utilities, solar developers, and other collaborators.

NC GreenPower has mitigated or avoided more than 481,000 metric tons of greenhouse gases through secured renewable energy generation or through carbon offset mitigation. NC GreenPower renewable energy generation includes solar energy, wind power, small-scale hydropower, and biomass energy projects, as well as solar installation projects at North Carolina K-12 Schools (e.g., the Solar+ Schools program). Over 1,020 NC GreenPower renewable energy projects have generated 1,059 GWh of renewable energy, which is the equivalent of powering over 80,000 North

Promoting Safe Reliable Renewables with Duke Energy Interconnection Commissioning

Because an increasing number of solar PV facilities are being connected in the Southeast, it was important to ensure their quality and dependability to protect the power quality, reliability, and safety of the utility grid. In 2017, Duke Energy selected Advanced Energy to lead its PV Interconnection Commissioning to ensure the safety and reliability of the grid in its North Carolina and South Carolina territories. The Interconnection Commissioning program assesses as-built construction at PV facilities to ensure that it is built to quality standards and that it complies with utility documentation. Program staff also verify interconnection protection setpoints and conduct testing.

"The value and quality of AE's work on the solar interconnections has been accepted and recognized by not only Duke Energy, but also the interconnection customers, NC Public Staff and NCUC," said Kevin Chen, lead engineer at Duke Energy. "The project plays a crucial role in continuously improving the safety, quality, reliability and contractual compliance of solar interconnections in North Carolina."

Helping Schools with Solar and STEM Education

In April 2015, NC GreenPower launched the Solar Schools pilot program, offering grants to fund the installation of small PV arrays at schools and provide an educational curriculum pack that includes training for teachers, STEM lesson plans, real-time PV monitoring, and a weather station.

For first-year grant recipient Meadowview Magnet Middle School in Surry County, North Carolina, the Solar Schools pilot has made a big difference. The educational solar array has opened doors for new teaching opportunities, making it easier for instructors to incorporate renewable energy into their lessons. It has also benefited the Surry County Schools Science Institute, which hosts programs for elementary school students on the Meadowview campus.

Most importantly, the array has received positive reactions from students. It sparks important questions that drive discussion and deeper learning. The grant even spurred the school to purchase additional small solar panels so students can investigate factors that affect energy production and solve their own research questions. In all, it has provided the students at Meadowview with greater study opportunities in the fields of science, technology, engineering, and mathematics.



Carolina homes for one year and avoiding 374,000 metric tons of CO₂e. This includes 553 MWh of energy produced from 235 kW of solar installed at 57 North Carolina schools across 39 counties. In addition, the Solar+ Schools program provides hands-on solar experience for more than 43,000 students through real-time monitoring and energy and STEM lesson plans. Furthermore, NC GreenPower carbon offset products have contributed to an additional 107,000 metric tons of greenhouse gas mitigation.

Advanced Energy partners with investor-owned utilities and electric cooperatives in the Southeast to ensure that PV facility interconnections provide high-quality, reliable, and safe power to the grid. To date, Advanced Energy has commissioned 872 MW of utility-scale solar across 213 projects through partnerships with Duke Energy, Randolph EMC, Four County EMC, Pee Dee EMC, South River EMC, Wake EMC and others. These inspections build installer understanding about best practices for constructing and connecting these systems to minimize delays, reduce downtime, and ensure the production of safe and reliable power. In addition to these in-field opportunities, Advanced Energy holds trainings and workshops with approximately 100 industry personnel each year on solar construction specifications, interconnection, and commissioning practices.



Advanced Energy's Future

Tierra's influence and impact review concludes that Advanced Energy is uniquely positioned as a neutral, non-biased, technically savvy nonprofit that brings together customers, utilities, the North Carolina Utilities Commission, and other stakeholders. This positioning results in collaborative, iterative, and sustained initiatives that transform markets and generate outsized impacts within North Carolina and across North America. As such, Tierra considers Advanced Energy to be well prepared to continue providing economic, environmental, and societal benefits through its innovative and practical approaches to energy issues.

In the years ahead Advanced Energy will continue to work on its formal vision — to ensure that energy is clean, affordable, reliable, efficient, and safe for all people — by focusing on the current drivers in the energy industry. The following presents examples of Advanced Energy's plans across each focus area.

- ▶ Advanced Energy recognizes that traditional energy efficiency efforts that create annual kWh savings are no longer sufficient to meet increasingly rigorous grid requirements. Therefore, to meet the current and future needs of residential customers Advanced Energy is actively researching new load management technologies that enhance and enable demand management strategies to shift electric loads to off-peak hours and to reduce kW demand during periods of high grid strain. Advanced Energy is also focused on utility member engagement and stakeholder outreach to build consensus around best practices for demand-flexible and -interactive homes.
- ▶ In the C&I sector, Advanced Energy will expand SEM activities and further their impacts by supporting energy managers with the tools they need. Additionally, Advanced Energy plans to expand its focus on carbon emissions to help businesses, utilities, and the state of North Carolina achieve their climate action goals. As Advanced Energy builds experience with formal reporting, it will explore advanced emissions calculations, such as time-of-use impacts, footprint boundaries, and local versus global impacts.
- ▶ Advanced Energy will continue making motor-driven systems more efficient and reliable while evaluating how motors and drives interact with advanced grid management techniques, like voltage reduction and self-healing. Advanced Energy will also ensure that manufacturer and customer efforts to achieve clean and efficient energy also align with reliability and power quality goals for utilities.
- ▶ Advanced Energy will support the integration of more diverse and flexible renewables onto the grid, and work with utilities, developers, and other stakeholders to ensure renewable assets are incorporated in a safe, reliable manner that preserves high power quality.
- ▶ Meanwhile, the organization will help the transportation industry transition to electricity as a new fuel source by addressing the challenges that continue to face the transformation, from infrastructure and interoperability to public education for communities, businesses, and industries.

In closing, this research concludes that Advanced Energy is well prepared and uniquely positioned to continue bringing together diverse stakeholder groups to provide economic, environmental, and societal benefits in the transition to a cleaner energy future.



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