

**Sargent & Lundy** LLC

# Renewable Energy



## Selected Experience

Wind | Solar | Biomass | Geothermal  
Hydroelectric | Energy Storage  
Integrated Resource and Power Supply Planning

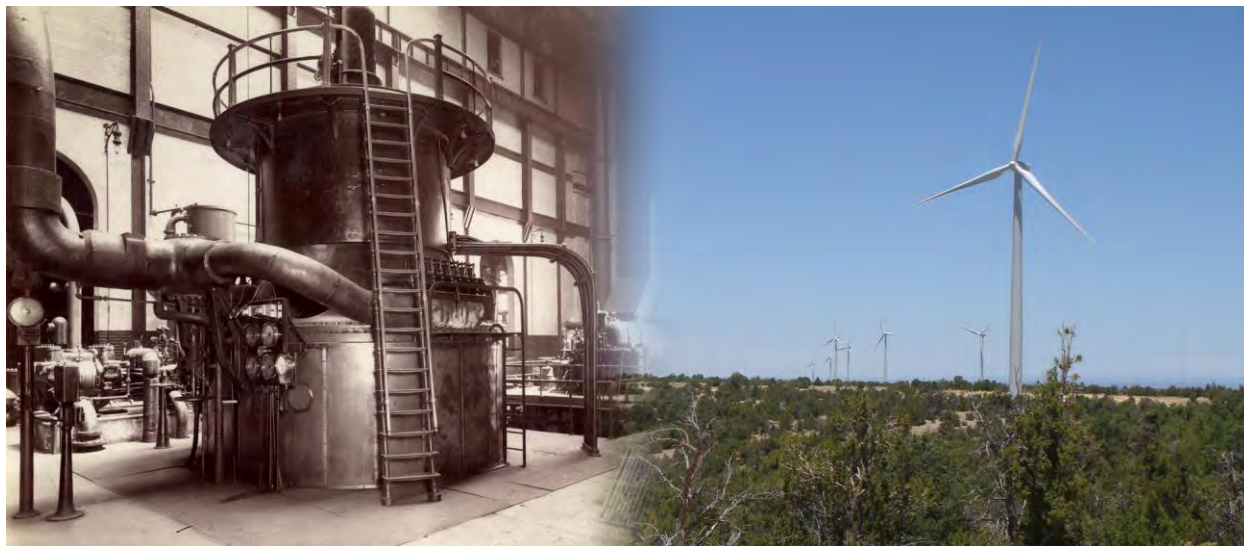


## Contents

<b>Contents.....</b>	<b>i</b>
<b>Sargent &amp; Lundy LLC Company Overview.....</b>	<b>1</b>
Leadership and Innovation.....	2
Range of Clients.....	2
Description of Services .....	2
Site Selection .....	3
Solar and Wind Resource Assessments.....	3
Feasibility Evaluations .....	4
Technology Selection.....	4
Due Diligence Reviews and Independent Engineering Services.....	4
Engineering, Procurement, and Construction Specification and Bid Assistance.....	5
Project Development Services .....	5
Conceptual Design and Studies .....	5
Engineering and Detailed Design.....	6
Engineering Review of Project Design.....	6
Licensing and Permit Support and Services.....	7
Construction Monitoring.....	7
Construction Management and Commissioning.....	7
Operations and Maintenance Support and Services.....	8
<b>Selected Sargent &amp; Lundy Renewable Energy Publications and Presentations .....</b>	<b>9</b>
<b>Wind.....</b>	<b>11</b>
Due Diligence and Independent Engineering.....	11
Owner's Engineering.....	14
Design.....	16
Conceptual Design and Studies .....	17
Construction Monitoring/Management .....	18
Operations and Maintenance Support and Services.....	19



<b>Solar .....</b>	<b>21</b>
Solar Resource and Energy Production Assessments.....	21
Independent Engineering Services .....	22
Solar Technology Reviews.....	23
Technology Due Diligence Reviews: Confidential Clients.....	24
Owner's Engineer Services.....	24
<b>Biomass .....</b>	<b>28</b>
<b>Geothermal .....</b>	<b>36</b>
<b>Hydroelectric .....</b>	<b>38</b>
<b>Energy Storage.....</b>	<b>40</b>
<b>Integrated Resource and Power Supply Planning .....</b>	<b>42</b>



## Sargent & Lundy LLC Company Overview

Sargent & Lundy, L.L.C. (Sargent & Lundy), has served the global electric power industry since 1891. During this time, we have provided engineering, design, and consulting services for numerous power plants of all types in over 85 countries. Sargent & Lundy has worked on and has significant experience with all primary renewable energy technologies—solar photovoltaic, solar thermal, wind power, hydroelectric power, waste-to-energy, and biomass. We have performed full plant design; conducted numerous site selection studies, solar and wind resource assessments, and technology evaluations; managed procurement; developed cost estimates; and managed construction for successfully operating units.

In view of the unique aspects associated with the development, construction, operation, and ownership of renewable generation assets, Sargent & Lundy has relevant experience providing the following services to clients actively involved in the renewable energy industry:



Sargent & Lundy's staff of approximately 2,500 enables the firm to conduct projects around the globe. In addition to headquarters in Chicago, Illinois, Sargent & Lundy operates international regional offices in Toronto, Canada, and Abu Dhabi, U.A.E., along with regional offices in the U.S. in Chattanooga, Tennessee; Wilmington, Delaware; Charlotte, North Carolina; Warrenville, Illinois; and Phoenix, Arizona. Additional resources are available from Sargent & Lundy's capitalized joint venture engineering offices in Vadodara and Faridabad, India. State-of-the-art facilities and resources are offered throughout the organization.

## Leadership and Innovation

Sargent & Lundy is a leader in the renewable energy sector, providing innovative solutions to challenges facing our clients. Several examples of our renewable energy leadership are listed below:

- Sargent & Lundy has delivered presentations and posters at major renewable energy conferences and technical meetings in the past decade; including the 2009, 2012, 2013, 2014, and 2015 American Wind Energy Association (AWEA) Windpower conferences. Presentations covered technical and financial topics, including energy storage, wind power purchase agreements (PPAs), renewable energy integration, and more.
- Sargent & Lundy has been a leader in establishing the codes and standards to be used in the design of wind turbine foundations in North America. We were actively involved in the American Society of Civil Engineers (ASCE) and AWEA committee that prepared a U.S. guideline for the design of wind turbine foundations. We also delivered a presentation, "Codes and Standards for Wind Turbine Foundations: An Overview and Future Outlook," at the AWEA Windpower conference in May 2009.
- Sargent & Lundy was the design engineer for the first large-scale solar thermal plant: the 80-megawatt (MW) Luz International SEGS VIII, IX, and X solar thermal project. Sargent & Lundy designed the thermal plant, the interface with solar field, and the balance of plant (BOP) systems. The project began operation in the late 1980s and Sargent & Lundy has remained an industry leader in solar energy ever since.
- Sargent & Lundy authored a comprehensive report for the United States Department of Energy and National Renewable Energy Laboratory (U.S. DOE/NREL) in 2003, based on our independent review and analysis of parabolic trough and power tower solar technologies. Sargent & Lundy was engaged by NREL in 2010 to update this report. Sargent & Lundy is also supporting the DOE's Solar Vision Study, which began in 2009.

Our clients receive knowledgeable, independent, and comprehensive support, based on experience, for each critical phase of evaluating and deploying renewable energy and emerging technologies.

## Range of Clients

Sargent & Lundy's renewable energy clients include developers, financial institutions, government- and investor-owned utilities, industrial companies, rural cooperatives, municipal and public power systems, equipment manufacturers, and others. Sargent & Lundy has designed renewable energy projects representing over 20,000 MW of generating capacity and has provided consulting and owner's engineering services for more than 25,000 MW of renewable energy projects.

Our exclusive participation in the power industry, providing a comprehensive range of engineering and consulting services, enables our clients to benefit from experience and insights that are critical to their success. Sargent & Lundy clients use our services and apply our expertise to optimize their utility- or industrial-scale applications of electric power generation technologies. Our clients rely on us to provide techno-economic feasibility evaluations, support services for asset acquisitions, complete plant design and engineering services, reviews of the commercial and technical aspects of new generation projects, asset valuations, cost estimates, and reviews of contracts and agreements. Lenders and investors considering proposed transactions have relied on our technical evaluations and assessment to identify and mitigate risks related to power project development, construction, and operations. In fact, our clients have engaged us to provide services at numerous facilities where we are not the designer of record.

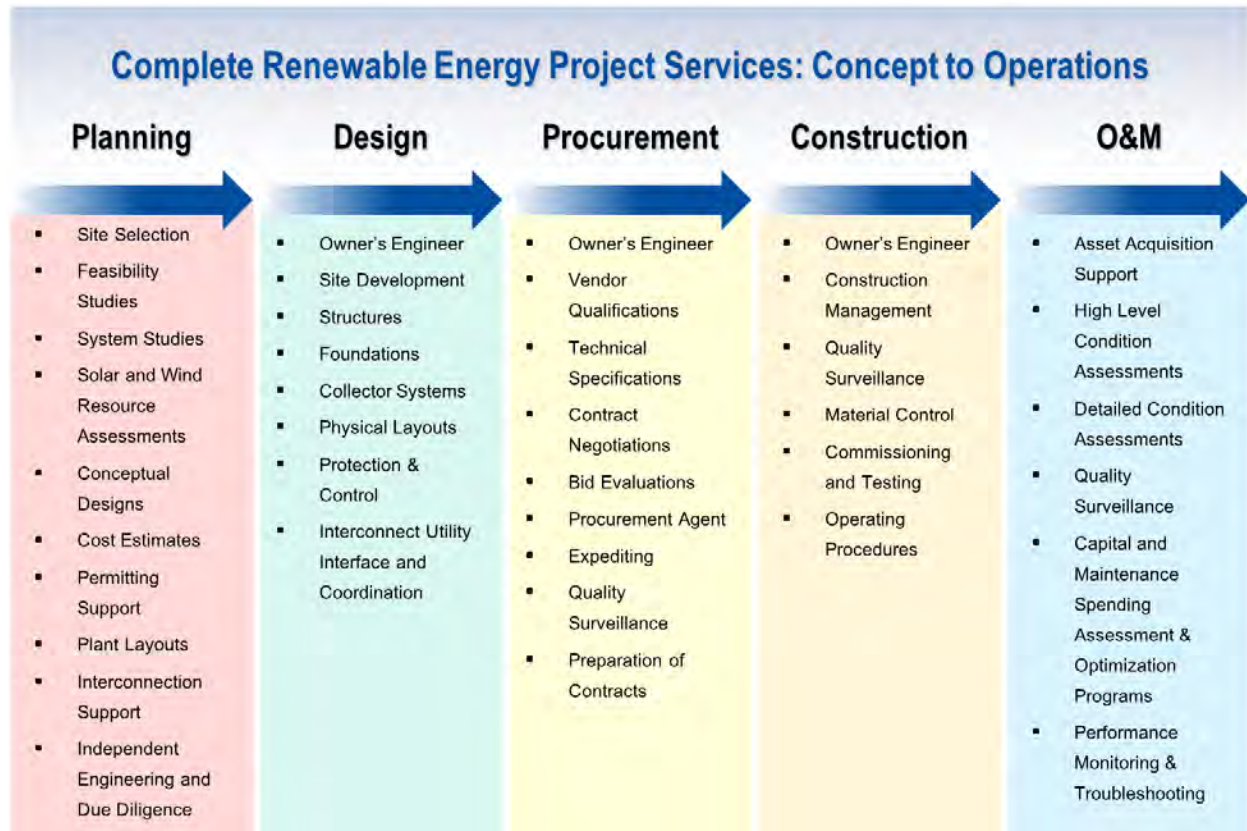
Sargent & Lundy's clients span the globe. We are currently providing, or have provided, services to clients in Africa, Asia, Australia, Europe/Eastern Europe, North America, and South America.

## Description of Services

Sargent & Lundy's roles on renewable energy projects range from full-design architect-engineer, owner's engineer, lender's independent engineer/technical advisor, or consultant. Our services range from specialized technical advisory and consulting services to complete engineering and program management, which encompasses procurement, construction management, technology transfer, and assistance with construction.



Sargent & Lundy provides professional consulting, engineering, and design services throughout the life cycle of renewable energy projects. As illustrated below, our services support clients from project concept and development all the way through detailed design and procurement, construction, and operation.



Selected services are described in more detail below.

## Site Selection

Sargent & Lundy can assist the owner in the review and evaluation of potential renewable energy power plant sites. We provide a quantitative and qualitative comparison of the potential sites, including solar and wind resource assessments, interconnection and transmission facilities, terrain and soil conditions, transportation access, infrastructure, social/economic resources, land use, and environmental and ecological impacts. Sargent & Lundy then issues a report on the suitability of the sites for development of the desired power plant. Typically, Sargent & Lundy's project manager and a site-selection engineer visit the proposed sites to confirm that all site-related features are properly addressed.

## Solar and Wind Resource Assessments

Sargent & Lundy can perform an assessment of the solar or wind resource at potential project sites. Our project teams use a variety of data sources, including ground-based and satellite derived data sets as well as onsite meteorological tower data and solar monitoring station data. We evaluate the quality of data sets in order to process the data appropriately and use the best combination of available information.

As part of our resource assessments, we determine the long-term expected mean generation and the uncertainty in order to provide P75, P90, P95, and P99 generation estimates. Our clients benefit from the different reports and tools we provide, such as 12x24 diagrams and 8760 data sets, which help project owners, developers, lenders, and other stakeholders plan and make decisions. Sargent & Lundy uses industry-recognized software for these assessments, such as PVsyst, Windographer, and Openwind®.

### ***Feasibility Evaluations***

Based on the site and technology selected, Sargent & Lundy can perform a feasibility evaluation addressing the following issues:

- ✦ The project can be constructed in accordance with generally accepted engineering practices and performed in accordance with the operating and financial projections.
- ✦ If the solar or wind resource is sufficient to meet targets.
- ✦ The technology risk can be properly managed. The technology selected for the project is sound and should provide reliable long-term service with proper operations and maintenance (O&M) practices.
- ✦ The plant can be designed, engineered, and constructed within the agreed upon cost and schedule.
- ✦ The O&M program, including provisions for planned major maintenance, is appropriate.
- ✦ The capacity and availability of the plant can meet or exceed the targets.
- ✦ The pro forma financial projections reflect projected plant performance and include appropriate estimates of future performance of the plant.
- ✦ The plant is capable of meeting the requirements of all regulatory agencies and those required by environmental permits.

### ***Technology Selection***

Sargent & Lundy can conduct a study of renewable energy technologies to determine the feasibility of utilizing the diverse range of technologies and fuels available in today's market.

For each technology, Sargent & Lundy identifies operational experience that exists for the technology and the suitability for the project being evaluated. We also assess the technical risk factors and environmental issues associated with each technology. For technologies identified as likely viable options, we conduct a technical review to provide a detailed assessment of each technology. The purpose of the review is to outline the parameters necessary to support operation of each technology, to give an opinion on constructability, and to assess the relative ranking of feasibility of the technologies. The technologies are evaluated for compatibility with the site, operating history comparison, relative capital costs, construction duration, performance comparison, expansion capabilities, and technological risk.

Sargent & Lundy then issues a report summarizing the technology evaluation and provides a recommendation on the technology selection for the power plant based on the life cycle costs of the various technologies. Only critical design features are compared for this evaluation. Specific design details, such as the codes that will be followed, the design live loads, equipment sizing, and the materials that will be supplied, are addressed as part of negotiations with the selected contractor.

### ***Due Diligence Reviews and Independent Engineering Services***

Sargent & Lundy's independent engineering services are tailored to the needs of clients who require expertise and industry knowledge to independently assess complex power industry financial and technical issues. Based on the client's specific needs, each due diligence review will have a defined scope and combination of services, such as:

- ✦ Technical, financial, and contract reviews to independently evaluate a power station or a utility for financing or acquisition by lenders, owners, or developers
- ✦ Independent solar and wind resource assessments
- ✦ Equipment installation and construction monitoring services
- ✦ Engineering due diligence reviews
- ✦ Asset valuations and independent forecasts of capital and O&M expenses
- ✦ Factory and performance acceptance test and test plan development, reviews, and witnessing
- ✦ Studies and evaluations of pending industry regulations and policies
- ✦ Power technology training services
- ✦ Other services as required to achieve client objectives

Our client list for due diligence services spans the globe, including hundreds of developers, owners, investors, contractors, original equipment manufacturers, multinational lenders, insurers, and legal advisors in all facets of the renewable energy industry.

### ***Engineering, Procurement, and Construction Specification and Bid Assistance***

Sargent & Lundy can prepare an engineering, procurement, and construction (EPC) specification based on the selected technology. The EPC specification either forms the basis for an EPC contract or is used to solicit competitive bids for the project.

Sargent & Lundy can assist the owner in the review and evaluation of proposals submitted by contractors in response to the EPC specification for the power plant. The bid evaluation includes evaluation of the design criteria, scope of work, guarantees, EPC contract price, O&M costs, performance, and financial analysis. Sargent & Lundy issues a report summarizing the proposal evaluation and provides a recommendation on the EPC contractor selection.

Sargent & Lundy can assist the owner in contract negotiations with the selected EPC contractor. Typically, we propose that our designated project manager or a lead project engineer participate in the negotiations with support, if and as required, from our staff in Chicago or one of our regional offices.

Depending on the contractual agreements for offtake of electricity, Sargent & Lundy reviews the proposed PPA. This is to verify that the risks, liquidated damages, and contractual obligations are clear and properly assigned in the project structure and that consistency exists among the project agreements. This task is similar to a due diligence review of these documents.

### ***Project Development Services***

Our project development services include the full range of support services needed to identify, evaluate, select, and implement specific power plant projects. We typically work as an extension of a client's organization, providing only the specific support services needed for each individual project, such as:

- ✦ Project contracting and implementation strategy development
- ✦ Project feasibility evaluations
- ✦ Site selection and environmental compliance reviews
- ✦ Solar and wind resource assessments
- ✦ Technology selection and suitability assessments
- ✦ Reviews and optimization studies
- ✦ Tariff and pro forma development
- ✦ Constructability assessments
- ✦ Due diligence reviews
- ✦ Capital and O&M cost estimates
- ✦ Reviews and evaluations
- ✦ Construction monitoring
- ✦ Commissioning
- ✦ Start-up consulting support
- ✦ Other services, as required, to achieve client objectives

We effectively support developers, owners, investors, and contractors in the development and implementation of renewable power projects.

### ***Conceptual Design and Studies***

Sargent & Lundy is uniquely positioned to provide a broad range of conceptual design and transmission system studies and evaluations for project owners, developers, independent power producers, government entities, financial institutions, and regulatory groups.

#### **Services**

- ✦ Conceptual project layouts and micrositing
- ✦ Generator interconnection studies
- ✦ Power transfer capability studies
- ✦ Transmission and interconnection screening



- ✦ System planning
- ✦ Congestion and curtailment analysis
- ✦ Failure analysis and root cause investigations
- ✦ Design and integration of energy storage
- ✦ Microgrid planning and design

Our conceptual design and study capabilities range from providing high-level planning support to more detailed analyses, such as short-circuit and transient stability studies.

### ***Engineering and Detailed Design***

Sargent & Lundy can perform the engineering and detailed design for projects utilizing renewable energy technologies, including wind power, solar power, and biomass. Sargent & Lundy applies its 125 years of power plant design expertise and experience to the complex challenges of renewable energy projects.

#### **Services**

- ✦ Solar photovoltaic (PV) project layout and collection system
- ✦ Solar PV project collection switchyards and interconnection substations
- ✦ Solar thermal balance-of-plant and steam turbine systems
- ✦ Wind turbine micrositing
- ✦ Wind turbine foundations, access roads, and crane pads
- ✦ Wind project power collection systems
- ✦ Wind project collection switchyards and interconnection substations
- ✦ Wind project transmission lines
- ✦ Complete biomass project design
- ✦ Design and integration of energy storage
- ✦ Microgrid design

Whatever the circumstances, Sargent & Lundy delivers the best for our renewable energy clients. We are a recognized leader in providing quality engineering, regulatory knowledge, and attention to constructability and operability.

### ***Engineering Review of Project Design***

In order to protect the interests of project owners and lenders, and to support project financing, Sargent & Lundy can perform independent reviews of project designs that have been prepared by the EPC contractor.

The purpose of the engineering review is to confirm that the EPC contractor can accomplish the following major goals:

- ✦ Design, engineer, and construct the facility in accordance with the contract documents and industry standards
- ✦ Provide a facility that is capable of performing substantially as expected, with regard to capacity, efficiency, and availability
- ✦ Design, engineer, and construct the facility within the agreed-upon cost and schedule
- ✦ Provide long-term O&M of the facility

The engineering review activities are typically performed in our Chicago headquarters or one of our regional offices. Questions that arise during the engineering review are resolved through telephone conferences and written correspondence. Concerning major issues, telephone communications are used extensively to reach swift consensus between the owner, Sargent & Lundy, and the EPC contractor. The final resolutions of all issues are documented in written correspondence. In order to facilitate communications and resolve problems quickly, monthly project status review meetings can be held, initially at the EPC contractor's design offices and, later, at the site. Discipline engineers attending the meetings are selected based on the applicability of their discipline to the key issues existing at the time of the project review meetings.

During the engineering review period, Sargent & Lundy monitors the performance of the EPC contractor's design, engineering, procurement, and fabrication activities. Sargent & Lundy's project manager issues a monthly status report that discusses the EPC contractor's progress during the month and the status of their work. Once construction has been initiated at the site, the monthly report discusses the status of construction, including photographs of construction progress at the site. The report addresses any major areas of concern, discussing our recommendations for mitigating the effects of such problem areas. The report includes the EPC contractor's updated schedule alongside our comments concerning this schedule as part of the engineering review process. We also review the contractor's requests to deviate from the specification, providing our recommendations to the owner concerning acceptance of the deviations.

During the engineering review process, Sargent & Lundy promptly advises the owner and the EPC contractor of any issues that arise that may affect the facility's cost, schedule, or quality.

### ***Licensing and Permit Support and Services***

Sargent & Lundy provides licensing and permitting support for power projects under development and in operation. We can identify required permits for projects in the planning stage and can provide technical support to owners and developers for permit applications. We maintain state-of-the-art computer modeling capabilities, including models approved by the U.S. Environmental Protection Agency and our own proprietary models. When onsite data is required, we design a monitoring program that meets regulatory requirements; we then subcontract a local company to conduct the program.

We can review the permits and licenses required for the construction and operation of the facility to confirm that the facility can operate in full compliance with the permits. Our review determines whether the required permits have been identified and whether any outstanding permits need to be received in support of the construction and operation schedule. The environmental impact assessment report is reviewed to determine if the local and national requirements, as well as the requirements specified by World Bank Environmental Guidelines, are met. We identify weaknesses that may exist, determining whether clarifications to the design and permitting of the plant are required. This review will include the general accuracy and quality of the environmental assessment.

Sargent & Lundy can issue a report summarizing the results of the environmental study and discuss any environmental concerns and potential issues related to the operation of the plant within the permit limitations. The report will address the capability of the equipment and systems to comply with regulations, the compatibility of the site with environmental requirements, the consistency of qualifications set forth in permits with contractual operating requirements, and the impact of the highest foreseeable international and domestic environmental laws and regulations could have on the plant.

### ***Construction Monitoring***

As part of our independent or lender's engineering services, we often perform construction monitoring services by visiting the project site throughout the construction period. The first trip by the project staff is typically scheduled to coincide with the mobilization of the construction contractor at the project site. This visit will usually include a project kick-off meeting and discussions of the requirements for the contractor to follow when reporting to Sargent & Lundy during the reporting period. During the rest of the construction period, we will perform monitoring visits approximately every three months. We attempt to plan these visits to coincide with either significant milestones or with project review meetings between the mandated lead arranger, the owner, and the contractor.

During the construction monitoring visits, we verify and analyze—together with the contractor—the progress of the project in the different areas involved, including permitting, engineering, procurement, and construction of the project in the different areas of work. We will also inquire about areas of potential economic or technical problems or delays, and we will discuss the project funding requirements, including future change orders that may be needed, with the contractor.

Our construction monitoring services are focused on ensuring common and clear understanding, between our client and other major project participants, of the schedule and budget performance. While maintaining our independence, Sargent & Lundy strives to support overall project completion by identifying issues and potential remedies for the project team to consider as soon as possible, with focused comments providing unambiguous bases for our remarks (clearly noting the contractual, industry code or standard, or other requirement that is not being met).

### ***Construction Management and Commissioning***

Sargent & Lundy provides complete construction management, oversight, and commissioning services for renewable energy projects. Services include the organization and management of teams of qualified firms to perform all aspects of construction for complex EPC projects. We manage Sargent & Lundy-designed projects as well as installations designed by others.

**Construction Management and Surveillance**

Our expert staff is available for onsite management and quality control surveillance of all construction activities. We can provide a complete construction services team for a project or individual personnel for staff augmentation. Our experience includes monitoring construction of wind power projects, hundreds of miles of transmission lines, and erection of multi-story buildings for enclosed urban substations.

**Testing and Commissioning Services**

We provide testing services for analysis and commissioning of renewable energy technologies, substation equipment, and complete substation installations. Our approach includes close collaboration with the owner to confirm that testing criteria and procedures comply with necessary requirements and that documentation is accurate and complete.

**Equipment and Material Procurement and Expediting**

In conjunction with the development of specifications for all renewable energy technologies, transmission and substation material and equipment, we perform a complete range of procurement services. We can serve as an owner's agent in soliciting and evaluating bids or we can incorporate this service into our scope of work under an EPC contract. We also perform supplier monitoring and expediting, including factory inspections, quality control reviews, and test witnessing.

**Operations and Maintenance Support and Services**

Sargent & Lundy provides O&M services to assist owners, operators, investors, and other stakeholders with reviewing and evaluating the operating performance of power generation assets. Our extensive power plant design, operations, and financial experience and expertise can help clients evaluate potential technical and financial improvement during power plant operations. We can help establish comprehensive performance improvement program scopes, schedules, and budget objectives.

**Services**

- ✦ Assessments in support of contractual and financial obligations, such as supporting loan payments and assessing major maintenance reserve requirements
- ✦ Performance improvement identification, review, evaluation, and implementation; including assessments of plant performance relative to industry peer group benchmarks
- ✦ Plant physical condition and life expectancy evaluations
- ✦ Operating procedure and practice review
- ✦ Organization and staffing evaluation
- ✦ End-of-warranty reviews

Our O&M services for renewable energy build on our long legacy of supporting the full range of technologies and fuels utilized for electric power generation, including solid-fuel, liquid-fuel, and nuclear power plants. Sargent & Lundy's utility-grade O&M philosophy and practices, which are focused on achieving high availability of cost-effective power production, combined with our renewable energy technical expertise in project development and implementation, provide a solid foundation for providing effective renewable energy O&M engineering and consulting services to our clients.

**Sargent & Lundy has been involved as an industry leader in renewable energy projects for decades. This document contains an overview of our recent experience with renewable energy assignments, with a specific focus on wind, solar, biomass, landfill gas, geothermal, energy storage, and integrated resource and power supply planning.**

## Selected Sargent & Lundy Renewable Energy Publications and Presentations

**"Wind Farms Without Borders: Top 5 Best Practices When Building in Developing Markets"**, presented and authored by T. Kantarek and E. Soderlund, American Wind Energy Association Windpower Conference, Orlando, Florida, May 2015.

**"Contracting Strategies and Lessons Learned on International Wind Projects"**, presented and authored by M. Thibodeau, American Wind Energy Association Windpower Conference, Orlando, Florida, May 2015.

**"Everything You Always Wanted to Know About Wind Power Purchase Agreements"**, presented and authored by G. Rainey and T. Kantarek, American Wind Energy Association Windpower Conference, Las Vegas, Nevada, May 2014.

**"Middle East and African Renewable Energy Markets: Impacts and Opportunities"**, presented and authored by M. Thibodeau, American Wind Energy Association Windpower Conference, Las Vegas, Nevada, May 2014.

**"What's in the Future for Clean Tech,"** M. Thibodeau (invited panel member), Global Midwest Alliance conference, Chicago, Illinois, September 2013.

**"Wind Plant O&M: Different Approaches, Risks, and Trade-Offs,"** presented and authored by M. Thibodeau, American Wind Energy Association Windpower Conference, Chicago, Illinois, May 2013.

**"Capacitor Bank Control in Wind Farm Substations,"** presented and authored by J. Kotal, D. O'Reilly, L. Raue, American Wind Energy Association Windpower Conference, Chicago, Illinois, May 2013.

**"Selection Considerations for Switchgear, Outdoor Circuit Breakers, and Gas Insulated Substations,"** presented and authored by D. O'Reilly, M. Braet, American Wind Energy Association Windpower Conference, Chicago, Illinois, May 2013.

**"Renewable Energy and Integrated Resource Planning for Utilities,"** presented by P. Geenen, co-author M. Thibodeau, Solar Power-Gen Conference, San Diego, California, February 2012.

**"Integrated Resource Planning for Utilities,"** presented and authored by M. Thibodeau, American Wind Energy Association Windpower Conference, Atlanta, Georgia, June 2012.

**"Renewable Energy and Integrated Resource Planning for Utilities,"** presented and authored by M. Thibodeau, Electric Power Conference, Baltimore, Maryland, May 2012.

**"Wind Turbine Structures & Foundations - Past Present & Future,"** presented and authored by S. Hagen, S. Fang, University of Illinois' 13<sup>th</sup> Annual Structural Engineering Conference, Champaign, Illinois, April 2012.

**"Construction Quality Control – Lessons Learned,"** presented and authored by D. Sleezer, American Wind Energy Association Windpower Conference, Dallas, Texas, May 2010.

**"Wind Energy Project Financing Challenges,"** presented and authored by M. Thibodeau, Energy & Environment Conference, Phoenix, Arizona, February 2010.

**"Integration of Battery Storage with Solar PV Plants,"** presented and authored by J. Patino, Energy & Environment Conference, Phoenix, Arizona, February 2010.

**"Electric Energy's Low Carbon Future and the Tough Choices Required,"** presented by M. Thibodeau, co-authors K. Davis, J. Bero, S. Hagen, Electric Power Conference, Rosemont, Illinois, May 2009.

**"Codes and Standards for Wind Turbine Foundations: An Overview and Future Outlook,"** presented and authored by T. Vazquez, American Wind Energy Association Windpower Conference, Chicago, Illinois, May 2009.

**"Cost Estimates for Utility-Scale Renewable Energy Projects,"** presented and authored by S. Hagen, American Association of Cost Engineers regional meeting, Chicago, Illinois, October 2008.

**"Grid Interconnection of the Largest Wind Farm East of the Mississippi,"** presented and authored by D. O'Reilly, American Wind Energy Association Windpower Conference, Houston, Texas, June 2008.

**"Optimizing Wind Farm Design for Profitability,"** presented and authored by S. Hagen with AWS Truewind, AWEA Windpower Conference, Houston, Texas, June 2008.

**"Municipal Utility Small Wind Projects: Challenges And Benefits - A Municipal Perspective - New Ulm, Minnesota,"** presented and authored by S. Hagen with New Ulm Public Utility, American Wind Energy Association Windpower Conference, Houston, Texas, June 2008.

**"Assessment of Concentrating Solar Power Technology Cost and Performance Forecasts,"** presented by R. Charles, Electric Power Conference, April 2005.

**"Assessment of Parabolic Trough and Tower Solar Technology Cost and Performance Forecasts,"** R. Charles and J. Smith, Golden, Colorado: National Renewable Energy Laboratory, October 2003, Report No. NREL/SR-550-34440 (full text available at: <http://www.nrel.gov/docs/fy04osti/34440.pdf>).



These and other papers are available upon request.





## Wind

As part of our extensive electric power industry experience, Sargent & Lundy has significant wind energy experience. We have provided a full range of services to the wind energy industry, including site screenings, project feasibility studies, wind resource assessments, independent engineering, interconnection planning, conceptual engineering, contract development, detailed engineering, design reviews, construction monitoring, commissioning, and O&M support. We have experience with a variety of wind turbine generators, including models from Acciona, Clipper, Enercon, Gamesa, GE, Goldwind, Kenersys, Mitsubishi, Nordex, REpower (now Servion), Siemens, Sinovel, Suzlon, and Vestas. Sargent & Lundy participated in and was actively involved in the ASCE/AWEA committee that prepared a U.S. code for the design of wind turbine foundations. We participate in the AWEA Offshore Wind Working Group and the AWEA Wind Power O&M Working Group. We also actively participate in the IEEE Wind Plant Collector Design Working Group.

The following recent projects provide an overview of Sargent & Lundy's wind energy experience.

### Due Diligence and Independent Engineering

#### GE Energy Financial Services

- ✦ 2014–2015 | Independent engineering review of Capital Dynamic's Briscoe Wind Project in Texas to support financing.
- ✦ 2014 | Construction monitoring review of Pattern Energy's Panhandle Wind Project in Texas to support financing.
- ✦ 2013 | Independent engineering review of Pattern Energy's Panhandle Wind Project in Texas to support financing.

#### Macquarie Capital

- ✦ 2015 | Independent engineering review of Big Sky Wind Project in northwestern Illinois as lender's technical advisor to support financing of project.

#### Standard Bank of South Africa

- ✦ 2011–2014 | Independent engineering review of MetroWind Van Stadens Wind Farm, which is being developed under the South African Renewable Energy Independent Power Producer Program. Sargent & Lundy's scope included pre-construction due diligence and construction monitoring.
- ✦ 2011–2012 | Independent engineering reviews of several proposed wind energy projects. Provided lender's technical advisory services to support project development and bidding into the South African Renewable Energy Independent Power Producer Program.

### Overseas Private Investment Corporation

- ✦ 2014–2015 | Independent engineering review as lender's technical advisor to support financing of a 36-MW wind project in Jamaica. Sargent & Lundy performed a technical review of the project, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection, key project contracts, and construction monitoring.
- ✦ 2013–2015 | Independent engineering review as lender's technical advisor to support financing of three 50-MW wind projects in Pakistan. Sargent & Lundy performed a technical review of the projects, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection, and key project contracts.
- ✦ 2013–2014 | Independent engineering review as lender's technical advisor to support financing of a 114-MW wind project in Peru. Sargent & Lundy performed a technical review of the project, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection, and key project contracts.
- ✦ 2011 | Independent engineering review as lender's technical advisor to support financing for a 5-MW wind project on an island in the Caribbean. Sargent & Lundy performed a technical review of the project, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection, and key project contracts.

### NextEra Energy Resources

- ✦ 2015 | Independent engineering evaluation and completion verification of the Breckinridge Wind Project in Oklahoma to support project financing. Sargent & Lundy's scope included review of wind turbine technology, BOP design and construction, SCADA systems, project contracts, and construction completion verification.
- ✦ 2015 | Independent engineering review of annual O&M budgets for wind projects in Oklahoma, South Dakota, and Pennsylvania.
- ✦ 2014 | Independent engineering evaluation of the Limon III Wind Project in Colorado to support project financing. Sargent & Lundy's scope included review of BOP design and construction, SCADA systems, and project contracts.
- ✦ 2014 | Independent engineering evaluation of the Mammoth Plains Wind Project in Oklahoma to support project financing. Sargent & Lundy's scope included review of BOP design and construction, SCADA systems, and project contracts.
- ✦ 2014 | Independent engineering evaluation of the Seiling I and II Palo Duro wind projects to support project financing. Sargent & Lundy's scope included review of BOP design and construction, SCADA systems, and project contracts.
- ✦ 2013 | Independent engineering evaluation of the 162-MW North Sky River Wind Project in California to support project financing. Sargent & Lundy's scope included review of BOP design and construction, SCADA systems, and project contracts.
- ✦ 2013 | Independent engineering evaluation of the Pioneer Plains Wind Portfolio, consisting of two wind energy projects (161-MW total) in Oklahoma to support project financing. Sargent & Lundy's scope included review of BOP design and construction, SCADA systems, and project contracts.
- ✦ 2012–2013 | Independent engineering evaluation of two wind energy projects (220-MW total) in Arizona and Michigan to support project financing. Sargent & Lundy's scope included review of the financial model, wind turbine technology, BOP design and construction, SCADA systems, project contracts, plant O&M, and construction monitoring.
- ✦ 2012 | Independent engineering evaluation of two wind energy projects in Colorado (400-MW total) to support project financing. Sargent & Lundy's scope included review of the financial model, wind turbine technology, BOP design and construction, SCADA systems, project contracts, plant O&M, and construction monitoring.
- ✦ 2011 | Independent engineering review of seven wind projects (totaling over 1,000 MW) to support financing. The plants, located in California, Oklahoma, and Texas, utilize GE and Siemens wind turbines. Sargent & Lundy's scope for each facility included review of the financial model, turbine technology, BOP design and construction, SCADA systems, project contracts, and plant O&M.
- ✦ 2009–2010 | Independent engineering review of the Mountain Prairie and Peace Garden portfolios to support financing of four wind energy plants in the midwestern U.S. The facilities utilize GE 1.5-MW and Siemens 2.3-MW wind turbine generators. Sargent & Lundy's scope for each facility included review of the foundations, power collection and SCADA systems, and BOP EPC contracts.

- 2008–2009 | Independent engineering review of the Heartland I and II portfolios to support raising third-party capital for five wind energy plants in the midwestern U.S. The facilities utilize GE 1.5sle wind turbine generators. Sargent & Lundy's scope for each facility included review of the foundations, power collection and SCADA systems, and BOP EPC contracts.
- 2008 | Independent engineering review of wind turbine foundations at two wind energy plants in eastern Canada. Facilities utilize Vestas 78M HH 1.8-MW wind turbine generators.
- 2007 | Independent engineering review of the Northern Frontier portfolio to support raising third-party capital for five wind energy plants in the midwestern and Rockies regions of the U.S. The Facilities utilize GE 1.5 and Siemens 2.3e wind turbine generators. Sargent & Lundy's scope for each facility included review of the foundations, power collection and SCADA systems, and BOP EPC contracts.

### **SunEdison / TerraForm Power**

- 2014 | Asset acquisition due diligence of four wind projects—three in Maine and one in Hawaii—to support the client's acquisition of First Wind.

### **E.ON Climate & Renewables**

- 2011–2014 | Wind project financial modeling support.
- 2012–2013 | Independent engineering review of wind turbine foundation designs on three projects, including complex geotechnical and foundation issues.

### **ContourGlobal**

- 2014 | Independent engineering review of a 114-MW wind project in Peru to support bond offering. Sargent & Lundy performed a technical review of the project, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection, and key project contracts.

### **Blattner Energy**

- 2007–2015 | Independent reviews and evaluations of the wind turbine foundation designs for more than 40 projects, including the North Sky River, Limon, Pheasant Run, Ashtabula, Crystal Lake, McAdoo, Story County, Capricorn Ridge, Langdon, Logan, and Peetz wind energy projects.

### **Fagen, Inc.**

- 2009–2015 | Independent reviews and evaluations of the wind turbine foundation designs for more than eight projects.

### **Patrick & Henderson**

- 2007–2015 | Independent reviews and evaluations of the wind turbine foundation designs for more than 10 projects.

### **Xcel Energy**

- 2013 | Evaluated, scored, and ranked 64 proposals that were submitted to Xcel Energy seeking funding from their Renewable Development Fund. The technologies involved included ground- and rooftop-mounted solar PV, utility-scale wind, small wind, biomass and biogas, anaerobic digestion, battery storage, fuel cells, and hydrogen production.

### **International Finance Corporation and European Bank for Reconstruction and Development**

- 2012–2013 | Independent engineering review of the 142.5-MW Bares Wind Project in Turkey to support financing. Sargent & Lundy's scope included reviews of project financial projections, contracts, wind turbine selection, designs and the construction plan and schedule. Sargent & Lundy monitored construction progress and start-up on behalf of the project lenders.

### **Confidential Client**

- 2011–2012 | Asset acquisition due diligence services to support the client's evaluation of investing in a wind power project in Canada. Sargent & Lundy performed a technical review of the project, which included the project financial statement, wind turbine technology and suitability, project construction plan and schedule, interconnection and grid congestion, and key project contracts.

### **BP Wind Energy**

- 2011–2015 | Independent engineering annual O&M assessment and budget review for the Goshen II Wind Project in Idaho.

- 2010 | Independent engineering review to support raising third party capital for Goshen II Wind Project in Idaho. Facility utilizes GE 1.5xle wind turbine generators. Sargent & Lundy performed technical review of project, including project financial statement, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection and grid congestion, and key project contracts.

#### **Confidential Client**

- 2011–2012 | Asset acquisition due diligence services to support the client's evaluation of investing in a wind power project in Canada. Sargent & Lundy performed a technical review of project, which included the project financial statement, wind turbine technology and suitability, project construction plan and schedule, interconnection and grid congestion, and key project contracts.

#### **BBVA Securities**

- 2010–2012 | Independent engineering review to support financing for the Glen Dhu Wind Project in Nova Scotia, Canada. The facility utilizes Enercon E-82 2.3-MW wind turbines. Sargent & Lundy performed a technical review of project, which included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection and grid congestion, and key project contracts.

#### **Exelon**

- 2010 | Technical due diligence services to support the acquisition of a 700-MW portfolio of 36 operating wind projects. Sargent & Lundy's scope included a fatal flaw analysis, a review of operating performance, a design review, and the provision of technical and financial input into the financial model used to develop the acquisition bid.

#### **enXco Development Corporation (now EDF)**

- 2010 | Independent review of commercial operation completion for the Linden Wind Energy Project in Washington.
- 2009 | Independent engineering review of the wind turbine foundation design for the Linden Wind Energy Project in Washington. The project utilizes P&H-type foundations for REpower 2-MW wind turbines.

#### **Enerjisa Enerji**

- 2009–2010 | Independent engineering review of a wind energy project in Turkey to support project financing. The facility utilizes Siemens SWT-2.3-101 wind turbine generators. Sargent & Lundy's review included the project financial statement, wind resource assessment, wind turbine technology and suitability, wind turbine foundations, power collection system, SCADA system, interconnection and grid congestion, and key project contracts.

#### **AES**

- 2008–2009 | Independent engineering review to support raising third-party capital for the Armenia Mountain Wind Project in Pennsylvania. The facility utilizes GE 1.5sle wind turbine generators. Sargent & Lundy performed complete technical review of the project, which included the wind resource assessment, project financial statement, turbine foundations, power collection system, SCADA system, and key project contracts.

#### **AWS Truewind / Iberdrola Renewables**

- 2008–2009 | Independent engineering review of the Aeolus VI portfolio of five wind projects owned by Iberdrola Renewables.

### **Owner's Engineering**

#### **Confidential Client**

- 2015 | Wind resource assessment and site evaluation for a wind project in eastern Africa.

#### **American Capital Energy & Infrastructure**

- 2015 | Owner's engineer to support the development of the 150-MW Taiba Wind Project in Senegal.

#### **NextEra Energy Resources**

- 2015 | Wind turbine foundation design assessments and analysis for three operating wind projects.

**Confidential Client**

- 2012 | Site selection and wind resource evaluation for a 30-MW wind project in the Caribbean.

**Confidential Client**

- 2012 | Cost estimating, scheduling, and project planning services to a client for a 30-MW wind project in Central America.

**Confidential Client**

- 2011 | Site selection and project feasibility study for a 2-MW wind project for a municipal utility located in the midwestern U.S. Sargent & Lundy evaluated suitable wind turbine models, estimated annual energy production, and developed project development plans.

**Mainstream Renewable Power**

- 2010 | Consulting and owner's engineering services to support the development and implementation of a wind project in Illinois. Sargent & Lundy provided advisory services for negotiation of the interconnection agreement and performed the transmission power flow study.

**BBVA Securities**

- 2010 | Developed a pro forma financial model for the project lenders to support financing for the Glen Dhu Wind Project in Nova Scotia, Canada.

**Energía Eólica de Honduras, S.A.**

- 2009 | Consulting services to support development and implementation of a 100.5-MW project in Honduras. Sargent & Lundy provided review of the client's draft BOP agreement and developed exhibits for the agreement, including the contractor's scope of work, technical specifications for all BOP components and systems, and completion criteria for all major systems and stages of construction.

**BP Wind Energy**

- 2009 | Consulting and BOP design review services to support development and implementation of the Titan 1 wind energy project.
- 2008–2009 | Construction consulting services to support development and implementation of the Fowler Ridge wind energy project.
- 2008 | Consulting and BOP design review services to support development and implementation of the Flat Ridge wind energy project.

**Gestamp Wind North America**

- 2009 | Supplied interconnection advisory services and prepared interconnection request forms, including wind turbine technical information and a one-line diagram, for the client's project under development in the midwestern U.S.

**E.ON Climate & Renewables**

- 2008–2009 | Geotechnical and structural design consulting to guide the client in selecting the optimal wind turbine foundation type for the Stony Creek wind energy project.
- 2008 | Consulting and BOP design review services to support development and implementation of the Panther Creek, Inadale, and Pyron wind energy projects.

**Third Planet Windpower**

- 2008–2009 | Consulting services to assist the client with EPC contractor oversight during construction and with evaluating non-conformances at the Lorraine Windpark project.

**REpower USA (now Senvion)**

- 2008 | Review and evaluation of the wind turbine foundation design for Phase 1 of the Windy Point Wind Project in Washington. The project utilizes P&H type foundation design.



### Half Moon Power

- 2008–2009 | Consulting services to support the development and implementation of multiple projects in the midwestern U.S. Sargent & Lundy's services included conceptual project siting and layout, and the preparation of interconnection requests.

### City of New Ulm

- 2008–2009 | Coordination and management of the development of a small wind energy project in Minnesota, including feasibility studies, contract development, and wind turbine selection.

## Design

### EDP Renewables (formerly Horizon Wind)

- 2015 | Engineering and design services for 115/34.5-kV collector substation, 115-kV transmission line, and 34.5-kV collection system for Arkwright Summit Wind Farm in New York.
- 2015 | Engineering and design services for 115/34.5-kV collector substation and 34.5-kV collection system for Jericho Rise Wind Farm in New York.
- 2015 | Engineering and design services for 345/34.5-kV collector substation, 345-kV transmission line, and 34.5-kV collection system for Hidalgo Wind Farm in Texas.
- 2015 | Engineering and design services for modification of collector substation and 34.5-kV collection system for a new project under development.
- 2008–2010 | Engineering and design services for three 345/34.5-kV collector substations, 345-kV transmission line, and 34.5-kV collection system for Meadow Lake Wind Farm Phases I-V in Indiana.
- 2008–2010 | Engineering and design services for one 345-kV interconnection switchyard, two 345/34.5-kV collector substations, 345-kV transmission line, and 34.5-kV collector system for the Top Crop Wind Farm Phases I and II in Illinois.
- 2007–2009 | Engineering and design services for two 345/34.5-kV collector substations and 345-kV transmission line for the Pioneer Prairie Wind Farm Phases I and II in Iowa.
- 2005–2007 | Engineering and design services for one 345-kV interconnection switchyard, two 345/34.5-kV collector substations, and 345-kV transmission line for the Twin Groves Wind Farm Phases I and II in Illinois. Sargent & Lundy's scope also included support to Horizon Wind Energy for procurement of project materials and equipment.

### NextEra Energy Resources

- 2015 | Engineering and design services for 60-mile 345-kV transmission line for Ninnescah Wind Farm in Kansas.
- 2015 | Engineering and design services for 20-mile 345-kV transmission line for Rush Springs Wind Farm in Oklahoma.
- 2015 | Engineering and design services for 40-mile 230-kV transmission line for Crowned Ridge Wind Farm in South Dakota.
- 2014 | Engineering and design services for 30-mile 345-kV transmission line for Javelina Wind Farm in Texas.
- 2014 | Engineering and design services for 38-mile 230-kV transmission line for Cedar Bluff Wind Farm in Kansas.
- 2014 | Engineering and design services for 7-mile 230-kV transmission line for Carousel Wind Farm in Colorado.
- 2014 | Engineering and design services for 12-mile 138-kV transmission line for Breckenridge Wind Farm in Oklahoma.
- 2013 | Engineering and design services for 5-mile 345-kV transmission line for Mammoth Plains Wind Farm in Oklahoma.

### BP Wind Energy

- 2010–2011 | Engineering and design services for one 138/34.5-kV collector substation, one 138-kV junction substation, 138-kV transmission line, and 34.5-kV collection system for the Sherbino Mesa II Wind Project in Texas.
- 2010–2011 | Engineering and design services for one 345/34.5-kV collector substation, 345-kV transmission line, and 34.5-kV collection system for the Trinity Hills Wind Project in Texas.

- 2010 | Engineering and design services for one 230/34.5-kV collector substation, 230-kV transmission line, and 34.5-kV collection system for the Golden Hills Wind Power Project Phase I.
- 2009–2010 | Engineering and design services for one 138/34.5-kV collector substation, 138-kV transmission line, and 34.5-kV collection system for the Ford Ridge Wind Farm Phase I.

### **Iberdrola Renewables**

- 2009 | Engineering, design, commissioning, testing and quality inspection services for the 345-kV interconnection substation of the Iberdrola Cayuga Ridge Wind Farm, as a subcontractor to Meade Electric.

### **Acciona**

- 2008 | Engineering and design services for the Ecogrove Project 138/34-kilovolt (kV) collector substation, as a subcontractor to the Morse Group. Sargent & Lundy also provided engineering and design upgrades at six remote-end substations to support the interconnection and provided commissioning, testing, and quality control services for the collector substation and 138-kV interconnect transmission line.

### **Confidential Client**

- 2006 | Design of substation connection to a wind power project in Wisconsin.
- 2006–2007 | Design of interconnection facilities for a wind power project substation in Wisconsin.
- 2006–2007 | Design support for a new switchyard for a wind power project.

## **Conceptual Design and Studies**

### **Electric Power Research Institute**

- 2010 and 2015 | Provided the Electric Power Research Institute (EPRI) with updates to the EPRI Wind Power Technology Guide. This included development of cost and performance data for sites in the U.S. and Saudi Arabia. Levelized cost of electricity (LCOE) calculations and sensitivities were conducted.

### **American Capital Energy & Infrastructure**

- 2014 | Performed a renewable energy integration assessment for the Senegal (country-wide) electric grid to assist the client with their evaluation of a wind power project acquisition.

### **Maui Electric Company**

- 2013 | Performed a renewable energy integration assessment to assist the client with their efforts to expand the use of wind and solar power while maintaining reliability requirements.

### **NRG**

- 2010–2011 | Conceptual engineering services for the landfall and underground portions of the 230-kV transmission interconnection for the offshore Mid-Atlantic Wind Park, including route evaluation, landfall and duct bank engineering, and support of permitting. The transmission line consists of two circuits, each serving half of the 450-MW wind farm.

### **Gamesa Energy**

- 2010 | Investigation and assessment of electrical failure at the Gamesa wind power project in the U.S.; issued findings and recommendations to correct the issue and prevent reoccurrence.

### **BP Wind Energy**

- 2009 | Transmission power flow study to support operation of the client's wind energy project in the Central U.S.
- 2008–2009 | Development of conceptual one-line diagrams and data required for the system impact and feasibility studies for five wind farms in Pennsylvania and Virginia.

### **Confidential Client**

- 2009 | Conceptual design and study for integrating energy storage with the client's wind energy project.

**Cherokee Nation**

- 2008 | Review and assessment of a wind energy project feasibility white paper.

**EDP Renewables (formerly Horizon Wind)**

- 2007 | Facility study for 99 MW of wind generation in Calumet County, Wisconsin.

**Noble Environmental Power**

- 2008–2009 | Preparation of conceptual one-line diagrams and general arrangement drawings; support of client in discussions with transmission system operator for a 350-MW wind park in Texas.

**Construction Monitoring/Management****Overseas Private Investment Corporation**

- 2015 | Independent construction monitoring of a 36-MW wind project in Jamaica.

**ContourGlobal**

- 2013–2014 | Independent construction oversight of a 114-MW wind project in Peru, on behalf of bond financing arrangers.

**NextEra Energy Resources**

- 2012 | Independent construction oversight on behalf of project lenders to support financing of the Tuscola Bay Wind Project in Michigan.

**CG Power**

- 2011 | Independent construction oversight of the Power County Wind Farm in Idaho.

**BBVA**

- 2010–2011 | Independent construction oversight on behalf of the project lenders to support financing for the Glen Dhu Wind Project in Nova Scotia.

**AES**

- 2009 | Independent construction oversight on behalf of the project lenders to support financing for the Armenia Mountain Wind Project in Pennsylvania. The facility utilizes GE 1.5sle wind turbine generators.

**Iberdrola Renewables**

- 2009 | Commissioning, testing, and quality inspection services for the 345-kV interconnection substation of the Iberdrola Cayuga Ridge Wind Farm, as a subcontractor to Meade Electric.
- 2009 | Development of operating procedures for the Cayuga Ridge Wind Farm interconnection substation for the interconnecting utility.

**Third Planet Windpower**

- 2010 | Independent certification of the Loraine Windpark Phase I Project Completion project in Texas.
- 2008–2009 | Onsite construction management and commissioning services for the Loraine Windpark project in Texas.

**Eco Energy/Acciona**

- 2008 | Commissioning, testing, and quality inspection services for the 138-kV transmission line and the 138/34.5-kV substation of the Acciona Eco Energy Wind Farm, as a subcontractor to Morse Electric.

**EDP Renewables (formerly Horizon Wind)**

- 2007–2008 | Commissioning services for substations of the Pioneer Prairie Phases 1 and 2.
- 2007–2008 | Construction management and electrical testing and commissioning for the substation and transmission for the Twin Groves Phases 1 and 2.

- 2007–2008 | Development of operating procedures for the Twin Groves interconnection substation and the Twin Groves I collector substation.
- 2007–2008 | Construction management services for the interconnection substation at the Top Crop Phase I.
- 2008–2009 | Development of operating procedures for the Top Crop Phases I and II interconnection and collector substations.
- 2007–2008 | Commissioning services for the collector substation at the Meadow Lake Phase I.
- 2009 | Development of operating procedures for the Meadow Lake Phase I collector substation.

### **BP Wind Energy**

- 2010 | Independent construction oversight on behalf of the project lenders to support financing for the Goshen II Wind Project in Idaho.
- 2009 | Commissioning services for the Fowler Ridge II Wind Project in Indiana.
- 2008 | Onsite construction management and commissioning services for the Fowler Ridge Wind Project in Indiana.
- 2008 | Onsite construction management for the Flat Ridge Wind Project in Kansas.

## **Operations and Maintenance Support and Services**

### **Confidential Client**

- 2015 | Independent engineering review of wind turbine foundations at an operating wind power project in Pennsylvania to assess potential remediation options.
- 2015 | Independent engineering review of wind turbine foundations at an operating wind power project in West Virginia to assess potential remediation options.
- 2015 | Independent engineering review of wind turbine foundations at an operating wind project in the midwestern U.S. Sargent & Lundy performed design calculations to assess the suitability of the original design.

### **BP Wind Energy**

- 2010–2015 | Annual O&M budget reviews for the Goshen II wind project, located in Idaho.
- 2010 | Engaged to develop a wind turbine foundation inspection guideline for our client's O&M personnel to use during their annual inspections and maintenance. The guidelines were developed based on Sargent & Lundy's extensive knowledge and experience with the design and operating considerations for wind turbine foundations.

### **Confidential Client**

- 2011 | Third-party failure analysis of wind turbine blade failures for a project in the western U.S.
- 2010 | Third-party failure analysis of a wind turbine gearbox failure for a project in the western U.S.

### **Confidential Client**

- 2009–2010 | Technical consulting services to the client to support their negotiations with a wind turbine supplier to resolve a serial defect with critical wind turbine components.

### **NextEra Energy Resources**

- 2010 | Independent engineering review of the Langdon Wind Project plant performance, turbine reliability, and O&M procedures and practices on behalf of the project lenders. Assessed the need for O&M budget and maintenance reserve adjustments based on the initial two years of plant performance.

### **Enel Green Power North America**

- 2010 | Technical advisory and independent engineering services to Enel Green Power North America to review and assess the causes of a wind turbine collapse. One 1.5-MW wind turbine collapsed at Enel's wind farm in New York, U.S., after 10 years of operation. Sargent & Lundy also provided design input for the revised foundation design and remediation plan. We also performed independent engineering reviews of the revised design.

**Confidential Client**

- 2010 | Engaged by an investment firm to perform technical due diligence on a wind O&M services company that the client was seeking to acquire. Sargent & Lundy evaluated the target firm's vibration monitoring technology and provided assessments and recommendations to the client on the effectiveness and market potential of the technology.





## Solar

As part of our extensive electric power industry experience, Sargent & Lundy has significant solar technology experience. Sargent & Lundy was the BOP engineer for the design of the SEGS VIII, IX, and X facilities in the late 1980s and has been active in the development of solar energy ever since. Sargent & Lundy is active in the renewable energy generation market, currently providing owner's engineering, technical due diligence, and conceptual design of solar energy generation for our clients.

Sargent & Lundy solar technology experience includes the following projects.

### Solar Resource and Energy Production Assessments

#### **SunEdison / TerraForm Power**

- ✦ 2015 | Performed independent solar resource and energy production assessment of two operating solar PV projects, located in Canada, to support the client's potential acquisition.

#### **Overseas Private Investment Corporation**

- ✦ 2014–2015 | Performed independent solar resource and energy production assessment of a 20-MW solar PV project, located in Jamaica, to support project financing.

#### **International Finance Corporation**

- ✦ 2014 | Performed an independent solar resource and energy production assessment of three solar PV projects (70 MW in total), located in the Philippines, to support project financing.

#### **Overseas Private Investment Corporation**

- ✦ 2013–2014 | Performed an independent solar resource and energy production assessment of a 5-MW solar PV project, located in Tanzania, to support project financing.

#### **Macquarie Capital**

- ✦ 2013 | Performed an independent solar resource and energy production assessment of a 30-MW solar PV project, located in Georgia, to support project financing.

## Independent Engineering Services

### SunEdison / TerraForm Power

- 2015 | Asset acquisition due diligence of two solar PV projects, located in Canada, to support the client's potential acquisition.

### Inter-American Development Bank

- 2015 | Independent engineer for a 110-MW concentrating solar tower project with molten salt storage. The project is located in northern Chile. Services include independent due diligence assessment and construction monitoring.
- 2015 | Independent engineer for a 100-MW solar PV project with single-axis tracking. The project is located in northern Chile. Services include independent due diligence assessment and construction monitoring.

### International Finance Corporation

- 2014–2015 | Independent engineer for a 70-MW portfolio of three solar PV projects in the Philippines being financed by the International Finance Corporation. Services include independent solar energy yield assessment, technical due diligence in support of funding, and construction monitoring.

### Overseas Private Investment Corporation

- 2014–2015 | Independent engineer for a 20-MW solar PV project in Jamaica being financed by OPIC and the IFC. Services include independent solar energy yield assessment, technical due diligence in support of funding, and construction monitoring.
- 2013–2014 | Independent engineer for a 5-MW solar PV project in Tanzania being financed by the Overseas Private Investment Corporation. Services include technical due diligence in support of funding and construction monitoring.

### U.S. Department of Energy: Tonopah Solar Project

- 2010–2015 | Independent engineer for the Tonopah Solar Project being developed in Nevada. Tonopah is a 100-MW molten salt solar tower project with 10 hours of storage. Services include independent technical due diligence, in support of funding by the DOE, and construction monitoring.

### U.S. Department of Energy: Mojave Solar Project

- 2010–2015 | Independent engineer for the Mojave Solar Project being developed in California. Mojave is a 250-MW parabolic trough solar project. Services include independent technical due diligence, in support of funding by the DOE, and construction monitoring.

### Macquarie Capital: 30-MW PV Solar Project

- 2013 | Independent engineer for a 30-MW PV solar project being constructed by Silicon Ranch in Georgia. Services include independent technical due diligence, in support of funding, and construction monitoring.

### U.S. Department of Energy: Rice Solar Project

- 2010–2011 | Independent engineer for the Rice Solar Project being developed in California. Rice is a 150-MW molten salt solar tower project with four hours of storage. Services include independent technical due diligence in support of funding by the DOE.

### Standard Bank of South Africa

- 2011–2012 | Independent engineering reviews of proposed solar PV projects; provide lender's technical advisory services to support project development and bidding into the South African Renewable Energy Independent Power Producer Program.

### Standard Bank: 75-MW PV Solar Project

- 2011 | Independent engineering for a 75-MW PV solar project being developed in South Africa. Services include independent technical due diligence in support of funding and construction monitoring.

### Standard Bank: 50-MW PV Solar Project

- 2011 | Independent engineering for a 75-MW PV solar project being developed in South Africa. Services include independent technical due diligence, in support of funding, and construction monitoring.

**Standard Bank: 100-MW CSP Solar Project**

- 2011–Present | Independent engineering for a 100-MW CSP solar project being developed in South Africa. Services include independent technical due diligence, in support of funding, and construction monitoring.

**Confidential Client: PV Solar Project in Arizona**

- 2013 | Independent engineering review of the root cause analyses and corrective actions related to the failures of pad-mount transformers at a PV solar power plant in Arizona.

## Solar Technology Reviews

Sargent & Lundy has been engaged by several clients to evaluate the current solar market: technology, costs, and potential cost reductions. A partial list of projects follows.

**Electric Power Research Institute**

- 2013, 2014, and 2015 | Provided EPRI with updates to the *EPRI Solar PV Technology Guide* and the *Solar Thermal Technology Guide*. This included development of cost and performance data for sites in the U.S. and internationally. LCOE calculations and sensitivities were conducted.

**Confidential Client**

- 2011 | Developed the conceptual design for a parabolic trough plant in India. The conceptual design included a review of technology; a solar resource assessment and projection; a conceptual design including solar field size, heat transfer fluid (HTF) system, and power block; and conceptual design drawings including solar field layout, heat balance, electrical one line, control block diagram, and water balance.
- 2011 | Developed the detailed design for the solar field and HTF system. The solar field design included foundations. The HTF system design included a complete design package for purchase, installation, and commissioning.

**Sandia**

- 2008–Present | Updated the Sargent & Lundy Report, "Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts" dated May 2003, to include parabolic trough, molten salt power towers, direct steam power towers, and dish technology. Issued the draft report for industry review in April 2009.
- Electric Power Research Institute 2009 and 2010 | Provided EPRI with plant descriptions, estimated cost, and associated technical information on solar thermal and PV electric power generation technologies. The information included current status and potential projections for development and/or commercialization activities over the next five to 15 years. Issues and activities associated with renewable power generation technologies, as they relate to planning, engineering, and project development, were discussed.

**Confidential Project(s)**

- 2010 and 2011 | Project and technology due diligence reviews of solar thermal project(s) in the southwestern U.S. The reviews included both technology and general project risk.

**Confidential Client**

- 2008 | Provided a consolidated report on the current status of concentrated solar power (CSP) technology. The information included the current market, participants, active projects and developers, current costs, cost reduction potential, and discussion of emerging technologies.

**BP America, Inc.**

- 2007–2008 and 2011 | Assisted the client in developing their solar renewable strategy. The strategy included evaluation of solar trough and tower technologies, including current costs and potential cost reductions.

**Duke Energy Generation Services**

- 2007 | Evaluation of solar trough and tower technologies, including current costs and potential cost reductions.

**Mitsui & Co., Ltd.**

- 2007 | Comprehensive technology survey and analysis of commercially available solar thermal and solar PV technology.

**Toyota Tsusho Corporation**

- 2011 | Comprehensive technology survey and analysis of commercially available solar thermal and solar PV technology.

**SkyFuels**

- 2010 and 2011 | Independent technical review of the SkyTrough parabolic solar collector. Services consisted of a review of the design, comparative product cost assessment, and performance assessment. Sargent & Lundy evaluated the prototype testing conducted on the SkyTrough collector and provided an independent review and opinion of the test results.

**Technology Due Diligence Reviews: Confidential Clients**

Sargent & Lundy has been engaged by several clients to perform due diligence reviews of solar technology. A partial list of due diligence reviews follows:

- 2009–2011 | Technical due diligence review of eSolar direct steam power tower technology.
- 2010 | Technical due diligence of a solar technology supplier.
- 2008–2011 | Technical due diligence review of SolarReserve molten salt power tower technology.
- 2008 | Technical due diligence of the current three solar distributed power tower technologies being developed in the U.S. Reviewed the design concept and implementation strategy for each of the technologies.
- 2007 | Due diligence review of concentrating PV systems. Developed a conceptual cost estimate for installation of large-scale projects.
- 2007–2009 | Due diligence review of a solar technology supplier (SkyFuels) for an investment group and developer.
- 2006 | Feasibility review of Ausra's linear Fresnel technology proposed for a 180-MW plant.
- 2006, 2009, and 2010 | Feasibility review of the Brightsource direct steam power tower technology proposed for large-scale solar plant.

**Owner's Engineer Services****Maui Electric Company**

- 2013 | Performed a renewable energy integration assessment to assist the client with their efforts to expand the use of wind and solar power while maintaining reliability requirements.

**Confidential Client**

- 2013 | Performed a pre-feasibility study for a 30-MW solar PV facility in South Africa. The scope included a solar resource evaluation, conceptual design, generation projection, interconnection review, and overall risk analysis.

**CPS Energy**

- 2011 | Engineering services for a technical review and construction monitoring of three 10-MW PV solar projects in Texas.

**Confidential Client**

- 2011 | Project and technical due diligence review for the client who was looking to invest in the Blythe CSP parabolic trough plant in California.

**HIRCO: Feasibility of Solar Power at Existing Site**

- 2010 | Engineering services for the feasibility of parabolic trough technology at an existing site in India, as well as an analysis of expected project costs, taking local factors into consideration.

**Intermountain Power Agency: Feasibility of Solar Power at Existing Site**

- 2009 and 2010 | Engineering services for the feasibility of various solar technologies (tower, trough, and PV) at an existing site in Utah.

**Entegra Power Group: Gila River Solar Feasibility Study**

- 2009 | Analysis of the use of both parabolic trough and PV technologies at the existing Gila River power plant site. The parabolic trough CSP configuration investigated for the Gila River plant was based on integration with the existing combined-cycle configuration. The PV configuration was based on non-tracking thin-film PV panels. The analysis included capital costs, O&M costs, water usage, land requirements, staffing, achievable performance, and technology maturity.

**Agrifos Fertilizer: Renewable Energy Feasibility Study**

- 2009 | Review and assessment of various renewable energy generation options that could be utilized at a site in southeastern Texas. Solar thermal and solar PV technologies were investigated. Performance, cost, and incentives were evaluated for the various technologies at the site.

**Sempra: Feasibility Study for Batteries in Large-Scale PV Plants**

- 2009 | Engineering services for the feasibility and selection of large-scale battery systems for a 50-MW thin-film PV plant in the southwestern U.S. The study included a review of available battery technology, maturity of the technology, capital and O&M costs, and methodology to size the battery and determine optimum battery type based on technology and cost.

**Sempra: Parabolic Trough Solar Plant in Southwestern U.S.**

- 2007 and 2009 | Engineering services for the development of a large-scale parabolic trough plant in the southwestern U.S. The services included conceptual design of the entire plant (solar and thermal), conceptual cost estimate, EPC specifications, technical input for permitting (emissions and transmission), schedules, and additional support as required.

**Southern California Edison**

- 2008 | Study of potential uses of the Mohave Site. Services included developing a conceptual design and cost estimates for a parabolic trough solar plant, power tower, and integrated solar combined-cycle plant.

**Total/Abengoa – United Arab Emirates**

- 2008 | Bid support for a solar thermal power plant in the United Arab Emirates. The services included independent technical verification that the EPC contract proposal for the bid was in compliance with the requirements identified in the RFP, including the PPA. Sargent & Lundy also provided technical assistance in preparing a competitive bid and identifying technical risks.

**Iberdrola: Parabolic Trough Solar Plant in Southwestern U.S.**

- 2008 | Conceptual design for 100-, 250-, and 500-MW parabolic trough power plants. A high-level capital cost estimate and estimate of O&M costs were developed.

**Total/Abengoa – Spain**

- 2007 and 2008 | A technical evaluation of bids for receiver tubes and mirrors for a parabolic trough project in Spain.

**Intergen: Integrated Solar Combined Cycle**

- 2008 | A feasibility study of a solar retrofit for a 501F 1x1 combined-cycle unit. The CSP technologies addressed were parabolic trough, power tower, and compact linear Fresnel receiver (CLFR). The relevant advantages and disadvantages of each type of system were identified. Evaluation areas included steam conditions achievable, technology maturity, comparative capital and O&M costs, and equipment availability.

**Mesa del Sol: Parabolic Trough Solar Plant in Southwestern U.S.**

- 2008 | High-level capital cost estimate and O&M costs for a 100-MW solar parabolic trough plant.

**Confidential Project: Parabolic Trough Solar Plant in Southwestern U.S.**

- 2007 and 2008 | Owner's engineering for the development of two 180-MW solar parabolic trough power plants.



**Arizona Electric Power Cooperative: Apache Station**

- 2007 | Functional specification for a gas turbine solar inlet chiller system.

**Goldman Sachs: Parabolic Trough Solar Plant in Southwest U.S.**

- 2006 | Engineering services for the development of a large-scale (600-MW) parabolic trough plant in the southwestern U.S. Services included conceptual design and conceptual cost estimate.

Sargent & Lundy's solar technology experience before 2006 includes the following projects:

**National Rural Electric Cooperative Association: Assessment of Renewable Energy Options to Enhance Combustion Turbine Performance**

- 2005 and 2006 | The National Rural Electric Cooperative Association (NRECA) engaged Sargent & Lundy to assess renewable energy options to enhance combustion turbine performance. Our scope included a technical and financial analysis of combustion turbine enhancement through the use of solar parabolic troughs and absorption cooling of inlet air. The final deliverable included a comprehensive report and working economic model.

**Southern California Edison: Study of Alternative/Complimentary Generation Resources for the Mohave Power Plant**

- 2005 | Southern California Edison engaged Sargent & Lundy to study alternate and complimentary generation to potentially replace 885 MW of generation at the Mohave Power Plant. The study included a feasibility analysis of renewable energy: CSP (parabolic trough, power tower, Sterling dish/engine, and PVs), wind, geothermal, and biomass.

**Florida Power and Light: SEGS III through IX: Due Diligence Reviews**

- Florida Power and Light (FPL), as one of the principal owners, engaged Sargent & Lundy to perform an independent due diligence review of the SEGS facilities. Services included:
  - 2005 | A due diligence review of the SEGS III-VII for a project refinancing, including a condition assessment, reviews of O&M practices and budgets, plant performance, financial projections, and status of permitting and licensing compliance.
  - 1998 | A due diligence review of SEGS VIII and IX for a project refinancing, including a condition assessment, reviews of O&M practices and budgets, plant performance, financial projections, and status of permitting and licensing compliance.

**The World Bank: Feasibility Study of Integrated Solar Combined-Cycle System**

- 1999 | Comisión Federal De Electricidad (CFE) received funding from the Global Environmental Facility (GEF) of the World Bank for the solar portion of an integrated solar combined-cycle system (ISCCS) thermal power generation project planned in Mexico. The World Bank engaged Sargent & Lundy to assess the plant feasibility based on a change in how the project was being contracted and because of technical changes. Our scope included summarization of current concentrating solar power technology development and experience; appraisal of the technical soundness of the CFE-proposed design and its status in terms of technological progress; a review of technological arrangement alternatives; an assessment of incremental costs and the economic feasibility of the CFE-proposed design; and an evaluation of technological performance risk, cash-flow risk, project financial return risk, developer financial return risk, and policy risk for the project. Our work included a review of the solar field (insolation, field configuration, and geotechnical) and the combined-cycle plant. The combined-cycle analysis included an evaluation of the absorption chillers, powered by solar generated steam, that were used for cooling the combustion turbine inlet air to maintain a constant 10°C inlet air temperature.

**U.S. DOE and NREL: Assessment of Parabolic Trough and Power Tower Solar Technologies**

- 2003 | This study for the DOE and NREL involved an assessment of the potential for developing concentrating solar power technology as an electric generating technology over the subsequent 10–20 years. We analyzed industry projections for technology improvement, progress of research and development (R&D), plant scale-up and economies of scale, economies of learning resulting from increased deployment, cost-reduction potential, and other factors. The study considered possible improvements in efficiency, tax credits, O&M cost, and total cost of produced electricity. This work provided Sargent & Lundy with

an extensive network of contacts in the solar thermal industry, including persons in government, research organizations, and equipment manufacturers. The analyses considered a variety of sensitivity studies, including impacts of owners' cost of capital (e.g., investor-owned utilities vs. other types of utilities that have lower financing costs).

### **CMS Generation**

- 2000–2001 | A technology survey and analysis investigation of commercially available renewable energy technologies, which included solar thermal and solar PV technologies.

### **LUZ Solar Partners: SEGS Original Design Work; Various Parties: Follow-On Work**

- 1988 | Sargent & Lundy participated in the original design of the SEGS VIII and IX—two 80-MW parabolic trough units. The units, in Harper Lake, California, have gas-fired HTF heaters, a hybrid design that was considered the lowest-cost and latest technology. Initial operation was in December 1989. Sargent & Lundy performed the design of the power block, balance-of-plant, and interface with solar field. Our efforts included the design of SEGS X, for which construction was started but not completed.
- 1997 | Since the original operation of the units, Sargent & Lundy has provided engineering support to the operating companies to improve the efficiency and reliability of the plant. For example, we designed the piping system for added condensate storage tanks, bypasses for the HTF heaters, and provided a study of variable-frequency drives, a structural design review, and assistance with turbine blade repairs.

### **Solar Chimney Projects: Gujarat and Rajasthan, India**

- 1996 | Sargent & Lundy, through our joint venture in India, L&T-S&L, was involved in three proposed solar chimney projects in India: a 5-MW project in Gujarat and 200-MW projects in Rajasthan and Gujarat. We advised the state governments on the proposed projects. This effort included a technical, economic, and design feasibility report, and coordination with the developers.

### **City of Austin, Texas**

- 1990 | A repowering study, which included evaluation of emerging technologies like solar, wind, energy storage, and fuels cells.

### **West Texas Utilities Company**

- 1982 | Preliminary design for the solar repowering of an oil-fired facility and preliminary design for a large hot-sodium storage facility.



## Biomass

Sargent & Lundy's involvement in the biomass industry includes feasibility studies, fuel supply assessments, evaluations of technology options, siting evaluations, identification of "target" emission rates for air permitting activities, layouts, cost estimating, and other conceptual design activities. This project development activity frequently included providing conceptual design with the ability of burning biomass. This work involved investigating optional equipment layouts based on information gathered from steam generator suppliers, material handling vendors, and air quality control vendors to assure our clients that new or existing coal-fired units could also be able to fire biomass in sufficient quantities to impact CO<sub>2</sub> emissions. In addition, we have investigated waste-to-energy (WTE) projects and biomass co-firing in existing units as well as new unit designs.

The summaries below discuss selected Sargent & Lundy engagements in biomass<sup>1</sup> and landfill gas (LFG) projects.

### International Finance Corporation – Philippines

- ✦ 2014 | Independent engineer for a 70-MW portfolio of three biomass projects in the Philippines being financed by the International Finance Corporation. Services included technical due diligence in support of funding, and construction monitoring.

### Confidential Project – Midwest U.S.

- ✦ 2011 | Phase 1 engineering study and report for utilizing waste fuel to be delivered to existing sites for gasifying the biomass material and using low-Btu fuel in existing boilers to offset the use of coal firing.

### Kauai Island Utility Cooperative – Hawaii

- ✦ 2011 | A high-level feasibility review of installing a new boiler to replace an existing oil-fired package-type boiler in order to combust biomass at the Port Allen Station (S1) in Hawaii. Options considered were to reuse the existing steam turbine generator, replace the steam turbine and reuse the existing generator and auxiliaries, or replace the entire steam turbine generator.

### NRG – Waste-to-Energy Facility

- ✦ 2010–2011 | Sargent & Lundy developed the conceptual design for a WTE facility using the AlterNRG (Westinghouse Plasma) gasification technology to produce syngas. We prepared design criteria for the plant; developed an emission profile for submittal of permits; prepared general arrangement drawings; and developed a plant cost estimate.

<sup>1</sup> Locations of Confidential projects in United States identified by region according to U.S. Census Bureau:  
[http://www.census.gov/geo/www/us\\_regdiv.pdf](http://www.census.gov/geo/www/us_regdiv.pdf)

**Biomass Products, LLC – Illinois**

- 2010–2011 | Owner's engineer support for obtaining transmission services for the proposed 25-MW Rock Falls biomass power plant. Scope included consultation regarding a proposal to the regional transmission authority and an analysis of the historical locational marginal pricing to assist in determining bid pricing. Analysis included identification and assessment of transmission service alternatives for delivery into regional transmission territories.

**Buena Vista Biomass Project – California**

- 2010–2012 | Lender's engineer support of financing the conversion of the brownfield, 18-MW Buena Vista biomass project in Northern California. The scope included an initial evaluation of the technical and commercial basis for the project and subsequent periodic reviews and approvals of contractor invoices and change orders. Site visits and regular project team communications included to maintain adequate level of insight into project progress.

**Confidential Project – West (Mountain) U.S.**

- 2010–Present | Biomass fuel supply and cofiring (up to 10% by heat input) study. Initially, a fuel supply investigation was conducted to determine the types of fuel readily available, the quantities and sustainability of each, and the suitable delivery concepts to the station. A technical assessment was also performed to determine the method(s) of cofiring the fuels that may be readily found near the station. Material handling concepts were presented based on viable fuel alternatives identified in the fuel assessment evaluation.

**NOVI Energy – Virginia**

- 2010–Present | Owner's engineer technical support for project start-up activities through EPC award for the brownfield development of a nominal 50-MW boiler facility. Scope includes development of a feasibility study to assess technology, fuel, interconnection, environmental, and site characteristics. Sargent & Lundy was retained to support permit applications, the PJM interconnection application, development of EPC specifications, EPC bid evaluations, and guidance for economic incentives. Sargent & Lundy performed detailed design in civil/structural areas outside of the power block and general owner's engineering support during project implementation. We supported the owner's application for the Department of Treasury's 1603 ARRA Grant funding, providing detailed cost estimate breakdowns and general grant application guidance.

**Confidential Project – Midwest (East North Central) U.S.**

- 2009–2010 | In conjunction with a re-powering study, Sargent & Lundy evaluated the conversion of two existing pulverized-coal-(PC)-fired boilers to burn biomass with a percentage of refuse-engineered fuel. Deliverables included site arrangement drawings, a cost estimate, a complete new biomass material handling system layout and flow diagrams, a fuel alternatives assessment, a conversion technology assessment (cofiring or switching to 100% biomass), a performance optimization, a project schedule, and emissions estimates for permitting input.

**Confidential Project – Midwest (East North Central) U.S.**

- 2009–Present | Biomass conversion of two existing PC-fired boilers to burn biomass with a percentage of refuse-engineered fuel. Deliverables include site arrangement drawings, a cost estimate, a complete new biomass material handling system layout and flow diagrams, a fuel alternatives assessment, a conversion technology assessment (cofiring or switching to 100% biomass), a performance optimization, a project schedule, and an emission estimates for permitting input.

**Confidential Project – West (Pacific) U.S.**

- 2009–2010 | Biomass conversion study for large coal-fired unit, including evaluating cofiring from 10–100% biomass. The report provided layouts, estimated costs, estimated emissions, and an evaluation of a new biomass material handling system (wood chips, grasses, pellets, and torrefied biomass) and fuel supply for type and quantity available.

**Confidential Project – South (South Atlantic) U.S.**

- 2009–2010 | Biomass conversion study for two older PC-fired boilers to burn 100% biomass, including material handling layout integration with an existing system. More than 15 material handling options were under consideration, involving various degrees of long-term and short-term storage, rail and truck delivery, and assessment of additional truck traffic. Deliverables included estimated cost, boiler technology selection (stoker vs. bubbling fluidized bed [BFB], or standalone gasifier), and emissions and unit performance projections, and emission estimates. Also developed a detailed conversion scope and inputs to the air permit application.

**ecoPower Generation LLC – 50-MW Biomass Facility**

- 2009–2010 | Owner's engineer technical support for project start-up activities for the greenfield development of a nominal 50-MW fluidized bed boiler facility to burn wood waste from a local Kentucky lumber industry and forestry. Scope included technology assessment and selection; conceptual design; technical support to the permitting process; site planning, including material handling unloading storage and reclaim operations; and permit support and consultation for economic feasibility.

**City of New Ulm – Minnesota, U.S.**

- 2007–2009 | Evaluation of converting an existing 10-MW stoker, currently firing natural gas, to burn coal and biomass. Scope included material handling options, boiler performance, and air emission estimates.

**Associated Electric Cooperative Inc. – Missouri**

- 2010 | Evaluated biomass cofiring options at five existing coal-fired units, ranging in size from 175 MW to 715 MW and utilizing pulverized coal and cyclone technologies. Scope included fuel analysis, cofiring technology options for both boiler types, performance calculations, material handling design considerations, emissions and permitting impacts, economic analysis, and implementation schedule analysis.

**Dairyland Power Cooperative – Wisconsin, U.S.**

- 2009–2011 | Evaluation of the availability of various biomass fuels for use at multiple stations in the client's fleet; also considered combustion alternatives applicable to each unit. Technologies included modifications to support several cofiring options; boiler conversions to stoker/BFB; and external combustion alternatives, such as Dutch ovens and full and partial gasifiers producing syngas. Different material handling options were identified for each of these firing options due to the different sizing requirements of the technologies. The study identified estimated quantities of each biomass type within reasonable distance from each site. Additional scope includes developing a test burn for several biomass fuel types and selecting the candidate unit for testing, as well as identifying fuel suppliers and temporary material handling equipment required for the test burn.

**South Mississippi Electric Power Association**

- 2009–2010 | Study of various renewable energy options potentially available to serve load requirements of South Mississippi Electric Power Association's (SMEPA's) member cooperatives. Performed an evaluation of biomass fuel alternatives, including review of potential renewable energy legislation; an investigation of renewable fuel sources and technologies; and a feasibility study on the use of potentially viable renewable fuels at existing SMEPA generating units, including integration of biomass handling with existing facilities. Technologies included modifications to support several cofiring options; boiler conversions to stoker/BFB; and external combustion alternatives, such as Dutch ovens and full and partial gasifiers producing syngas. We also performed an economic evaluation of these renewable project alternatives.

**Confidential Project – Midwest (West South Central) U.S.**

- 2009–2010 | A biomass conversion study for two large coal-fired units, which included evaluating cofiring from 10% biomass. The report included material handling layouts, estimated costs, estimated emissions, and evaluations of the material handling system preparation equipment costs (wood chips, grasses, pellets, and torrefied biomass) and the fuel supply for type and quantity available.

**Confidential Project – Midwest (West North Central) U.S.**

- 2009–2010 | Independent engineer assessment of an operating biomass unit with a single boiler and steam turbine. The assessment included reviews of fuel supply, system performance, environmental compliance, operations, staffing, and PPA and FSAs. Fuel consists of 100% biomass from multiple sources, including wood, harvest, and poultry farm byproducts.

**Antilles Energy Cooperative – Lower Somerset Renewable Energy Facility**

- 2009 | Owner's engineer support for project start-up activities for the conversion of an existing generating facility from fuel oil to a biomass feedstock of poultry litter and agricultural feed. Feedstock processing included gasification for combustion, liquefaction-to-liquid biofuel products, and associated process stream cleanup. Sargent & Lundy assisted in developing the project's commercial structure, defining the plant's division of responsibilities and preliminary permit scoping, and generating an integrated project schedule.



**Confidential Client – Existing CFB Unit**

- 2008–2009 | Study of material handling issues associated with receiving and unloading wood chips at the site and conveying to the boiler. Target biomass fuel consumption was ~20% on a yearly average basis, maximum of 40%, by heat input of wood chips.

**Cleveland-Cliffs Northshore Mining – Silver Bay**

- 2008–2009 | Evaluated cofiring up to 25% biomass (heat input) from a product line called Renewafuel, owned by the parent company. Evaluated methods of burning the fuel, as defined by the Renewafuel specifications, in Unit 2 at the Silver Bay Unit 2 boiler. (Renewafuel proprietary fuels are a blend of renewable feedstock and can be sized for boiler- or furnace-specific applications. Densified and custom-sized pellets allow immediate use in most existing solid fuel systems, with minimal capital improvements. The densified biofuel is consistent in size, heat value, and moisture content, so it is easier to store and use than raw biofuels.)

Also, Sargent & Lundy reviewed installation of new burners dedicated to the biomass fuel alone. We reviewed several standalone combustion options (e.g., Dutch ovens, gasifiers), which minimized the impact to the existing mills and burners. All options reviewed included evaluation of a new material handling system.

We also evaluated unit performance impacts and estimated changes to sulfur dioxide (SO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), particulate matter (PM), mercury (Hg), and carbon dioxide (CO<sub>2</sub>) emissions. We estimated capital expenditures, O&M costs, and completed an overall plant economic evaluation, including projected cash flow.

**Entergy – Little Gypsy**

- 2008 | Feasibility study of circulating fluidized bed (CFB) boilers (2x330 MW each) to repower an existing steam turbine fired on biomass. The evaluation included environmental considerations, performance assessments, and economic analyses based on a 2010 service date. We also reviewed the quantity and type of biomass near the site.

**Tondu Corporation – Filer City**

- 2008 | Evaluated NO<sub>x</sub> control options for two ~30-MW (each) stoker boilers. The boilers cofired biomass (wood chips).

**MidAmerican Energy – Systemwide Biomass Evaluation**

- 2008 | Evaluated the availability of various biomass fuels for use at several coal-fired stations in the client's fleet. The study involved assessment of boiler operations, air quality control equipment, and material handling and the impact onsite space requirements. Sargent & Lundy also studied sensitivity of providing up to 10% biomass fuel to each unit. We estimated emissions with the different types of fuels studied, including SO<sub>2</sub>, NO<sub>x</sub>, PM, Hg, and CO<sub>2</sub>, and provided economic analysis of the capital expenditures, O&M expenses, delta fuel costs, and sensitivity on the value of CO<sub>2</sub> credits.

A separate study reviewed the technologies available for a 100% biomass-fired steam generator supplying a separate steam supply, including the appropriate material handling system, which is different from that used to prepare the fuel for direct injection into the boiler. The approximate size was 30–35 MW, including stokers, CFB boilers, and small gasification units.

**City of Escanaba and Wisconsin Public Power, Inc.**

- 2006–2008 | Siting and project feasibility study for new solid fuel generating unit of up to 300 MW to be located in Escanaba, Michigan, and jointly owned and operated by the City of Escanaba and Wisconsin Public Power, Inc. The fuel considered was a blend of coal and petroleum coke, with up to 8% heat input provided by wood chips.

**Confidential Client – British Columbia, Canada**

- 2007 | Conceptual design of the power block, including material handling layouts for a nominal 200-MW greenfield CFB unit, with the capability of firing up to 40% wood chips. The wood source considered for the study was the Pine Bark Beetle Kill affecting forests in British Columbia. Layouts were prepared for wood truck unloading, storage, reclaim, and preparation to feed an existing CFB boiler. Sargent & Lundy supported the air permit application on behalf of the client. Our scope included developing performance values, such as heat rate, emissions, waste quantities, and water consumption, along with estimated bus bar costs.

**Credit Suisse First Boston – Aokam Perdana Timber Complex, Malaysia**

- 2007 | Technical evaluation and feasibility for the sale of a 10-MW wood-waste power plant in Malaysia. Included review of the process, high-level condition assessment of the equipment, and review of the O&M and production capability.



**CLECo – Rodemacher Unit 3**

- 2007 | A feasibility study of 2x330-MW CFB boilers under construction to burn biomass. Sargent & Lundy's evaluation included environmental considerations, performance assessments, and economic analyses based on a 2010 service date. We also reviewed the quantity and type of biomass near the site.

**Upper Peninsula Power Company**

- 2003–2004 | A siting and technology screening study for the use of wood waste. Sargent & Lundy evaluated the best locations on the transmission system, identifying the generation technology and capacity options to be used as the basis for the site evaluations and in developing the conceptual designs and cost estimates. Options centered on steam generating units capable of burning a mix of wood waste and Powder River Basin (PRB) coal.

**Mitsui & Co. Ltd – Thailand**

- 2003 | Developed technical and EPC contract information for the client to submit an offer for a 3x100-MW project using coal and biomass with CFB technology in Thailand. Sargent & Lundy's scope included development of general arrangements, performance calculations, emission evaluations, site environmental parameters, single-line diagrams, costs estimates, scheduling, and functional plant and system descriptions, such as water supply and treatment.

**Southern Illinois Power Cooperative – Marion Station Units 1-3**

- 2000–2003 | Engineering and design to support the repowering of units that were originally commissioned in 1963. Existing steam turbines remained intact while the existing steam generators were retired and replaced with a single 120-MW circulating fluidized steam generator capable of burning coal refuse, petroleum coke, wood refuse, and tire-derived fuel.

**Minnesota Power – Laskin Station**

- 2001 | Studied the addition of a new boiler to an existing site and the repowering of existing steam turbines, including 70% PRB and 30% wood chips, and integration of a new material handling system with the existing coal yard.

**Minnesota Power - Rainy Station**

- 1997 | Condition and cost evaluation of the Blandin Paper Mill Cogeneration and Hydroelectric Facility. Evaluated the existing facility condition (four wood waste/coal boilers, two turbines – 27 MW total; two hydroelectric turbines – 1 MW total) and performed a valuation in terms of potential sale value (capital value versus revenue for an assumed rate of return) and remaining life value. Also evaluated the potential partial replacement/expansion of the facility by integrating a variety of technology options: CFB, combustion turbine/heat recovery steam generator (HRSG), gas-fired boilers, and/or wood waste/coal stoker boilers.

**Indiana Inland Steel Company – East Chicago**

- 1989 | Assessed the condition of the powerhouse system and its components; identified and evaluated alternatives for upgrading the powerhouse. Alternatives included burning process waste, paper, and wood currently being recycled.

**Minnesota Power – Hibbard Station**

- 1985–1987 | Conceptual design, feasibility study, and detailed design for converting Units 3 and 4 to burn wood and coal on a traveling grate stoker spreader. Sargent & Lundy's scope encompassed engineering, procurement, and onsite engineering liaison during construction to convert oil-fired boilers, originally designed to burn coal, to fire on wood and coal; and to provide a steam supply to a paper mill one half mile away. Early studies established the feasibility of converting two of the units but dictated an ambitious 24-month schedule from authorization to completion. The boilers required extensive modifications to convert to traveling grate spreader stokers for efficiently firing the new fuel and meeting the paper mill's steam requirements.

Sargent & Lundy has been actively involved in numerous LFG projects, including the following explored below.

**Dallas Clean Energy – McCommas Bluff LFG Facility**

- 2010–2011 | Sargent & Lundy performed a due diligence review for the purposes of bond financing of the proposed project to improve existing wellfield infrastructure and to expand processing capacity from 9.8 million standard cubic feet per day (mmscf) to 14.8 mmscf. Our analysis included a wellfield and processing facility technology assessment, economic analysis of the project

pro forma, validation of LFG recovery projections, forward renewable gas pricing analysis, and impact assessment of environmental regulations.

### Electric Power Research Institute LFG Industry Report

- 2007 | Sargent & Lundy was retained by EPRI to prepare an assessment of the LFG industry in 2009. As part of EPRI's Technical Assessment Guide (TAG<sup>®</sup>) program, Sargent & Lundy prepared the LFG section in the renewable energy module entitled "Renewable Power Generation Technologies – Current Status, Cost & Performance and Future Trends." The LFG module prepared by Sargent & Lundy addressed:
  - Latest industry trends for use of LFG (i.e., projects utilizing LFG for power generation, heating, conversion to pipeline gas, etc.)
  - Capital costs of LFG projects
  - LFG filtering and treatment approaches and trends
  - Emissions and efficiencies of LFG projects
  - Regulatory status and forecast
  - O&M costs
  - Expected future trends in LFG projects and challenges ahead
  - Identified major LFG project participants (i.e., equipment vendors, government agencies, non-profits, etc.)

### Exelon Fairless Hills LFG Generating Station Project

- 2003–2008 | Fairless Hills was purchased by Exelon from U.S. Steel in 1997. The boiler plant was being used to support the steel production at the site. The boilers burned off-gas product with a heat content ranging from 100–200 Btu. Fairless Hills was converted to burn LFG in 1997 when it was purchased by Exelon Corporation. At that point, Exelon converted Boilers 4 and 5 from burning off-gas to burning LFG with a heat content of approximately 500–600 Btu. Exelon has a long-term contract with Waste Management Corp. to supply LFG to the facility. Boiler 6 still burns natural gas as a peaking boiler.

There are two turbines and three boilers with each turbine producing roughly 30 MW. One boiler usually supports one turbine, but the LFG flow will increase such that two turbines and two boilers will need to be online at all times.

Since 2003, Exelon has invested approximately \$8–\$12 million each year to support this facility. Sargent & Lundy has been involved with and supported turbine inspections/overhauls, boiler studies, and outages to support the dual unit operation. In addition to the boiler and turbine work, Sargent & Lundy has also been involved with all of their BOP improvement services.

The following summarizes some of the projects Sargent & Lundy has performed at Fairless:

- Boiler 4 and 5 outages: scope of work specifications, contractor evaluations, and recommendations
- Turbine 2: scope of work specifications, contractor evaluations, and recommendations
- Boiler 6 study on the scope and cost to convert to LFG
- Installation of a revenue LFG flow meter interfaced with Waste Management Corp.
- Replacement of the low-temperature and high-temperature air heaters on Boiler 4.
- Conceptual design, detailed design, and follow-on work associated with adding a new water treatment plant; downsized from the old facility.
- Modified BOP systems:
  - Designed new environmental storage facility for waste drums, etc.
  - New security fencing around facility
  - New security system
  - Condenser tube replacement project for one of the boilers
  - New turbine lay-up system for the turbines when they come off line
  - Optimization of the service water system

**E/S Energy Solutions – McCommas Bluff Landfill Gas Projects**

- 2006 | Performed due diligence reviews for E/S Energy Solutions on two alternatives for the McCommas Bluff LFG facility in Texas.

**LFG to High-Btu Gas Conversion Project (4.0 Million Cubic Feet/Day)**

- 2005 | The existing LFG to high-Btu gas conversion project had been underperforming in capacity factor and availability. Sargent & Lundy performed a due diligence review of E/S Solutions' plans to improve the performance and availability of the facility. Areas of potential improvement or upgrades included reliability of the LFG flow from the landfill, LFG purification, maintenance program, and selected equipment replacement or upgrading.

**LFG Engine Project (14 x 1.75-MW Reciprocating Engines)**

- 2005 | Sargent & Lundy reviewed an alternate plan to install LFG engines to utilize the McCommas Bluff LFG. Proposals were reviewed for the engine supply and installation work, and engine maintenance. Sargent & Lundy reviewed the LFG flow capability from the landfill to support a multiple engine project over the long term and the proposed LFG purification strategy.

**Richland & Anderson County LFG Projects**

- 2004–2006 | Sargent & Lundy was the owner's engineer for the design and installation of two power generation LFG facilities located in South Carolina. The client negotiated the rights to take LFG currently being flared from existing landfills and installed Solar Taurus 60 combustion-turbine-based power generation facilities at both sites. The solar equipment and the LFG conditioning skids were reviewed by Sargent & Lundy and purchased by the client.

Sargent & Lundy's scope included the review of client-prepared specifications for various LFG system components and associated prefabricated buildings, and review of the vendor design drawings and direct vendor interface. In addition, we provided engineering support for all BOP systems and structures, including assisting with the final site general arrangement, development of an installation package for all of the plant equipment, integration of the fuel system components, and reviews of vendor data.

**Dairyland Power LFG Project**

- 2004 | Sargent & Lundy was retained by Dairyland to evaluate the costs associated with potential LFG to energy projects to be constructed at two different landfill sites within the Dairyland service territory. The scope of the study included (a) estimates of LFG production and evaluation of generation technology options, sizing and performance; (b) range estimates for capital costs and for O&M costs; and (c) development of a project pro forma that estimated the annual revenue requirements derived from electric energy sales needed to provide a reasonable rate of return. The pro forma calculated annual income based on fixed and variable operating costs, debt service, taxes, insurance and general administrative costs.

**Johnston, Rhode Island – Florida Power & Light LFG Project**

- 2004 | Sargent & Lundy was retained by SCS Engineers to investigate the utilization of LFG at Florida Power & Light's Johnston, Rhode Island, combined-cycle plant, which is located adjacent to the Rhode Island Resource Recovery Corporation landfill. The Johnston combined-cycle plant consisted of two Westinghouse W501FD combustion turbines, including supplemental burners in the heat recovery steam generators. The facility did not possess an auxiliary boiler or any other gas burning components. Sargent & Lundy, in conjunction with Earth Tech Solid Waste Services, evaluated the impact of both treated as well as untreated LFG in terms of performance issues (e.g., power output, heat rate, and emissions), maintenance issues (e.g., wash frequencies, maintenance cycles, and warranty issues), HRSG performance issues (e.g., duct burners and SCR catalyst), and the feasibility and economics associated with various LFG cleaning technologies.

**Arrow Canyon LFG Project**

- 2003 | Sargent & Lundy was retained by Reliant Resources, Inc., to investigate the use of LFG at its proposed Arrow Canyon combined-cycle facility in Nevada. The following production options were evaluated:
  - Compression and treatment of LFG for use as a supplemental fuel in the Siemens-Westinghouse combustion turbines
  - Compression and treatment of LFG for use in the combined-cycle burners
  - An independent steam boiler/steam turbine facility for electrical generation
  - Steam boilers fueled by LFG integrated with the combined-cycle boilers and steam turbines

- Internal combustion engines without heat recovery
- Internal combustion engines with heat recovery
- Gas turbines without heat recovery
- Gas turbines with heat recovery

The above options were evaluated in terms of plant performance, maintenance, reliability, and cost.

### **Jacksonville Electric LFG Project**

- 2003 | Sargent & Lundy was retained by Jacksonville Electric Authority to evaluate and solve a significant corrosion problem associated with the BOP piping on the reciprocating engine skids firing LFG. The problem was caused by inadequate treatment of the LFG.



## Geothermal

Examples of Sargent & Lundy's active involvement in geothermal energy projects are summarized below.

### Enel Green Power North America, Inc.

- ✦ 2013 | Independent engineering assessment of the Cove Fort Geothermal Project in southern Utah to provide a completion certification report in accordance with application requirements of the *United States Treasury American Recovery and Reinvestment Act of 2009 (ARRA) Payments for Specified Energy Property in Lieu of Tax Credits Section 1603*. Sargent & Lundy performed a site visit and reviewed project design documents and agreements. The project was completed by Enel Green Power North America, Inc., a branch of the Italian utility Enel SpA, with Ormat Technologies, Inc., as the EPC contractor and major equipment provider.

### Inversiones Energeticas S.A. DE C.V.

- ✦ 2007–2010 | Berlin Unit 3 is a 44-MW geothermal power plant in the Usulután province in eastern El Salvador. The plant is a direct-injection geothermal plant, and the steam turbine is designed for steam conditions of 160°C and 8 bar at the inlet. During inspections of the steam turbine, cracks were discovered by the owner in the last stage blades. Sargent & Lundy provided engineering services to identify the root cause of the cracks and to evaluate potential solutions. We worked with the owner and the steam turbine manufacturer to identify and implement modifications. We also participated in steam turbine inspections to verify the success of the modifications.

### Electric Research Power Institute

- ✦ 2010 | Updates to the geothermal sections of the EPRI *Technology Assessment Guide*.

### Confidential Client

- ✦ 2008 | Environmental reviews for 10 geothermal generating plants in the southwestern United States.

### Confidential Client

- ✦ 2008 | Study for additional generation adjacent to an existing facility. This included non-combustible renewable energy and geothermal.

### Confidential Client

- ✦ 2007 | Technical support on two geothermal projects in Central America. This included evaluation of failure modes on new and operating turbines, reviewing manufacturer's root cause analysis results, and formulating independent recommendations on addressing reliability issues.

**PacifiCorp**

- 2005 | Services associated with well bearing cooling water issues, BR-6 brine pump repairs, derating, and a controls system upgrade for the Blundell Geothermal Plant.

**Southern California Edison**

- 2005 | Study of alternative/complimentary generation resources for the Mohave power plant. Our study included a feasibility analysis of renewable energy, including geothermal.

**CMS Generation**

- 2001 | Technology survey and analysis investigation of commercially available renewable energy technologies for CMS Generation (Michigan) to incorporate into their long-term power generation strategic plan. The renewable energy technologies surveyed included geothermal power.

**ESI Energy**

- 1997 | Heat balance model for the Calistoga Geothermal Plant.

**DesignPower New Zealand**

- 1993 | Revised cash flows for geothermal generation.





## Hydroelectric

Sargent & Lundy has provided extensive independent engineering services for hydroelectric power projects worldwide. Recent hydroelectric power consulting and engineering service engagements are summarized below.

### **International Finance Corporation, West LB, Akbank, and European Investment Bank**

- ✦ 2007–2015 | Nine Enerjisa hydroelectric projects in Turkey totaling over 1,000 MW. Lender's engineering, including preconstruction due diligence and environmental review; construction and performance test monitoring; and monitoring during startup. Sargent & Lundy has performed more than 70 construction monitoring site visits.

### **American Electric Power**

- ✦ 2015 | Independent engineering review of a small hydroelectric project in Ohio.

### **Kaukauna Utilities**

- ✦ 2015 | Owner's engineer bid review to support relicensing of an existing small hydroelectric power plant in Wisconsin.

### **Overseas Private Investment Corporation**

- ✦ 2013–2014 | Independent engineering review as lender's technical advisor to support financing of acquisition and refurbishment of a hydroelectric project in Armenia. Sargent & Lundy performed a technical review of the project, including project financial statement, hydrological studies, refurbishment plan, interconnection, and key project contracts.

### **Comisión Ejecutiva del Río Lempa (CEL)**

- ✦ 2005–2007 | 180-MW hydroelectric plant in El Salvador. Sargent & Lundy performed owner's engineering services for a generator re-wind and other changes in order to increase two generators' power output by approximately 20%.

### **West LB**

- ✦ 2004–2007 | El Cajon 750-MW hydroelectric project in Mexico. Sargent & Lundy performed lender's engineering services, including preconstruction due diligence and environmental review; construction and performance test monitoring; and monitoring during startup.

### **Inter-American Development Bank (IDB)**

- ✦ 2006 | Abanico 15-MW run-of-river hydroelectric project in Ecuador. Provided lender's engineering services, including preconstruction due diligence.



**Total Fina Elf**

- 2000 | Piedra del Aguila 1,400-MW hydroelectric project in Argentina. Provided a due diligence review for potential acquisition.

**Inter-American Development Bank (IDB) and MAESA**

- 1999 | Machadinho 1300-MW hydroelectric project. Provided lender's engineering services, including preconstruction due diligence and environmental review, construction and performance test monitoring, and monitoring during startup.

**AES**

- 1998 | Quebrada de Ullum 45-MW hydroelectric project in Argentina. Performed a power plant environmental audit.

**FPL Energy, Inc.**

- 1997 | Multiple units in the U.S. — 14 operating hydroelectric plants, one storage reservoir, and one pumped storage facility. Provided technical and environmental due diligence.



## Energy Storage

Sargent & Lundy has been actively involved in numerous energy storage projects that have used a variety of technologies, including batteries, compressed air, and pumped hydropower. Energy storage is a major issue with renewable generation: intermittent fuel availability creates challenges aligning generation with demand. Sargent & Lundy has assessed and designed systems for both energy supply and grid stability applications. Below is a summary of our experience.

### **Confidential Client**

- ✦ 2014–2015 | Engineering services for an energy storage project in the northeastern U.S. totaling 20 MW, including conceptual studies, conceptual design, detailed design, and interconnection studies.

### **NextEra Energy Resources**

- ✦ 2015 | Independent engineering services for two energy storage projects in the northeastern U.S.
- ✦ Confidential Client 2013, 2015 | Provided cost and performance estimates to a midwestern U.S. utility for battery storage and pumped storage systems to support client's resource planning activities.

### **Confidential Client**

- ✦ 2013–2014 | Bid reviews of more than a dozen energy storage proposals on behalf of a utility client in the northeastern U.S.

### **Confidential Client**

- ✦ 2009–2011 | Engineering services for several energy storage projects totaling in excess of 60 MW, including conceptual studies, conceptual design, detailed design, construction oversight, and interconnection studies. The objectives of the projects were to provide services, such as grid stability and power plant ancillary services, and enhance wind facilities' operation.

### **Confidential Client**

- ✦ 2009 | Study and development of a plan, including conceptual design, to integrate 10 MW of battery storage with the client's utility-scale solar PV project in the southwestern U.S.

### **PacifiCorp**

- ✦ 2005 | Owner's engineering services, including development of compressed air energy storage (CAES) conceptual design.

### **CAES – Norton**

- ✦ 2004 | Owner's engineering services, including development of CAES conceptual design.

**Electric Research Power Institute**

- 1998 | Study and preparation of a technical report (EPRI Report TR-111691, "Compressed Air Energy Storage with Humidification – An Economic Evaluation") on compressed air energy storage with humidification (CASH). This project encompassed technology evaluation and financial modeling; preliminary system design, including layout drawings and conceptual equipment arrangements; capital cost estimates for this technology and competing technologies; market price study for electricity; fuel cost estimates; and development of pro formas for each technology.

**Westinghouse**

- 1992 | Owner's engineering services, including development of CAES conceptual design.

**U.S. DOE, EPRI, Public Service Company of Indiana, Westinghouse Electric Company**

- 1982 | Three-year study of CAES and preparation of a report (EPRI Report EM 2351, "Compressed Air Energy Storage Preliminary Design and Site Development Program in an Aquifer"), including project coordination, power system studies, geotechnical review and design, site study and selection, turbine design, BOP design, cost estimating, schedule preparation, licensing assessment, and environmental impact study.



## Integrated Resource and Power Supply Planning

Sargent & Lundy's power supply planning services develop and evaluate integrated resource plans and associated analyses in order to identify the optimum power supply options for our clients. Based upon a detailed evaluation of each client's specific needs and situations, we balance the diverse engineering, economic, and environmental issues associated with new power generation and load reduction to develop feasible options. We evaluate the potential value of energy efficiency and demand-side management programs to effectively meet supply needs without new generation.

As more clients determine the need to integrate renewable energy into their power generation plans and systems, Sargent & Lundy's integrated resource planning and power supply planning experience and expertise, combined with our knowledge of renewable energy power generation technologies, provides invaluable resources. Summaries of services and past projects are explored below.

### Services

- ✦ Load forecasting
- ✦ Forward pricing analyses and evaluations
- ✦ Electric market forecasts and projections
- ✦ Renewable energy build vs. buy analyses
- ✦ Feasibility studies and planning of energy storage and microgrid projects

### NIPSCO

- ✦ 2013, 2015 | Provided cost and performance estimates for various power generation and energy storage systems to support client's resource planning activities.

### Confidential Client

- ✦ 2013, 2015 | Managed power supply planning process for a utility client in northeastern U.S. Reviewed and evaluated more than 50 power supply and load reduction bids. The bids included technologies such as combustion turbines, reciprocating engines, energy storage, microgrids, and demand-side projects.

### American Capital Energy & Infrastructure

- ✦ 2014 | Performed a renewable energy integration assessment for the Senegal (country-wide) electric grid to assist the client with their evaluation of a wind power project acquisition. As part of the study, Sargent & Lundy assessed the existing generators on the system and their reserve capabilities.

**Maui Electric Company**

- 2013 | Performed a renewable energy integration assessment to assist the client with their efforts to expand the use of wind and solar power while maintaining reliability requirements.

**Agrifos Fertilizer**

- 2009–2010 | Prepared a study of onsite renewable energy alternatives for an industrial company located in the Houston, Texas area. The evaluation included solar PV, solar thermal, and wind power.

**Unilever**

- 2008–2009 | Performed a study of energy usage, boiler replacement options, and onsite renewable energy alternatives for Unilever's industrial facility in Southern California. The evaluation included combined heat and power, solar PV, and energy efficiency.

**Southern California Edison**

- 2005 | Prepared a study of alternatives for replacement or to complement the share of electrical capacity generation of Southern California Edison's ownership share of the 1,580-MW Mohave generating station, in response to a California Public Utilities Commission (CPUC) order. The evaluation included solar, wind, other renewables, demand side management and energy efficiency, integrated gasification combined-cycle, and combined-cycle natural gas.

**City of Ames, Iowa**

- 2004 | Developed of a recommended resource plan that identified the generation resources required to meet the forecast electricity needs of Ames Electric Services' customers through 2025. The resource options included renewable energy resources that would be appropriate for the Green Choice program, primarily biomass and wind along with efficient, low-emission generating technologies like natural gas or other fuels.

**San Diego Gas & Electric**

- 2003 | Consulting support and services to San Diego Gas & Electric (SDG&E) for new power supply resources, including renewable generation, fossil generation, and demand-side resources; provided consulting support through the evaluation of options, contract negotiation, and utility commission filings for PPAs and turnkey plant purchases.

**CMS Generation**

- 2000 | Performed a technology survey and analysis investigation of commercially available renewable energy technologies for CMS Generation (Michigan) to incorporate into their long term power generation strategic plan. The renewable energy technologies surveyed included wind power, biomass, geothermal, solar thermal, and solar PVs.

**Nevada Power**

- 1992 | Evaluation of 92 power supply contract proposals from power suppliers, including wind power, hydro-pumped storage, simple-cycle combustion turbine, combined-cycle, and cogeneration. Evaluations included a check of technologies, heat rate verification, financeability, and financing plan. Provided expert assistance in writing the PPAs.

**City of Austin, Texas**

- 1990 | Prepared a repowering study, which included evaluation of emerging technologies such as solar, wind, energy storage, and fuels cells.