

## Advanced Technologies Experience

- *CO<sub>2</sub> Removal*
- *Integrated Gasification Combined-Cycle (IGCC)*
- *Coal Plant Retrocommissioning (Heat Rate Improvement)*
- *Alternative Fuels*
- *Emerging and Proven Multipollutant Technologies*



### CO<sub>2</sub> REMOVAL

Client	Project/ Location	Project Type	Scope Summary	Date
CARBON 360/Petra Nova/ NRG Energy	W.A. Parish 8, Texas	Carbon capture and sequestration (CCS) Implementation	Primary scope: 1) Owner's Engineer during development and design phase of project. Included design reviews and HAZOP participation in addition to detailed drawing review. 2) Detailed design of Hastelloy and fiberglass reinforced plastic (FRP) ductwork system capable of handling a 240 MWe slipstream (646,800 SCFM) of flue gas that is interconnected to the host unit (Unit 8) and the carbon capture island. This design included a computational fluid dynamic (CFD) model, ductwork design, support steel design, and foundation design. 3) Performed evaluation of MHI's amine based process producing 1.6 million tons of CO <sub>2</sub> per year (4776 tons/day).	2013-2017
Confidential Client	Confidential	Carbon Capture for Enhanced Oil Recovery (EOR) Economic Evaluation	Assisting client in evaluating the feasibility and economics of integrating CO <sub>2</sub> capture technologies at an existing plant for use in EOR at nearby oil fields. As part of this project, S&L defined the balance-of-plant impacts and estimated the associated costs for the station.	2016-2017
Confidential Client	Confidential	Carbon Capture for Enhanced Oil Recovery (EOR) Economic Evaluation	Assisting client in evaluating the feasibility of installing a CO <sub>2</sub> capture system at an existing plant for use in EOR at nearby oil fields. This project included an evaluation of the permitting requirements for both the onsite capture equipment and the associated CO <sub>2</sub> pipeline. Subsequent to the permitting evaluation, S&L is evaluated the technical feasibility of integrating various configurations of CO <sub>2</sub> capture technology within the limitations of the existing station.	2016
Basin Electric	Dry Fork Station 1, Wyoming	XPrize – Carbon Capture Technology Evaluation	Conducted preliminary engineering and costs to support the development of an integrated test center using a 20-MWe (87,500-ACFM) slip stream of flue gas from Dry Fork divided amongst six test sites to evaluate six different CO <sub>2</sub> capture technologies for X-Prize's Carbon Capture Contest to demonstrate beneficial utilization of the recovered CO <sub>2</sub> .	2015- ongoing

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Confidential Client	Confidential	Novel CO <sub>2</sub> Solvent Technical and Economic Assessment	A developer of a second generation CO <sub>2</sub> capture solvent contracted S&L to perform a technical and economic assessment of a CO <sub>2</sub> capture facility based on the use of their proprietary solvent. This assessment evaluated the incremental cost of CO <sub>2</sub> capture using this solvent based on installation at a theoretical green-field power plant, including development of the conceptual design for the base plant, and capital and O&M cost for the entire facility including the CO <sub>2</sub> Capture Island.	2015-2016
Confidential Client	Confidential	Novel CO <sub>2</sub> Capture Technology Evaluation	A major U.S. utility company contracted S&L to perform a FEED study, in conjunction with the technology developer, to determine how to integrate the technology into an existing power plant; provide preliminary design information, identify risks and unknowns; and to conduct capital and O&M cost estimates to help the client evaluate the economics of developing the project further. The system was designed to capture 100,000 tons per year of CO <sub>2</sub> , roughly equivalent to a 15-MWe slipstream of flue gas.	2014-2015
NRG Energy	W.A. Parish 8, Texas	Carbon capture and sequestration (CCS) FEED Study	Work described below at W.A. Parish 7 evolved to Unit 8 and was expanded in size to a 240-MWe slipstream. Owner's engineering services and balance-of-plant (BOP) design for a 240-MWe Carbon Capture Utilization and Storage (CCUS) demonstration project. Project received a funding grant from the U.S. DOE. S&L was heavily involved in the development of the proposal to the DOE. As owner's engineer, S&L reviewed all technical aspects of the project, including HAZOP reviews for the facility.	2010-2013
U.S. DOE	Indiana and Mississippi	Gasification projects	Perform due diligence analyses on the projects for the U.S. DOE Loan Guarantee Program. Projects intended to produce substitute natural gas (SNG) from coal and petroleum coke to power two plants ranging in size from 300 to 400 MW. Sale of CO <sub>2</sub> is beneficial to use in enhanced oil recovery (EOR) applications.	2010-2014
U.S. DOE	Generic	Efficiency study	Develop conceptual design for a new 500 MW PC power plant equipped with CO <sub>2</sub> recovery that is fully thermally integrated. Determined overall efficiency improvements that are possible due to integration and compared these to existing concepts.	2009-2013

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NRG Energy	W.A. Parish 7, Texas	Carbon capture and sequestration (CCS) DOE Proposal	Supported proposal development to DOE for Clean Coal Power Initiative (CCPI) 3 for 60-MWe slipstream (161,700-SCFM) demonstration facility on Unit 7. Facility would remove SO <sub>2</sub> and capture 1,194 tons per day of CO <sub>2</sub> using Fluor Econamine Plus and wet limestone scrubbing technology. The captured CO <sub>2</sub> would be used for EOR in nearby oil fields. As owner's engineer, S&L provided all BOP engineering, including CO <sub>2</sub> compression.	2008-2010
Confidential	Western U.S.	Repowering/CCS	Compared costs for repowering several existing steam turbines totaling approximately 500 MW with natural gas combined-cycle power systems with installations of retrofit carbon capture system technologies on existing boilers.	2010
US/EPA	Generic	Pulverized coal and IGCC plants	Developed cost estimating workbook for applying efficiency enhancement technologies at existing power plants. Assessed reduction in CO <sub>2</sub> footprint possible for each technology. Compared the enhancements to installation of new pulverized coal and IGCC power plants.	2009-2010
Confidential	--	Due diligence	Performed due diligence analysis of the FutureGen project for a prospective participant in the FutureGen Alliance.	2009
ENMAX Corporation	Canada	Feasibility study	Worked with Hatch on studies of combined-cycle and IGCC projects, including evaluation of variations to syngas for combustion turbines: <ul style="list-style-type: none"> <li>• NGCC to IGCC retrofit prefeasibility study</li> <li>• High-hydrogen content Syngas combustion effects on CTGs prefeasibility study</li> <li>• IGCC/SNG/CO<sub>2</sub> EOR plant prefeasibility financial/market analysis</li> </ul>	2007-2009
NRG Energy	W.A. Parish and Limestone, Texas	SO <sub>2</sub> and CO <sub>2</sub> capture	Evaluated SO <sub>2</sub> and CO <sub>2</sub> capture using Powerspan's ammonia based ECO-SO <sub>2</sub> and ECO <sub>2</sub> technology. Powerspan's system was designed to use a 125-MWe slipstream of flue gas to produce 3000 tons per day of CO <sub>2</sub> .	2007-2009
Nebraska Public Power District	Generic	CO <sub>2</sub> utilization	Evaluated CO <sub>2</sub> utilization using CO <sub>2</sub> captured from a 700 MW power plant.	2008

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Duke Energy	Confidential	Carbon management	Carbon capture and compression retrofit feasibility study for a 600 MW coal plant.	2007-2008
Midwest Generation	Generic	CO <sub>2</sub> control pre-feasibility studies, carbon management	CO <sub>2</sub> control prefeasibility studies and carbon management: <ul style="list-style-type: none"> <li>• FGD technology selection, cost analysis, and site layout (SDA wet FGD, Powerspan technology)</li> <li>• FGD technology selection and CO<sub>2</sub> retrofit impacts</li> <li>• CO<sub>2</sub> transportation retrofit pre-feasibility study</li> <li>• CO<sub>2</sub> technology for capture and compression site constraint pre-feasibility study</li> <li>• CO<sub>2</sub> technology site selection, site layout, and performance impacts</li> </ul>	2007-2008
Confidential client	Confidential	Site selection	Site selection, feasibility studies, and carbon management.	2007
IP&L	Generic	Carbon capture	Prepared white paper on carbon capture.	2007
OG&E	Fleetwide	Carbon management	Provided emissions data and costs for 25 units.	2007-2008

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U.S. DOE	Indiana and Mississippi	Gasification projects	Performed due diligence analyses on the projects for the U.S. DOE Loan Guarantee Program. Projects intended to produce substitute natural gas (SNG) from coal and petroleum coke. Sale of CO <sub>2</sub> is beneficial use in enhanced oil recovery (EOR) applications.	2010-2014
Duke Energy	Edwardsport, Indiana	IGCC	Partial BOP design of 560 MW support systems for IGCC facility, which was a U.S. DOE Clean Coal Power Initiative (CCPI) 12 project using high-sulfur coal and oxygen-blown gasification technology.	2007-2012
Confidential	Confidential	Waste-to-energy facility	Developed BOP costs for using syngas to repower existing municipal steam turbine systems to replace aging boiler plant infrastructure at two sites.	2011
Confidential	Confidential	Waste-to-energy facility	Developed conceptual design for waste-to-energy (WTE) facility using the AlterNRG (Westinghouse Plasma) gasification technology to produce syngas. Prepared design criteria for plant; developed emission profile for submittal of permits; prepared general arrangement drawings; and developed plant cost estimate at two sites located in separate regions in the United States.	2010-2011
Entek Elektrik	Turkey	IGCC study	Evaluated alternative generation technologies for 100% petroleum coke firing of nominal 300-MW power plant for IGCC, circulating fluidized bed (CFB) combustion, and pulverized coal combustion.	2009
ENMAX Corporation	Canada	Feasibility study	Worked with Hatch on studies of combined-cycle and IGCC projects, including evaluation of variations to syngas for combustion turbines: <ul style="list-style-type: none"> <li>• NGCC to IGCC retrofit prefeasibility study</li> <li>• High-hydrogen content Syngas combustion effects on CTGs prefeasibility study</li> <li>• IGCC/SNG/CO<sub>2</sub> EOR plant prefeasibility financial/market analysis</li> </ul>	2007-2009

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Luminant	Brownfield installation, Texas	Owner's IGCC engineering	Owner's engineering support for development of IGCC facility using Powder River Basin (PRB) coal and Texas lignite as primary fuels. Scope included: <ul style="list-style-type: none"> <li>• Support pre-front-end engineering design (FEED) request for proposals to suppliers responding to letter of interest to conduct pre-FEED study</li> <li>• Evaluate pre-FEED proposals to establish preferred technology providers for pre-FEED study</li> </ul>	2008
CMS Energy	Michigan	IGCC fatal flaw study	Fatal flaw review of new IGCC plant with use of alternate fuels. Study for repowering existing steam turbine with new gasification equipment.	2007
Confidential client	China	SES technology evaluation	Evaluated SES technology development in China.	2007
Midwest Generation	Generic	IGCC site selection, pre-feasibility studies, carbon management	Evaluated potential sites in Illinois for IGCC power plant. Scope included evaluation of compliance with project feasibility criteria, and development of consensus numerical scores. Project schedule included evaluating site proposals. Project postponed after ranking of selected sites.	2007
OG&E	Oklahoma	IGCC repowering estimate	IGCC repowering estimate for system planning for 570-MW unit.	2007
PacifiCorp	Jim Bridger, Wyoming	IGCC owner's engineer studies	Owner's engineer services, including technology selection and oversight of IGCC pre-FEED.	2007
Tondu Corporation	Filer City, Michigan	IGCC study	Conceptual study of IGCC plant with use of alternate fuels. Study for repowering existing steam turbine with new gasification equipment. Technologies considered included U-GAS and other gasification technology.	2007

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Mitsui Corporation	Ohio coal plant	IGCC repowering study	Reviewed viability of incorporating PC, CFB, and IGCC projects at existing coal site with economic comparison performed on a levelized bus bar basis. Technology screening done to evaluate the application of the MHI IGCC technology, including a comprehensive evaluation of generation equipment, emission alternatives, anticipated interconnection for industrial steam and water hosts, proposed operation and staffing, anticipated guarantees for thermal performance as well as availability, pro forma, description with the regional power market, project benefits, project approach, and management plan.	2006
Confidential client	Southeast U.S.	Conversion retrofit study	Assessed conversion of 550-MW natural gas-fired combined-cycle unit to IGCC. Included comparing coal transportation options (rail, barge, truck), and providing general arrangement drawings, cost estimate, and performance projection. Assessed modification work to existing gas turbines, HRSGs, and BOP. Reviewed potential federal incentive programs.	2006
Confidential client	Western U.S.	IGCC addition to existing brownfield site	Assessment study of existing site to add 500-MW IGCC unit, including CO <sub>2</sub> removal. Prepared BOP cost estimate, project schedule, and general arrangement drawings. Also assessed interconnections (water, natural gas, transmission, etc.), coal delivery, permitting, and emissions. Reviewed potential federal incentive programs.	2006
Confidential client	Western U.S.	IGCC greenfield site	Assessment study of greenfield site for new mine-mouth 500-MW IGCC unit, including CO <sub>2</sub> removal. Prepared BOP cost estimate, project schedule, and general arrangement drawings. Also assessed interconnections (water, natural gas, transmission, etc.), coal delivery from the mine, permitting, and emissions. Reviewed potential federal incentive programs.	2006
FutureGen Alliance (U.S. DOE, Battelle Labs, and Industry Participants)	Various locations, U.S.	IGCC study	Evaluated potential sites for IGCC power plant in Illinois, Kentucky, North Dakota, Ohio, Texas, West Virginia, and Wyoming. Scope included site visits, evaluation of compliance with project feasibility criteria, and development of consensus numerical scores.	2006

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Mitsui & Co., Ltd. (USA)	Generic	IGCC comparative market and technology study of gasification vendors	Researched and provided update of marketing approaches of major coal gasification vendors (Shell, GE, Conoco-Phillips, and MHI). Scope included confirming the vendors' current teaming arrangements, standard designs, and market focus (such as U.S. market, project size, and fuel types). Prepared technical comparison of vendors' technologies, citing advantages and disadvantages of each vendor, and their IGCC experience to date.	2006
Montana-Dakota Utilities	Gascoyne Mine, North Dakota	Coal gasification study	Gasification study of coal to produce substitute natural gas (SNG).	2006
Old Dominion Electric Cooperative	Indian River, Delaware	IGCC capacity addition to existing site due diligence review	Due diligence services for potential investor in planned 630-MW IGCC project. Scope included reviewing the technical aspects, costs, projected availability, schedule, general arrangement, and permitting aspects of Owner's plans, and assessing soundness of project plan and potential risks to Owner.	2006
Southern California Edison	Mojave and Black Mesa Mine, Arizona	Study of potential alternative/ complementary generation resources	Study of alternatives for replacement or complement of Southern California Edison's ownership share at two existing IGCC sites share in response to California Public Utilities Commission (CPUC) order.	2006
Suez Energy Generation North America	Choctaw Gas Generation Project, Mississippi	IGCC refueling feasibility study	IGCC feasibility refueling study of existing 266-MW Siemens SGT6-6000G combustion turbine.	2006



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Tondu Corporation	Nueces Bay, Texas	Owner's IGCC engineering services – feasibility study and cost estimate	<p>Conceptual design study of IGCC plant (based on Shell gasification technology) for location originally in Michigan, then in Indiana, and subsequently (2006), to a new site in Texas.</p> <p>Owner's engineering support included:</p> <ul style="list-style-type: none"> <li>• Develop project definition report, similar to a typical design criteria document, including performance estimates, equipment lists, design criteria, system descriptions, water balance, electrical single-line diagram, and project EPC schedule</li> <li>• Cost estimate</li> <li>• Electrical interconnection study</li> <li>• Permitting support, including preparation of Best Available Control Technology (BACT) analysis and emission estimates for air permit application</li> </ul>	2006
Westmoreland Coal Company	Absoloka Mine, Montana	H <sub>2</sub> production waste coal feasibility study	Feasibility study to produce SNG from North Dakota lignite.	2006
Xcel Energy	Colorado	IGCC facility	<p>Owner's engineering support for development of IGCC facility, including site selection and technology selection. Scope included:</p> <ul style="list-style-type: none"> <li>• Evaluate technology to determine short list of suppliers to conduct Pre-FEED study.</li> <li>• Evaluate pre-FEED proposals to establish preferred provider for FEED study</li> <li>• Evaluate sites for preferred site</li> <li>• Develop contract materials for negotiation of EPC contract with selected technology supplier</li> <li>• BOP engineering</li> <li>• Support permitting for submittal of Air Emissions and National Pollutant Discharge Elimination System (NPDES) Permits</li> <li>• Study of electrical interconnection</li> </ul>	2006 (cancelled)

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Client	Project/ Location	Project Type	Scope Summary	Date
Confidential	Southwest U.S.	Site selection report and technology comparison	<p>Site selection report and technical and economic comparison study of proposed 1,500-MW IGCC plant based on four alternative generating technologies (subcritical PC, supercritical PC, IGCC, and CFB). Scope included:</p> <ul style="list-style-type: none"> <li>• Assess characteristics of study area, such as air quality, water availability/wastewater disposal potential, fuel delivery, and transmission interconnection</li> <li>• Assess potential for sale or geologic disposal of CO<sub>2</sub> recovered from coal gasification</li> <li>• Assess the potential for sale of byproducts produced by gasification and/or power generation</li> <li>• Establish plant design basis, determine land areas required for principal plant features, and develop plant arrangements</li> <li>• Screen regional study area and identify candidate sites that satisfy physical requirements for plant</li> <li>• Identify and discuss issues related to development of candidate sites</li> <li>• Identify and discuss potential environmental and permitting issues</li> <li>• Establish criteria for evaluating and for comparative scoring of various candidate sites</li> <li>• Identify site infrastructure development requirements and comparative cost estimates</li> <li>• Select/recommend the preferred site</li> <li>• Determine applicability of potential incentives under 2005 Energy Policy Act</li> </ul>	2005-2006

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Eastman Gasification Services	Illinois	Feasibility study, technical and economic market study, and capital expenditures cost estimate	<p>Independent engineer services to support client prepare conceptual gasification power plant design using Illinois coal. Plant intended to be used for co-producing methanol, which could serve as alternative power plant fuel. Scope included:</p> <ul style="list-style-type: none"> <li>• Prepare heat balances, site plans, equipment lists, process flow diagrams, and cost estimate for plant components</li> <li>• Evaluate permitting issues</li> <li>• Perform power market forecast</li> <li>• Conduct survey of potential power plant users for methanol fuel in the Midwest</li> <li>• Contact equipment manufacturers and research the suitability of methanol as a viable fuel for combustion turbines and duct burners</li> <li>• Prepare coal characteristics database for Illinois region to help identify which coal would be best suitable for syngas process</li> </ul>	2005-2006
American Electric Power (AEP)	Various sites, Eastern U.S.	IGCC site selection study	Site selection study of states served by AEP to identify those capable of supporting IGCC plant up to 1,200 MW.	2004-2006
Steelhead Power, LLC	Illinois	Owner's engineer; IGCC environmental support services	Prepared, compiled, and submitted all forms and applications to permitting authorities in Illinois for IGCC plant.	2004-2006

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PSI Energy/Destec Now Duke Energy and Conoco/ Phillips -E-Gas	Wabash River 1, Indiana	265-MW IGCC repowering design	<p>Engineering and design of new power block for this project, which earned 1995 Engineering Excellence Award, Gasification Experience with Power Block (American Consulting Engineers Council). Scope included:</p> <ul style="list-style-type: none"> <li>• Assess condition of existing equipment for reuse, particularly Westinghouse 105-MW steam turbine. Included managing turbine refurbishment required for increased steam flow and cycle variations.</li> <li>• Engineering and design of thermal cycle, including assistance in identifying thermal sources within gasifier for use in power block and gas cleanup cycle. Worked closely with Destec to optimize thermal integration concepts that were eventually utilized in final plant design.</li> <li>• Conceptual design and specification of new HRSG, which developed into unique single-pressure configuration, capable of superheating large quantities of saturated steam produced in the gasifier heat recovery unit (HRU), while maintaining flexibility during startup, and preserving capability to provide wide variety of tightly controlled hot water and steam flows with varying pressures and temperatures needed for various ancillary services throughout wide range of operating scenarios.</li> <li>• Assist PSI with technical portions of Gas Services Agreement. Document later specified flow, temperature, and pressure limits for all coal, gas, water, steam, and waste streams between gasifier, ASU, HRU, HRSG, STG, and existing plant support facilities (coal yard, service water, service air, etc.), and provided the commercial structure for those transfers that were subject to monetary compensation terms.</li> <li>• Prepared heat, material, and water balances for all phases of operation and assisted in preparation of startup curves, prediction of startup low-load, and emergency operating characteristics (flow, temperature, and pressure) for flow transfers between major components.</li> <li>• Technical assistance with permitting efforts, preparation of environmental compliance and monitoring plans, and with presentations to DOE, regulatory agencies and various civics groups.</li> </ul>	1994-1996

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Ameren Corporation	Rush Island, Missouri	Cost comparison	Coal gasification study comparing the cost of adding a coal fired unit, versus the cost of a proposed IGCC addition.	2005
Southern California Edison	Mohave, Nevada	IGCC study	Study of IGCC as potential generation resource, as alternative or complement to station. Included technical feasibility; conceptual design; capital costs; O&M costs; determination of land, water, and fuel requirements; construction and operating resources; permit issues; and expected emissions.	2005
Exelon Corporation	Generic greenfield site, U.S.	IGCC generating facility development and technology analysis	Prepared design criteria package for proposed 577-MW IGCC plant.	2004
WPS Power Development	Existing IGCC plants	IGCC industry experience assessment	Assessed IGCC operating experience.	2000
WPS Power Development	Tracy Pinon, Nevada	IGCC due diligence	Due diligence for potential acquisition of operating IGCC plant.	2000
Normandie - Gonfreville L'Orcher France	France	Thermal cycle and conceptual power block design	Conceptual design of 280-MW, 2x2x1 IGCC unit, including heat balances, P&IDs, general arrangement drawings, and equipment specifications. Unit included two trains each with ChevronTexaco gasifier and GE-9E gas turbine, plus one steam turbine with steam export to a Totalfina refinery. Fuel to gasifiers was refinery carbon waste byproduct.	1999–2000
Virginia Power	Generic	IGCC facility options evaluation	Evaluated IGCC facility options, including capital, operating, maintenance, and life-cycle costs. Study reviewed alternate gasifier offerings from Shell, Destec (E-Gas), and Texaco (GE).	1993

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J. Makowski (IPP developer)	Greenfield installation	IGCC conceptual Design	Developed conceptual design for 300-MW IGCC plant operating on 100% petroleum coke. Conceptual design was developed to support turnkey proposal. Deliverables included site development drawings, performance data, construction schedules, environmental analysis, and petroleum coke storage and handling.	1992
Illinois Power (now Dynegy)	Wood River, Illinois	Coal Gasification – Refueling	Preliminary design study for proposed addition of 38-MW gas turbine installation for the Allis-Chalmers Corporation KILnGAS demonstration plant. Design basis included firing with low-Btu synthetic gas generated from a fixed-bed coal gasification process using a rotary kiln. Prepared process flow diagrams, engineering flow diagrams, logic diagrams, and preliminary physical drawings of combustion turbine demonstration plant. Prepared design criteria for compressor design, instrumentation and control, electrical design, and structural design. Specifications prepared for fuel gas and buffer gas compressors, main power transformers, and switchgear. Also prepared equipment list, utility list, and instrument data sheets.	1985-1986
Early projects	U.S.	Numerous studies and reference plant designs for EPRI, utilities, IPPs, and government agencies	S&L and Argonne National Laboratory performed engineering and prepared economic and environmental report on Lurgi process for production of syngas and major study of IGCC technologies and plant reference designs.	1975-1987

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### COAL PLANT RETROCOMMISSIONING (HEAT RATE IMPROVEMENT) FOR CO<sub>2</sub> REDUCTION

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Salt River Project	Coronado and , Navajo, Arizona	Energy audit	Evaluation and identification of heat rate improvement options.	2014
Nebraska Public Power District	Gerald Gentleman, Sheldon, and Beatrice; Nebraska	Energy audit	Evaluation and identification of heat rate improvement options.	2014
Tucson Electric	Four Corners and Springerville, Arizona	Energy audit	Evaluation and identification of heat rate improvement options.	2014
Cleco	Dolet Hills and Rodemacher (Brame Energy Center), Louisiana	Energy audit	Evaluation and identification of heat rate improvement options.	2014
National Rural Electric Cooperative Association	Various	Energy audit	Evaluation and identification of heat rate improvement options for various member utilities.	2014
Exelon Corporation	Various coal plants	Energy audit	Evaluation and identification of heat rate improvement options for various existing plants. Evaluation of potential conversions to biomass and natural gas firing.	2013-2014
Associated Electric Cooperative	Various	Energy audit	Evaluation of steam turbine and preparation of specifications for upgrade.	2012
PacifiCorp	Various	Energy audit	Evaluation of impact to balance-of-plant from turbine upgrade to replace auxiliary power for environmental controls equipment.	2010

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Genesis Energy	Various	Energy audit	Evaluation and identification of heat rate improvement options, including cost estimates.	2009
Confidential	Western U.S.	Energy efficiency	Technology survey of various coal drying processes from around the world. The process implemented at Great River Energy's power plant was further evaluated for a typical PRB-fired and lignite-fired power plants.	2013
U.S. DOE	--	Carbon capture and sequestration	Detailed evaluation of coal drying process and its integration with future innovative carbon capture and sequestration project for 600-MW ultra-supercritical boilers. Evaluation included conceptual cost estimate for coal drying process utilizing low-level heat from flue gas as well as from steam cycle.	2012
NRG Energy	Texas W.A. Parish	Carbon capture and sequestration	Detailed evaluation of coal drying process and its integration with future carbon capture and sequestration project for 600-MW PRB-fired boiler. Evaluation included utilization of low-level heat from flue gas exiting baghouse.	2010
Confidential	Western U.S.	Coal drying	Evaluated coal drying technology for implementation at existing coal plant for investment group.	2009



## Advanced Technologies Experience

- *CO<sub>2</sub> Removal*
- *Integrated Gasification Combined-Cycle (IGCC)*
- *Coal Plant Retrocommissioning (Heat Rate Improvement)*
- *Alternative Fuels*
- *Emerging and Proven Multipollutant Technologies*



### ALTERNATIVE FUELS

Client	Project/ Location	Project Type	Scope Summary	Date
Portland General Electric	Boardman, Oregon	Torrefaction	Consulting services to evaluate the limitations of the torrefaction process employed at Boardman Station. Provided input to modify multiple subsystems in order to streamline the production.	2012-ongoing
NRG Energy	Florida	Plasma gasification	Evaluation and conceptual design for municipal sludge gasification using plasma gasification technology.	2012
Quadris Canada Fuel Systems Inc.	Generic	Alternative fuel feasibility study	Engineering feasibility study of burner and boiler design parameters for combustion of Multiphase Superfine Atomized Residue (MSAR™).	2006-2009
EnCana Oil & Gas Partnership	Christina Lake, Canada	Steam-assisted gravity drainage (SAGD) study	Study of candidate steam generators for firing neat or emulsified bitumen. Also evaluated emission control technologies to identify viable processes for removal of SO <sub>2</sub> , NO <sub>x</sub> , particulates, and SO <sub>3</sub> from flue gas emissions resulting from combustion of bitumen (either neat or emulsified) produced from Canadian oil sands.	2007

## Advanced Technologies Experience

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### EMERGING AND PROVEN MULTIPOLLUTANT TECHNOLOGIES

Client	Project/Location	Project Type	Scope Summary	Date
Hunt Enterprises, LLC	Generic	Technology evaluation	Evaluation of the Pahlman process to determine technical and economic feasibility.	2008
Nebraska Public Power District	Generic	Water from flue gas evaluation	Evaluated technologies for producing water from flue gas.	2008
Ameren Corporation	Generic	Cost estimate	Evaluated Dow sulfuric acid process feasibility and develop cost estimate.	2007
Confidential client	Confidential	Technology evaluation	Evaluated Powerspan technology on behalf of potential financial backers.	2007
Quadrise Fuel Systems Ltd.	---	Multipollutant options study	Conducted a multipollutant options screening study of candidate emissions control technologies to identify viable processes for the removal of SO <sub>2</sub> , SO <sub>3</sub> , NO <sub>x</sub> , particulate flue gas emissions from combustion of a bitumen-water emulsion produced from Canadian oil sands.	2006