Glowsworth Engineering Limited

(EPC)- ENGINEERING, PROCUREMENT, CONSTRUCTION

ENGINEERING

Many EPC engineers offer a Front-End Engineering & Design (FEED) study as a means of producing a system design that better meets the customer's particular situation.
We take the FEED study a step farther by including construction issues into the study-design process. Our integrated control, power, instrumentation, and construction study starts with a thorough site audit that applies our 18-plus years of experience to produce a detailed scope of work, piping, electrical instrumentation detail, a construction approach, and cut-over planning.
The scope of work includes I/O, instrument, and engineering deliverable list, plus control system and HMI definitions, and the detailed construction approach. When we're done, you will have an appropriation/PO-worthy estimate. You may bid out the estimate if you wish, but we guarantee to install the defined scope of work for the estimated price.

A key element of the FEED+ study involves the site survey. Our site survey team consists of personnel with expertise in control systems engineering, field engineering, plant support, and construction.

They start with a thorough investigation of the as-is control system, which includes the control board devices, operator interviews, examining manual operations, need for automation, and taking into account appropriate safety considerations.

They also do a P&ID walk-down. This includes physically locating equipment and drawings, recording current manufacturers and models, tagging/color coding wiring and cables, taking photographs of in-place material, evaluating the condition and version levels of in-place equipment, and creating as-found drawings.

The site survey helps the team strategize the project approach, including identifying panel locations, major cable raceways, a material marshalling area, and determining which equipment will need to be replaced and which equipment will require modification.

The survey team also develops the I/O list. A master drawing index is created that reviews every existing drawing, determining any revisions needed, and identifies what new drawings are required. A repository of all information gathered during the survey is created and made available to the entire team.
The FEED+ study requires approximately 4 weeks by 4 people and accounts for about 20 percent of the total engineering cost.

But it results in a comprehensive, highly accurate scope of work document that typically experiences less than a .5 percent scope “creep”. It results in a fully audited plant and mitigates risk. It also results in a high degree of adherence to schedule and to budget.

Industrial Design-Build Services

Design-build is a method of project delivery in which the design-build entity works under a single contract with the project owner to provide design and construction services. In the context of our business, this addresses strictly the automation portion of a total project. The result of one entity and one contract is a unified flow of work from initial concept through completion, thereby re-integrating the roles of designer and constructor. Design-build is an alternative to the traditional design-bid-build project delivery method. Under the latter approach, design and construction services are split into separate entities, separate contracts, separate work. Design-build successfully delivers automation projects with superior results, no matter what the project type.

Streamlining project delivery through a single contract between the owner (or the construction manager) and the automation design-build team allows for the automation project to be successfully completed faster, more cost effectively, and with fewer change orders. Construction Industry Institute research shows that compared to the design-bid-build method, design-build results in 6% less cost and 33% faster delivery, with accompanying reductions in cost overruns and schedule creep.

A related, foundational component of design-build is the FEED+ study. This process takes the traditional FEED study one step further by incorporating constructability issues and elements into the study

process. This further contributes to the compression of the schedule by assuring that mechanical, electrical, piping, structural construction requirements are part of the project design process.
With PMI-certified project managers and others engineering disciplines construction and installations capabilities, we are perfectly positioned to deliver these benefits to your next automation project.
FRONT END ENGINEERING DESIGN- FEED
CONCEPTUAL DESIGN
DETAIL ENGINEERING DESIGN - DED

Oil & Gas Automation Systems

Oil and gas extraction, processing and transportation are complex applications that place stringent demands on the automation and control systems employed to make those processes function effectively and efficiently. Environments can be challenging. Safety is a huge concern. Regulations are demanding. Up time is critical.

At Glowsworth, we thrive on the difficult and the challenging projects in the oil & gas, fabrication, piping, Instrumentation & automation industry. Our expertise and experience in the oil & gas industry is extensive.
Our underlying goal throughout all projects is risk mitigation by identifying the aspects of each project that contribute to risk and taking action to eliminate or reduce such risks. We accomplish that in many ways, including the FEED+© study at the outset of a project, and the design-build project delivery method that unifies the engineering and construction elements to provide single source responsibility and accountability.

Oil & Gas Applications

- Gas processing and midstream/downstream processing-addressing safety, reliability, and security of transmission
- Pipeline control & monitoring-reliably detect leaks, damage, and theft that are risks to safe operations
- Natural gas distribution-regulation and monitoring flow to improve distribution efficiency
- Compression & pump station control-monitor and control critical junctions in oil and gas handling
- Liquefied Natural Gas (LNG), LPG, CNG, piping, handling-maintaining temperature and pressure parameters is critical to safe handling

Our project participation includes centralized automation and control, oilfield SCADA (Supervisory Control and Data Acquisition) systems, vibration monitoring, electrical load monitoring, industrial networking optimization and security, flow monitoring, motor control centers, pump controls, measurement systems, and instrumentation integration. We are also available to perform a full range of field services, including 24/7 total facility maintenance availability, checkout, startup, calibration and outage support. We also offer a full range of project life cycle services to our clients.

Midstream/Downstream Automation

Our design, construction and installation experience in the oil, chemicals, liquids and gas transportation and storage tanks segment makes us a perfect choice for midstream and downstream applications. In pipeline experience includes:

- Low pressure and high pressure gathering systems pipeline SCADA control and monitoring
- Pump stations electrical, instrumentation, and control design and implementation
- Transmission compressor control, electrical and automation design and implementation
- Transmission SCADA, host and RTU, and wireless communications systems
- Lease automatic custody transfer (LACT) instrumentation, electrical, and control design and implementation
- Gas transmission metering station RTU design
- Alarm management for liquids gathering and transmission SCADA

Glowsworth Engineering provides power generation (power) process engineering services for retrofit and new plant construction. We support services to the fossil and bio-energy power generation industries, renewable energy projects, civil construction, and infrastructural, marine construction.

Whether addressing coal, oil, natural gas, biomass, biogas, or waste heat recovery, we support projects ranging from Greenfield power generation / CHP feasibility studies to BOP systems upgrade. We have substantial experience in addressing complex power process projects successfully from conception through startup and commissioning.

We have particular expertise in existing power plant support services, frequently providing retrofit evaluations and designs related to heat rate improvement, BOP upgrade/replacement, fuel handling modifications and other related projects. Often, these projects require modeling of existing and modified plant operation. We employ a broad range of modeling tools to support these efforts, including STEAM PRO, GT PRO, Gate Cycle and others, completing efficient early options evaluation and analysis to support client decision processes. These same tools are employed in new generation facilities options evaluation and design.

Areas of power process engineering expertise include the following:

- New Generation Options
- Combined Heat and Power Assessments
- Water Use Minimization
- Water Balances
- Water Treatment Options Evaluation
- Codes and Standards Interpretation

- Existing Plant Performance and Upgrade Options
- Fuel Options and Co-Firing Evaluation
- Single- and Two-Phase Flow Hydraulic Analysis
- Wastewater Treatment Options Evaluation
- Zero Liquid Discharge Design

Power process engineering services and deliverables include:

- Feasibility Studies
- Heat and Material Balances / Flow Diagrams
- Piping and Instrumentation Diagrams
- Options Analysis
- Controls Narratives
- Design Basis / Criteria Development
- Program Documents / System Descriptions
- Regulatory Compliance Support

Power process equipment specification, evaluation, and selection services include the following:

- Combustion Turbine Generators
- Steam Turbine Generators
- Steam Generators
- Reciprocating Engine Generators
- Filtration / Separation Equipment
- Air Quality Control Systems
- Low BTU Biogas Treatment Systems
- Condensers / Heat Rejection Systems
- Emissions Control Equipment
- Water / Wastewater Treatment Systems
- Balance of Plant Equipment
- Fuel Conditioning Systems
- Coal Combustion Residuals Systems

Glowsworth Engineering provides plant layout services for retrofit and new plant construction. We support our clients in early conceptual equipment and system layout planning through final engineering and design using AutoCAD®, Plant 3D®, Revit®, and CADWorx® 2D and 3D design platforms. Autodesk Navisworks® integrates these CAD platforms for model reviews, which is an essential element of our project quality control work processes, allowing detection of interferences and clashes. We conduct progressive collaborative model reviews with our clients' engineering, operations and maintenance staff as well as contractors, vendors, technology providers, and other stakeholders. 3D models significantly aid in visualization and facilitate evaluation of the constructability, operability, and maintainability and safety aspects of the design. Our use of these design tools mitigates the potential for costly rework in the field and consistently improves the quality of the designed facility.

To be efficient and cost effective, each plant layout is specifically tailored to the client's needs and desired level of detail. However, we have the expertise to develop comprehensive plant layouts for complex systems, integrating components such as process equipment, piping, cable tray, electrical equipment, instrumentation, structural framing and platforms, underground piping and foundations.

Plant retrofits commonly occur in congested areas with significant equipment and complex layers of piping, structural steel, cable tray and other services. Record design drawings are typically unavailable, incomplete or inaccurate. This is common to nearly every project we develop. We focus on early, thorough field documentation, often completing full 3D scans or 3D point scans to establish the locations of existing equipment, tie-ins and related systems/elements. We then integrate these scans into the plant 3D model, providing a "real world" basis for the plant layout.
We can developed conceptual plant layouts for initial site studies focusing on overall plant arrangement, transportation of raw materials (truck or rail) and waste collection and disposal. These layouts may be utilized for early permitting or investment. Beyond the initial conceptual stage, we integrate vendor supplied equipment, engineered equipment and structures together to provide a complete 3D model that can be used for many different stakeholders needs, including construction.
We routinely use 3D platforms to engineer and design modular systems that require the efficient use of space, while maintaining adequate maintenance and operations interface, all to meet our client's expectations.

Piping / Pipeline

The Piping/Pipeline Department has the capabilities of performing Piping and Pipeline Design using the latest technology in the market today that includes Conceptual Study to Front-End Engineering Design (FEED), Detailed Engineering Design (DED) and Engineering Support during Construction Stage
The Department Personnel are responsible for executing all piping/pipeline related activities to meet the Client's requirement and satisfaction including Quality Assurance to ensure all documents and drawings are done in accordance with the Project Requirements, Specifications, Standards and Codes prior to any review submittals and Issued for Construction (IFC) Packages.
The function of Piping/Pipeline Department includes a wide range of activities such as:

Development of -

- Detailed Design Engineering (DED) drawings and documents,
- Conceptual Study and Design Basis Scoping Paper (DBSP),
- Technical Specifications and Procedures,
- Construction Scope of Work, Construction Specifications and Cut-Over Plan/Procedures,
- Material Take-Off list / Bill of Materials.

Performing -

- Piping Material Selection,
- Technical Bid Evaluation and Review/Approval of Vendor Drawings,
- Pipe Stress Analysis (Static and Dynamic),
- Safety Instruction Sheets (SIS) Calculation for Critical Piping and Cross-Country Pipelines,
- Constructability Study,

• Population Density Analysis,
• Various engineering calculations such as, Hot Tap, Road Crossing, Minimum Required Pipe Cover, Elastic Bend and other miscellaneous calculations,
• Engineering calculations for Firewater and Fire Protection System Design using Water Cad and Fire Elite Software,
• Field Verifications to check the actual site condition prior to start of any design activities.
• Preparation of As-Built drawings and Project Record Books.

Through the years, Piping/Pipeline Department has been involved in doing wide variety of projects such as:

A. On-Shore / Off-Shore Piping:

- Oil Refineries
- Gas Plants
- Petrochemical Plants
- Steel Plants
- Desalination and Power Plants
- Gas and Oil Separation Plants (GOSP)
- Petroleum Product Bulk Plants
- Tank Farm Facilities
- Waste Water Treatment Facilities
- Water Injection Facilities
- Seawater Intake Facilities
- Industrial Support Facilities
- Firewater and Fire Protection Systems

B. Pipeline:

- Cross-Country Oil and Gas Transmission Pipelines
- Scraper Launcher/Receiver and Main Line Valve Station Facilities
- Flow Lines / Trunk Lines and Remote Header Facilities
- Water Supply Pipeline and Storage Facilities
- Natural Gas Distribution Networks
- Pipeline Laterals and Day lighting

Glowsworth Engineering provides Plant layout services for facilities/systems including:

- Petroleum Refineries and Refinery Units
- Industrial Minerals Facilities
- Truck or Rail Loading/Offloading Stations
- Cement Plants and Terminals
- Tank Farms

- Steam Generation Facilities
- Water/Wastewater Facilities
- Chemical Plants
- Power Generating Plants
- Transload Facilities
- Utility Gas Yards
- Bulk Materials Handling Systems
- Air Quality Control Systems
- High Energy Piping Systems

Glowsworth Engineering provides Civil / Structural engineering and design services for retrofit and new plant construction. Complex retrofit projects often involve unique engineering challenges, requiring reuse, repurposing and/or expansion of existing foundations and structures. Whether adding levels to existing pipe racks, floors to existing buildings or new equipment to existing foundations, cost-effective solutions require an experience-based combination of engineering judgment and analysis. This is the environment of nearly every project we support.

We provide comprehensive services, including modeling and analysis, preparation of construction specifications and construction documents, and technical / field liaison and support services. We have substantial experience in local, national and international building / fire codes and analytic techniques to support any industrial project.

In conjunction with our technical partners, civil engineering and design services and deliverables include:

- Site Grading and Paving
- Subsurface Utilities
- Plant Road / Access Layout and Design
- Railway Layout and Design
- Geotechnical Investigation Specification
- Site Survey Specification / Coordination
- Process Sewer Systems
- Tank / Vessel Dikes and Containment Design
- Crane Pad and Heavy Lift Planning and Design
- Storm Water Management

Structural engineering and design services and deliverables include:

- General and Critical Equipment Foundations
- Piling, Caissons and other Deep Foundation Systems
- Pre-Engineered Buildings Specification
- Modular Structures and Industrial Enclosures
- Bulk Material Silos, Bins and Hoppers
- Conveyor Structures and Transfer Towers
- Bulk Material Conveyor Design
- Structural Design & Analysis
- Foundation Design
- Bulk Material Stockpile Reclaim Tunnels
- Fireproofing

- Fall Protection
- Liquid Retaining Concrete Structures
- Steel, Concrete, and Masonry Structures
- Pipe Racks and Engineered Supports
- Equipment Structural Support and Access
- Below-the-Hook Lifting Devices
- Monorails and Bridge Cranes
- Permitting Assistance
- Corrosive Chemical Containment Liner Specification
- Industrial Elevators
- Trestle Bridge Systems

Glowsworth Engineering has extensive mechanical engineering and design experience in a broad range of industries. We bring significant technical depth and analytical capability to complex projects execution, whether on retrofit upgrades or new facility design. Whether related to plant utility systems or high energy piping; liquid or solid fuel handling systems or high pressure gas systems; high viscosity batch pumping systems or high purity gas compressors; or detailed code interpretation or equipment/system specifications preparation, we offer depth of experience and versatility to complete the most challenging projects. We provide a comprehensive range of mechanical engineering and design services to support our clients' materials handling, piping / vessels and rotating equipment projects.

Glowsworth Engineering provides piping and vessel engineering and design services for retrofit and new plant construction. We support our clients in comprehensive analysis and design of complex systems and equipment, ranging from high energy piping systems in power generation facilities to highly-hazardous service piping and vessels in hydrocarbons and chemical facilities.

Glowsworth Engineering has particular experience in mechanical piping and vessel analysis, employing experienced staff and industry standard software and analysis tools, including CAESAR II®, NozzlePRO™, FE/Pipe™ and PV Elite®. GlowsworthCADWorks's approach focuses on incorporating accurate boundary conditions as well as realistic solutions. Our clients identify us as a preferred service provider for time-critical turnaround / outage piping projects involving complex designs and challenging sequencing. These projects take place in a "real world" environment, highly space constrained and always lacking in existing accurate documentation. Field documentation is essential as a starting point to our designs and we employ various work processes and tools, including 3D laser scanning, to establish a basis for our design.

Thorough understanding and application of relevant codes and standards in mechanical analysis is critical for project success. Areas of expertise include:

- Piping Static Flexibility (Stress) Analysis (ASME B31.1, B31.3, B31.4 and B31.8)
- Piping Hydraulic Transient Analysis
- High Energy Piping System Evaluation
- Underground Piping Analysis
- Spring Hanger, Guide and Anchor Evaluations
- Piping Flanges Analysis (ASME B&PVC Section VIII Div.1 Mandatory Appendix 2)
- Equipment Nozzle Evaluation (NEMA SM23, API 560, API 610, API 617, API 618, API 661, ASME B&PVC Section VIII Div. 2)

- Pressure Relief Valve Reaction Analysis (ASME B31.1 Nonmandatory Appendix II, API 520 Part 2)
- Metallurgical Engineering / Material Selection
- Single- and Two-Phase Hydraulic Analysis
- Vessel Design / Rerating (ASME B&PVC Section VIII)
- Field-Erected and Shop Fabricated Tanks (API and AWWA)
- Turbine Water Induction Protection Design (ASME TDP-1)
- Insurer Compliance Evaluations

Piping and vessel engineering and design services and deliverables include:

- Piping and Vessel 3D Models
- Orthographic and Isometric Piping Drawings
- Inspection Isometric Piping Drawings
- Vessel Specification Drawings
- Piping and Valve Material Specifications
- Piping Line, Valve, Tie-in and Specialty Item Lists
- Steam Tracing Design
- Engineered Spring Hangers Specification and Design
- Piping Supports Specification and Design
- Tank Specification Drawings
- Demolition Drawings
- Fire Protection Design Basis
- Fire Sprinklers Systems
- Large Bore, Heavy-Wall, and Alloy Piping and Valves

Glowsworth Engineering provides electrical engineering and design services for retrofit and new plant construction. We provide comprehensive electrical engineering and design services, including modeling and analysis, and preparation of equipment / construction specifications and construction documents. We have substantial experience in low-, medium-, and high-voltage design, from 110V to 330kV. Thorough understanding and application of relevant codes and standards in electrical analysis is critical for project success. In conjunction with our technical partners, areas of expertise include:

- Short Circuit Analysis
- Load Flow Analysis
- Dynamic Motor Starting and Protection Evaluation
- Arc Flash Hazard Evaluation
- System Stabilization Transient Modeling
- Power Quality and Harmonics Analysis
- Buried Feeder Temperature Derating
- Power Factor Correction
- Relay Coordination and Protection Studies
- Grounding, Bonding and Cathodic Protection
- System Voltage Drop Analysis
- Hazardous Area Classification Evaluation
- Insurance and Code Compliance

Electrical engineering and design services and deliverables include:

- Power Distribution Systems

- Substations / Switchyards
- Station Power Systems
- Heat Trace and Electric Heating Systems
- Standby / Emergency Generator Systems
- UPS and Emergency Standby Systems
- Grounding and Lightning Protection
- Fire and Gas Detection Systems
- Fire Protection Electrical Systems
- Raceway and Cable Tray Systems
- Lighting Systems
- Communication and Security Systems
- Energy Conservation and Management
- Relay Calibration, Testing and Programming
- Startup and Commissioning Support

Electrical equipment specification, evaluation and selection addressing the following:

- Small and Large Power Transformers
- Modular Power Distribution Centers
- Low / Medium Voltage Switchgear
- Low / Medium Voltage Motor Control Centers
- Ductbank
- Bus Duct
- Variable Frequency Drives
- Reduced Voltage Starters
- Load Commutated Inverters
- Battery, UPS and Generator Systems
- Low / Medium Voltage Motors
- Synchronous Motors
- Protective Relays and Panels

Glowsworth Engineering provides instrumentation / controls engineering and design services for retrofit and new plant construction. For retrofit application, we select instrumentation and control system components that will integrate with existing legacy systems. We provide comprehensive instrumentation / controls engineering and design services, including modeling and analysis, and preparation of equipment / construction specifications and construction documents. We have substantial experience in addressing complex process and control problems successfully.

Thorough understanding and application of relevant codes and standards in instrumentation / control analysis is critical for project success. Areas of expertise include:

- Process Stability and Control Evaluation
- Thermowell Wake Frequency Analysis
- Safety Integrity Level Analysis
- Control Valve and Flow Element Calculations
- Hazardous Area Classification Evaluation

Instrumentation / Controls engineering and design services and deliverables include:

- Piping and Instrumentation Diagrams
- Safety Instrumented Systems (SIS)
- Interlock and Automated Sequencing Logic
- Foreign Device Controls Integration
- Controls Narratives / Functional Specifications
- Control Loop and Logic Diagrams
- Safety Interlocks Definition
- Conduit / Cable Schedules
- Instrument Location Plans
- HMI Configuration
- Emergency Shutdown Systems
- Control System Transition / Cutover Planning
- Fiber Optic Networks and Communications
- Modular Control Rooms
- Cause and Effect Matrix
- Batch Sequence Diagrams
- FAT / SAT Definition and Support
- Instrument Installation Details
- PLC Programming

Instrumentation / Controls equipment specification, evaluations and selection include:

- Instruments and Control Valves
- Analyzers and Sample Conditioning Systems
- Distributed Control Systems
- Panels
- Continuous Emissions Monitoring Systems
- Programmable Logic Controllers
- SCADA System

Glowsworth Engineering provides process engineering services for retrofit and new plant construction to the hydrocarbons and chemicals industries. We support services ranging from process debottlenecking and upgrading for existing plants to new process plant design. We have substantial experience in addressing complex process projects successfully from conception through startup and commissioning.

We have particular expertise in batch and continuous process simulation and modeling, employing experienced staff using the most sophisticated commercial modeling packages, including AspenOne®, PRO/II®, ChemCAD®, and METSIM®.

For any particular project, we select the modeling tools that best support the specific simulation – often those that are in common use by our clients. We believe successful modeling requires a collaborative team approach. There are significant challenges in modeling, including ensuring parameters and material properties are correct and that modeling results are reasonable. We work with our clients to validate process modeling results against existing process operations, testing data and/or literature.

In addition to process simulation, areas of process engineering expertise include the following:

- Process Debottlenecking Studies
- Heat Exchanger Design and Rating
- Relief System Modeling
- Flare Hydraulic Studies
- Process Troubleshooting Evaluation
- Process Hazards Analysis (PHA)
- Process Intensification Studies
- Energy Efficiency Optimization Studies
- Single- and Two-Phase Flow Hydraulic Analysis
- Process Economics Evaluation
- Codes and Standards Interpretation
- Level of Protection Analysis (LOPA)

Process engineering services and deliverables include:

- FEL / FEED / Schedule A Packages
- Feasibility Studies
- Block Flow Diagrams / Process Flow Diagrams
- Heat and Material Balances / Stream Catalogs
- Piping and Instrumentation Diagrams
- Controls Narratives
- Design Basis / Criteria Development
- Process Design Packages
- Options Analysis
- Technology / Licensing Implementation
- Process Unit / Equipment Repurposing
- Regulatory Compliance Support

Process equipment specification, evaluation, and selection services include the following:

- Fractionation Columns
- Reactors
- Heat Exchangers
- Water / Wastewater Treatment Equipment
- Filtration / Separation Equipment
- Flare and Vent Systems
- Pressure Relief Devices
- Fired Equipment
- Emissions Control Equipment
- Fans / Blowers / Compressors

PROJECT SERVICES

Effective project management is essential for successful project outcomes. Delivering constructible, operable, maintainable and safe process facilities projects while achieving quality, schedule and budget goals is challenging, but we do it every day.

Our core project management philosophy is that all projects are fully scoped, work breakdown structures are defined and project execution plans are developed to ensure alignment and define common expectations with the client. During execution, disciplined management of scope, quality, budget and schedule is a focus through project closeout.

We provide leadership and management of projects for clients. Project Management services include:

- Stage-Gated Project Delivery
- Portfolio Management
- Project Execution Planning
- Risk Analysis and Mitigation
- Financial Analysis
- Constructability, Operability, Maintainability and Safety Analysis
- Quality Management and Assurance
- Variance Management
- Value Engineering

Project controls is an essential element of our project management work processes. Using a combination of industry software (e.g., Primavera P6®, Deltek Vision®) and internally-developed tools, we provide forecasting and real-time tracking of projects in a project size-scaled format. Project reporting and analysis supports our **project management** and client staff in achieving successful project outcomes.

Project controls services include:

- Risk Assessment/Management
- Resource-Loaded CPM Scheduling
- Change Order Administration
- Cost Control and Reporting
- Accrual Reporting
- Project Metrics Reporting (SPI, CPI, etc.)
- Project Auditing
- Cash Flow Forecasting
- Earned Value and Earned Schedule Management

CAPITAL COST ESTIMATE

We collaborate with our clients and apply a rigorous methodology in cost estimate development in alignment with AACE International® (AACE) criteria and client standards. Our clients commonly employ a stage-gated front-end engineering work process in which cost estimates are developed at the conclusion of various project phases. Cost estimate accuracy is refined as the project progresses, moving from early concept estimates to project authorization / control budget estimates. We employ different approaches for each estimate stage consistent with industry and client standards. Estimates are organized to reflect the planned engineering and construction execution approach. We have developed several cost estimates based on this approach, supporting our clients' project investment decisions.

We develop a comprehensive Basis of Estimate (BOE) report with each cost estimate. The BOE documents the scope, procedures, data sources, assumptions and exclusions related to the estimate development. The BOE includes a project scope and cost summary and a detailed explanation of each cost category. Glowsworth uses AspenTech® In-Plant Cost and Capital Cost Estimator software (Aspen) as its primary estimating platform. Aspen is supplemented with other estimating references and in-house developed tools.

Cost estimating services include:

- Estimating Plan Development
- Capital Cost Estimating
- Contingency Assessment / Range Estimating
- Escalation Assessment
- Estimate Review / Validation
- Labor Rates Evaluation
- Risk Analysis
- Basis of Estimate Development
- Basis of Schedule Development
- Reserves Evaluation
- Peer Reviews
- Owner's Costs Development Facilitation
- Financial Pro Forma Development

PROCUREMENT

We can manage the procurement work process from procurement plan development through contract closeout, or provide services to augment a client's procurement organization. Procurement documents can be developed within our systems or within a client's purchasing or enterprise management system. When beneficial to our clients, we provide limited-agency procurement support, assuming responsibility for the full scope of project procurement. We apply project-tailored approaches to reduce costs, ensure supplier accountability and shorten delivery times. We have significant experience in supporting industrial project procurement, from complex capital equipment and engineered systems to bulks and services.

Procurement services include:

- Procurement Plan Development
- Procurement Database Development
- Sourcing Planning, Supplier Evaluation and Bidders List Preparation
- Shop Surveillance
- Contract Terms and Conditions Development
- Request for Quotation Development and Issuance
- Bid Process Management
- Bid Receiving, Conditioning and Adjudication
- Supplier Reference Verification
- Purchase Award Recommendation
- Contract Negotiation
- Purchase Order Preparation
- Contract Management through Closeout
- Invoice / Payment Coordination
- Change / Variance Management
- Spare Parts Definition and Procurement
- Lay-Down and Warehousing Planning

- Receiving Coordination and OS&D Resolution
- Procurement Status Reporting
- Field Procurement Plan Development
- Cash Flow Forecasting and Tracking

Expediting services can be provided, from order placement through receiving and contract closeout to ensure schedule maintenance. Expediting services include:

- Monitor Supplier Compliance
- Monitor Shop Drawings Turn Around
- Monitor Supplier Purchasing Progress
- Monitor Supplier Fabrication Progress
- Monitor Supplier Shipping Progress
- Monitor Supplier Data Supply

Observation services can be provided to verify contract compliance and quality requirements. Observation services include:

- Review Supplier Quality Program
- Conduct Supplier Audits
- Non-Conformance and Observation Reporting
- Confirm Resolution of Non-Conformities
- Conduct Hold-Point and Witness Observation
- Conduct Final Observation Prior to Shipment
- FAT Support

Logistics services can be provided to plan, coordinate, and execute shipping and receiving of equipment and materials. Logistics services include:

- Transportation and Logistics Management Plan Development
- Transportation Options Evaluation
- Freight Forwarder Coordination
- Transportation Monitoring and Reporting
- Inventory Control Coordination

CONSTRUCTION COORDINATION

Construction coordination is essential for successful project delivery. Contractors provide construction management and control staffing, sequencing and means / methods of construction. We provide continuity from engineering execution to the field, facilitate planning, resolve issues quickly and ensure contractor accountability on behalf of the client.

Construction coordination services include:

- Pre-Construction Planning
- Safety Coordination and Management
- Contracting Strategy Definition
- Construction Execution Plan Development
- Site Facilities Planning
- Construction Sequence and Logistics Planning
- RFI Program Implementation and Resolution
- Interface Management Planning
- Quality Assurance and Control
- Cost and Schedule Management
- Material Control / Procurement Support
- Field Contract Administration
- Field Document Control Management

- Inspection Coordination
- Client Representation

STARTUP / COMMISSIONING

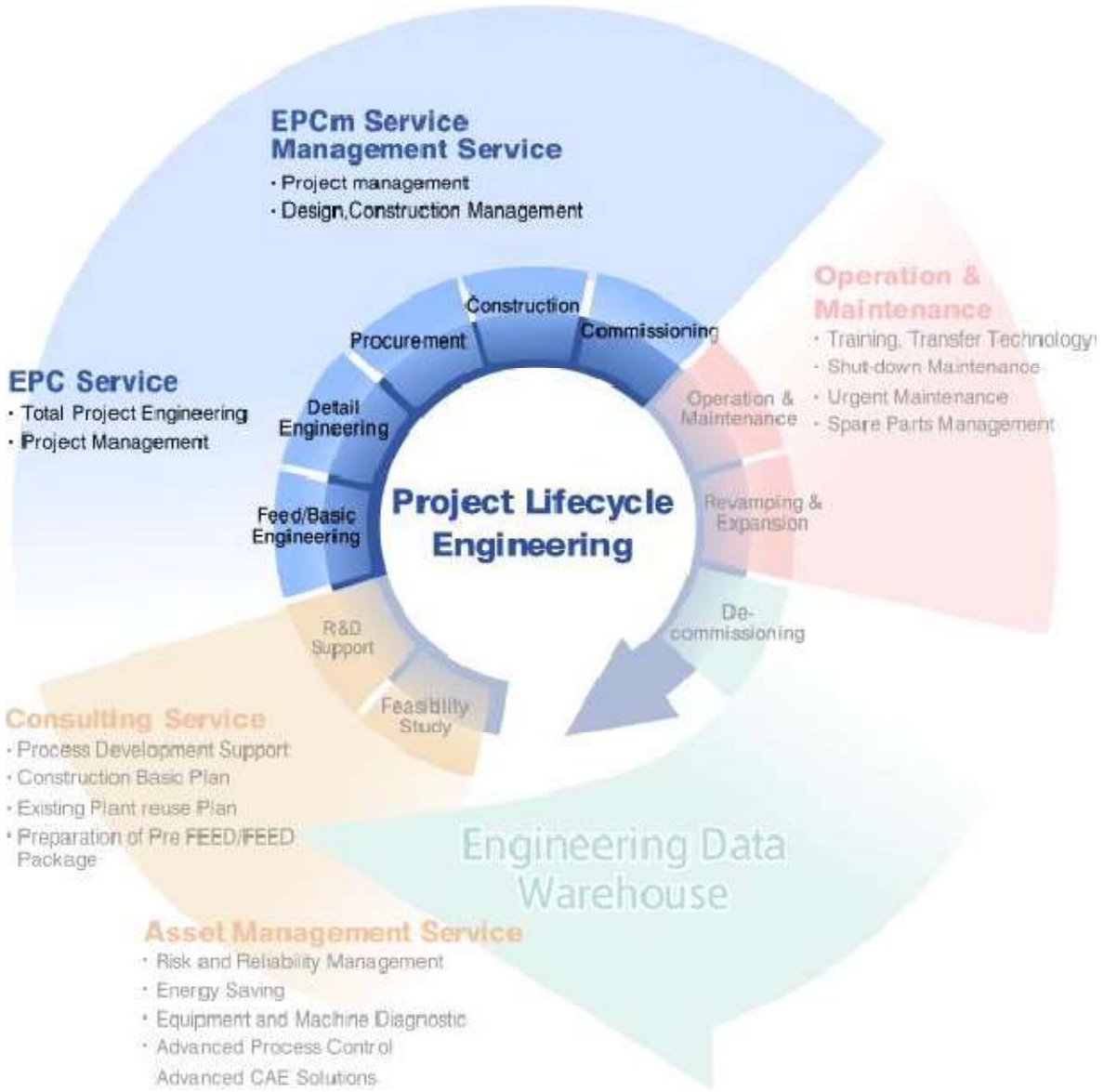
The startup / commissioning phase of a project is arguably the most critical, with more opportunities for failure than success if not planned and executed properly. A structured program is essential to support an efficient, effective and safe startup, moving a new process facility from the construction phase to an operating status. It is also essential to have a structured team of operations, maintenance, engineering and construction personnel implementing the startup / commissioning program with clearly defined roles and responsibilities. From experience, we know the best startup / commissioning planning begins early in the engineering phase and continues throughout the project. Maintaining availability of key engineering personnel is critical to ensure the institutional project design knowledge is available for startup / commissioning planning and execution.

We provide startup / commissioning support to our clients, ranging from field engineering staffing to development and management of full programs. There is no single "best" approach. We favor integrated startup / commissioning teams, with responsibilities assigned to achieve the best value and outcome for the project and client.

Early development of operating procedures and training of operations and maintenance staff is important. Our experience is that such efforts serve as another verification step in the facility design, and pay significant dividends in enabling the staff to participate in the commissioning planning and execution. We frequently collaborate with our clients in development of operations and maintenance procedures and conducting training.

Startup / Commissioning areas of support include:

- Startup / Commissioning Plan Development
- Operating Procedures Development
- Operator Training
- FAT / SAT Coordination
- Testing Plan Development
- Check-Out Verification
- Process Control Loop Tuning
- Field Device Calibration
- Vendor Startup / Commissioning Coordination
- Pre-Startup Safety Reviews
- Handover / Turnover Planning
- Punch List Development
- Startup / Commissioning Management
- Augmentation of Client Staff
- Software Verification and Validation



PROJECT LIFE CYCLE SERVICES