Northwest Construction Consumer Council

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NWCCC Presents

Managing Retrofit Projects

Presented by:

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What is a Retrofit Project?

- A retrofit project is the modification or conversion (not a complete replacement) of an existing process, facility, or structure. Such modification may involve additions, deletions, rearrangements or not-in-kind replacements of one or more parts of the facility. Changes may alter the kind, quantity, cost or quality of the products or services being produced by the facility.

Introduction

- Economic conditions are affecting project decisions more than ever:
  - Capital is constrained.
  - Owners need to maximize value on each dollar spent.
  - Owners want to get more out of their existing facility.
  - Greenfield projects may not fit the current mode of cost containment and cautious spending.
  - Retrofit projects may be the more attractive alternative in today's business climate.
  - Retrofit projects may be a direct result of today's business climate – downsizing, consolidating.
  - Each business case is unique – there is no absolute standard.

Introduction

- The presentation will discuss project execution methods and suggested means that, when undertaking retrofit project work, can increase the probability of a successful outcome.

Presentation Overview

- MANAGING RETROFIT PROJECTS:
  - Harris Group Inc. white paper - perspective from Engineer
  - Shell Retrofit Case Study– perspective from Owner
  - The Boeing Company & Lease Crutcher Lewis (project partners) Retrofit Case Study – perspective from Owner and Contractor
  - Q&A / Wrap-up

Why Consider Retrofit Projects?

- Productivity (efficiency) improvement.
- Production (capacity) improvement.
- Regulatory compliance.
- Safety improvement.
- Energy efficiency improvement.
- Reliability improvement – reduce maintenance costs.
- Incorporate new technology.
- Increase/improve quality.

What are Some of the Advantages?

- Optimize use of existing facility to achieve improved profitability.
- Possible improved schedule – shorter time to market.
- Possible lower capital investment as compared to Greenfield (but typically higher per unit cost)
- Possible fewer permitting issues.
- Opportunity to establish real world baseline for measuring results.

What are Some of the Risks and Challenges?

- Managing Expectations
- Code Issues
- Scope creep
- Sufficient level of engineering and design
- Dealing with the unknowns
- Minimize impact to existing operation
- Contract type
- Inadequate auxiliary systems and equipment
- Conflicts with maintenance during shutdown

What are Some of the Risks and Challenges?

- Support during construction
- Materials management – on time availability
- Commissioning and startup
- Training

Managing the Risks

Risk Area: Are Expectations too High?

- Challenges
  - Expectations for the project must be tested against the risk that they might not be possible given the amount of funding that can be justified.
  - Few plant retrofits have been approached with the thoroughness required to address the issues and complexities consistent with the operational equivalent of a new plant.
- Suggested Approach
  - A survey of similar vintage plants making similar upgrades is a good way to review the achievement "risk" of the project.
  - Suppliers and outside consultants can provide input.
  - A "due diligence" review of the project is a necessity – whether it is done internally or with outside assistance.

Risk Area: Code Compliance

- Challenges
  - Structural codes change over time. New and/or additional loading may require seismic reinforcement. Building officials continue to be more involved in the work being done within industrial facilities to ensure the work meets code.
  - It is often found that old electrical equipment is not suitable for the modifications necessary to support a retrofit.
  - In some cases, factory pre-wired equipment has to be re-wired in the field because it doesn't meet code.
  - It is frequently found that there is a problem with the existing process, or the plant infrastructure is in poor physical condition and has to be fixed as part of the project.

Risk Area: Code Compliance

- Challenges
  - The presence of asbestos is sometimes not identified early. Its removal during a shutdown is a major schedule and cost issue.
  - The use and storage of flammable and/or health hazardous chemicals in the existing process is not fully defined. Design requirements for hazardous occupancy and/or permitting constraints including fire marshal requirements may dictate design features that are costly, extend lead times, and impose revised operational procedures.
  - The cost of code compliance work, added to the project, may make the project impossible to justify.

Risk Area: Code Compliance

- Suggested Approach
  - A code evaluation should be done on the existing facility to determine its situation relative to current standards.
  - As the project scope is developed, the impact of the new systems and equipment on the existing facility must also be analyzed. If needed, the existing structure(s) may have to be reinforced. Electrical equipment may have to be replaced.
  - Make sure project specifications require any pre-wiring to be done to local and national codes and that it is properly labeled. Satisfy yourself that the supplier knows what your specifications mean.
  - An infrastructure review needs to be included in any assessment of the plant as part of the rebuild scope preparation. Assess the physical and operational condition of the existing facility. Problem areas may have to be fixed as part of the project.

Risk Area: Code Compliance

- Suggested Approach
  - Make sure that an asbestos survey is done early of all potential areas where asbestos can be found on equipment, structures, or piping and develop a plan for its removal.
  - Where chemicals with flammable and/or health hazards are used in the facility, perform an audit of the chemicals involved to develop a complete inventory. Do this in conjunction with a comprehensive code evaluation, to clearly define the design criteria in compliance with the codes, local jurisdiction, and fire marshal. Where conditions dictate, perform an appropriate HAZOP analysis during the design, preferably in the early phase of concept development. Be diligent about performing these assessments during the upfront planning and design phase.
  - Overlooking these items may result in significant project cost and schedule impacts. Requirements must be determined as early in the project as possible.

Risk Area: Scope Creep

Challenges

- Facility retrofits are notorious for exceeding budgets. There are a number of reasons for this:
  - Unreasonable management expectations of the potential cost. Every retrofit is different and cannot be directly compared with previous “similar” projects.
  - Not doing enough analysis of the process as it exists to know what needs to be done.
  - Not performing enough up-front engineering and design to provide a solid/complete scope of work.
  - Not having adequate up-front input from production, maintenance, construction, and other affected parties.
  - Not having an adequate contingency allowance for the project.

Risk Area: Scope Creep

- Suggested Approach
  - Put together a team consisting of plant engineering, production, and maintenance staff together with outside consultants and an experienced contractor. Empower the team to make decisions relative to the project scope and estimate. Make the team responsible for managing the project cost.
  - Where plant staff is involved, free them from normal duties enough that they can devote adequate time to the project. On a large project, this may mean full time dedication to the project.
  - Have a good scope change/approval process in place as soon as the project is approved.

Risk Area: Scope Creep

- Suggested Approach
  - Plan on spending enough as the project is developed to have a well-detailed scope.
  - Plan for involvement by the construction firm to provide constructability reviews, risk assessments, and value engineering.

Risk Area: Lack of Complete Engineering

- Challenges
  - There are a number of methods being used to reduce engineering costs. In alliance arrangements the designer sometimes only issues sketches to the contractor for certain types of work. This approach while suitable for small plant projects may not be adequate for retrofit work.
- Suggested Approach
  - Make sure the design engineering approach is suitable for a retrofit project.
  - Through risk assessment and up-front planning involving owner, engineer, and contractor, determine where additional design information will facilitate the construction process to better manage schedule and cost objectives.
  - Pre-fabrication of piping and modules should be as complete as possible and done well in advance of shutdown. In order to accomplish this, design must be carried to a detailed level and must be accurate.

What not to do

What not to do

What not to do

Risk Area: Dealing With the Unknowns

- Challenges
  - More often than not, facility retrofits involve structures, equipment, and systems that have been around for many years. During this time, maintenance activities, other projects, facility reorganizations, equipment upgrades, and a variety of other circumstances will have modified the original facility. Frequently, these changes have not been well documented.
  - Facility records do not represent current as-built condition. This may have been the condition since the original construction.
  - Owner facility knowledge is spread between engineering, maintenance, and operations.
  - Sometimes, facility knowledge has been outsourced to vendor suppliers.
  - Original design basis including codes, standards, and process criteria may be difficult to verify.

Risk Area: Dealing With the Unknowns

- Suggested Approach
  - Spend appropriate amounts of time during the design and planning phase to perform field investigations that are comprehensive. Don't short cut this activity.
  - Take pictures. Do this during design and planning for the project. Also do it during ongoing maintenance to document areas that may normally be hidden but become exposed during the maintenance activities. The library of picture information may be an invaluable tool for a future retrofit project.
  - Perform utility locates and site surveys to supplement facility records when in doubt.

Risk Area: Dealing With the Unknowns

- Suggested Approach
  - Include maintenance, operations, and facility engineering staff during design development to capture their knowledge. Continue their involvement throughout the project execution phase.
  - Maintain an archive of facility records including drawings and equipment O&M data. Where retrofits are frequent, a well maintained archive is invaluable.
  - Be diligent about maintaining red-lines to document field modifications during construction. This may not help you on the current project, but it will allow record drawings to be developed for the benefit of ongoing maintenance and the next project.

Risk Area: Impact to Existing Operation

- Challenges
  - Taking a plant out of production for a major retrofit can be a traumatic experience. Not only is the bottom line impacted but also arrangements have to be made for customer support during this period.
  - The final shutdown to accomplish a major retrofit is critical. The organization, planning, and logistics effort are significant.
  - The work has to be accomplished with a large number of workers in a confined space. Many tasks must be completed in a short duration.
  - In the push to limit the shutdown duration and still accomplish all of the work, the probability increases that the quality of the work will suffer. Maintaining the quality standard is a key challenge of retrofit work.

Risk Area: Impact to Existing Operation

- Suggested Approach
  - Have a work plan detailed to the point where every activity is identified prior to the shutdown. Include appropriate time for all QC checks and inspections.
  - Do as much pre-assembly of equipment and piping as possible prior to the shutdown.
  - Don't schedule the shutdown too tight with the delivery of key components.
  - Hire a contractor with a proven track record on this kind of project. Their experience must include good safety performance, and the availability of good planning and scheduling personnel.
  - Select a construction contract with terms that don't interfere with work progress. Make early completion of the work an incentive.

Risk Area: Impact to Existing Operation

- Suggested Approach
  - Use pre-assembled equipment “modules” where items such as smaller tanks, pumps, motors, piping, and some instruments can be pre-assembled on a fabricated skid.
  - Check other plants in the area for timing conflicts. They may be doing a major retrofit at the same time you are, overloading the construction resources in the region.
  - Work during holiday’s may offer the advantage of minimizing impact to the existing operation. Take care if/when scheduling the work over a holiday period as workers may be hard to obtain and premium costs will be high.

Risk Area: Impact to Existing Operation

- Suggested Approach
  - Do as much work on preliminary shutdowns as possible including all tie-ins. Some systems can be started up early on. Early startup of items such as DCS systems – even on a limited number of control loops – can help with operator training.
  - Understand the tradeoff between schedule optimization and the cost to achieve it. Some of the techniques used to reduce downtime may add to the project cost.

Risk Area: Inappropriate Contracting Style

- Challenges
  - The type of construction contract used may not be appropriate for a retrofit project. No matter how well the project is planned, unforeseen changes will occur.
  - In the case of a lump sum approach, change orders will be particularly hard to manage especially with a substantial percentage of the work compressed into a final shutdown.
- Suggested Approach
  - Consider a cost plus fee arrangement for the construction contract with an experienced retrofit contractor.
  - Employ the contractor's services early in the project – even during the scope development and estimate preparation. Contractor input on constructability and construction methods is valuable.

Risk Area: Inadequate Auxiliary Systems & Equipment

- Challenges
  - The project objectives will not be met unless all of the systems and equipment (both new and existing) can function together under the design conditions.

- Suggested Approach
  - An adequate survey of the existing process and all of the auxiliary systems is needed to benchmark capacity.
  - The needs of the new equipment and systems need to fit the available capacity of those systems.

Risk Area: Conflict with Maintenance Work

- Challenges
  - During shutdowns arranged for the retrofit project, the plant maintenance department will likely plan to take care of PM and other repair work.
  - Competing for material lay down space, congestion in the work areas, and conflicts with crane use are typical issues.
- Suggested Approach
  - Maintenance activities must be included in project planning as much as if they were part of the construction.
  - If a project work area is competing with maintenance, consider letting the group (either project or maintenance) that has the most predominate work scope take care of all activities in that area.

What not to do

What not to do

What not to do

What not to do

Risk Area: Lack of Support During Construction

- Challenges
  - Some facility retrofit projects lack enough support staff during construction, especially during the major shutdowns.

- Suggested Approach
  - Make sure plant staff are dedicated to the project during construction. These people can be a tremendous asset to the project because of their knowledge of the plant.
  - Include the people who were involved during the design.
  - Make sure that shift coverage is included for the support staff, as well as vendor erectors and commissioning/startup people. Where vendor and other outside help is needed, make arrangements well in advance.
  - The costs associated with the above need to be included in the project budget.

Risk Area: Materials Management

- Challenges
  - Because so much of the work on a retrofit project is done during shutdowns, all materials must be purchased and available when needed for the work.
  - Items removed during the early part of the shutdown – which have to be reinstalled – may end up disappearing.

Risk Area: Materials Management

- Suggested Approach
  - Have a material coordination plan that identifies who is responsible for purchase, expediting, and storing all materials.
  - Make sure adequate time is given for manufacture and delivery of vendor supplied equipment.
  - An experienced contractor will have systems in place for securely storing and managing materials.
  - A plan should be in place for laydown areas and methods of staging equipment and parts in sequence for their installation.
  - Shipments of vendor-supplied equipment should be adequately checked for completeness when it arrives – even if it means un-crating.
  - Parts which are removed early in the shutdown which must be re-installed later must be properly tagged and stored.

Risk Area: Commissioning and Startup

- Challenges
  - The plant is restarted with new equipment and new systems installed. Sometimes getting old equipment started up under new conditions can be a bigger issue then getting the new equipment started up.
  - During lengthy shutdowns, materials left in pipelines can harden, motors can take on moisture, etc.

- Suggested Approach
  - Planning for a retrofit project should include measures needed for laying up the existing equipment and systems. Proper flushing should be done. If required, heat should be put on motors during the outage.
  - A commissioning and startup plan needs to be in place. A designated person should be responsible for overseeing the activities. Teams of people should be made available for this project phase.
  - Don't forget to include restarting of existing systems and equipment in the commissioning plan.

Risk Area: Training

- Challenges
  - A major retrofit can drastically change the configuration and operation of a process plant.
  - In some cases commissioning and start up after a retrofit can be more difficult than that of a new system.

Risk Area: Training

- Suggested Approach
  - Make sure that planning for the retrofit includes adequate training for operators and maintenance. A long shutdown period can provide an opportunity for some of the classroom training.
  - Include operators in the preparation of training manuals – long before the shutdown.
  - Use operators during the shutdown period to tag equipment and piping. Operator assistance during commissioning is extremely important.
  - Make sure the budget includes funding for adequate training.
  - If a new control system is being installed, pre-install an operator's station with a few loops in a well defined system to get operators up to speed on the new equipment.

What not to do

What not to do

What not to do

What not to do

Key Considerations - Engineer's Perspective

- Accuracy and availability of existing facility information
  - As-built records
  - Equipment product data
  - Process criteria
- Field investigation – this is essential when records are not accurate and/or complete
  - Confirm layouts
  - Take measurements
  - Utility locates
  - Attempt to identify that which is hidden and undocumented
  - Attempt to eliminate surprises
- Access to equipment

Key Considerations - Engineer's Perspective

- Load modeling
  - System capacity assessment
  - Estimating additional loads
  - Direct measurement
  - Estimates based on mutually acceptable demand and diversity values
- Developing sufficient detail to support shutdowns, tie-ins, and high risk areas
- Avoid overdesigning relative to the amount of confirmed data
- Availability of equipment data during design – procurement issue
- Effective design reviews with owner and contractor involvement – include constructability review.

Key Considerations - Engineer's Perspective

- Managing tie-ins
  - Communicate early any restrictions on tie-in locations.
  - Develop a tie-point list in conjunction with the P&ID's. Review it thoroughly, and early in the design phase.
- Shutdown planning
  - Include the engineer in the planning process.
  - Communicate the requirements early to optimize design sequencing if phased construction is anticipated.
- Contingency planning – retrofit design has a higher potential for error and/or omission.
- Support during construction – include the engineer.
- Managing red-lines for record drawings at closeout.

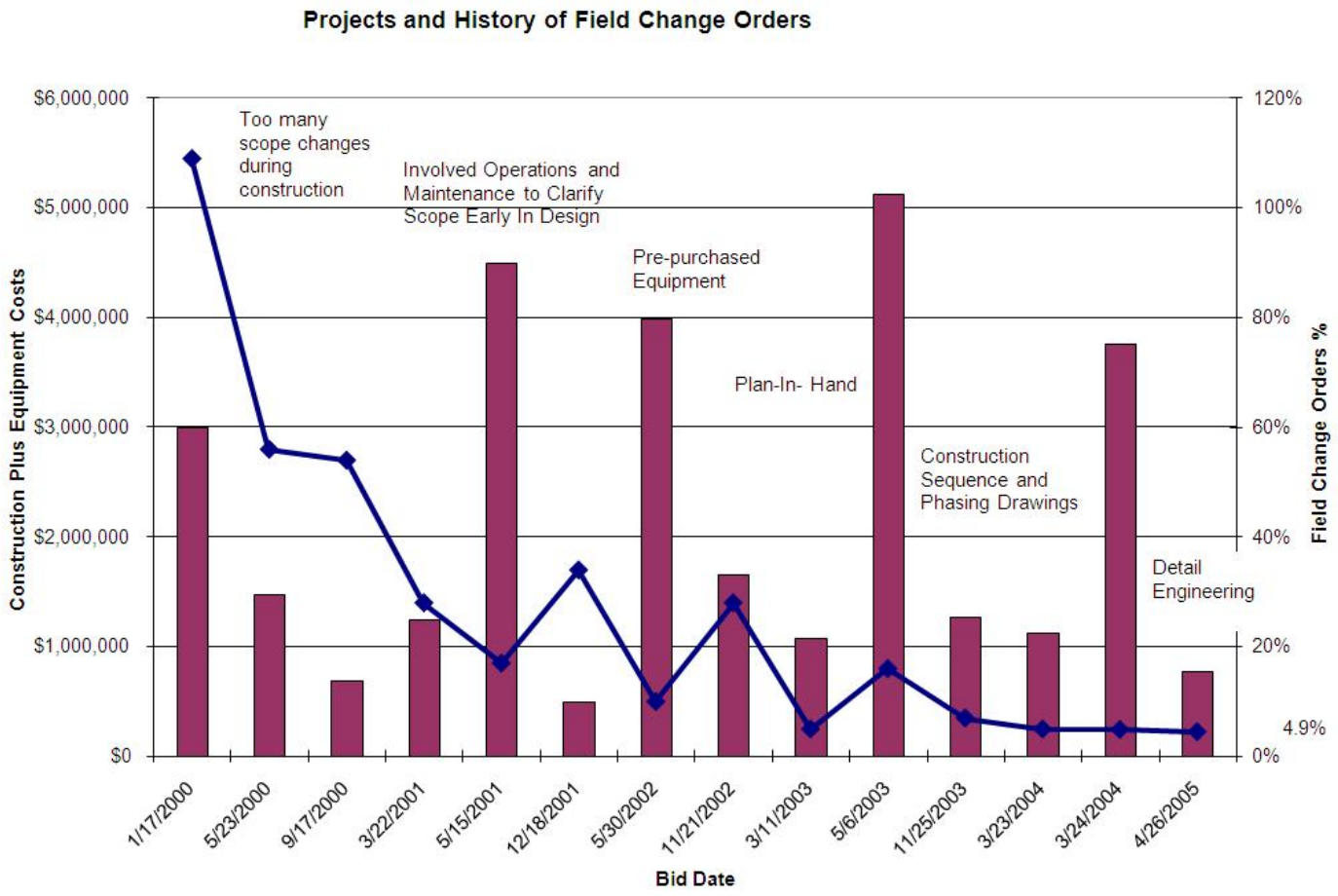
Project Example

- Local owner with multiple facility retrofit projects, primarily electrical infrastructure
- 14 projects over a 5-1/2 year period
- Each measured for TIC, and percent field change orders
- Owner had experienced a history of high percentage changes during construction and desired to modify project delivery process to improve that outcome.

Project Example

- Percentage of change orders was reduced. Key steps taken to achieve this included:
  - Involvement of maintenance and other stakeholders to clarify project scope early in the design process.
  - Implemented owner pre-purchased equipment.
  - Implemented plan-in-hand reviews.
  - Required development of construction sequencing and phasing drawings as part of the design package.
  - Emphasis on detailed engineering.

Project Example



Study of Retrofit Projects – Best Practices

- Study of 16 retrofit projects done in the 1990's.
- Study performed jointly by team from Georgia Institute of Technology, Pennsylvania State University Department of Architectural Engineering, in collaboration with the Construction Industry Institute (CII).
- Project sizes ranged from $1 million to over $100 million.
- Study included projects in Power, Biotech, Chemical, Petrochemical, Building, and Industrial.
- Project locations covered all regions of the United States.
- Objective of the study was to identify the critical management, engineering, and construction factors that will facilitate successful execution of retrofit projects.

Study Findings - Constraints

- By definition, the retrofit project involves work in an existing facility.
- This condition imposes constraints on the owner, operators, designers, and constructor.
- At a high level, the constraints include insufficient information, physical limitations, and operational factors related to the existing facility.
- All projects have constraints; however, retrofit projects are more limited on the options available to address the constraints. There is less freedom available to the affected parties.

Study Findings - Constraints

- The study identified four main constraints that appeared to have the most affect on executing a retrofit project:
  - INFORMATION
    - Existing data is often limited. Project scope can be unclear, the condition of the existing equipment may be uncertain, and as-built drawings may not be up-to-date.
  - TIME
    - Many retrofit projects must be completed during a very narrow window during a plant shutdown.

Study Findings - Constraints

- SPACE
  - By the very definition of working within an existing facility, the retrofit project competes for space. Space congestion introduces problems of laydown areas, access to the facility for workers, rigging, and work sequencing of equipment.
- ENVIRONMENT
  - Temperature extremes, working with flammable and toxic materials, noise, vibration, and the surrounding operation create unique challenges for retrofit work.

Study Findings - Success Factors

Primary Factor: SELECTING THE RIGHT PROJECT TEAM

- The single most dominant factor that influenced the project outcome.
- Team attributes include:
  - Being cohesive with good chemistry between the players.
  - Is flexible and can respond to changes, but is decisive.
  - Is formed early in the project and work together until the end.
  - The owner, engineer, constructor, and operator provide early input as a team.
  - Members have experience in retrofit projects, and usually have worked in the given plant.
  - The owner has a decisive project champion who wants the project to succeed.
  - Design and construction contractors are located on the site in proximity to each other for the project duration.
  - Operations provide a single point of contact and dedicated operator support.

Study Findings - Success Factors

Primary Factor: SELECTING THE RIGHT PROJECT TEAM

- "There is sometimes a tendency to assign inexperienced people to retrofit projects in a well meaning effort to give them experience. This approach may be misplaced given the potential negative impact; but if necessary, it is perhaps better to assign them initially to subordinate rather than decision making roles."
- "The people who comprise an effective retrofit project team must have an aptitude for the fast paced, hands on demand of that type of work. Good retrofit people are not necessarily good grass roots project people."

Study Findings - Success Factors

- Secondary Factors
  - Contract incentives used to improve performance of the designer, contractor, and labor.
  - Partnering agreements used with the engineer and constructor on appropriate projects.
  - Special procurement procedures – more liberal use of sole source, duplicate buying of lower cost materials.
  - The owner manages and understands the scope of work.
  - Contractor personnel have prior knowledge of the facility.
  - Pre-planning is used to help the team understand and develop common goals.
  - There is constant, open communications among the team members.
  - There is an adequate supply of resources and top management support for the project.

Summary

- Retrofit projects offer certain advantages over Greenfield with regard to facility optimization - make the most out of what you have.

- Retrofit projects also come with unique challenges that are different than for Greenfield projects. Understanding these challenges, anticipating their eventuality, and preparing for them in the course of the project development and execution, will increase the probability of a successful outcome.

Summary

Things to consider:

- Understand what you can reasonably expect from your facility retrofit.
- Invest liberally in the front end development through:
  - Process evaluation
  - Facility and Infrastructure evaluation
  - Code studies
  - Field Investigations
- Develop a detailed scope of work, carefully planned to address shutdown and tie-in opportunities while minimizing the impact to the existing operation.
- Coordinate with maintenance activities.
- Include the right amount of engineering and design to align with the schedule and shutdown constraints, as well as the availability of existing information.

Summary

Things to consider:

- Involve all stakeholders including operations, maintenance, engineering, and the contractor – as early as possible and throughout the construction
- Select appropriate contract methods for both the engineering and construction services. There needs to be flexibility in the terms and conditions to accommodate the unknowns without impacting progress – time is usually of the essence. Effective change management is important.
- Prepare in advance effective commissioning/startup and training plans.

Summary

Select the Right Team

- Cohesive with good chemistry between the players.
- Form the team early and keep it consistent through to completion.
- Needs to be flexible and adaptive to change, but decisive.
- Retrofit expertise and prior knowledge of the facility are key factors.