THE VALUE OF REPLICATION — RASGAS EXPERIENCE IN THE EXECUTION OF LNG TRAINS 3, 4, AND 5

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ABSTRACT

In 2001 RasGas awarded an Engineering, Procurement and Construction (EPC) contract to a joint venture of Chiyoda Corporation, Snamprogetti, Mitsui and Al Mana W.L.L. (CMS&A) for onshore facilities within the RasGasII Expansion (or RGX) Project. The basic building block to these projects was a technically-innovative LNG train, based on the Air Products and Chemicals, Inc. (APCI) liquefaction process that at that time was the world's largest capacity LNG train, capable of producing 4.7 million tones of LNG per annum (Mta). As part of the RGX Onshore project, RasGasII and CMS&A executed three similar LNG trains in rapid succession and three essentially identical LNG storage tanks over a 5 year period. In addition, the RGX Project portfolio included the 750 million cubic feet per day (Mscfd) Al Khaleej Gas Project which shares utilities and infrastructure with the LNG trains, as well as using the same front-end (gas treating) facility design. The Al Khaleej Gas Project is wholly owned by Exxon Mobil Middle East Gas Marketing Ltd. and RasGas executed the project on their behalf under a Services Agreement.

The RGX projects have been very successful, with all completed projects delivered on or ahead of schedule and within budget. This achievement was recognized in the award of "Best Project of the Year" by "Pipeline Magazine" and "Excellence in Project Integration Award" by the International Petroleum Technical Conference in 2005. Design and execution strategy replication have been key components to this success.

This paper will describe how and where replication has been applied on the project. It will also summarize the resulting benefits including:

- Reduced capital costs – 30% reduction in unit cost from Train 3 to Train 5.
- Reduced execution time - from EPC award to Mechanical Acceptance reduced from 36 months for prior RasGas Trains 1 and 2, to 33 months for Trains 3 and 4, and 28 months for Train 5.
- Continuously enhanced safety performance – already world leading safety performance was improved by 50% in the 4th year of construction, and a further 50% in the 5th year.
- Facilities quality – completion quality and initial facility availability improved with each project.

Finally, lessons learned relative to application of design and execution plan replication will be discussed.

BACKGROUND

RasGas, owner of Trains 1 and 2, is an incorporated joint venture of Qatar Petroleum, ExxonMobil, LNG Japan, Itochu and KORAS involved in the production, treatment, liquefaction and transportation of gas from the North Field in Qatar. In 1999, only six years after its inception, RasGas initiated operations from it first LNG train, followed less then 2 years later by start-up of the nearly identical LNG Train 2. A key strategy employed in those projects was to replicate the design and award multiple “projects” simultaneously to a single set of contractors. Given the success of the RasGas Trains 1 and 2 projects, this strategy was selected as the basis for execution of the ambitious RGX Project that was initiated via award of Front End Engineering and Design (FEED) contracts in 2000.

The RGX Project is expected to be finished in the middle of 2007 with the completion of the last component; LNG Storage Tank 6 and associated facilities. Along the way, the onshore project included the following components[1], all completed within budget and on or ahead of schedule:

- **LNG Train 3** which started-up in February 2004 and is designed to produce 4.7 Mta of “Rich” (higher-BTU) LNG
- **LNG Train 4** which commenced production in August 2005 and is designed to produce 4.7 Mta of “Rich” (higher-BTU) LNG
- **Al Khaleej Gas (AKG) Project** phase 1, which initiated operations in November 2005 with the capability to produce 750 Mscfd of domestic sales gas for local markets along with associated natural gas liquids (NGL) and shared fractionation, LPG storage and LPG loading facilities
- **LNG Tank 4**, a 140k m^3 tank which received first LNG in October 2005
- **LNG Berth 3**, which loaded its first cargo in January 2006
- **LNG Tank 5**, another 140k m^3 tank which received first LNG in March 2006
- **NGL Recovery from LNG Train 4** which started-up in February 2006, recovering NGL from LNG Train 4, and allowing Train 4 to produce a “lean” (lower-BTU) LNG to supply new customers in Europe and Asia
- **LNG Train 5**, which achieved LNG production more than three months ahead of schedule in November of 2006

Figures 1 and 2 show the various components of the RGX onshore project within the RasGas plant and the Ras Laffan City port area, respectively.

Feed gas to the RasGas facilities comes from Qatar’s vast North Field, the world's largest non-associated gas field. In early 2000, the state of Qatar was embarking on the

[1] The RGX Project also included execution of the Ras Laffan Helium Project. It is not discussed within this paper since it involved the use of a different (specialized) EPC contractor, and a unique design.

rapid and extensive development of the North Field in support of a strategy to become the world's leading manufacturer of LNG and a major regional gas supplier. To secure RasGas' position as a key contributor to the expansion of Qatar's gas business, RasGas devised an expansion strategy that strove for the lowest installed facilities costs and most efficient project execution while providing flexibility to respond to growth opportunities.

Exploiting economies of scale was one key strategy to driving down capital costs. Economies would be achieved by taking advantage of technology advances developed by RasGas shareholder ExxonMobil and key technology partners, in particular APCI and General Electric Company Inc. These efforts resulted in the design of the world's largest LNG train at that time. Further economies of scale were achieved through extensive facilities sharing, both within RasGas facilities and within the broader Ras Laffan Industrial City. In addition, there were significant technology advances employed in the offshore production facilities (including the world's largest offshore wells and shared large diameter gas pipelines) that contributed to economies of scale, as well as synergies derived from design and execution replication[2], but which are not the subject of this paper.

To be able to respond to new market opportunities required a strategy providing development timing and scope flexibility. This flexibility, as well as further significant cost reductions, were obtained via design replication and associated contracting strategies. In the sections that follow, the Contracting Approach implemented as part of the design replication strategy will be explained along with the Extent of Replication, followed by a discussion of the Value Achieved through Replication, leading to a review of the Challenges and Lessons Learned, which are already being applied in the next phase of RasGas' expansion in Qatar.

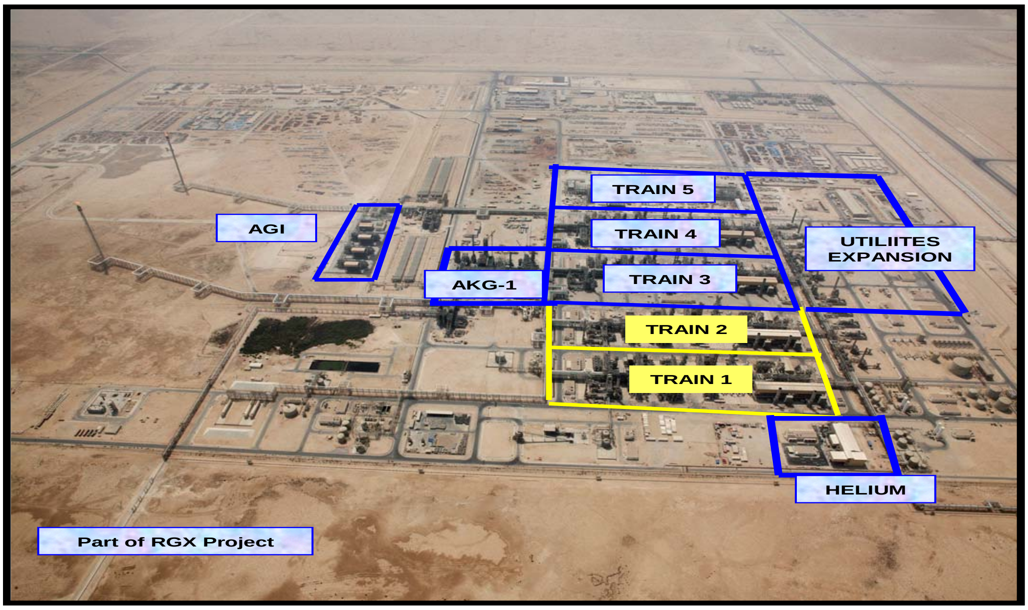


Figure 1: RasGas Expansion (RGX) Facilities on the RasGas Site

2. The RGX offshore facilities included four Wellhead Platforms, two 38" gas trunklines, and two 28" intrafield pipelines. J. Ray McDermott was the single EPC contractor for all the offshore scope, which enabled design and execution benefits similar to those experienced with the onshore facilities.

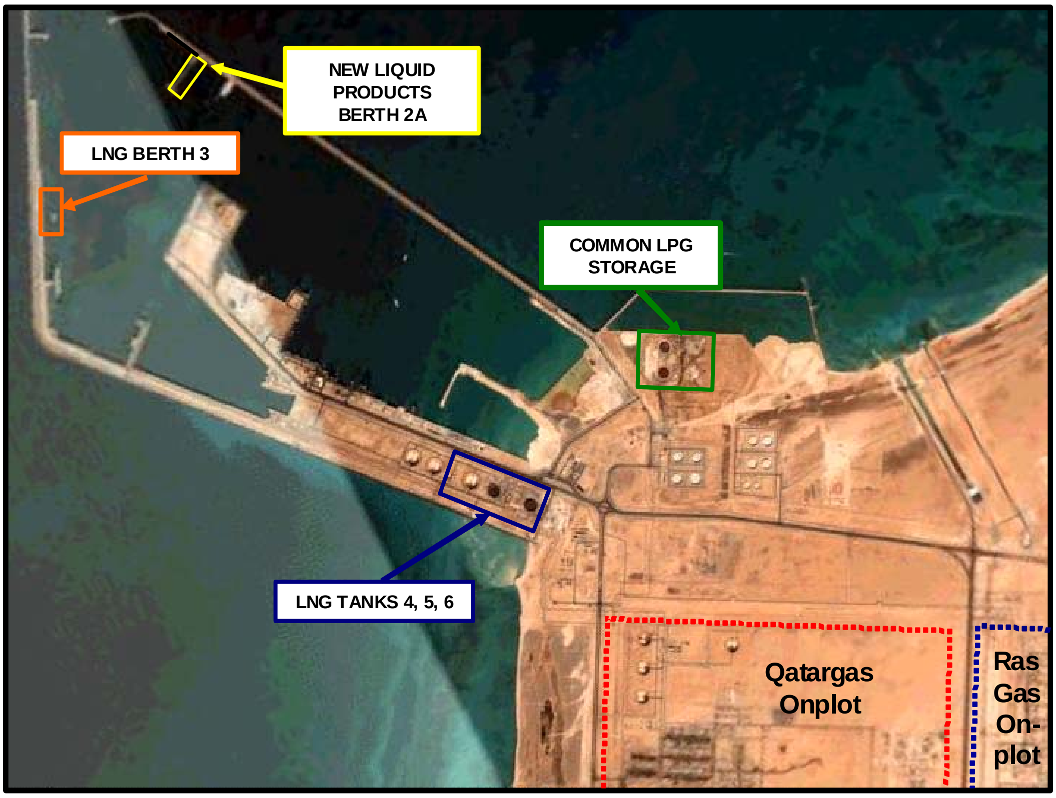


Figure 2: RasGas Expansion (RGX) Facilities within Ras Laffan Industrial City

CONTRACTING APPROACH

Following FEED studies in 2000, the engineering, procurement and construction of the RGX onshore project was competitively bid to a short list of international contractors pre-qualified as being capable of executing both the Base Scope and defined Option work, over a potential 5 year period. In April 2001, this contract was awarded to the joint venture CMS&A. The design and execution approach reflected a number of key strategies, including:

- Maximum replication of design, by both overall plant or component replication (as reflected in the original designs for LNG Trains 3 and 4 as well as LNG Tanks 4 and 5), and where that is not practical, process unit replication as reflected in the design of the Al Khaleej gas processing facilities. This is discussed further in the following section.

- The use of common facilities, where practical, to achieve cost reduction through facilities sharing and economies of scale. This strategy is evident in the design of the shared inlet facilities, common utility systems, and shared Offplot facilities (e.g., LNG and LPG storage and loading).

- Maximization of work to a single EPC contractor, in order to facilitate execution synergies and therefore cost and schedule reduction within the contractor's work scope.

The Base Scope included in the original CMS&A contract included:

- Pipeline receiving and slug catcher facilities capable of supporting four expansion plants (i.e., either LNG trains or the comparably sized gas sales plants).
- Inlet processing facilities (gas metering, condensate stabilization and deodorizing) capable of supporting two expansion plants.
- LNG Train 3, including gas sweetening, gas dehydration, mercury removal, liquefaction and LNG rundown piping.

LNG storage was not included, as the original 3 tanks installed with LNG Trains 1 and 2 were sufficient for handling the additional production.

Options within the original CMS&A contract, and ultimately executed, included:

- LNG Train 4, including additional inlet processing facilities
- LNG Tank 4
- LNG Berth 3

In order to capture further development opportunities arising from the dynamic market situation, RasGas elected to negotiate additional EPC work that was not anticipated within the scope of the original contract Options with CMS&A, as summarized below. The decision to negotiate this work was strongly influenced by the expected value of further design and execution plan replication.

- Al Khaleej Gas Project Phase 1. This project was included as an Option in the original EPC contract, but subsequent to contract award, the scope was expanded to include NGL recovery, fractionation, and the initial phase of the Common LPG Storage and Loading Facility. A separate EPC Agreement was negotiated and executed by Exxon Mobil Middle East Gas Marketing Inc with CMS&A. The modified plant retained as much replication (of "units") as practical with the LNG trains, and shares common inlet facilities and most utilities with the LNG trains.
- Al Khaleej Gas Project Phase 1B of the Common LPG Storage and Loading Facility. This project added two refrigerated LPG tanks and additional LPG rundown refrigeration facilities, based on replicating the design of the original tanks and facilities within the scope of Al Khaleej Phase 1.
- Addition of NGL Recovery facilities to LNG Train 4. This project replicated elements of the Al Khaleej NGL recovery facilities, wherever practical[3].
- LNG Tank 5, which was required to support the production of a second LNG product ("Lean LNG") from LNG Train 4 after inclusion of NGL recovery.

[3] For additional information on this project, please refer to the paper "Capturing an Opportunity - NGL Recovery from RasGas LNG Train 4", by Douglas C. Smith and Brett L. Ryberg, RasGas Company Ltd., GasTech 2005

- LNG Train 5, including NGL recovery and an additional BOG compressor in the Common LPG Storage and Loading Facility.

- LNG Tank 6, required to handle the additional volumes of "Lean LNG" production.

EXTENT OF REPLICATION

Replication was achieved in two basic areas; design and execution. At the highest level, the following facility components employed essentially duplicated designs:

- LNG Trains 4 and 5

- LNG Tanks 4 and 5 (including Boil-off Gas Compression and tankage flare systems)

- LPG Tanks and processing (refrigeration) facilities within the Al Khaleej Gas Common LPG Storage and Loading Facility

In addition, Figure 3 shows how design replication was employed at a lower (unit) level. As shown in the figure, inlet, gas processing and acid gas injection facilities utilized essentially the same design in all four plants (i.e., LNG Train 3, 4 & 5 and Al Khaleej Gas Phase 1). Liquefaction facilities were similar in all LNG Trains, but essentially identical in LNG Train 4 and 5, as were the NGL recovery units in those LNG trains.

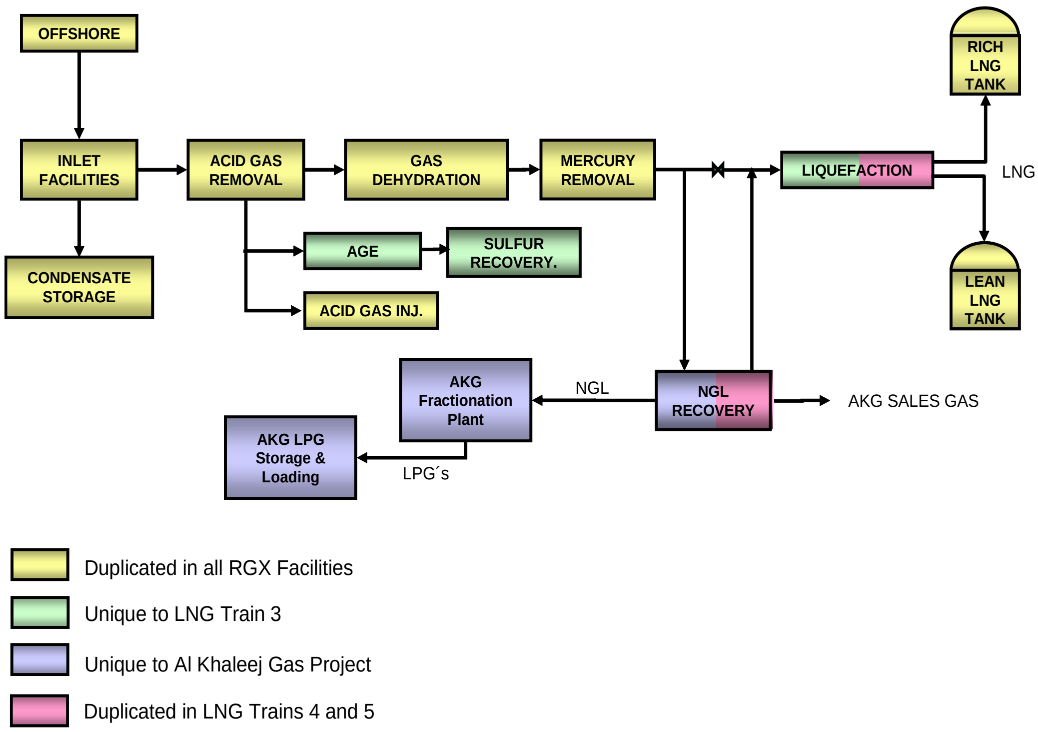


Figure 3: Design Replication in RGX Facilities

While LNG Tank 6 shares a common structural and mechanical design with the other two LNG Tanks, Tank 6 required a modified foundation in order to accommodate unique soils conditions.

Replication in the execution of the RGX onshore projects was primarily found within the EPC contractor's scope of work. Ways in which CMS&A took advantage of replication include:

- Re-use of engineering deliverables with minimal rework.
- A single Contractor project team was used throughout all of the EPC work. Emphasis was placed on continuity of personnel (at all levels in the contractor and sub-contractor organizations) throughout the 6 year execution of EPC work.
- Use of options in the initial LNG Train 3 purchase orders for additional identical equipment for potential future plants.
- Retention of key subcontractors and vendors for similar work and equipment throughout the project.
- Careful sequencing of engineering and construction activities to optimize demobilization of resources from one facility directly to another.
- Facilities to support construction (field offices, workshops, warehouses, casting yards, etc.) were shared throughout the extended construction period.

RasGas also took advantage of replication in execution by utilizing a single project execution team, with shared business and technical resources, to most efficiently manage the work.

VALUE ACHIEVED THROUGH REPLICATION

Design and execution replication resulted in significant benefits to the RGX onshore project. The value of this strategy to the project is summarized below in terms of cost and schedule reduction, as well as improvements in project safety and quality.

1. Cost Reduction

The impact that replication had on facility capital cost reduction is clearly illustrated in Figure 4 that shows the relative installed cost for RasGasII Trains 3, 4, and 5. The largest contributor to cost reduction was savings in the EPC contract cost, which benefited from replication through:

- Reduction in design effort. According to the EPC contractor's records, direct engineering man-hours for LNG Train 5 were about 30% of those expended on LNG Train 3.
- Reduction in subcontractor and equipment costs through minimization of subcontractor/vendor design work but also via enhanced purchasing power and control of cost escalation resulting from locking in commitments to future resources and equipment at the time of initial commitment.

- Productivity gains achieved through optimization of repetitive tasks, incorporation of lessons learned, and continuity of trained and experienced personnel.

Cost reduction through replication was also achieved in “owner” (RasGasII) costs. For example, RasGasII project management costs, measured as a percentage of project capital costs, decreased by 40% from LNG Train 3 to Train 5. Furthermore savings were seen in spares parts procurement (where equipment commonality resulted in less unique spares per project and economies of scale produced lower stock levels per equipment count) and other less tangible areas such as insurance, where underwriter familiarity with the RasGas execution team, practices, and facilities translates into less risk for the underwriters and better terms for the owner.

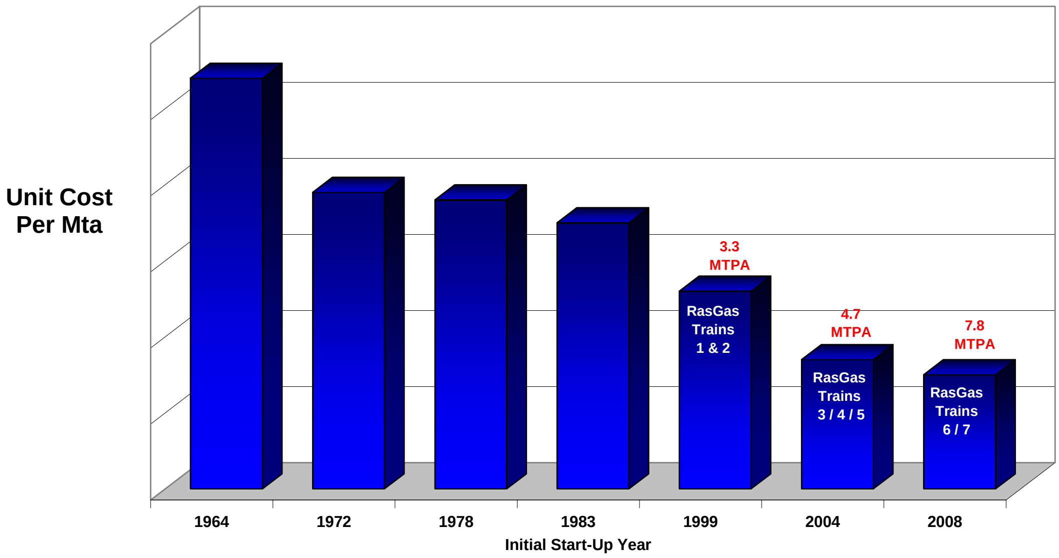


Figure 4: LNG Plant Unit Cost per Mta

2. Schedule Reduction

Design and execution plan replication facilitated schedule reduction in the following ways:

- Reduces critical path engineering activities by both contractors and vendors which allows for the earliest practical start of construction. This benefit can be seen in the reduction in the time from contract award to start of construction, as shown in Table 1 for certain key activities and tasks. Note, similar reductions in time to place purchase orders were not seen and this anomaly is addressed below under “Challenges and Lessons Learned”.

Table 1: Comparison of Start-date of Selected Activities/Tasks for Replicated Work

Activity/Task	Project Month Started		
	Train 3	Train 4	Train 5
Civil Work	2	1	1
Steel Structure Fabrication	2	1	1
Main Piperack Steel Erection	13	10	10
Process Sub-Station Construction	10	9	6
Underground Piping Installation	13	11	10
Aboveground Piping Prefabrication	13	13	11
Main Cryogenic Heat Exchanger Erection	22	19	16
Main Compressor Installation	21	17	14

- Supports optimized construction sequencing as design deliverables are more readily available from the start of construction. A key contributor to the fast and safe completion of the various facilities within the RGX onshore project was the ability to fully complete work in logical sequences starting with site civil, underground and excavation work and proceeding upward with minimal need to retain access for incomplete work below.

- Minimizes changes and their associated potential schedule impact, via incorporating any changes defined in prior projects into subsequent ones, from the beginning.

- Retention of key subcontractors throughout the project.

Figure 5 illustrates the reduction in EPC schedule that has been achieved with each successive Train, clearly showing the benefits of effective capturing of execution lessons and leveraging of design replication. This is most apparent on Train 5, which accomplished an EPC Award-to-Mechanical Completion duration of just under 28 months - believed to be a world record for large scale LNG trains.

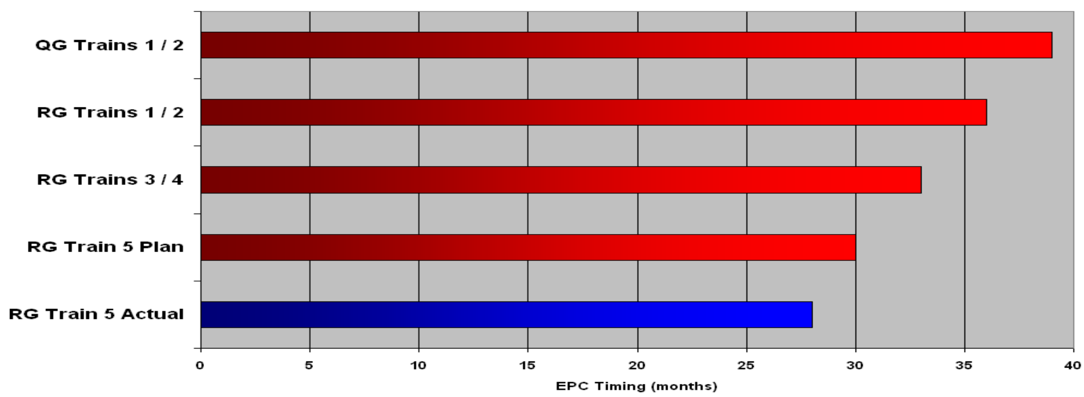


Figure 5: LNG Plant EPC Timing

3. More Effective Commissioning & Start-Up

The completion of multiple projects within a relatively short period of time allowed for the development of optimal processes and organizations for achieving safe and reliable commissioning and start-up, in the shortest possible time. Following the experience of LNG Train 3 start-up, RasGas opted to create a dedicated operations interface group, called the Operations Expansion Department (OED), to manage the commissioning and start-up process and act as an interface between project completion and reliable operation of new trains. This not only relieved the base operating organization from the potential distractions of new start-ups but improved the interface between the project and operating organizations. The OED team benefited from being a focused core team of experienced staff, starting up one facility after another. Processes for optimal sequencing and handover of completed systems were established and enhanced after each start-up. The results for the last major start-up, Train 5, confirmed the effectiveness of these processes when it started up in just 24 days. Figure 6 shows the actual days from facility mechanical completion to first LNG production for LNG Trains 3, 4, and 5, and the time from completion to first gas for the Al Khaleej Gas Project.

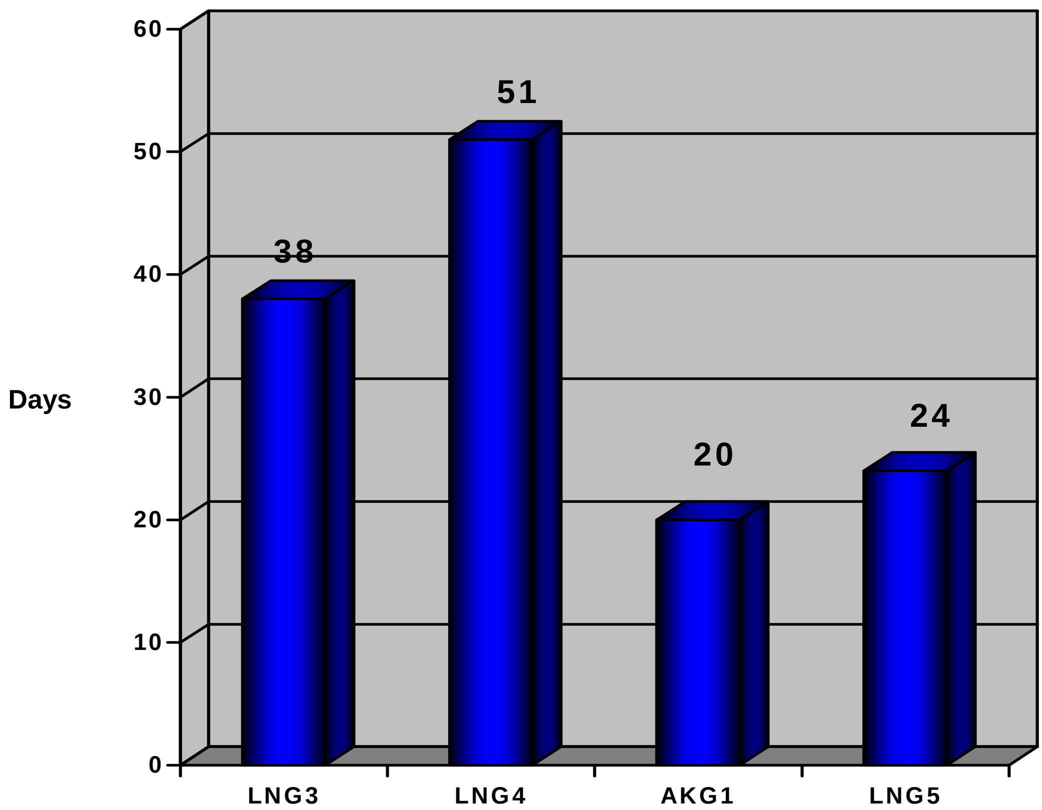
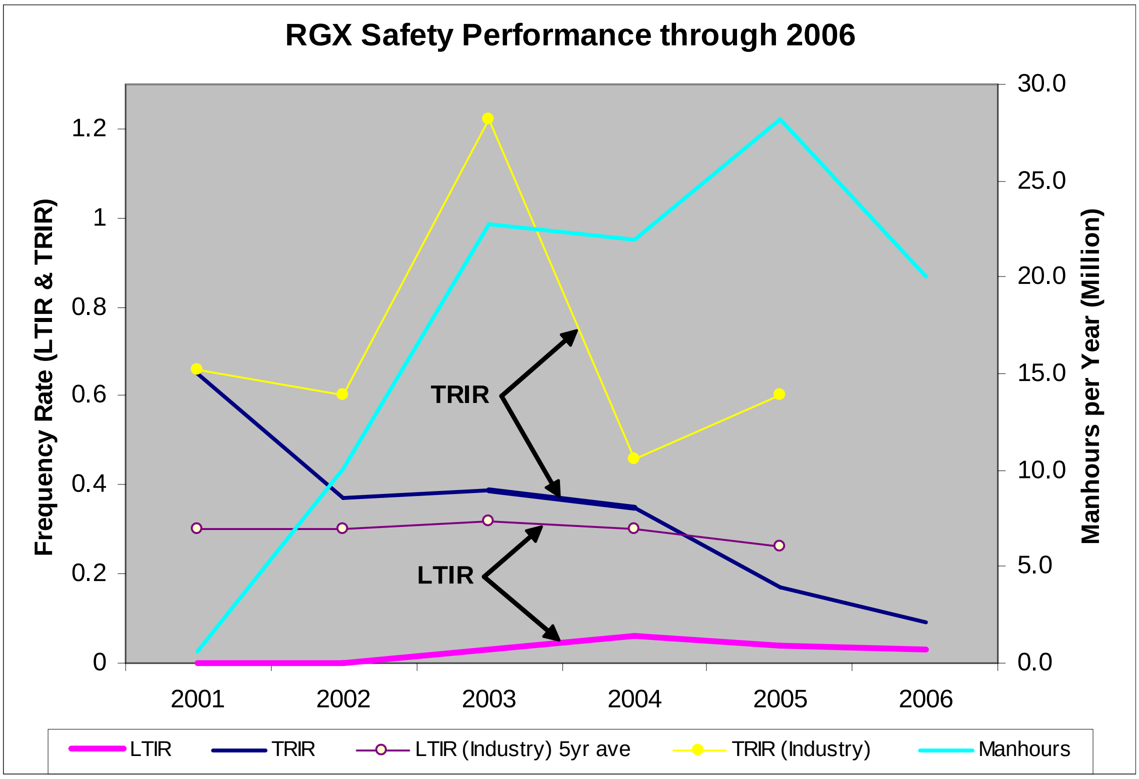


Figure 6: Comparative Time to Commission and Start-up Facilities

4. Continuous Safety Improvement

The RGX Project inherited a legacy of exceptional project safety performance from the execution of RasGas LNG Trains 1 and 2. From the onset of the work in 2001, the RGX onshore project matched that performance, but then went on to improve safety performance each year. After over 100 million man-hours worked, the result is a safety record that is among the best in industry. Figure 7 summarizes safety performance over the life of the project. RasGas, as well as every significant contractor on the RGX onshore project established corporate safety records during the execution of this work.



Notes:
1. LTIR = Lost Time Injury Rate or frequency per 200,000 man-hrs worked
2. TRIR = Lost Time Injury Rate or frequency per 200,000 man-hrs worked
3. Industry data is from the OGP (Oil and Gas Producers) for Middle Eastern region

Figure 7: RGX Safety Performance (LTIR and TRIR per 200,000 man-hrs worked)

The value of replication is best illustrated in how safety performance has continuously improved during the project. Using the Total Recordable Injury Rate (TRIR) as a measure, year-on-year safety performance improved 10% in 2004 as compared to 2003, was then reduced by one-half in 2005, and then reduced by about one-half again in 2006. The resulting TRIR for 2006 was over 6 times lower than the 2001 – 2005, 5-year industry average as measured by the Oil and Gas Producers, for the Middle Eastern Region. While RasGas' fundamental safety strategies and systems provided the basis for outstanding safety performance, a key feature of the execution replication strategy (Owner and Contractor project management team continuity) contributed significantly to the safety performance. This facilitated not only effective capturing of lessons learned but also encouraged the development of a true Owner-Contractor shared safety leadership and accountability culture. A key challenge to continuous safety improvement was the potential for complacency as similar tasks were repeated frequently over the 6 year construction program. This was addressed via continuous innovation in the safety program. New safety campaigns, reward programs, etc. were (and continue to be) frequently introduced.

5. Continuous Quality Improvement

As the world's first LNG train to produce 4.7 million tons of LNG per annum, RasGas Train 3 offered a wealth of learning in both design and project execution. Given the similarities between Train 3, subsequent LNG Trains 4 and 5, and the Al Khaleej Gas project, it became obvious that both the RasGas and Contractor project teams needed the capability to rapidly capture, assimilate, action, and feed-forward these learnings into upcoming projects. Furthermore the continuity of the project teams provided a unique opportunity and environment in which to implement continuous improvement.

Continuous improvement was therefore implemented from the onset of the RGX onshore project, and continued to evolve throughout project execution. Key elements of the RGX continuous improvement process are summarized below:

- The RasGas project team developed an electronic Continuous Improvement Data Base (CIDB) and supporting CI Process. The CIDB allowed a convenient way to capture not only Lessons Learned, but also Warranty Claims and Technical Queries submitted by the RasGas operating organization. As of the end of 2006, over 1000 individual items had been captured in the CIDB. The supporting CI Process includes procedures for reviewing items submitted to the CIDB (to ensure relevance and value), a standing committee (including representatives from the project and operating organizations) to assign and steward follow-up responsibilities, and automated reporting to promote close-out and provide CI Process performance indicators to management. The CIDB and supporting CI Process has allowed for effective real-time capture of lessons learned during each project phase, and provides the capability to easily and effectively disseminate solutions for early, and often immediate, implementation in future phases or projects.

- The use of professionally facilitated workshops at various milestones to define areas for improvement and associated recommendations, as well as best practices to be replicated. To date, over 15 such workshops have been conducted, starting with multiple workshops to capture lessons learned from the execution and initial performance of LNG Trains 1 and 2, workshops focusing on design and construction execution, mechanical completion, and operations interface, as well as workshops with selected key suppliers (such as General Electric). With the exception of the initial Trains 1 and 2 feedback workshops, the results of which were fed directly into the RGX FEED work, the findings from each workshop are captured and stewarded within the CIDB.

- The EPC contractor maintained a parallel "Lessons Learned" list addressing not only aspects of detailed design and construction for which the Contractor was primarily responsible, but also capturing a list of every change implemented in the facilities along with a plan for how each was to be addressed in the subsequent replicated or similar facilities. Where practical, previously agreed changes from a project were included (by negotiation) up front into subsequent, replicated, projects.

Continuous quality improvement has contributed to both the cost and schedule reductions discussed previously. In particular, RasGas believes that enhanced quality is a key reason for the reduced time required to commission and start-up replicated plants. The value of continuous quality improvement can also be illustrated by various performance indicators such as those included as Figures 8 – 10, and discussed below:

- Figure 8 compares all CI items between Train 3 and the subsequent Train 4 and Al Khaleej Gas projects. This figure most dramatically illustrates the success of the CI program. There were 252 total warranty claims (WCs) submitted and actioned on LNG Train 3. This figure was reduced by over 75 percent to 61 total warranty claims on Train 4 and to only 19 on the Al Khaleej Gas project[4], a success largely due to the effective implementation of Train 3 lessons learned into future projects. Similarly dramatic reductions are evident in Lessons Learned (LLs), Technical Queries (TQs), and Other Improvements (OIs). Note, Train 5 data is not reported since it was only recently completed and CI items may yet be submitted.

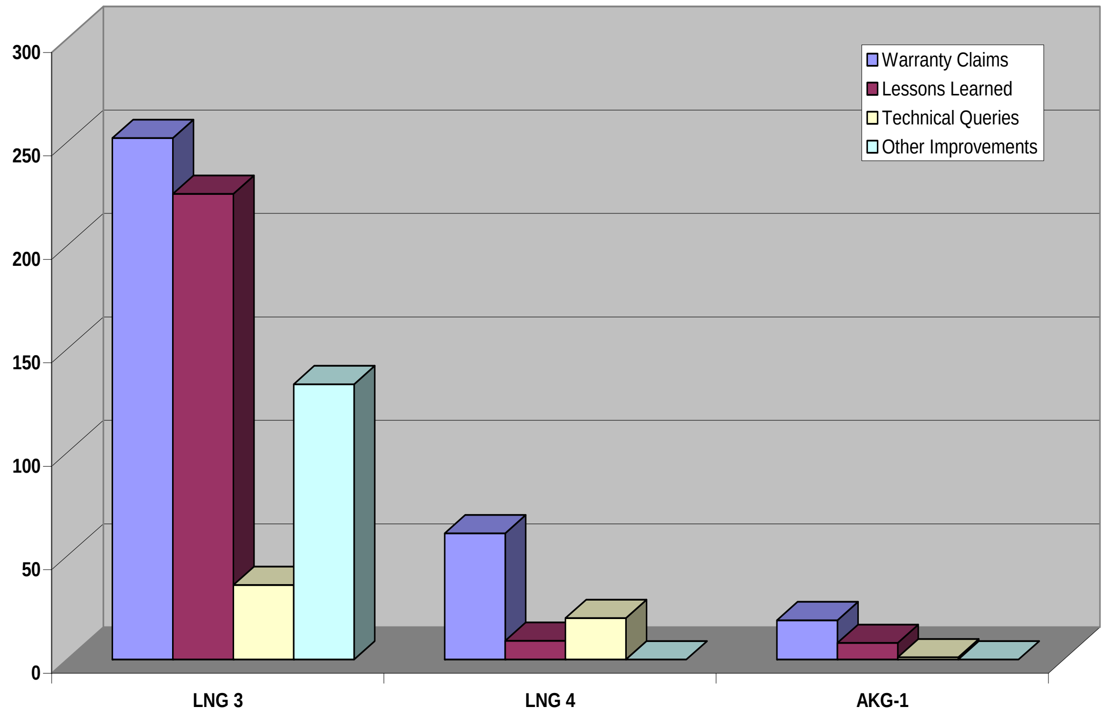


Figure 8: Comparison of CI Items across Projects

- Figure 9 compares the individual "Punchlist" items, or list of non-critical work to be completed by the Contractor at the time of facility mechanical completion, for the three LNG Trains. This list is prepared jointly by the RasGas Project Team and Operating organization. The 95% reduction in Punchlist items from Train 3 to Train 5 is a clear indication of improving quality.

[4] Scaled for project size (AKG is approximately 40% smaller than LNG Trains 3 / 4 / 5), this number equates to approximately 32 warranty claims for an LNG-sized project, a reduction of 48% versus Train 4.

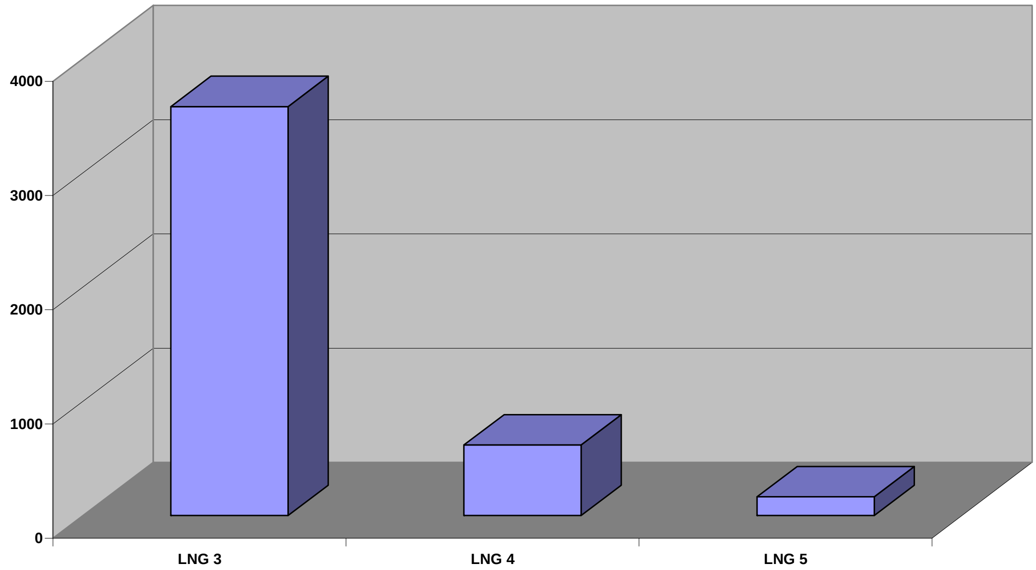


Figure 9: "Punchlist" Items at Time of Completion

- Finally, Figure 10 further illustrates the successful application of lessons-learned in dramatically reducing the number of flange leaks on plant start-up. This number was reduced from approximately 300 individual start-up leaks on LNG Train 3, to roughly 40 on Train 4 - an improvement of 87 percent. LNG Train 5 successfully achieved zero start-up leaks via the implementation of a dedicated, joint RasGas and Contractor, "Zero-Leak Team", which was specifically charged with achieving this goal.

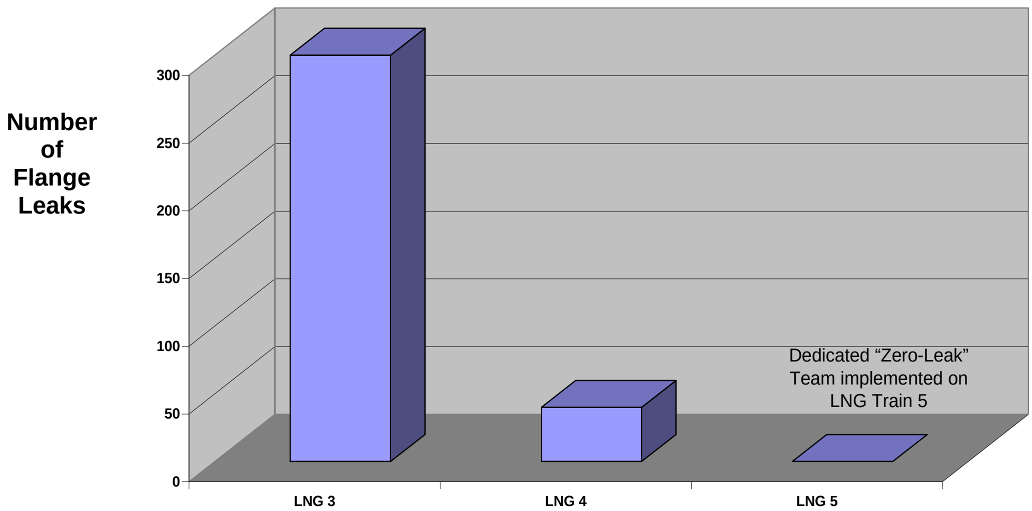


Figure 10: Comparison of Flange Leaks during Start-up

CHALLENGES AND LESSONS LEARNED

Implementing design replication to achieve maximum value as described above introduces a number of challenges to project execution and management. While none of these are unique to projects using replicated designs, each of the challenges discussed below, along with associated lessons learned, is more profound in design replication projects.

1. Management of Change

Controlling change is often cited by project managers as one of the most difficult aspects of their job. Meanwhile effective change management is frequently identified as a key factor to the success of projects. In replicated projects, management of change has a new dimension that increases the challenge to project management. Put simply, the value of design replication is quickly eroded by the introduction of changes from one project to the next. The loss of value occurs most obviously in the contract price for replicated projects, but 'value' loss occurs in all the areas discussed previously above.

It is therefore particularly important to introduce strict discipline in change requests, assessment and approval. On the RGX project, change was strictly controlled through formal procedures involving various levels of approval as a function of the potential impact to cost and schedule. In the negotiation of EPC agreements for replicated project components, no changes were incorporated in the EPC scope unless they were previously incorporated in the original project (i.e., via Change Order). This discipline was essential to negotiation of a fair price and schedule for the replicated facilities.

2. Equipment Borrowing

When implementing projects within a "brown field" environment (i.e., within or adjacent to existing operating facilities), there will likely be pressure from a company's operating organization to provide resources to respond to critical plant needs. Typically requests to "borrow" are associated primarily with materials, bulks and labor/construction resources. In the case of replicated designs, requests will also extend to borrowing of engineered equipment and specialty items, as these will be common between the previously completed (and operating) facilities and those under construction. During the execution of the RGX project, numerous such requests were received and mostly accommodated in order to serve RasGas general interests (i.e., improved performance and availability of operating facilities). To ensure that any impacts of such borrowing to the projects were managed, the project team established a formal process for approving such requests, which included confirmation of equipment return or replacement dates, assurance that replacement dates were compatible with construction schedules, and rigorous tracking of return progress and commitments.

Another implication of equipment borrowing is that sparing on the last replicated project will require a higher degree of attention as subsequent projects are not available to borrow from. On the RGX project, a comprehensive assessment of all previously borrowed equipment was conducted in order to define additional sparing requirements for the LNG Train 5 project.

3. Timely Mobilization of Resources

Each additional "project" added to the scope of the RGX onshore projects was executed by the same basic Contractor and RasGas project teams. Staffing plans for the new "projects" relied partially upon presumed availability of existing resources, and partially upon mobilization of additional resources. In practice both the release of existing resources and the mobilization of new ones was delayed. This probably results from the ability, within a matrix-organization structure, to delay release (which would not be tolerated if the released resource was committed to a separate team or contract) compounded by the perception that the team is already “on the ground” and therefore mobilization of new resources is not as critical.

Despite these perceptions, the delay in staffing-up for new work impacted initial work productivity. It is not apparent in the time to initiate construction work (see Table 1) but it did result in procurement delays. In some cases the placement of purchase orders for replicated equipment was actually delayed relative to the initial project.

4. Risk of “Presumed” Replication

In practice, replication can occur at many levels, starting with design, and potentially including vendor, sub-vendors, material suppliers, sub-contractors, etc. In the implementation of quality assurance and control procedures on the RGX onshore project, more than once the project management team assumed incorrectly that a component was fully replicated, only to determine that there were changes which impacted quality introduced by different vendors, sub-vendors, material suppliers, etc. To address this, the value of replication was de-emphasized in RasGas’s quality criticality rating process, and confirmation that replication met the expectations implicit in the quality plan, was added to the engineering and procurement surveillance programs.

SUMMARY

As a project execution strategy, replication has been successfully applied in both the original RasGas LNG Trains 1 and 2 projects and more extensively within the RGX Project. Keys to success involved not just continuity of contractors, and company’s project management team members, but also development and maintenance of cooperative, effective and amicable relationships with those contractors and other key participants (e.g., vendors) in the projects.

The success of the RGX Project and lessons from the value of replication have served as a springboard for even larger LNG expansions already underway in Qatar. Both RasGas3 and sister QatarGas companies are currently building six of the worlds largest LNG trains while employing the same contracting and replication strategies that have been tested and proven by the RGX Projects. RasGas is confident that these strategies will continue to deliver superior value to our shareholders, and showcase Qatar as the premier LNG supplier in the world.

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