Enabling Affordable and Reliable Delivery of Low-Carbon Fuel for the Energy Transition

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Introduction: Liquefied Natural Gas Is a Strategic Component of the Global Energy Supply

Natural gas is uniquely positioned as a transition fuel to support an affordable and secure energy transformation through displacement of coal power electricity generation and supplementing renewable electricity.

Ideally, natural gas is transported via pipeline. If that is not feasible, natural gas is compressed into a liquid for ready transport to alternative delivery locations. Safe, reliable and environmentally sustainable delivery of LNG to consumer markets requires investment in new and expanded infrastructure, continuous process improvement, increasingly robust supply chain networks and collaboration between members of the value chain. This can be achieved by applying digital solutions across the asset lifecycle.

A Variety of Obstacles in Place

A New Global Gas Order

The LNG market is poised for continued near-term growth, fueled by market demand in Europe and Asia, the beneficial outcome of displacing coal fired electricity generation with natural gas and petrochemical demand. McKinsey, for example, recently reported that the global demand for LNG is expected to increase as much as 5% per year until 2035.[1] Preventing a shortage in supply requires additional investment in both liquefaction and regasification facilities; however, conflicting energy transition scenarios and evolving regulation is a risk for future market expansion and may deter investment. Capital discipline and supply chain agility will be required to entice the additional investment needed to meet forecasted LNG demand.

Limited Responsivity to Market Dynamics

Looking to the future, the global LNG market is likely to be subject to substantial geopolitical and price risk. Inflexibility of long-term contract commitments, current infrastructure constraints, and the cost of LNG storage and transportation are a few of the challenges the LNG industry must overcome to be more responsive to market dynamics. To address these challenges the industry needs to invest in infrastructure and improve collaboration across the value chain such that volume can be best allocated to meet demand and effectively optimize the system.

Personnel Limitations–A Double-Edged Sword

According to McKinsey, LNG projects have been hit with a 10-20% cost escalation due to raw material pricing, increased labor costs and rising equipment charges.[1] As such, the market is reliant on long-term supply contracts to reduce project risks between owners and suppliers. Acceleration and improved feasibility of capital projects with data-centric engineering is crucial to offset the shortage in skill engineers and enable continued collaboration across the value chain.

In addition, upon becoming operational natural gas and liquefication plants often run with limited resources. Advanced sensors and automation technology to improve operational efficiency and site agility are a valuable supplement to boots on the ground.

LNG Production Is an Energy-Intensive Process

One of the primary challenges in the LNG industry is managing high energy demand of the cryogenic multi-stream heat exchangers, which are central to the gas liquefaction process. These heat exchangers are complex due to their geometry, exposure to external weather and temperature variables and the multiple streams flowing through them. Improved operation of these units presents a significant opportunity for margin improvement as energy costs represent the largest controllable cost to an LNG operator, with a typical plant consuming 10% of its own feed.

Enhancing site run rates based on the thermal efficiency of these trains, with digital solutions and advanced sensors, can drive overall profitability, optimize energy demand and provide a substantial pathway for carbon abatement.

Feed Variability

Variability in natural gas inlet feed composition and impurities make it imperative to have a robust pretreatment program. Common impurities include:

- **Mercury:** Managed with a mercury removal unit (MRU) to minimize potential for corrosion on the aluminum heat exchangers downstream of the pretreatment plant.
- **CO_2 and H_2S:** Gas sweetening commonly via amine treatment facilities or membrane technology is done to prevent corrosion and meet pipeline quality and safety standards.
- **Water:** Dehydration of the gas feed prior to the cryogenic process is necessary to prevent the water from freezing and affecting load capacity.
- **Higher molecular weight hydrocarbons:** Methane is liquefied at -260°F, but C5+ linear alkanes and aromatics such as benzene have high freeze points and can cause a fouling issue resulting in reduced capacity if not removed prior to the cryogenic process.

In the design phase of a project, understanding the purity and sources of the natural gas prior to entering the cryogenic process is critical to defining the best plant configuration, technology, and procedures to prevent load disruptions and reduce capital requirements. Digital twins can help to simulate and predict the effects of feed quality on operations and prioritize corrective action.

During operations, the agility to respond to feed quality variability is imperative to reduce the operating costs of pretreatment and liquefaction. Assessing the feed quality on the front end enables engineers to determine the most cost-effective means of managing the process streams, thereby improving responsiveness to potential upsets such as an upstream liquid plant going offline or increased water content in the feed. The ability to respond to feed quality changes with Advanced Process Control (APC) can improve the consistency of operations and maximize throughput.

Evolving Policy Around Carbon Intensity

Calls to action to transition away from fossil fuels, increase renewable energy production and improve energy efficiency are increasing. As are the policies, regulations and commitments to do so. While natural gas itself in the near term has been given a bit of a reprieve, to maintain its benefit increased weight is being placed on producers to limit CO_2 and CH_4 emissions during the production and transportation of LNG. Industry leaders must plan strategically to lower the carbon intensity of their operations in advance of increased future regulations. This can be accomplished via improved site efficiency, optimized energy consumption, electrification of assets with renewable energy, blending natural gas with hydrogen, leak detection and prevention and carbon capture technologies.

Key Drivers to Overcome Industry Headwinds

Industry headwinds are increasing and activities to offset them can be summarized in three key strategic areas. These are all critical as any shortfalls can lead to a loss in profit—and potentially impact safety and environmental compliance.

Ensure Reliable Production and Distribution. Establishing a robust supply chain entails strategic action on capital efficiency and optimal designs for greenfield and brownfield liquefaction and regasification plants, and maintenance and upgrades of equipment to ensure the most efficient use of resources over an asset's lifecycle.

Reduce Emissions and OPEX with Improved Energy Efficiency. Improving plant thermal efficiency on a real-time basis is fundamental to lowering energy use and emissions reducing costs and aligning with environmental sustainability goals.

Optimize Liquefaction and Safety Performance. Ensuring plant performance and achieving production targets is another key area. This involves fine-tuning operations and maintenance schedules to ensure that output meets the desired standards of quality and quantity maximizing profitability and customer satisfaction.

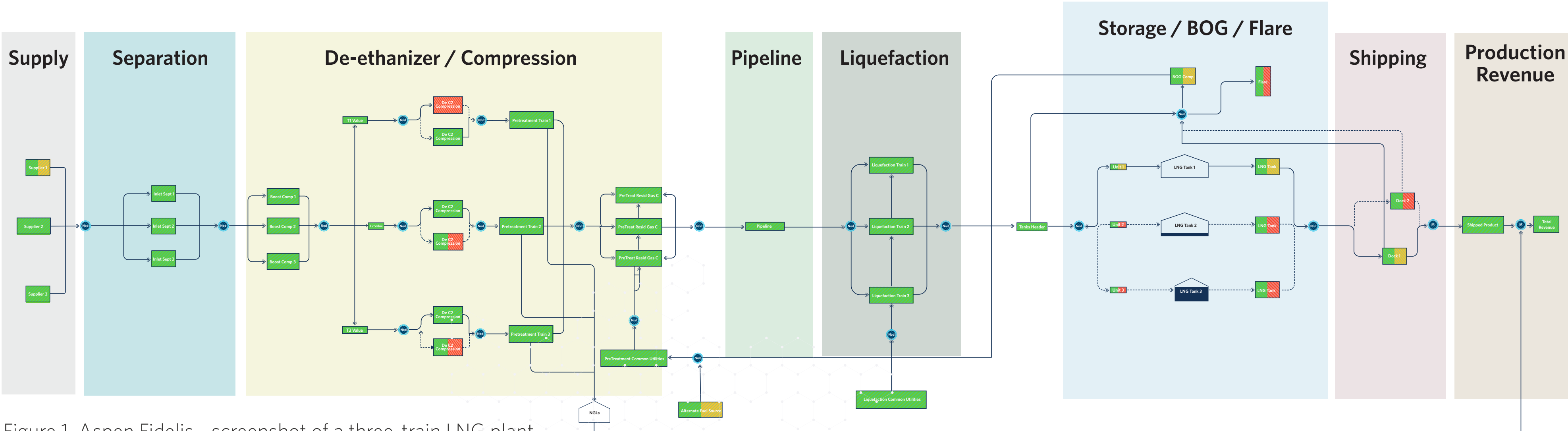


Figure 1. Aspen Fidelis - screenshot of a three-train LNG plant.

Building Digital and Predictive Analytics Capabilities to Enable Long-Term Financial Success

Each of these key initiatives is interconnected; deficiencies in any one of them can have a cascading effect on the others. Digital technologies can be leveraged to determine the optimal balance between critical performance metrics and sustainable production.

Ensure Capital Efficiency and Optimal Design for Greenfield and Brownfield Liquefaction Plants

LNG global trade reached 404 million tonnes in 2023 and the market is forecasted to continue to grow at a compound annual growth rate (CAGR) of 3.6% between 2023 and 2040.[2] As of mid-April 2023, 997.1 MTPA of aspirational liquefaction capacity was in the pre-FID stage of project development to support this growth potential.[3] In order to remain competitive in this environment, engineering companies and their partners are leveraging demonstrated modular designs to accelerate project schedules and maximize return on capital investments.

Embedding digital technology and insights from conceptual design to FID allows key stakeholders to analyze technical and economic feasibility. Projects can be delivered in a greener, safer, and more efficient manner by enabling engineers to evaluate a number of design alternatives, decrease design time and execution, optimize performance and efficiency.

Improve Investment Confidence with a Holistic Approach to Reliability, Design and Operations

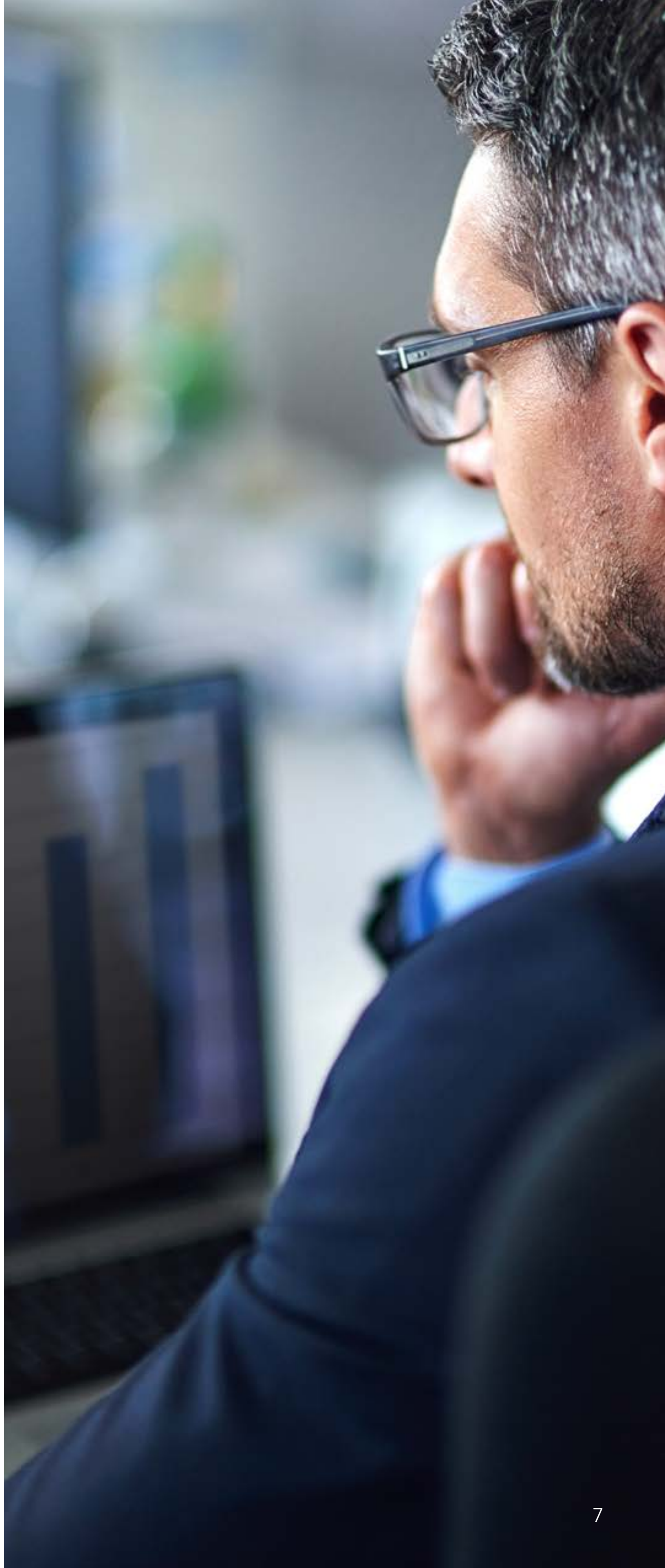
The profitability of a project, regardless of size, can be improved with system-wide performance simulation. This quantifies the business impact of planned and unplanned events along a specified timeframe by taking into consideration internal and external variables that may affect overall return. These variables include the asset connectivity in the system, material and energy flows between assets, operational logic, storage elements, volatility in weather, supply, demand prices, shipping and more. This diligence allows for a primary understanding of financial risks and the opportunity to evaluate alternatives for improved long-term viability and performance guarantees. Key benefits of this system-wide performance analysis include the following:

- **Increase probability to achieve business targets** (e.g., production throughput, revenue, levelized costs, NPV, etc.)
- **Identify challenges** (assets or events) in the design and mitigate risk
- **Compare different technologies and/or system configurations**, and determine which is the best based on a quantitative analysis
- **Improve availability and utilization** of the overall system
- **Generate a digital representation** of the system that can be used later on for continuous improvement

The outputs from system-wide performance simulation help identify trade-offs between performance, cost and risk and quantify the expected variability in KPIs in the early stages of a project and improve investor confidence overall.

Embed Economic Considerations and Optioneering into Asset Designs

In a project's design phase, digital tools are essential for engineering and cost estimation, enabling techno-economic feasibility studies, accelerating projects with optimized CAPEX/OPEX and ensuring a balance of safety and production. The Performance Engineering solution offers system-wide simulation using equipment models. Engineers can utilize highly accurate, off-the-shelf process simulators for gas processing and liquefaction plants.[4]



Key benefits of simulation at the design phase include:

- **Drive down the cost of production and boost operational efficiencies** by simulating the process behavior under multiple scenarios, sizing equipment and estimating costs.
- **Improve energy efficiency** by analyzing design, equipment configurations and the impact of ambient temperature and weather conditions.[5]
- **Achieve safe operations** by accounting for overpressure protection and evaluate alternatives to debottleneck existing relief networks.

> **Rate-based modeling can describe a complex behavior correctly and that's the reason we can reliably and comfortably use that for the design.**
>
> **- Paul Mathias, Senior Fellow and Technical Director, Fluor**

FLUOR®

Case Study: Rate-Based Modeling of Gas Drying Using Sulfuric Acid[6]

Fluor used rate-based absorption modeling tools to simulate and design a complex gas dehydration column with sulfuric acid (H_2SO_4). The complexity of the equipment is derived from the design, which requires three pump-arounds to maintain the H_2SO_4 concentration at the top of the dehydration column. These simulations proved to be a valuable tool, enabling estimation of the column height and diameter, packing type and size, and accurately calculated pump-around rates and other variables. The simulation also provided insights into the absorber, where rate-based absorption simulations correctly described the behavior, with results that can confidently be used in designing the system. This ultimately required accurate thermodynamic and physical properties models as well as adequate equipment correlations, which were provided by the process simulation solution.

The model shows high accuracy of water absorption in acid when compared to plant data, falling within a 20% confidence range and showing superior estimates relative to traditional models. The traditional models use theoretical trays with stage efficiency and are not sufficient for design since they show a much lower water concentration in the dry gas than what is really being absorbed.

Petrofac

Case Study: Petrofac Improves Process Design Accuracy by Debottlenecking Gas Processes Increasing Capacity by 20%

Petrofac was asked to determine the most cost-effective and efficient way to increase a gas plant's capacity by 20%. Leveraging AspenTech's engineering portfolio, Petrofac was able to validate the technical and economic feasibility of multiple process improvement schemes, leveraging rigorous heat exchanger modeling with the broader process simulation to understand the overall impact and determine the most cost-effective pathway to meet the target increase. This exercise found that it was not necessary to add a new train and that the project goal could be met by replacing three of the existing exchangers with more appropriately sized models. This revamp allowed the site to meet 20% increased capacity requirements, with limited CAPEX and with a one-month payback period.

> **"The rigorous Aspen Exchanger Design & Rating models available within Aspen HYSYS® have enabled us to solve debottlenecking problems in a way not otherwise achievable.**
>
> **– Sr. Manager, Petrofac**

Improve Capital Efficiency by Understanding Costs at the Granular Level

Cost estimation software can accelerate project execution and increase the accuracy of capital cost estimates from conceptual design to detailed engineering. This tool can effectively determine the best configuration

of heat exchanger trains and compressors by assessing benefits (e.g., thermal efficiency, capacity, availability) and costs (e.g., capital, maintenance, energy requirements) for projects in the design phase as well as for equipment re-vamps. Once complete, the chosen configuration can be streamlined for detailed cost estimation and process review, accelerating project timelines and facilitating coordination with contractors for equipment installation.

CHINA HUANQIU CONTRACTING & ENGINEERING CORP.

Case Study: Dynamic Simulation of a Natural Gas Liquefaction System

China Huanqiu Contracting & Engineering Corporation (HQC) is an affiliate of China National Petroleum Corporation (CNPC), one of the largest integrated energy groups in the world. HQC has a proprietary natural gas liquefaction technology called the Dual Mixed Refrigerant (HQC-DMR). This technology, which makes use of two refrigeration cycles, two mixed refrigerants and plate fin heat exchangers, is adaptable to a wide range of feed and environmental conditions and already in operation at the Ansai (500K Mt/yr) and Taian LNG Plants (600K Mt/yr).

HQC evaluated the feasibility of scaling this technology to 3-5M Mt/yr using dynamic simulation technology to ensure reliability, improve operability and maximize safety and profitability. This was accomplished by leveraging existing designs and simulations from the Taian Plant for the evaluation. The results from dynamic base case models were in line with the design data. The dynamic model also proved to be robust, by doing an interference test and confirming the model recovered back to steady state conditions.

In addition, the following four key features were evaluated to ensure safe startup, shut down and maximum efficiency:

1. **Front-end simulation of the natural gas separation system** resulted in a recommendation to add a reflux drum temperature control loop and remove the PCV of the reflux drum.
2. **The liquefaction unit cold start-up was dynamically modeled** reducing the start-up time of the plant.
3. **Verified the anti-surge period** during compressor emergency shutdown to be within the acceptable range of less than one second.
4. **The control scheme was analyzed and optimized**, improving the operability of the process system.

These opportunities to increase performance in the early stage of the asset lifecycle found the startup time of the plant can be shortened by six hours; resulting in equivalent savings of $200K USD for a 1M Mt/yr LNG plant.

Enhanced Visualization Capabilities with 3D Conceptual Layout

3D conceptual models can be integrated with front-end design and cost estimation to ensure constructability, identify the optimal layout, leverage modular or repeat designs and accelerate optioneering. This revolutionary tool enhances a user's ability to ingest data, evaluate modifications and prioritize alternative concepts. **ExxonMobil** leverages these tools to decrease concept selection time from months to weeks and drive cost savings.

Develop Proactive Strategies to Minimize Future Variance in Facility Performance

The capacity of a liquefication plant is often limited by equipment constraints from the compressors and cryogenic multi-stream heat exchangers. Implementing a robust protocol for managing events that would adversely affect these asset's performance and training operators to respond effectively to dynamic process changes can lead to a reduction in potential for safety incidents and increase production.

Case Study: Evaluating the Impact of Cooling Water Temperature Variations on LNG Production

Sonotrach's Arzew GL1Z LNG terminal entails six trains and has a total capacity of 8 Mtpa. The site uses a wet liquefaction process to convert NG to LNG, relying on seawater as the primary cooling agent. A specialized coolant mixture (MCR) extracts heat from the NG and is cooled by propane, which is cooled in turn by seawater in an open circuit. While this system works effectively at moderate temperatures, production rates significantly decrease during summer when seawater temperatures exceed 24°C. This decline presents operational challenges and impacts LNG output.

Sonotrach used simulation tools to investigate the cause of this decline and explore solutions to maintain optimal production throughout the year. A preliminary simulation of the propane loop, scrub tower, MCR loop and liquefaction section was conducted to replicate the impact of the seawater temperature increase on LNG production and validate the models.

Finally, a study was conducted to evaluate the impacts of a 24-28°C seawater temperature increase on LNG production rate. As a result, it was found that as sea water temperature increases, part of the propane inventory does not condense, remaining in a vapor state. This reduces the amount of propane available for pre-cooling of NG at the heat exchangers and cooling of MCR, resulting in a decreased rate of the NG flow and consequently a reduction in the quantity and volume of LNG produced. Conversely, a significant decrease in the amount of C_3 evaporated in the propane accumulator was observed following an increase in the pressure of discharge, close to the compressor stop threshold.

A prescribed discharge pressure at the propane compressor was identified to offset the increase in sea water temperature during the summer season. This setpoint is specified to reduce the amount of C_3 evaporated in the propane accumulator and therefore reduce the continuous booster to the propane loop and increase the production rate of the process trains during warmer months.

Drive Operational Excellence with a Sitewide View of the Plant

The prime objective of an operational liquefaction plant is to minimize energy consumption and maximize production while operating at changing product demand rates, feed qualities and under varying ambient temperature and weather conditions.

Improve Production Performance with Digital Twins

Process digital twins enable optimized production, being highly accurate replicas of the physical plant at both a molecular and sitewide level. Digital twins can be used to drive higher production performance and collaboration across siloes. Offline models allow a company to run simulations, identify and troubleshoot bottlenecks and optimize asset performance with "what-if" analyses in a risk-free environment. In addition, this solution can accurately model critical equipment such as compressors and cryogenic heat exchanger trains and drive better understanding of the impact of external temperature and weather conditions on efficiency.

Data-driven decisions can be made even more feasible by combining first principles models with real-time plant operational data to optimize the assets online. These rigorous models can dynamically update scheduling plans for higher fidelity and map the operations more effectively to external constraints.

This solution has been effectively integrated into ConocoPhillips' Optimized Cascade® Process, under the product called OCP Navigator, which uses customized equation-oriented simulations to optimize a liquefication plant online.[7]

Coupling digital twins with integrated safety and control systems can be used to improve overall site safety and further derisk operations.

Empower Operations with Advanced Process Control (APC)

APC technology can significantly enhance operational efficiency, yielding maximum product output at minimal costs and drive more autonomous operations. This helps to achieve new performance standards, improve quality control and minimize the need for operator intervention by improving the ability of an asset to respond to external variables automatically and in a timely manner.

Case Study: Achieving a 1-2% Increase in LNG Production with Advanced Process Control

A supermajor operates a large two-train liquefaction plant in a remote tropical location. The plant is integrated with a local offshore gas facility. The liquefaction plant was constrained as the site relies on air fin-cooled technology to liquify natural gas. The plant was therefore susceptible to ambient temperature, weather and wind speed conditions, which significantly limited production rates on warmer days. Prior to installing APC technology, operators manually adjusted production rates to ensure the plant was within safe operating limits (constraints include propane compressor discharge pressure, CO_2 content of sweet gas, etc.) and to avoid freezing in the cryogenic system.

To overcome these limitations and improve consistency of operations the site deployed APC to control the production rates against thermal constraints. As part of this upgrade, the key control

variable was reassigned from the LNG flow to the mixed refrigerant discharge temperature and flow rate. This allowed the site to reduce operator interventions by 90%, cut flaring from the boil-off gas (BOG) system resulting in a reduction in emissions and improve LNG production by 1-2%.

Automated control systems enable online adjustment of LNG plant operations, ensuring optimal performance and minimizing operational costs from energy waste. These systems are also integral to Asset Performance Management (APM) solutions, incorporating predictive and prescriptive maintenance capabilities.

Maximizing Asset Utilization with Technologies that Proactively Identify Signs of Degradation in Performance or Equipment

In recent years, APM has advanced significantly enabling proactive identification of degradation in performance of physical infrastructure. These digital technologies identify normal operational patterns, detect anomalies and recognize signs of degradation that could lead to equipment failure if unaddressed.

These solutions leverage a combination of existing monitoring technologies, data analytics and advanced AI and machine learning techniques, abstracting complex engineering and data science elements to ensure user-friendly functionality and enable current personnel to develop sophisticated detection strategies. As a result, APM can provide early warning of potential issues, with notice typically weeks, sometimes months in advance. The early warning and guided insights provide time to plan, which is crucial for LNG operations, allowing for process adjustments to prevent incidents or plan safe, orderly shutdowns.

Leading APM solutions offer the ability to apply learnings from one asset to similar equipment with minimal effort. This scalability ensures that once a pattern is detected in one machine, it can be quickly identified in others, providing comprehensive coverage.

This increase in visibility into operational health is instrumental in prioritizing maintenance schedules and capital decisions, meeting production targets, improving safety and reducing potential for environmental excursions. Improved operations and asset uptime give a company the overall competitive edge needed to persevere in the face of industry transformation.

LNG

Case Study: Protecting Critical Equipment in Natural Gas Liquefication Production

Safeguarding critical equipment is an important objective in the liquefaction process. A Latin American LNG company's prior attempts to automate its preventative maintenance schedules fell short. However, driven by corporate digitalization objectives, the company looked for an effective solution that helped monitor asset health and maintenance planning. Asset performance management was deployed to predict failures and improve maintenance planning and execution. By predicting failures in two gas turbine axial compressors with over 15 days of lead time, catastrophic turbine failures were averted, resulting in substantial cost savings and minimized downtime. Moreover, the solution's implementation led to a reduction in broken pipes within the main cryogenic heat exchanger, thereby improving unit efficiency and ensuring consistent production output. Additionally, the solution enabled multidisciplinary coordination for plant/equipment shutdown planning, further optimizing operational efficiency. In total, these interventions resulted in an impressive $13M USD in savings, underscoring the transformative impact of proactive maintenance strategies in enhancing operational reliability and cost-effectiveness in natural gas liquefaction operations.

Establish a Robust Supply Chain Network

The transformative impact of digital solutions extends to the scheduling and long-term planning processes in LNG production. Supply chain analytics can be used to better understand inlet gas feed quality, supply and volume requirements to improve responsivity to production targets.

By having access to this information in a proactive manner, sites can also systematically adjust operations to account for changes in feed quality that may have otherwise had a detrimental effect on production. In addition, having the ability to optimize production to meet forecast demand with insight into storage limitations of the compressed gas and transportation schedules improves the reliability of the supply chain network as well as enhances safety and environmental compliance.

INPEX

Case Study: INPEX Enhances Ability to Meet Pipeline Specifications

INPEX insources LNG for Japan through the Naoetsu LNG Terminal where it is regasified. The Gas Business Act sets a stringent specification that sales gas must be rated at 45 MJ/Nm^3 prior to distribution. Insourced LNG is shipped from all over the world and is characterized by calorific values ranging between 40-45 MJ/Nm^3.

The site only has two storage tanks which limits the number of levers available to meet the calorific value specification. In addition, the properties of LNG change over time primarily due to evaporation of lighter components, which is difficult to accurately monitor. To maintain compliance with pipeline specifications, INPEX is conservative around inventory management; limiting the company's ability to procure cargos on the spot market and the regasified natural gas is blended with domestic gas and purchased LPG.

Accurate planning, communication between procurement and operations and increased insight into product variation over time would allow the site to achieve incremental margin improvement.

INPEX's Naoetsu LNG Terminal first developed a comprehensive steady state process model to simulate various importation scenarios and blending models. It further improved the sensitivity of the models with dynamic process simulation, which provides insights into how the calorific value, composition of stored LNG and even boil-off gas (BOG) will fluctuate over time. This ensured the safe and efficient management of INPEX's gas supply chain and resulted in an estimated $5M USD per year savings from improved procurement and reduced LPG demand.

AUSTRALIA PACIFIC LNG

Case Study: Integrated Production Modeling with Steady State and Dynamics for Gathering Systems

Origin, ConocoPhillips and Sinopec have joined together to form Australia Pacific LNG. Located on Queensland's coast, the resulting company is an agglomerate of natural gas wells,gathering systems, pretreatment facilities and a liquefaction plant. As this is a well-integrated supply chain network, there is ample opportunity to balance production rates across the pretreatment plants to improve margins. To streamline this activity, Xodus Group provided Australia Pacific LNG with an integrated production model to empower engineers with the ability to identify and resolve bottlenecks.

The resulting interface enabled the customer to model the gas gathering network, gas processing facilities, high pressure pipeline network and the LNG plant in one environment where it can conduct offline studies to analyze various production scenarios. In addition, Xodus Group extended the digital footprint to include online compressor modeling to improve responsivity to bottlenecks in the distribution system. This allows for rapid evaluation of multiple scenarios to allow optimum operating conditions to be identified, balancing critical factors such as power usage and line pack availability. Origin can now easily identify and rectify bottlenecks in the distribution network resulting in an estimated savings of $3M USD per year from optimized LNG production.

Emissions Intelligence and Decision Support

Technology exists today to make a significant impact on emission abatement opportunities at gas processing, liquefaction and regassification plants. AspenTech Operational Insights™ provides users with the context needed to make fast, confident decisions to quickly identify those most critical items demanding priority attention and action. This emissions management solution not only serves as a monitoring tool, but also provides real-time decision support for prioritizing correction actions. It also enables users to perform easy-to-audit calculations for transparency to financial markets, regulators and NGOs.

AspenTech Operational Insights integrates different modeling tools and datasets to ensure they are synchronized and working in concert. This data can include disparate information such as feedstock variability, utilities, thermal efficiency reports, weather conditions and CO_2 market prices. The solution interpolates these often-incongruous insights into a singular backbone for human or machine analysis. Ultimately, this allows for contextualization of large amounts of data to effectively report and predict emission as well as empowers decision makers to weigh business trade-offs against emissions reduction opportunities.

Looking to the Future: The Right Balance to Achieve Reliable Energy and Lower Emissions

By adopting simulation and advanced process control for design and process optimization and harnessing the power of asset performance management systems, incorporating predictive and prescriptive maintenance capabilities, LNG operators can significantly enhance operational efficiency. These technological advancements are not only instrumental in driving down costs and optimizing production, but also play a crucial role in ensuring environmental sustainability and meeting regulatory requirements.

As the global LNG market continues to grow and evolve, the adoption of sophisticated digital and analytical tools will be a key differentiator for industry leaders. By embracing these technologies, LNG operators can navigate the complexities of the modern energy landscape, ensuring profitability, sustainability and resilience in an ever-changing world.

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About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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