The LNG Specialists

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CORPORATE PROFILE

INTRODUCTION

This profile is intended to give an overview of the experience and expertise of the CH·IV International organization. In addition to this Introduction, the three remaining sections cover LNG Industry Services (Page 3), Project Synopses (Page 5), and Publications and Presentations (Page 24).

WHO IS CH·IV INTERNATIONAL?

Founded in 2001, CH·IV International (CH·IV) is a specialized consulting and engineering firm servicing the liquefied natural gas (LNG) industry. The Company provides engineering and consulting services ranging from the initial feasibility; conceptual, pre-FEED and FEED; regulatory permitting support and acquisition; oversight of detailed design, procurement and construction (EPC); facility commissioning, cooldown and start-up; and ongoing operations. CH·IV also provides due diligence and business development support to entities investigating investment in LNG programs.

The Company was formed as a joint venture between MPR Associates of Alexandria, Virginia, and CH·IV Cryogenics LP of Hanover, Maryland. In August 2014 Clough Limited,1 a large Perth, Australia-based engineering company, acquired 100% of CH·IV International. Clough is a market leader in the providing LNG engineering and project services in the Australian and Papua New Guinea market. The company provides engineering, construction, commissioning and brownfields services to some of the world’s largest energy companies and has been present on every LNG project undertaken in the Australian and PNG in recent years. Clough employs a workforce of nearly 4,000 people across Australia, Papua New Guinea, Asia, United Kingdom and Africa.

The acquisition by Clough compliments CH·IV with growth through the provision of project management expertise and engineering resources from Clough’s global offices. The combined forces provide clients with technical support the entire LNG project lifecycle to manage risk and drive out inefficiency for clients across the life of their asset.

HOW DOES CH·IV SUPPORT THE LNG INDUSTRY?

The LNG industry is comprised of various related and unrelated technologies, for example:

- The international LNG trade involves very large scale natural gas liquefaction and marine export operations, marine transport and LNG import facilities. Smaller scale “Hub & Spoke” marine transport operations are under development supporting localized geographic areas in a smaller but similar market.

- Natural gas utilities liquefy and store natural gas in order to use the LNG for peakshaving during high gas demand periods where the LNG is pumped out of the LNG storage tanks and injected into the gas distribution system.

1  www.clough.com.au
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- LNG is gaining worldwide acceptance in motor fuel programs re-powering heavy-duty diesel engines. Such programs cover the gamut of applications from large marine vessels, to locomotives, to oil and gas well operations, to mine haul, to over-the-road trucking.
- Most notably in North America, LNG is now seen as an economic fuel replacement for remote industries using boiler and heaters currently fired on petroleum distillates or propane.
- In order to support the last two bullets above, purpose-built natural gas liquefaction facilities are often required where the LNG can them be trucked to the end-users.

CH·IV’s highly experienced staff have proven to be highly responsive and extremely efficient in addressing client needs in the various industries described above. Their consulting and engineering services can be summarized in five overlapping areas:

- Project Feasibility – Initial feasibility, conceptual design, site selection, business case modeling.
- Project Development – Pre-FEED and/or FEED, regulatory permitting, support of commercial agreements, e.g., LNG sourcing, marine transportation, EPC pre-qualification and bid development.
- Engineering, Procurement and Construction (EPC) – EPC bid evaluation, EPC (including commissioning) oversight, operating procedure (including cooldown and start-up) development, training, start-up leadership or support. This would also include the role of Lender’s Engineer during the various EPC phases.
- Operations Support – Operations, maintenance, engineering, on-going training and regulatory support for an operating LNG facility.
- Due Diligence – Independent of the project stage (Feasibility, Development, EPC or Operations) services associated with due diligence protecting the potential investment into a given project.

Why CH·IV? . . . CH·IV is intended to be read as “C-H”- Roman numeral “4”; or simply CH4, the chemical formula for methane (the primary natural gas constituent).

Additional information and pictures about CH·IV and LNG can be found at our web site: www.CH-IV.com
LNG IMPORT, EXPORT AND PEAKSHAVING FACILITIES

Development –

Filing/Permitting –

Design/Construction –

Start-Up/Operation –

OWNER’S/LENDER’S/REGULATOR’S ENGINEERING SUPPORT


TECHNICAL SUPPORT

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LNG SERVICES

CONTRACT ENGINEERING SERVICES
Optimization/Revitalization Teams – Owner’s/Lender’s Representation – Commissioning Teams – Start-Up and Operations Teams

REGULATORY, SAFETY AND HAZARD MINIMIZATION SUPPORT

OPERATIONS SUPPORT

SELECTED COMPUTER APPLICATIONS

Pro/II®
Process simulation software customized by CH-IV specifically for natural gas and LNG/LPG applications. Suited for conceptual design studies as well as verifying detailed work performed by others.

BREEZE® Modeling Software
Predicts LNG vapor dispersion from LNG spills, thermal radiation flux from LNG fires and numerous other impacts of air emissions, fires and explosions.

PHAST v6.7 Uniform Dispersion Model
Predicts LNG vapor dispersion from LNG spills – model approved by DOT PHMSA in October, 2011 to perform vapor dispersion analysis to demonstrate compliance with 49 CFR 193.2059

Klosek-McKinley Density
Calculates the total energy of LNG cargoes. Enhanced by CH-IV.

LNGSIM™
LNG shipping / rail trade simulator (used for fleet, tank, and end-use and vaporization sizing calculations). Developed by CH-IV.

Hub & Spoke Model™
Computer model of “grass roots” LNG program based on new natural gas liquefaction plant(s), LNG trucking / barging-based distribution and multiple end-use applications (power plant, industrial, vehicular, local gas distribution, etc.). Developed by CH-IV.
A quick review of a partial listing of recent LNG projects will show that CH·IV International is and has been involved in a number of active, major LNG projects as well as other projects supporting the claim of “The LNG Specialists.” This list of activities includes providing the FEED (Front End Engineering and Design) to numerous US and international LNG import projects, multiple US LNG export projects and small-scale / LNG peakshaver projects. CH·IV also acted as the Regulatory Engineer for the States of Connecticut in oversight of the Waterbury LNG peakshaving project and the LNG Technical Advisor for the Government of Jamaica. CH·IV also successfully supported the permitting process of many new LNG projects and provided project management of a California offshore LNG import terminal for Crystal Energy.

CH·IV is active in multiple projects in a variety of roles involving production and/or use of LNG as fuel for heavy-duty dual-fuel applications including over-the-road, locomotive, well-head support and marine.

It should be noted that CH·IV has provided the FEEDs for the four of the last five U.S. (FERC permitted) import terminals (Downeast, AES Sparrows Point, Oregon LNG and EcoElectrica Expansion). Additionally, CH·IV is currently either involved with or is entirely responsible for the preparation of FEED for vast majority LNG liquefaction and export facilities proposed for the U.S. that are also currently under the FERC permitting process.

**USA, Florida – Eagle LNG JAX I**
*Small Scale LNG Production and Export Facility*
CH·IV is providing the FEED required for a FERC filing which includes confirming the siting of the proposed facility, engineering permitting package, offsite consequence analysis, design of hazard detection and mitigation systems and demonstration of code compliance. CH·IV is also providing other project services including subcontract management and oversight of environmental permitting efforts. (2015 to present)

**USA, Massachusetts – Access Northeast**
*LNG Peakshaver*
As part of developing a solution to supply natural gas to the growing need in the Northeast, Access Northeast retained CH·IV to perform feasibility and siting analysis, provide a pre-FEED package and develop the FEED for permitting with FERC and DOT PHMSA. The FEED package will also serve as the technical portion of the EPC bid package for the new LNG peakshaver.

CH·IV will also serve as Owner’ Engineer, supporting the project team develop its EPC contracting strategy, prepare the EPC bid and review bids, provide oversight during preparation of final engineering design, construction, commissioning and startup. (2011 to present)
Bermuda – Ascendant
*Small Scale LNG Import Terminal*
CH·IV completed a fatal flaw analysis for a new small-scale LNG import terminal in Bermuda to fuel a new 50 MW power plant. CH·IV is currently performing feasibility for alternate locations. CH·IV is currently awaiting go-ahead on developing FEED study to the Project. (2013 to Present)

USA, Texas – Freeport LNG
*4.5 MTPA Train 4*
CH·IV is managing the development of the formal Federal Energy Regulatory Commission (FERC) application, including engineering and design, for Freeport LNG’s Train 4 at the Quintana Island Facility. CH·IV provided the pre-filing support for this project prior to this assignment. (2014 to Present)

USA, Massachusetts – Hopkinton LNG
*LNG Peakshaver Upgrade*
CH·IV is providing a Massachusetts gas utility with a technical bid package to replace their 40+ year old LNG vaporization system. Additionally, CH·IV is providing the FEED for replacing the pretreatment, liquefaction and LNG truck loading system. CH·IV’s first assignment was to provide a Preliminary Siting report to assure the modifications could be sited under the new USDOT PHMSA requirements. (2013 to Present)

USA, Puerto Rico – Eco Eléctrica L.P.
*EcoElectrica LNG Terminal*
Provided and providing a wide range of services including:
- LNG facility RAM study
- Perlite® intrusion investigation
- LNG transfer line damage root cause analysis and replacement
- BOG blower failure investigation
- Revised and updated all LNG terminal standard operating procedures, operator training
- NFPA 59A fire protection evaluation and preparation of action plans, regulatory support
- Prepared FEED for facility expansion, preparation of equipment specifications for procurement of major equipment associated with the facility expansion project, prepared EPC contractor scope of work included in an RFP for the expansion project and evaluated all bids
- Prepared FEED and providing regulatory support in the development of an LNG Truck Loading project
- CH·IV is currently preparing engineering studies for a facility expansion.
(2006 to Present)
USA, Rhode Island – National Grid

Natural Gas Liquefier Installation

CH·IV commenced its support to National Grid evaluating a series of options to replace its total historical peak shaving LNG demand including location, sizing, technology evaluation and liquefaction compressor driver. Capital and O&M cost estimates were also generated for 16 different cases. The study resulted in the selection of the Providence LNG facility, with a single train 20 mmscfd, electric motor-driven nitrogen expansion liquefaction technology and mixed bed acid gas and water removal.

CH·IV provided the engineering that became the technical portion of the EPC bid package. EPC has commenced and CH·IV is the Owner’s Engineer on the project providing oversight during preparation of permitting and final design. (2011 to Present)

USA, Louisiana – Harvey Gulf Marine

Marine LNG Fueling Facility

CH·IV provided the engineering, procurement and construction (EPC) and permitting support for the first such permanent facility in the U.S. The facility is located in Port Fourchon where LNG-powered offshore support vessels (OSV) support critical operations of the offshore oil and gas industry. The facility is currently in operations. (2013 to 2016)

USA, Florida – Sea Star – Tote

Port of Jacksonville LNG Bunkering Facility

CH·IV provided Owners Engineering supporting Sea Star in the development of an interim LNG bunkering facility at the Port of Jacksonville. CH·IV has provided or managed the submission of all compliance documents associated with the US Coast Guard. CH·IV has overseen the design of the LNG Bunkering system, as well. (2014 to 2016)

USA, Oregon – Oregon LNG

9.0 MTPA LNG Production and Export Project

CH·IV provided Pre-FEED including liquefaction technology selection and size, cooling system choice and LNG trade ship simulation. Provided total FEED utilizing previous LNG tank and marine infrastructure design from LNG import FEED (2008). CH·IV next provided the FERC technical filing. Project has recently withdrawn its FERC application. (2011 to 2016)
USA, Hawaii – Hawaii Electric Company  
*Natural Gas Re-Powering Project*  
CH-IV is completed the pre-FEED to convert electric power plants at eight locations across the Hawaiian Islands to operate on natural. The source of the natural gas is revaporized containerized LNG. The project entails both the design of the LNG systems and the re-powering of the individual power units. The project is currently on HOLD. (2014 to Present)

People’s Republic of China, Shandong Province – Nanshan Group  
*Longkou LNG Import Terminal*  
CH-IV provided the pre-FEED for the 3.5 MTPA Longkou LNG Import Terminal located in the Port of Longkou. The design comprised: Four 160,000 m³ FCT LNG tanks, 28 LNG trailer loading bays, a high pressure LNG vaporizer system and a combination LNG unloading/re-loading and bunkering berth for world-class LNG import, world-class re-loading of LNG and bunkering of vessels and barges (2014)

Philippines – Energy World Corporation  
*Pagbilao Hub Terminal and Power Station*  
CH-IV provided the FEED for a hybrid LNG import, transshipment and vaporized LNG sendout facility. The project is currently under construction in Pagbilao, Philippines. CH-IV continues serving Energy World Corporation as their Owner’s engineer. (2012 to 2014)

USA, Maine – Downeast LNG  
*4.5 MTPA LNG Export Facility*  
CH-IV provided the Pre-FEED and U.S. Federal Energy Regulatory Commission (FERC) pre-filing technical support for this bi-directional facility on the St. Croix River in Maine near Calais, Maine. CH-IV had previously provided siting studies, feasibility and Pre-FEED studies during early phases for the original greenfield 3.5 MTPA LNG import terminal. CH-IV went on to provide the non-marine FEED package and FERC technical filing for the terminal. (2012 to 2016)

Suriname – Sol Group  
*LNG Import Terminal and Power Plant*  
CH-IV provided the feasibility and pre-FEED study for a greenfield LNG import terminal supporting a new combined cycle gas turbine (CCGT) power plant. CH-IV’s current scope of work involves developing FEED for moving project to engineering, procurement and construction (EPC) phase. (2013 to 2014)
Canada, Ontario - Thorold LNG
LNG Production, Storage and Truck-Out Facility
CH·IV provided Lender’s Engineering support for this greenfield 180,000 gallon per day LNG facility. (2014)

USA, Multiple Locations – Confidential
Locomotive Fuel Production and Fueling
CH·IV provided a feasibility study identifying locations, liquefaction technology, conceptual design and siting feasibility for a major North American rail company. (2013 to 2014)

Canada, Quebec – Gaz Métro Transport Solutions
Brownfield and Greenfield LNG Facility Feasibility Studies
CH·IV provided the feasibility studies and conceptual designs for adding liquefaction to accommodate an expanding need for LNG as vehicle fuel. Studies included the existing LSR peakshaving facility in Montreal and a greenfield site about 120 km away. Pretreatment, liquefaction, cooling, LNG storage and compressor driver technologies were evaluated for each location to allow for client decisions regarding the project. Construction at the LSR site is expected to be completed in the summer of 2016. (2012 to 2014)

USA, Texas – Confidential
Technical Investor Due Diligence on Train 2 Freeport LNG
CH·IV provided a technical due diligence study for a major international investment firm. The scope of work included review and comment on the design, capital cost and O&M costs for one of the 4.5 MTPA liquefaction trains. (2014)

USA, Louisiana – Magnolia LNG
Magnolia LNG 8.0 MTPA LNG Production and Export
CH·IV prepared FEED (including siting analysis) and compiling Resource Report 11 and 13 for the proposed 8 MTPA LNG production and export facility located near Lake Charles, Louisiana. CH·IV was providing Owner’s Engineering until the project was paused in early 2016. (2012 to 2016)

USA, Texas – Freeport LNG
Freeport LNG Liquefaction
CH·IV provided the FEED for the NEPA process (Federal Operations Application) for Freeport LNG (FLNG) for its 13.4 MTPA Liquefaction Facility for the Balance of Plant and developed the FERC RR13 for the entire project. (2010 to Present)

Hawaii.
USA, Washington – Puget Sound Energy
LNG Peakshaver and LNG Bunkering System
CH·IV provided a pre-FEED and siting study for a brownfield LNG production, storage, vaporization, truck-out and LNG bunkering facility. The primary objective of the project was to provide 400,000 gallons of LNG to two LNG-powered roll-on/roll-off ships transiting between the Port of Tacoma (WA) and Anchorage, AK. (2012 to 2014)

USA, Maryland – Dominion Cove Point
Cove Point LNG Liquefaction Expansion Project
CH·IV supported the development of Resource Reports 11 and 13 and associated 49 CFR Part 193 requirements for the liquefaction proposal. (2011 to Present)

Kenya – Mott MacDonald
Kenya LNG Import Terminal
CH·IV provided the conceptual design for a greenfield, onshore LNG import terminal in Kenya, East Africa. (2011)

USA, Louisiana – Trunkline LNG
Lake Charles Liquefaction Project
China, Shanghai – Halcrow Engineers

*Chinese LNG Import Terminal Mechanical Design Review*

CH-IV provided Engineering Design Review services to Halcrow (Project Management Services) for Mechanical and Controls equipment and systems. Work was carried out in Halcrow’s offices in Shanghai.

USA, Alaska – Confidential

*Project FEED Design Due Diligence Review*

CH-IV provided technical review of a proposed LNG supply project for a gas turbine electric generating unit. Project included a 20 mmscfd LNG liquefaction system and storage system; LNG truck transport; and an LNG receiving, storage and regasification facility. The LNG trucking route would be the same made famous by the “Ice Road Truckers” series.

Papua New Guinea – Liquid Niugini Gas, Ltd

*LNG Production and Export Project*

CH-IV conducted a study evaluating various piping and LNG storage configurations for the production and export of LNG from the facility and determined the impact of various configurations and pipe insulation options on the amount of generated boiloff gas (BOG). The study also included cost estimates for several pipeline systems, comparison of available options and proposed methods of BOG management.

USA, Louisiana – Sempra LNG

*Cameron LNG Terminal*

CH-IV provided O&M services to prepare the terminal Emergency Response Plan and also to perform a Health and Safety audit for the facility owner, Sempra Energy. CH-IV provided engineering services to Cameron LNG to perform flammable vapor dispersion exclusion analysis modeling to satisfy DOT and FERC requirements associated with its BOG Liquefaction Project.

USA, Vermont – Confidential

*LNG Peakshaver*

CH-IV provided LNG technical support to a study that compared natural gas supply pipeline installation with LNG satellite and peakshaving supply options for a gas utility to extend its supply area to include two additional remote municipalities. Various size and location options were provided along with CapEx & OpEx estimates for the LNG facilities.

Malaysia – Integrated Petroleum Services

*Sabah LNG Facility*

CH-IV provided the Pre-FEED study for a modular eLNG Facility, (all electrical driven liquefaction facility) for 1.0 MTPA liquefaction capacity. The liquefaction trains consisting of two 0.5 MTPA trains with associated Pretreatment facilities LNG storage and Jetty with LNG ship loading dock.
Indonesia – Energy World Corporation  
*PT South Sulawesi LNG Facility*  
CH·IV provided the FEED for the balance of plant for this 2.0 (expandable to 5.0) MTPA natural gas liquefaction and marine export plant.

USA, North Carolina – Piedmont Natural Gas  
*Robeson County LNG Facility*  
Acted as Owner’s Engineering Advisor; starting in the early phases of the project to assist with development of the Design Basis, site layout and EPC contract for going to the next phase for detailed design and construction. Project is currently on hold pending re-evaluation of the system needs.

Pakistan – Mashal LNG Holding B.V.  
*Phased LNG Importation Facility*  
CH·IV provided the FEED for the process portion of an expedited, phased LNG import terminal utilizing an LNG storage ship, vaporization & power barge and permanent marine facility. The facility will eventually include onshore LNG storage.

Singapore – Gunvor  
*Due Diligence - Confidential*  
CH·IV provided due diligence research and study for confidential project undergoing development in Asia.

USA, Oregon – LNG Development Company  
*Oregon LNG Terminal*  
Prepared the FEED for a proposed greenfield 1.0 BSCFD LNG import terminal near Astoria, Oregon.

CH·IV has updated the import terminal FEED to include 9.0 MTPA LNG liquefaction and export capabilities.

USA, Texas – Freeport LNG  
*Import to Export Modification*  
CH·IV provided pre-FEED services investigating the design and regulatory requirements for converting the existing LNG import terminal to world class LNG production and export facility.

Italy – Adriatic LNG  
*Offshore LNG Terminal*  
CH·IV provided commissioning, cooldown start-up advisory services, including development of maintenance isolation procedures and auditing of other start-up and operating procedures.
USA, Maryland – Baltimore Gas & Electric  
*Spring Gardens LNG Peakshaving Facility*  
CH·IV provided on-site engineering support ranging from oversight of cold box replacement start-up, operating procedure updating, hazard mitigation studies and hazard exclusion zone calculations.

India – Petronet LNG Limited  
*Dahej Jetty Expansion Project*  
Working with a marine structures design firm, CH·IV developed a detailed feasibility study and cost estimate for an expansion project to accommodate increased terminal capacity from 5 MTPA to more than 10 MTPA. This was followed by preparation of topsides FEED, a comprehensive bid package and RFP to allow Petronet to award contracts to carry out the detailed design, construction and startup of the expanded facilities.

USA – Confidential  
*Floating Liquefaction Technology*  
Provided owner’s engineering services associated with floating and other offshore LNG applications.

New Zealand – GasBridge  
*LNG Import Terminal*  
Providing Owner’s Engineer and LNG technical advisor support for the LNG Import and Regasification Terminal Consenting Application. Phase 1 involved Pre-FEED conceptual design and engineering to allow application for consenting and environmental review. Phase 2 will involve a more formal FEED package and RFP documents to allow for EPC bids once the consenting is approved.

USA, Texas – Freeport LNG  
*Freeport LNG Terminal*  
CH·IV provided independent validation of novel NGL extraction process to be incorporated with the existing LNG vaporization process.

Mexico – Black & Veatch  
*Energia Costa Azul LNG Terminal*  
CH·IV assisted in managing various commissioning tasks including directing the repair of hundreds of cryogenic valves. CH·IV wrote the procedure for and directed the facility dry out. CH·IV also provided oversight of the cooldown of the LNG tanks, assisted in directing the preliminary and final terminal cooldown and start-up.

USA – Confidential  
*East Coast LNG Peakshaving Facility*  
Providing conceptual design and feasibility study on greenfield satellite LNG peakshaving facility.
USA, Gulf Coast – GasFin  
*Gulf of Mexico Liquefaction Facility*  
Providing permitting, conceptual design and feasibility studies on greenfield small to midscale liquefaction facility.

USA, Alaska – ConocoPhillips  
*Kenai LNG Facility*  

USA – Esperanza Energy  
*Esperanza Energy, LLC*  
Provided Owners Engineering services during the design phase of the deepwater terminal and will lead the deepwater port application development with the United States Coast Guard. For a floating LNG receiving terminal 10 miles off the Port of Long Beach, California.

Jamaica – Petroleum Corporation of Jamaica  
*Port Esquivel Offshore FRSU*  
CH-IV is serving as the Government of Jamaica’s Technical Advisor in the development of a 1.5 MTPA floating offshore LNG storage and regasification system (FRSU) and natural gas distribution network.

Chile – GNL Quintero  
*Fast Track LNG Import Terminal*  
Review design basis for the terminal, P&IDs, and technical parts of EPC contract. Onsite visit to verify compliance with NFPA 59A requirements. Review operational and design documentation to determined readiness for start up. Preparation of report, which included details of noncompliance, best practices and design basis.

USA, New York – Consolidated Edison  
*Astoria Peakshaving Plant*  
CH-IV vetted technical bids for a replacement liquefaction plant, which included process simulations of competing bidders’ designs.

Europe – Confidential  
*Medium Scale Offshore Liquefaction*  
In depth study of the availability of medium scale offshore liquefaction systems, process plant including pretreatment design, NGL fractionation, power requirement utilities and weight and footprint development. The maritanization analysis of the evaluated components, units and equipment played a crucial role in this study. In the order of 20 different offshore liquefaction systems where analyzed and ranked using an evaluation matrix developed by CH-IV.
USA, Maryland – Dominion Cove Point
Cove Point LNG Terminal
CH-IV provided the following LNG specific consulting services with the completion of construction of a major expansion of the Terminal:
- Perform engineering walkdowns of equipment and systems for the owner as part of the mechanical completion process
- Review EPC contractor prepared commissioning procedures
- Review EPC contractor prepared operating and maintenance procedures
- Prepare and deliver commissioning training to owners operating and maintenance team
- Direct purge, dryout and cooldown activities for the owner
- Prepare schedules for startup and “tuning” of equipment

USA, Connecticut – Energy East Corporation
LNG Peak Shavers – Milford and Rocky Hill
Prepared technical report that quantified the impact of possible changing feed gas quality due to imported LNG on the existing liquefaction plants. Using CH-IV-proprietary optimization software developed 15 high-fidelity simulation models to predict the maximum performance for both facilities. The report identified equipment, system bottlenecks and probable Cold Box replacement points and recommended modifications and retrofits.

USA – Confidential
Small to Medium Scale Offshore Liquefaction
Bank due diligence report based on the review of the design concept for a small to medium scale offshore liquefaction vessel.

Norway – Flex LNG
Small to Medium Scale Offshore Liquefaction
Prepared a due diligence report based on the review of the design concept for a small to medium scale offshore liquefaction vessel. The study entailed the review on the chosen liquefaction system as well as the different pretreatment options and their placement on the given vessel surface.

USA, Connecticut – State of Connecticut, DPUC
Yankee Gas’ Waterbury LNG Peakshaving Facility
CH-IV provided regulatory oversight for the State of Connecticut, including regulatory compliance, RFP development, detailed design review, on-sight construction inspection oversight services and various engineering inspection services.
USA, Minnesota – Chart Energy & Chemicals

*Wescott Plant Peak Shaving Facility*

Performed a diagnostic performance analysis of the Wescott liquefaction system. Using CH·IV-proprietary optimization software, developed 15 high-fidelity simulation models to analyze the existing liquefaction process, check the operation of the mixed refrigerant loop and troubleshoot the lack of performance of the main liquefaction exchanger. Developed process simulation models to perform data reconciliation and compare the actual performance against the expected. Performed “what if” diagnostics and sensitivity tests to pinpoint the root-cause of degraded performance. CH·IV recommendations resulted in re-establishing design performance levels.

USA, Maryland – U.S. Pipeline

*Cove Point LNG Terminal*

Prepared de-inventory/warm-up and cooldown/start-up procedures supporting the maintenance turnaround and expansion project tie-ins for the terminal in 2007. Directed implementation of procedures.

Jamaica – Government of Jamaica

*Port Esquivel - LNG Import Terminal, Regasification and Distribution Project*

Provided technical oversight in the development of a greenfield 1.6 MTPA LNG import facility and developed the RFP for FEED phase. Contracted as Technical Advisor to the Project Joint Development Team (JDT) for FEED oversight, Regulatory support and EPC project management. Additionally, CH·IV provided technical support to the JDT in its consideration of developing a Floating LNG Storage and Regasification Unit (FSRU) as an interim / permanent alternative to a land based LNG import terminal.

USA – Confidential

*LNG Peak Shaving Facility*

Assisting the client’s zoning studies by performing exclusion zone calculations for an existing LNG peak shaving facility located adjacent to a rapidly developing commercial and residential area. Analyzed options for tank and berm modifications to reduce thermal radiation and vapor dispersion exclusion zone radii and prepared cost estimates for modifications. Provided cost estimate for a new comparable Greenfield facility.

USA, Maryland – AES Corporation

*AES Sparrows Point*

Prepared the FEED for a proposed brownfield 1.5 BSCFD LNG import terminal near Baltimore, Maryland. The FEED was included in a permit application to construct the terminal (including preparation of the FERC Resource Reports 1, 10, 11 and 13) and was prepared in accordance with 18 CFR 380.12c, 49 CFR Part 193, NFPA 59A and 33 CFR Part 127. Project was formally submitted to the FERC in January 2007.
USA, Offshore California – Crystal Energy
*Crystal Clearwater Port*
Provided overall project management, public outreach, preliminary design and permit application development for Crystal Energy’s offshore LNG regasification facility located on Platform Grace.

USA, Florida – Suez Energy
*Calypso LNG*
Prepared draft Operations Manual (technical, port security and management) for DWPA filing.

Oman – Pyramid Consulting Engineering Pvt. Ltd.
*Oiltanking Odjfell Terminals & Company, LLC LPG Facility*
Provided engineering consulting services in support of a FEED for the project. The scope of work included a review of documentation associated with development of the plot plan, review of the design basis, and commentary on the heat and material balances, process flow diagrams and major equipment data sheets. Participated in HazOp and review of the report issued to the Client prior to release of the FEED documents.

USA, Maine – Downeast LNG
*LNG Import Terminal*
Prepared the FEED for a proposed greenfield 0.5 BSCFD LNG Import Terminal near Robbinston, Maine. The FEED was included in a permit application to construct the terminal (including the preparation of FERC Resource Reports 1, 10, 11 and 13) and was prepared in accordance with 18 CFR 380.12c, 49 CFR Part 193, NFPA 59A and 33 CFR Part 127. Project was formally submitted to the FERC in December 2006.

USA, New York – Atlantic Sea Island Group
*Safe Harbor Port*
Prepared all process design support required to submit an application to the U.S. Coast Guard under a Deep Water Ports Act (DWPA) filing for a greenfield 2.0 BSCFD LNG import terminal that will be built on a man-made island along the U.S East Coast.

Indonesia – Pacific Oil & Gas
*LNG Export Facility*
Provided a “Dock Occupancy Study” using CH-IV proprietary ship simulation software to determine if existing marine infrastructure was adequate to meet needs of potential expansion of LNG production.
El Salvador – Cutuco Energy
La Unión Energía Center
Provided all non-marine engineering, including design, cost estimating and schedule development required to submit a regulatory application to the El Salvador government for a greenfield LNG import facility-powered 550 MW combined cycle power plant.

UK – Dragon LNG
LNG Import Terminal
Prepared contractual and technical audit for the 6 bcm Dragon LNG import terminal in Wales. The project includes two 154,000 m³ full containment LNG storage tanks, LNG regasification plant, send out capabilities and marine docking and offloading facilities for use by LNG Carriers.

USA, Texas – Gulf Coast LNG Partners, L.P.
Calhoun LNG
Provided a thermal flux analysis for proposed LNG receiving terminal in Port Lavaca-Point Comfort, Texas.

The Bahamas – Blue Marlin
South Riding Point LNG Import Terminal
Acted as Owner’s Engineer. Provided pre-RFP preliminary design package, design studies and evaluations of current design package.

West Coast Africa – Confidential
Mid Scale Offshore Liquefaction Plant
Performed feasibility study focusing on the gas pretreatment and liquefaction technology supporting the development of a floating 1 to 2 MTPA natural gas liquefaction, storage and offloading facility. Identified qualified liquefaction technology providers by comparing efficiency parameters, equipment layouts and equipment loads best suited for topside mounting on suitable floating vessel designs. Identified outstanding technology issues, provided input to development of the marine equipment and developed cost information for topside equipment as part of the total concept.

Mexico – Sonora Terminal GNL de Sonora, S. de R.L. de C.V.
Sonora, Mexico - Terminal GNL de Sonora
Prepared all non-marine FEED, including cost estimating and schedule development required to submit an application to the Mexican regulatory agencies for a 2.0 BSCFD, greenfield LNG import terminal near Puerto Libertad.
Chile – GASCO S.A

*Bahia Quintero, Chile - LNG Import Terminal Project*

Prepared an economic feasibility study for a proposed 2.7 MTPA LNG import terminal to be located at Bahia Quintero in Chile. Assisted GASCO S.A. responded to a tender issued by a “pool” of customers for the sale of natural gas to the pool located in Chile. Prepared a tolling based tariff for the sale of natural gas to the pool, which included a calculation of the regasification fee and the development of technical and economic reports associated with the design, operation and maintenance of the facility.

USA, Offshore Alabama – TORP, Inc.

*Terminal Offshore Regasification Plant*

Provided technical and engineering services for Project Development/Management and Deepwater Port Act permit preparation for a Deepwater Port in the Gulf of Mexico. FEED, permit application development, and extensive interaction with various US federal agencies (including United States Coast Guard) and other stakeholders in the development of this Gulf of Mexico LNG regasification project.

USA, New Jersey – PSE&G

*Burlington LNG Peakshaving Plant*

Provided code compliance audit relative to recent adoption by DOT 49 CFR Part 193 of the 2001 edition of NFPA-59A.

Nova Scotia – Anadarko Petroleum Corporation

*Bear Head LNG Import Terminal*

Served as Owner’s Engineer. Provided bidder evaluation of LNG tank contractors. Providing design review of FEED prior to incorporation in EPC RFP. Provided process optimization studies. Developed EPC RFP and the O&M Mobilization Plan.

USA, Virginia – Chesapeake LNG

*Chesapeake LNG Facility*

Evaluated a proposed plant design modification and recommended alternative solutions.

USA, Texas – Sempra Energy International

*Port Arthur LNG Facility*

Acted as Owner’s Engineer for Sempra during pre-FERC application phase on this import and regasification terminal project.
USA, Maryland – Washington Gas  
Chillum LNG Peakshaving Facility
- Provided engineering oversight of EPC activities. Provided preliminary engineering, regulatory permit application development and EPC qualification and RFP development. Provided expert testimony on the safety of LNG before the Prince Georges County Zoning Hearing Examiner.
- Provided the engineering and environmental support to bring the selected alternative to the permit submission stage.

Canada – Confidential  
Maritime Province LNG Import Terminal
Provided “Fatal Flaw” analysis of greenfield location. Provided conceptual design and feasibility study for 1.5 BSCFD LNG import terminal. Prepared preliminary engineering and regulatory permit application development.

Mexico – Sempra Energy International  
Costa Azul LNG Facility
Acted as Owner’s Engineer for Sempra during FEED phase for their Baja, Mexico import and regasification terminal project.

USA, Pennsylvania – Philadelphia Gas Works  
Richmond LNG Facility
Provided supplemental LNG supply study. Study included qualitative and quantitative analysis of a variety of natural gas liquefaction processes, as well as potential modifications to existing liquefaction plant.

Equatorial Guinea – Marathon Oil Company  
Bioko Island LNG Facility
Supported Marathon as Owner’s Engineer during the FEED of this greenfield 3.7 MTPA baseload LNG export project including liquefaction technology assessment.

USA, Louisiana – Sempra Energy International  
Cameron LNG Facility
Provided technical due diligence prior to Sempra’s acquisition of this Louisiana LNG import and regasification terminal project. Currently acting as Owner’s Engineer during FEED phase.
India – SBI Banking Consortia
  
  **Dahej LNG Import Facility**
  
  Provided Lender’s Engineering and technical support to an assessment and evaluation of the Petronet LNG import terminal and regasification facilities project in Dahej, Gujarat, India. The 5.0 MTPA capacity plant has been in operation since December 2003.

Europe – Confidential
  
  **LNG Barging Study**
  
  Provided feasibility studies, cost estimating, marine transport logistics and siting strategies for an LNG barge-based trade in a Mediterranean location.

USA, Arizona – City of Phoenix
  
  **Vehicular LNG Fuel Supply Study**
  
  Completed study to determine future vehicular LNG demand and evaluate alternative supplies, including local production. CH-IV provided a technical and economic feasibility study supporting local LNG production.

Mexico – Marathon Oil Company
  
  **TREC LNG Receiving Terminal**
  
  Providing Owner’s Engineering support during permitting phase with Mexican authorities and on all work being performed by FEED contractor. Provided Design Basis Package for new import facility including technical description, plant operations narrative, PFD, plot plans, schedule, costs, environmental considerations and alternative designs.

USA, Louisiana – Trunkline LNG Company
  
  **Lake Charles LNG Receiving Terminal**
  

USA, Arizona – City of Phoenix
  
  **North Phoenix Transit Bus LNG Fueling Station**
  
  Provided Engineering design package and well as construction, commissioning and start-up oversight for multi-dispenser, heavy-duty LNG and LCNG fueling station.

Bahamas – Confidential
  
  **Bahamas LNG Receiving Terminal and Pipeline**
  
  Provided due diligence on potential acquisition of Enron Global LNG assets for client.

USA, Georgia – U.S. Coast Guard
  
  **Introduction to LNG Training**
  
  Provided two-day training session to Savannah Marine Safety Office (MSO) prior to reactivation of Elba Island LNG Terminal.
USA, Maryland – Dominion Resources

*Cove Point LNG Receiving Terminal*


North America – Confidential (multiple clients)

*Potential LNG Receiving Terminals*

Providing or have provided client review of EPC-supplied design and feasibility studies for the siting of various LNG import terminals for various clients in North America (U.S.A., Canada and Mexico).

USA, Maryland – Williams Energy

*Cove Point LNG Receiving Terminal*

Provided Owner’s Engineering support for the restart of the largest LNG receiving terminal in the U.S. at that time. This support included review and critique of the documentation required for the FERC filing for reactivation along with providing preliminary designs of vapor handling and LNG blending systems.

USA, Illinois – Gas Technology Institute

“Preparation of LNG Vehicle Nozzle and Receptacle Test Program”

Provided an investigative program to determine the current state-of-the-art of design, manufacture and operation of LNG fueling nozzles. Provided a comprehensive testing program and budget cost estimate for appropriately identified test candidates.

USA, Massachusetts – Fleet Bank Leasing Group

*Natural Gas Liquefaction Plant Evaluation*

As Lender’s Engineer, provided an evaluation of the condition of the Lynn, Massachusetts peakshaving facility.

South Korea – Korea Gas and Mobil

*LNG Training Program*

Provided training to 30 KoGas staff and management on design, operations, and safety of LNG import facilities.

USA, Pennsylvania – ICF Consultants

*Philadelphia Gas Works, Richmond LNG Facility*

Performed liquefaction plant replacement study. Performed liquefaction compressor replacement study. Provided equipment and system operability study, including recommendations for future reliability enhancements.
CORPORATE PROFILE
OLDER PROJECT SYNOPSISES

USA, CO – Rocky Mountain Natural Gas
Satellite LNG Gas Plant
Designed, integrated and managed the installation of a temporary satellite LNG facility that was placed in service 44 days after “go-ahead” from client.

Special Acknowledgment:

CH·IV Cryogenics’ Self-Serve LNG Fuel Dispenser
Bloomfield, New Mexico (1995)

Edinburgh, Scotland (1997)
CH-IV staff has authored over seventy papers, articles and presentations and presented testimony on all things LNG over the past 20 years. In addition, Jeff Beale, CH-IV’s President Emeritus was the columnist for *The Cold Corner* for “Natural Gas Fuels Magazine” for three years. Below lists some of the more recent activities. A number of papers and presentations can be found at [http://www.ch-iv.com/publications](http://www.ch-iv.com/publications) including *The Cold Corner* articles authored by Jeff Beale.

**Reverse Chronology**

“Putting a Plan into Action”  
LNG Industry  
April 2016

“Safety History of International LNG Operations”  
CH-IV International Publication (See cover at right)  
Living document

“Design, Siting Considerations for LNG Facilities”  
Pipeline and Gas Journal  
March/April 2015

“Steps for Successful US Project Development”  
Natural Gas for Off-Road Applications USA Conference  
Houston, TX  June 2014

“Practical Implementation of New LNG Facility Siting Requirements”  
AGA Operations Conference  
Pittsburgh, PA  May 2014

“Design Considerations for Small-Scale LNG Facilities”  
AIChe Spring Meeting, 14th Topical Conference on Gas Utilization  
New Orleans, LA  April 2014

*Not Your Father’s LNG Production Facility*”  
LNG 17  
Houston, TX  April 2013

“Integration of Major Liquefaction Units within Existing Import Terminals”  
LNG 17  
Houston, TX  April 2013

“Natural Gas Liquefaction/Process Selection”  
AGA Operations Conference  
San Francisco, CA  May 2012

“Readying an Existing LNG Facility for LNG Fuel Sales”  
World LNG Fuels Conference 2012  
Houston, TX  January 2012
CORPORATE PROFILE
PUBLICATIONS AND PRESENTATIONS

“Natural Gas Liquefaction”
   SGA Operations Conference
   Jacksonville, FL  July 2011

“To Distribute or Not to Distribute: LNG Facilities Dilemma”
   Downstream LNG Markets & Distribution
   Houston, TX  January 2011

“The Cool-Down Gap”
   AGA Biennial Operations Conference
   Pittsburgh, PA  May 2009

“Optimizing LNG Peakshaver Cold Box Operations”
   AGA Biennial Operations Conference
   Pittsburgh, PA  May 2009

“Cold Box Optimization Program”
   AIChE Spring National Meeting
   Tampa, FL  April 2009

US Firm Outlines its LNG Terminal Cool-Down Procedure at Start-Up
   LNG Journal
   February 2009

“LNG Terminal Cooldown Issues”
   LNG Facility Commissioning and Startup
   Houston, TX  February 2007

“The Facts About the Safety of LNG, with a Focus on LNG Ships”
   CH-IV International Publication (See cover at right)
   June 2006

“LNG Technology, Safety and Gas Quality”
   Gulf Coast Power Association Spring 2006 Conference
   Houston, TX  April 2006

“LNG Safety Testimony”
   Prince Georges County Zoning Hearing
   Upper Marlboro, MD  January 2006

“LNG Import Terminal Training, Commissioning and Start-Up”
   Burckhardt LNG Symposium
   Houston, TX  November 2005

“Liquefied Natural Gas – An Introduction”
   Gulf Coast Power Conference
   Houston, TX  April 2004