# PERP Program – Fuel Switching with NGLs/Small Scale LNG

## New Report Alert

September 2005

Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***Fuel Switching with NGLs/Small Scale LNG (04/05S1)***. To view the table of contents or order this report, please click on the link below:
http://www.nexant.com/products/csreports/index.asp?body=http://www.chemsystems.com/reports/show_cat.cfm?catID=2

## Introduction

### Limited Planning for Fuel Price Volatility

In planning a chemical manufacturing operation, or any other industrial or commercial facility, the focus is on designing the facility to produce the products or provide the service that will satisfy customer's needs and optimize the profits of the owner. Initially, at least, developers of processes and planners of facilities use averages to calculate economics and extremes of physical conditions (temperatures, pressures, etc.) to design equipment. For economic analysis and planning, if they think at all beyond the average conditions and inputs to which the operations must respond, they consider primarily the effects of fluctuations in product demand and /or feedstock pricing. Often, only average fuel and power prices are considered for planning purposes, and it is left to the operations managers to struggle with price spikes for these commodities. In the chemical industry, fuel and power costs are usually a small fraction of the total cost of production, but are often a very significant fraction of the value added (sales-minus-raw materials), or marginal cash cost of production.

### Cogeneration, Renewables Use May Exacerbate Fuel Price Volatility

Process facility owners are increasingly adopting cogeneration, or combined heat and power (CHP) systems, integral with the facilities, to insulate themselves from the volatility of the grid electricity prices, and reduce overall energy costs. While more-or-less achieving the desired economies, depending on their design, sizing and type of fuel used, cogeneration systems have in turn tended to put these facilities more at the mercy of fuel price volatility. Of course, if they use recovered process waste heat or process waste fuels (off-gas, residues, biomass, etc.), they will not face this dilemma. Lacking these opportunities, and to minimize capital investment in fuel logistics and storage, combustion equipment and emissions controls, many chemical plants and other facilities have selected natural gas as the fuel for their steam boilers, furnaces, heaters, and cogeneration systems. The U.S. chemical industry, through lobbying efforts of its representatives, such as the American Chemistry Council, statements to the press, and failures of a number of operations attributed to high and spiking natural gas prices, has clearly signaled its vulnerability to these high prices.

As society develops, and comes to rely more on renewable fuel sources for electricity generation, many of which, like wind power, solar photovoltaics, and biomass are variable on an hourly, daily or seasonal basis, we will exacerbate the already volatile demand for the fossil fuels that they will supplement, and especially for natural gas, which tends to be the fuel most used to supply peak electricity generation. Many government agencies and private entities are working to develop electricity storage technologies, but these are still a long way from being efficient and economical for mass storage. Also, industry has reasonable concerns over potential national security threats to fuel supply infrastructure and, with ongoing climate change, increasing frequency and severity of weather emergencies such as floods, snowstorms, droughts, and hurricanes in different regions that can threaten fuel supplies.

**Fuel Switching Used Together with Other Hedging**

It falls upon fuel users to hedge against volatility in fuel prices and provide for secure supplies. A large fraction of chemical plants and other process facilities burning natural gas, as well as those using other fuels, use financial hedging strategies, and off-site physical hedging, such as contracted natural gas storage, but have also installed on-site handling, storage and combustion equipment to enable using other fuels on occasion or for longer periods in case of price spikes and/or supply emergencies. This is the strategy for which this report is named – "Fuel Switching". In many cases, only some of the burners in a facility can be switched because of practical, safety and/or environmental concerns. Natural gas users are usually backed up with LPG or fuel oil with the required adaptive equipment in place. This report examines these conventional fuel-switching strategies compared to some attractive alternatives of:

- Utilizing other stored natural gas liquids (NGLs), seasonally acquired at advantageous prices
- Liquefied natural gas (LNG) made in small-scale units using conventional and emerging liquefaction technologies.

## Fuel Switching with NGLs

Natural gas liquids (NGLs) are hydrocarbons generally in the $C_3$-$C_6$ range (e.g., propane through hexane). These are condensed from natural gas, mostly the saturated species, and are byproducts of various refinery processes, including unsaturated species.

Gasoline in the United States has for more than a decade been subject to Federal government regulated seasonal adjustments in composition to meet certain volatility criteria (Reid Vapor Pressure, or RVP), as well as specification of limits on aromatics and other components as part of Reformulated Gasoline (RFG). As MTBE has been phased-out as the gasoline oxygenate in California, New York, and Connecticut, and probably in other states in the future, ethanol has become the seasonal oxygenate of choice. Substituting ethanol, which is much more volatile than MTBE, exacerbates the problem of meeting RVP limits, so that the lightest hydrocarbons, starting with propane, must be removed in even greater quantities to do so. Now, butanes and pentanes are being removed in greater quantities, but only seasonally. These components are useful octane and cold-start enhancers in winter, so refiners tend to store them to the limits of physical and economic practicality, which are commonly being exceeded recently. Therefore, seasonal gluts of propane, as well as butane and pentane, can appear on the market in various venues.

Besides LPG (which is mostly propane), heavier butanes and pentanes, or mixtures of these with propane, can be strategically purchased, stored, and used as a price peaking or security substitute for natural gas.

**"Fuel Switching" With LNG from Small Scale Liquefaction (SSL)**

**LNG More Convenient Than Other Substituted Fuels**

As shown in Table 1, LNG has a greater energy density than other substitute fuels being proposed and developed for vehicle applications, such as CNG and hydrogen, and lower than conventional vehicle fuels, but is comparable to the leading substitute clean fuel for stationary applications, propane (or LPG).

**Table 1**
**Volumetric Energy Content of Substitute Fuels**

Comparison of Fuel Energy Content

| Fuel Type | Btu/Gallon | Ratio to LNG |
|---|---|---|
| LNG | 73,500 | 1.00 |
| CNG @ 3,000 psi | 29,000 | 0.39 |
| Liquid hydrogen | 34,000 | 0.46 |
| Hydrogen @ 3,000 psi | 9,667 | 0.13 |
| Diesel | 129,000 | 1.76 |
| Gasoline | 111,400 | 1.52 |
| Propane | 84,000 | 1.14 |

When a facility uses re-vaporized, stored LNG as a substitute for its normal pipeline natural gas supply, it is not really fuel switching. Since the substitute fuel is essentially identical to the normal fuel (albeit, probably somewhat purer methane), there are minimum or no problems in any on-site fuel applications, whether in burners or engines, with respect to performance or emissions, as there can be with, say, substituting fuel oil, LPG or other NGLs for natural gas. Because of sulfur content and burning characteristics, there may be limits to how long the facility can operate with substitute fuel oil with respect to sulfur oxides and nitrogen oxides emissions permitting. Also, handling and combustion characteristics require equipment modifications and additions to handle fuel oil or NGLs substituting for natural gas.

### LNG Technology is Well Developed

LNG-based peakshaving plants are common in the United States, the Netherlands, Germany, and in other highly developed gas supply regions. Even in Japan, which depends on large LNG imports from the Middle East, North America, Indonesia, etc, for most of its natural gas supply, small-scale LNG systems are used for strategic distribution of landed gas among the islands of its archipelago.

Many concerned about the security of the natural gas supply grid are looking to both increased LNG imports in the long term as well as increased "distributed LNG" facilities, using peak-shaving type technology as a near term solution. Interest is shown in this strategy among forward-looking natural gas industry midstream (gas transmission) and downstream (local distribution companies) operators, and also significant natural gas customers such as process industry facility owners.

### LNG is Likely to Become More Common

Large gas customers (such as independent power producers, or IPPs, many now based on natural gas fueling) as well as local gas distribution companies could install SSL LNG as a hedging tool against natural gas price spikes and/or for their own fuel security (and, for some customers, as an alternative to using fuel oil or LPG in the same way). For economy of scale and for continuous utilization of invested capital, such firms could increase the size of such SSL LNG installations to also supply others. Potential customers for regular LNG supply could include truck, bus, taxi, service van or passenger auto fleets (using LNG or CNG), small industrial plants without pipeline gas supply, and needing clean fuel (that are currently burning LPG), or others that burn fuel oil and wish to reduce their emissions for a number of possible reasons.

### New SSL Technology is Emerging

Some new SSL systems are being developed and commercialized. Among these are developments by the Gas Technology Institute and Brookhaven National Laboratory, and a radically simpler, more economical technology developed by Idaho National Energy and Environmental Laboratory (INEEL – Idaho Falls, ID). One important version of INEEL's technology is driven solely by the energy normally wasted in letting down gas from pipeline pressure to a distribution system or large user such as a power plant or industrial facility (say, from 450 psig to 50 psig). This is not a unique approach - there are more than 10 so-called "turboexpander" LNG peak shavers around the United States. Uniquely, however, by avoiding physical/chemical impurity removal before liquefaction, and simply solidifying most impurities in the cryogenic cycle to form a dry ice "slush" that is mechanically separable from the LNG, the INEEL technology is simpler and has a potentially lower cost than competing approaches. Only a minor portion of the letdown gas is converted to LNG, with the impurities vented back to the main gas flow. The LNG can be used for peakshaving, as regular or switching fuel in industrial or utility burners, or to fuel transportation systems. Pacific Gas & Electric (PG&E) is in the final phases of development, commercial demonstration, and operational shakeout (nearly 100 percent complete) with its first facility using the INEEL technology and conventional expander technology in Sacramento, CA (nominal capacity of 10,000 gpd/13,500 gal

LNG storage, nominal cost $0.5 million), and are planning a second facility based on experience gained from the first.

Still another new SSL technology, also based on a turboexpander, is commercially aimed at exploiting smaller gas resources, including offshore natural gas reservoirs with floating production systems. This would compete with other strategies for monetizing such resources, such as Fischer-Tropsch and other gas-to-liquids (GTL) technologies, ammonia/urea and methanol. Offered by Randall Gas Technologies – ABB Lummus Global, Inc., this approach is called the Dual Independent Expander Refrigeration Cycle. Like the INEEL approach, this system makes LNG with refrigeration generated by the isentropic expansion of gases, and without conventional mechanical refrigeration, which greatly simplifies the process. Unlike the INEEL approach, however, this process requires conventional gas cleaning ahead of liquefaction.

In a turboexpander-based process, a stream of gas at high pressure is expanded isentropically to a lower pressure. The gas is cooled by the extraction of work in the expander, and refrigeration and shaft power from the expansion process are utilized to aid the liquefaction process. While the efficiency of early turboexpanders was very low (60 to 70 percent), current expander efficiencies are exceeding 85 percent.

Other applications of SSL include those for making LNG to supply natural gas (in competition with LPG and fuel oil) to remote ("off-pipeline") industrial or commercial customers, or "stranded gas utilities" that serve remote communities such as in rural and sparsely populated areas, mountainous regions, or on islands.

World-scale LNG import projects in various countries or U.S. states can actually enable SSL LNG by providing a structure of experience and needed regulations and standards. Typical economics are presented that could generally apply to SSL LNG systems that are available from a number of sources and developers that are enumerated in the report.

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