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PEAK SHAVING WITH SNG

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Executive Summary
A Context for Discussion

A dangerous dependence on natural gas isn't just an American concern. Arguably, Europe has more to fear than North America and Asia a little less. Most of us have probably read that coming to our rescue is Liquefied Natural Gas, or LNG. The popular press suggests LNG is a "new" technology; that LNG will "replace" natural gas. Since LNG is natural gas – I suppose they're at least partially right.

These and similar observations allow coronation of LNG as the natural gas industry's main savior to supply and deliverability issues. Clearly, LNG is a critical strategic tool. It allows transportation of inter-regional gas to help meet large scale demands where they exist. But LNG is not perfect for all applications – it is slow to implement and hugely expensive. For smaller, local supply and deliverability issues, LPG can be a key. Blended with air, LPG can be used to supplement natural gas via peak shaving, base-load and back-up fuel applications.

This white paper begins with a short discussion of SNG – what is it. Second, we discuss the relevancy of interchangeable fuels as either strategic or tactical tools in today's natural gas markets. Third, we discuss and evaluate the opportunity for using SNG for peak shaving in a somewhat typical natural gas dominated market (i.e. Hungary). This section of the paper also addresses the infrastructure needs to make SNG commercially viable. To avoid focusing only on central Europe, we look briefly at opportunities for SNG use in South America and in Pakistan. We conclude the white paper by providing a technical overview to the process of using SNG itself.

Our overall goal is to share awareness of the technology of LPG-Air interchangeability and to stimulate thought in using more LPG in both regional and global applications within the broad natural gas markets.

SNG: What is it?

To create SNG we dilute LPG vapor with air to a ratio of approximately 45% air and 55% LPG. In this paper we refer to this blend as Synthetic Natural Gas, or, SNG for short. Do not confuse LPG based SNG with methane based SynGas from a naphtha cracker. And do not be offended by the term SNG. Without apologies, SNG is a term borrowed to sugar coat the concept of fuel interchangeability using LPG. Believe it or not, a discussion with lay people of synthetic natural gas is easier than the same discussion trying to explain propane + air replacement. Jargon aside, LPG-Air or SNG can play a both a strategic and tactical, albeit niche, role in meeting specific energy needs.

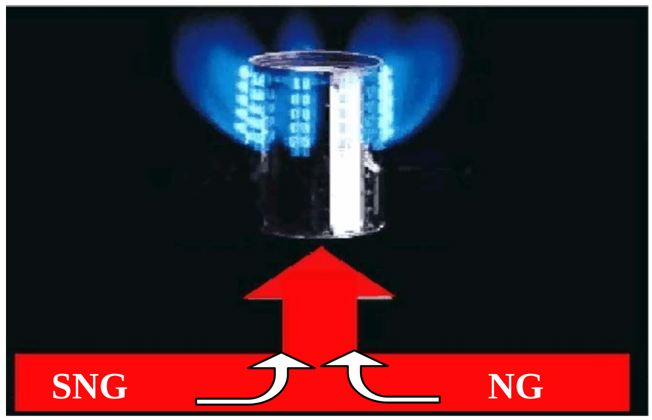

Figure 1: Simplified depiction of SNG and NG interchangeability.

The Background…

More than half a century has passed since the American Gas Association (AGA) published Bulletin 36 addressing fuel interchangeability. However, it is safe to assume our industry is still not well informed on the concept of fuels interchangeability. The same holds true for the derived benefits. Opportunities for fuel interchangeability occur globally – Hungary, Chile, Argentina, Brazil and Pakistan are but a few. Opportunities range from using SNG to supplement natural gas during peak demand periods (e.g. peak shaving), using SNG during natural gas curtailments (e.g. industrial back up), or using SNG as a base fuel prior to the arrival of natural gas in a region.

Using today's high accuracy flow meters, PLC's and precision control valves, our ability to provide near perfect gas quality has never been better. That said, using LPG-Air blending, or SNG, to simulate natural gas remains an under valued and nearly invisible application for LPG.

The Characteristics of SNG…

If the natural gas and the SNG have an identical or nearly identical Wobbe Index, they produce an equivalent amount of energy and require the same amount of combustion air. Burners operating on SNG will not require pressure adjustments and the measured and observed combustion characteristics show essentially complete acceptance. Table 1 illustrates the basic functional characteristics of SNG as compared to NG.

FUEL TYPE	CHARACTERISTICS				INTERCHANGABILITY of NG and SNG		
	COMPOSITION	TOXIC	SAFE	TYP. WOBBE	PRESSURE ADJUSTMENTS	BURNER ADJUSTMENTS	APPLIANCE'S SAME
NG	METHANE (~95%)	NO	YES	Same	NO	NO	YES
SNG	LPG + AIR	NO	YES	Same	NO	NO	YES

Table 1: Comparison on SNG to NG

There are numerous quantitative techniques to measure interchangeability. These techniques include Wobbe, Knoy, Weaver and others.

Wobbe Index is considered one of the better indicators of the interchangeability. Wobbe Index can be generally defined as "energy flow". It is calculated as the ratio of the calorific value to the square root of the specific gravity relative to air (i.e. SG air = 1). Figure 2 illustrates the basic equation. Wobbe is used when "energy input" rather than "gas flow" is of interest. This is the case for example, with a gas appliance. With an appliance, the gas input rate is controlled by the jet or burner. If the gas is supplied at a constant pressure, the flow is proportional to the reciprocal of the square root of the specific gravity.

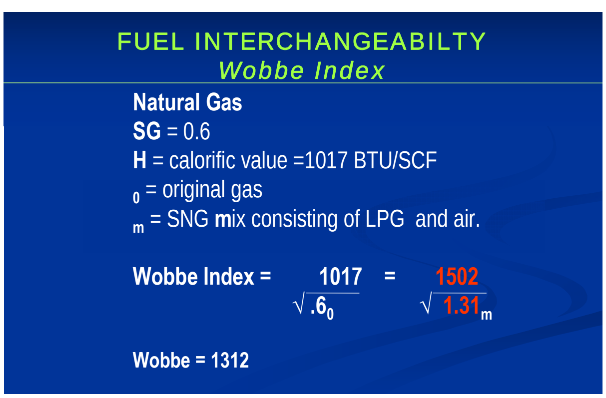

Figure 2: Wobbe calculation to compare energy value of SNG vs. NG

Hence, energy input is proportional to the Wobbe index. Such an index is necessary in cases where the feedstock LPG (i.e. blends of propane and butane) varies and can alter the calorific value.

For example, assuming the LPG is propane, an SNG mixture to replace natural gas will have a specific gravity of about 1.29–1.31 and a BTU value of 1400–1500 BTU/Ft^3.

Relevancy of Interchangeable fuels

Natural gas interchangeability strategies make sense when the economic investment to provide the interchangeable fuel costs less than obtaining pipeline capacity to deliver the same amount of natural gas. In addition, an SNG system can be a tangible investment in both long term security and flexibility of a gas supply.

A significant number of utility SNG systems have been installed around the world. All of these have been constructed to either supplement natural gas via "peak shaving" or to both precede the arrival of natural gas in a region *(e.g. natural gas pipeline is not yet constructed but the desire is to have distributed natural gas equivalent available)*, and then to augment as needed after natural gas is present via peak shaving.

Today's natural gas markets are not the same markets we knew in the 1970's or 80's. Today the natural gas industry faces not one but two seasonal peak demand periods. The traditional winter "heating" peak is now followed by an emerging summer peak as natural gas is increasingly used

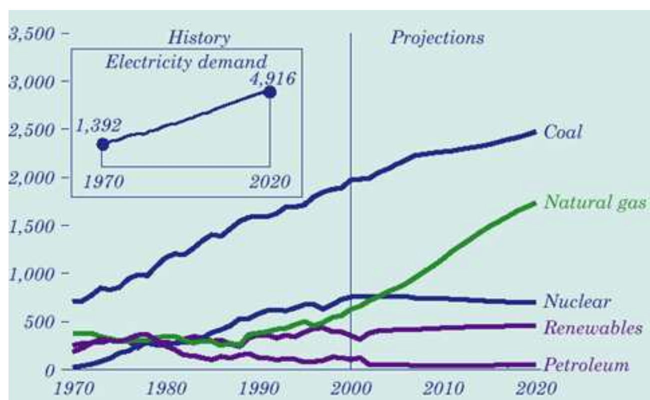

Figure 3: Illustrates the increased use of NG in power generation (Courtesy of EIA – Annual Outlook 2004 – 2020)

for "peak demand" power generation. This growing reliance on gas-fired power generation exerts even more demand on gas deliverability. In the 1990's we saw almost 95% of **new** power generation capacity fueled on natural gas. Conventional wisdom suggested decades of low cost, clean burning natural gas were in store. Now that wisdom itself is in question.

With increased price variability and seasonal volatility, the ability to strategically manage natural gas shortages is critical. Using LPG/air blends to simulate and replace natural gas can be a powerful tool.

A municipality in the mid-west of the USA is currently installing a propane based SNG system capable of supplying 25,000 Decatherms per day (i.e. 22 tons/h of propane) at pressures up to 160 PSIG. The system requires an investment, excluding land, well in excess of 5 million USD. They are installing this because it makes economic sense.

SNG is typically utilized in one of three ways

- **Peak Shaving Systems**: Allows both NG local distribution companies (LDCs) and industrial gas consumers to supplement their NG during peak demand periods.
- **Base-Load Systems**: Provide a "natural gas equivalent" bridge fuel in regions where NG will be implemented but is not yet available. Later the SNG system will later revert to a peak shaving function.
- **Backup Systems:** Allows industrial natural gas customers to use SNG during curtailment periods, and, allows taking advantage of arbitrage opportunities.

Interchangeable fuels should form part of a strategic and tactical approach to energy management. Stripped to their essence, SNG systems are asset management tools. They can benefit either the demand side or supply side of the natural gas (NG) market – or both at the same time.

Its all about options…

The June 2006 issue of ***Pipeline & Gas Journal*** contained an article titled, *Reliability Means Key to Success for Gas Marketers*. The article addressed the concerns of industrial natural gas customers regarding their suppliers. The concerns were: 1) reliability, 2) dependability, and 3) trustworthiness. Cost of gas supply was not even mentioned! At a time when natural gas prices have exhibited manic behavior, energy manager's seem most concerned with "*will I have gas…?*", not, "*what will it cost me*". These concerns do not appear to be a US issue only. Rather, the concern is a global issue, with each region biased by its own supply and demand circumstances.

A relevant question for gas users and gas suppliers then becomes, "*what is my strategy for fuel switching*?" In other words – what are my options? Let us look at an example of a natural gas market and the opportunities for using SNG for peak shaving to improve the security of gas supply.

Hungary for Gas

Hungary lies at the geographic heart of central Europe. Poor in natural resources, this former socialist country enjoyed artificially cheap energy until the demise of Soviet influence in 1989. When the Soviet Union disappeared - access to cheap gas disappeared too. Russia began billing based on world market prices forcing the Hungarian government to make a key decision: continue to subsidize gas prices to keep prices low or pass the new high prices on to the consumers. With political stability the driving issue, natural gas prices were kept low.

As Figure 4 indicates, Hungary's appetite for natural gas since liberation from Soviet influence has been strong. Hungary's natural gas grid covers nearly three quarters of the country. Over 2600 of its 3600 towns and villages are served by natural gas. In fact, Hungary has the highest proportion (45%) of natural gas use as a primary energy of the entire 26 member IEA or International Energy Agency. This organization, for those not familiar with it, is described, per their website, as an "intergovernmental body committed to advancing security of energy supply, economic growth and environmental sustainability through energy policy co-operation".

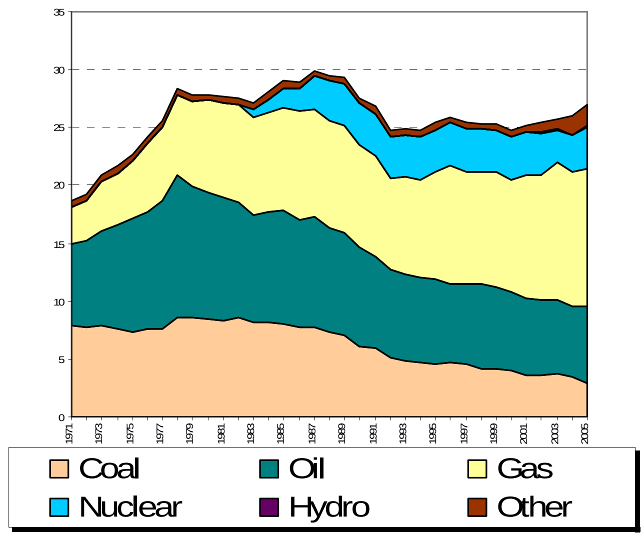

Figure 4: Hungary's primary energy use by source

Now, approaching two decades after the fall of the Soviet Union, the energy structure in Hungary remains artificially supported by subsidies. To be fair, industrial and household gas prices have risen dramatically. They still, however, remain below full liberalization prices.

Complicating Hungary's situation, a tax imposed on heavy oil in 2004 resulted in nearly three hundred large interruptible heavy oil customers converting to natural gas. These former oil customers felt the opportunity to source lower cost, "uninterruptible" NG was too good to be true. They were right.

The (semi) unexpected happened in January 2006. GAZPROM cut off gas supplies to Ukraine in a dispute over price. This reduction affected not just Hungary, but Austria, Poland, Slovakia, Italy, and the Czech Republic. MOL, the Hungarian National Oil and Gas Company, requested major consumers of natural gas with interchangeable oil capability (i.e. natural gas to oil – not SNG….) should switch back to oil. Not as easily done as said.

As the natural gas shortage continued, Hungary's gas grid threatened collapse. Pressure dropped to 32 bar g. The vulnerability of gas supply – and the lack of real interchangeable fuel options became apparent.

Hungary does have a good natural gas storage network intended to help manage commodity pricing and buffer peak consumption periods. Hungary's winter peak typically requires 86-90 million m^3/day while summer peaks require about 18 million m^3/day. Temperature sensitivity to gas consumption, however, is high. As an example, -1°C to -2°C requires an additional 2 million m^3. When temperatures drop below -3°C interruptible users should activate their alternative fuel systems. Historical data indicates interruptions can average 19 days by year.

Could an Interchangeability Strategy Help?

The characteristics of **any** interchangeable fuel strategy should provide:

- A reliable and (preferably) independent energy source.
- An environmentally friendly energy source.
- A flexible and transportable energy source. (*e.g. able to use rail, ships, barges and containers*)
- An energy source that would allow seasonal product purchases and storage and an acceptable ROI.
- A proven robust technology for interchangeability.

SNG ***could*** fulfill this need– but there are other mitigating problems in Hungary that have prevented LPG from being recognized as a suitable option for peak demands. Ultimately – the main problem is economic. The price of world market LPG is about 3 times more expensive than the equivalent subsidized NG based on a MJoule comparison. For the Hungarian market, logistics play a key role in the economics of LPG.

In 1996 a study by MOL identified elements of the Russian LPG import chain that significantly impact the ultimate cost of LPG:

1. Transport distances
2. Bottle necks of railcars, especially in winter
3. Trans-loading
4. European railcar availability
5. Compatibility of Russian and European railcars and equipment
6. Volume programming and residue handling at trans-loading
7. Producing countries lack the infrastructure to bring their LPG into the global markets. For example, Russia, Kazakhstan, Turkmenistan, Libya, etc.

Derivative observations and ideas from the MOL study included:

1. *Transport distances*: the average transport distance of Russian LPG is about 3400 km. There is nothing to be done about that fact – except work to mitigate the impact
2. *Bottle necks of Russian railcars:* more investment in rail cars
    a. *Trans-loading* Use changeable modern bogey or adjustable bogey types to reduce handling costs
    b. Availability of European railcars
    c. Compatibility of Russian and European railcars and equipment
    d. Offloading logistics and residual LPG handling at trans-loading sites

After digesting all of the above, the research suggested a savings of 15-30% on transport and handling costs and 30-40% savings based on 3-6 months seasonal storage. These assumptions required an appropriately located and designed LPG terminal to allow purchase of LPG at prices that could help close the spread between high cost LPG and subsidized NG. More economic purchasing combined with perhaps a tax rebate for industrial SNG use during prescribed periods could create a viable approach to aiding the risk management needs of Hungary's supply strapped market. The typical 19 days of natural gas interruption per year could in theory generate sales of 43, 000 tons of LPG for use in Peak Shaving or SNG back-up markets. This would be about 20% of Hungary's current annual LPG market.

What this means…

SNG technology is never more than part of an equation when it comes to energy management. But to consider using SNG requires an understanding of the overall LPG logistics required to make the tactic viable. If supply and pricing are appropriate, SNG can be an attractive energy alternative to natural gas for peak demand periods, off grid expansion projects and industrial back up.

Beyond Central Europe…

As stated early, Hungary is not alone in terms of their gas supply vulnerability. Since the mid-90's Chile has purchased essentially all their natural gas from Argentina. Chile's purchases have equaled about 70% of Argentina's gas exports. In Chile, as elsewhere, electrical power generation is a substantial consumer of natural gas with over 40% of all Chilean power relying on natural gas.

In a scenario not dissimilar to what was observed in Hungary in January 2006, April 2004 saw Argentina reduce Chile's natural gas supply. The valve was tightened and flow to Chile was reduced by 14 percent or by about 2.3 million m^3 per day. The reduction was in part due to Argentina's reduced natural gas output as well as their rise in domestic consumption. The reduction in flow to Chile sent natural gas distributors and users scrambling for options. One option was find an alternative natural gas supplier. Chile reconsidered Bolivia but Bolivia tied discussions on energy sales to restoration of access to the Pacific – access she had lost to Chile during their 1880's war. That option – for the time being at least – was out.

Another tactical option was SNG. Fortunately, both Chile and Argentina were familiar with using SNG. Both used it to support their natural gas infrastructures. In fact, both countries had installed numerous Peak Shaving Systems in the last few years. Photo 1 is of a peak shaving facility

Photo 1: SNG Peak Shaving System, Bariloche, Argentina (Photo courtesy of Camuzzigas, Argentina)

owned by Camuzzigas, located near Bariloche.

The primary gas company serving Santiago (Chile) as well as two smaller gas utilities responded to the Argentine crisis by increasing existing SNG capacity and installing new SNG systems. Photo 2 shows a modular SNG system being installed a few months after the crisis in Chile. A virtue of SNG that needs to be mentioned is the agility with which SNG can be used to respond to a crisis – unlike the process of installing a complete LNG facility.

Brazil, another developing natural gas market, also lives in the shadow of political instability regarding their natural gas supply. Bolivia provides nearly two-thirds of the natural gas consumed in Brazil. Sales of natural gas from Bolivia to Brazil increased from 23 million dollars in 1999 to over 750 million dollars in 2005. On the reciprocal side, Brazil's economic presence in Bolivia represents 20% of Bolivia's gross domestic product. Given the tumultuous relationship between the two neighbors, the risk of a natural gas cut-off by political decision or sabotage has never been too far

Photo 2: SNG Blending System being installed at Chile jobsite.

away. However, the May 2006 announcement by Bolivian President Evo Morales to nationalize all foreign energy assets in Bolivia certainly has escalated fear factors.

Brazil's difficult situation is even more exacerbated since Brazil, unlike Hungary and many other countries, lacks an infrastructure to store natural gas for emergencies. Hence they have no viable short-term options in place. This environment again opens the door to the possibility of using SNG either for Peak Shaving at the utility level or for larger industrial gas clients. This could be especially attractive to some of the LPG distributors who have seen their industrial LPG market contract as natural gas becomes more prevalent in the market.

Base Load of SNG…

In addition to being used to augment inadequate natural gas supplies, or, as a curtailment period substitute, SNG can be used for true base load applications. There are many examples ranging from Uruguay to China to Chile to Korea to Canada to the USA to Pakistan and more. We will focus on Pakistan.

Interestingly, Pakistan has a mature history of using LPG based SNG systems. Pakistan's first base load SNG system was commissioned over 30 years ago. The system served Quetta City, the capital of Baluchistan providing 7,500m^3/h of SNG via a pipeline grid at approximately 2 bar g. The system was installed by Indus Gas Company Limited who merged in 1989 with Sui Gas Transmission Company and Karachi Gas Company to form what is now Sui Southern Gas Company.

In 1973, the Government struggled how to best serve Quetta City with a modern convenient gaseous fuel. The Pakistani governmenrt evaluated the following alternatives:

- Use natural gas and construct a natural gas pipeline

- Provide LPG in cylinders
- Construct a coal gasification system and piped grid system
- Construct an SNG system and piped grid system that would allow conversion to NG in the future

The last alternative was selected. Performance of the system was very good and three decades later when Sui Southern Gas Company (SSGC) faced a similar challenge SNG was again selected.

In late 2005 Southern Sui Gas Company began construction of an SNG system in the city of Gwadar, a port city also located in Baluchistan near the border of Iran. Baluchistan, incidentally, is the largest province in Pakistan with a population of only around one million. The port of Gwadar is being developed under the state government for trade with Afghanistan, China and other Central Asian states.

Photo 3 shows the SNG system installed at the Gwadar facility. It was commissioned in early Janaury 2006 with President General Musharreff in attendance. Various other cities in Pakistan are targeted to be supplied SNG in 2006-2007.

Photo 3: SNG Blending system installed at Gwadar, Pakistan (Photo courtesy of SSGC, Pakistan)

The concept used by SSGC in both these applications is a concept well proven. SNG is distributed from a local CityGas facility as the primary fuel prior to the the arrival of natural gas as illustrated in Figure 5.

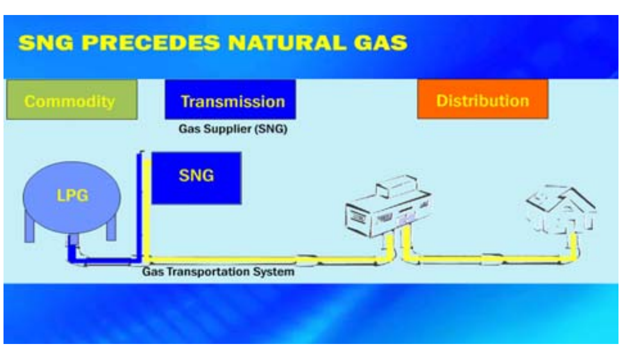

Figure 5: Illustrates the use of SNG for CityGas distribution prior to the arrival of NG to a region

After arrival of natural gas at some future date, the SNG system reverts back to a peak shaver function as depicted in Figure 6. Two excellent examples of countries that employed this technique on a large scale are China and So. Korea.

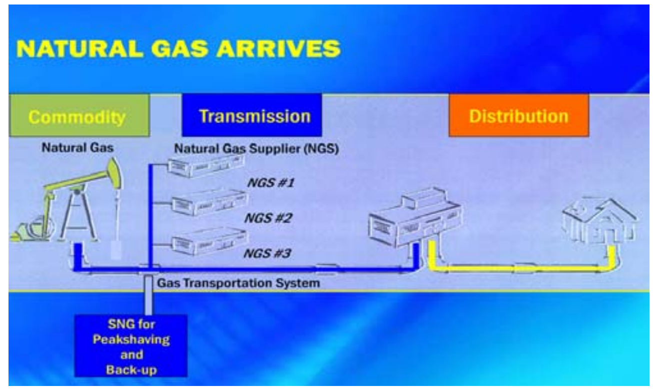

Figure 6: Illustrates the use of the SNG system reverting to a Peak Shaving function after NG arrives in a region

SNG : A Technical Overview…

Figure 7 depicts a typical flow process for an SNG system. Liquid LPG is stored in tanks under pressure. The amount of storage required is determined based on the output capacity of the proposed facility, the projected hourly usage, the logistical ability to replenish the LPG, and so forth. When the SNG system is in operation, LPG is transferred from the tanks via a pump to an LPG vaporizer. As the LPG liquid

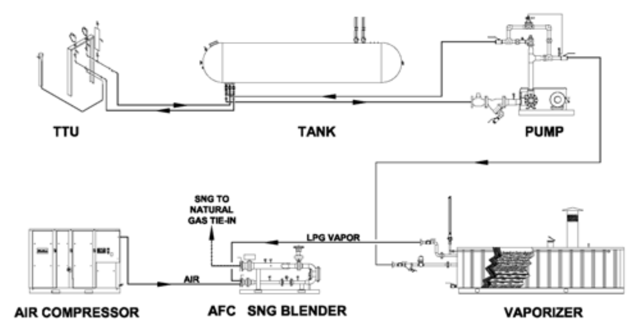

Figure 7: Typical flow schematic for an SNG system

passes through the vaporizer, it is heated to the vapor phase. The vaporizer also provides adequate super-heat to prevent re-condensation.

The super-heated LPG vapor is then blended with air supplied from an air compressor to a specific ratio creating the SNG. This mixing occurs in a proportional blending system as illustrated in Figure 8. The system's flow control system then allows injection of the SNG into the gas distribution grid as required.

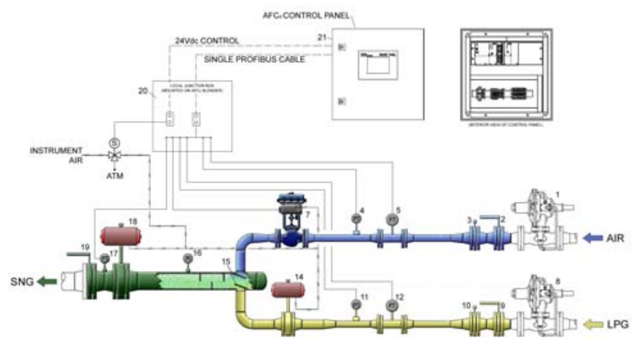

Figure 8: Typical LPG + Air mixer used to create SNG

SNG for peak shaving is typically injected into the natural-gas grid to replace up to about 25 to 40% of the total gas flow. The "right" mixture quality (BTU/Ft^3) for a peak shaving site involves several factors, including the composition of the natural-gas and LPG streams and the interchangeability criteria to be met.

When peak shaving, there are two common control methods: Ratio Control Figure 9 or Pressure Control Figures 10.

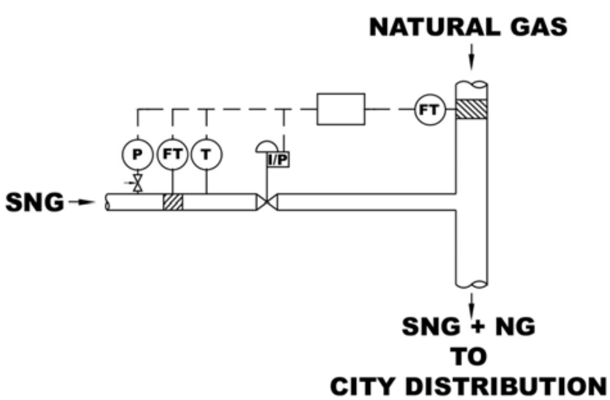

Figure 9: Peak shaving using ratio control

In Ratio Control, a pressure and temperature corrected flow signal from a meter in the natural gas line upstream of the SNG tie-in is required. A similar flow signal is required from an SNG meter. These signals allow a Flow Control Valve installed after the blender to regulate a volumetric ratio up to ~40% of SNG to natural gas in the pipeline. This ratio ensures the overall specific gravity of the SNG/NG will remain below 1.00 (lighter than air). The control system

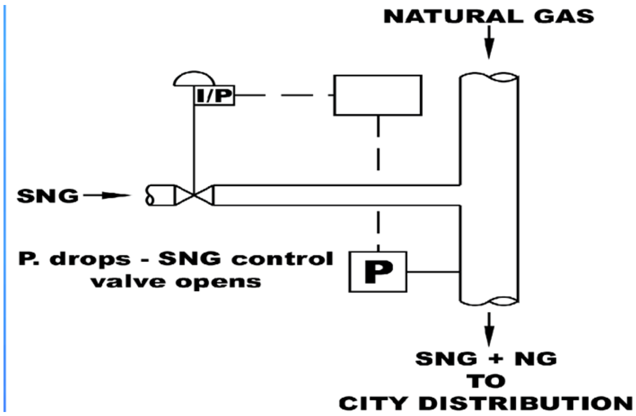

Figure 10: Peak shaving using pressure control

also allows the SNG flow to vary as necessary, in a fixed ratio, as the natural gas demand varies.

An alternate method of peak shaving control is Pressure Control. When peak shaving in Pressure Control, the amount of SNG replacement of NG can vary from minimal to 100%. The role of the SNG is simply to maintain line pressure and flow in the NG pipeline — regardless of SNG/NG ratio! During operation, a pressure transmitter provides a flow control bias that will reduce the SNG flow rate as the natural gas pressure in the pipeline approaches some fixed pressure setpoint. If the natural gas system pressure rises above that set value, the flow control valve closes and SNG injection will stop. When the line pressure drops, the flow process will begin again.

Both systems have various safeties that ensure safe operation. These will be discussed in a following section.

Design and Construction

The design and construction activities associated with an SNG peak shaving facility can be sub-divided into discrete activity blocks. These include:

1. Economic feasibility confirmation
2. Site selection
3. System design and specification
4. Site permit / Fire Safety Analysis completion
5. Manufactured Equipment ordered
    - Liquid LPG unloading facility
    - Liquid LPG storage facility
    - Liquid LPG transfer systems (storage to vaporizer)
    - Liquid LPG vaporization system
    - SNG mixing system (i.e. LPG and Air blending)
    - SNG flow Control System
    - Control philosophy and hardware
6. Field preparatory work (as necessary)
7. Field concrete / foundations

8. Tanks and manufactured equipment set
9. Field interconnecting piping completed
10. Field interconnecting electrical completed
11. Field "tie-in" to Natural Gas Grid completed
12. Site security and landscaping
13. Commissioning / Training / Hand-over to Client

Construction Times/Costs

The amount of time required to design and construct a peak shaving facility depends on the complexity and size of the system. Four to eight months are reasonable construction estimates. These estimates include the design, manufacturing, field erection and commissioning activities.

Costs also vary dramatically depending on system capacity and sophistication. As LPG storage requirements increase — costs increase significantly. Estimates from $400,000 to $7+ million USD are reasonable. Storage capacities, soil conditions and amount of field piping have the most direct impact on costs.

Modular "plug and play" pre-packaged, wired and piped (see Photo 4) systems constructed inside ISO containers are common. These modules reduce construction and commissioning time and costs.

Photo 4: Modular SNG Blending System (Photo courtesy of Ely Energy)

SNG System Sizing

Proper sizing of equipment requires the following information be provided by the client:

- Maximum hourly SNG capacity output for the system
- Heating value of the Natural Gas (to allow Wobbe matching)
- SNG discharge pressure required
- Site information (e.g. site plan of area to allow equipment layout design)

LPG Delivery Facilities

LPG delivery via truck transport is the most common method of product delivery. Transport capacities range from 9,000 to 11,500 (water) gallons and typically unload via a PTO driven pump mounted on the transport. A level unloading area is required to ensure effective transfer of the liquid LPG from the transport to the storage facility.

LPG is transferred using a TTU or Truck Transport Unloading station. The TTU has two hose connections; one is a vapor line connection piped to the vapor connection of the storage tanks. The second connection is the liquid transfer connection, which is piped to the liquid connection on the storage tanks. During the transfer process, high pressure hoses connect the transport to the storage tanks creating a circuit. As liquid is transferred from the transport to the storage tanks, vapor is displaced from the storage tanks to the transport.

After completion of the liquid transfer, from the transport, the unloading process is complete. The vapor remaining in the transport can constitute up to ~3% of the load. However, recovery of the vapor phase requires use of an LPG transfer/recovery compressor.

Rail Delivery

Rail tanker deliveries require different equipment than road tankers. Rail tank cars generally are not "bottom drop" like LPG delivery trucks. Rather — the LPG is off loaded via connections on the top of the rail car. To accomplish this, rail unloading facilities must have a railroad unloading tower and unloading transfer compressor. A stationary LPG transfer compressor is used to "push" the liquid LPG out of the rail car. This is accomplished by drawing vapor from the ("empty") storage tank(s), compressing the vapor to a slightly higher pressure while adding some heat from compression, and then pushing the compressed vapor into the rail car. This vapor volumetrically displaces the liquid LPG in the rail tanker, forcing the liquid to transfer out of the rail car to the storage tanks.

After most of the liquid has been removed from the rail tanker, the process is reversed enabling the vapor in the rail car to be recovered and transferred to the storage tanks as well. To accomplish this, the compressor flow path is reversed using a 4-way valve arrangement. Vapor is sucked from the rail car and discharges to the storage tanks via the liquid line connection.

LPG Storage System

Sizing of the liquid LPG storage facility depends upon the demands on the process and the availability of LPG supply. An analysis of the projected use can define the minimum appropriate storage required.

Example: An SNG facility has a projected usage operating 24 hours per day, at an average of 300 million BTU/hr for up to 3 consecutive days. The LPG this requires at peak flow will be approximately 3,300 gallons per hour. A 60,000 gallon storage tank will provide a 16-hour supply. (A 60,000 gallon storage tank can only be filled to ~88% capacity at

60°F.) For three days (24h x 3 = 72h), 72/16 = 4.5 or a requirement for five (5) 60,000 gallon tanks.

Although LPG storage tanks can be installed underground, costs are high relative to above ground tanks. Underground tanks can have additional requirements including protective coatings, ballasts, special types of pumping scenarios, top penetrations versus bottom and so forth.

LPG Pumps

LPG is delivered to the SNG mixing system at a pressure elevated above equilibrium pressure. Vapor pressure in the tank is dependent upon the "percent full" and ambient temperature of the LPG. As the LPG temperature drops and/or the storage tank level drops as with use, the vapor pressure in the tank will also drop. Hence, liquid pumps ensure sufficient LPG flow and pressure are available at the SNG mixing systems. LPG pumps are rotary pumps, generally either positive displacement or turbine type.

Vaporizers

Vaporizers convert liquid LPG to vapor by adding heat. For a utility application, the vaporizer is typically a gas-fired water-bath. The vaporizers (see photo 5) use either an atmospheric or forced draft power burner system to heat a solution of ethylene-glycol and water. The ratio of water to ethylene-glycol for freeze protection is established based on local temperatures. The waterbath indirectly heats the LPG via the LPG heat exchanger. Waterbath capacities are available up to 15,000 gallon/h in one unit.

Photo 5: Typical Large Waterbath Vaporizer (Photo courtesy of Aprogas, Peru)

LPG-Air Blending = SNG

The typical SNG blender provides discharge pressures from 15 – 70 PSIG but 100 to 250 PSIG are available. Modern blenders operate on molar (volumetric) relationships. The percentage of gaseous LPG and compressed air are then blended to maintain a specific SNG mixture. An optional Wobbe Index meter (see photo 6) monitors the SNG gas quality and determines its interchangeability with the natural gas.

The blender will use the Wobbe Index signal to adjust the mixing ratio to the desired gross WI value. Typical correlation is +/- 1.5% of setpoint. The Wobbe Index meter also alarms any High or Low Wobbe value that might be measured.

Modern SNG blenders monitor the following conditions. If one of these process characteristics is out of normal range, the blender will alarm and shutdown as necessary.

- Low LPG Supply Pressure
- Low LPG Supply Temperature
- Low Air Supply Pressure
- Flow Control System (*Faults if the flow ratio of two gas streams is incorrect)*
- Air Flow Control Valve — (*Faults if the actual Air Control valve position differs by more than 2% of the required theoretical position)*
- Low Wobbe Index
- High Wobbe Index

Photo 6: Wobbe Index Meter for monitoring of SNG quality

The SNG Blender has the capability of operating in two different modes of operation as we previously discussed for peak shaving. It can operate in Ratio Mode, wherein a fixed ratio of the natural gas flow is displaced by SNG. Alternatively, the blender can operate in so called Pressure Mode, wherein all natural gas is displaced (or made up by…) by SNG.

When in Pressure Mode, the Blender typically operates at 1" to 3" of water column pressure higher than the regulated natural gas. This configuration requires a check valve be installed in the Natural Gas piping up stream of the SNG injection point. When SNG is being injected at the slightly higher pressure, it will automatically close this check valve shutting off the Natural Gas supply. SNG now supplies all the gas into the pipeline. If the blender were to shutdown, the gas distribution system pressure will fall allowing the natural gas check valve to re-open and Natural Gas to flow back into the facility.

When in Ratio Mode, a Flow Control Valve is required on the discharge of the Blender. The blender will operate similar to the Pressure Mode we described above with the SNG discharge pressure 1” to 3” of water column higher than the regulated Natural Gas pressure at the point of injection. The SNG Flow Control Valve will control the SNG injection rate using a dedicated PID Process Controller that monitors the ratio of the corrected Natural Gas and SNG volumetric flows. The natural gas flow signal will be provided from a meter installed upstream of the SNG tie-in. The blender creates a corrected flow signal for controlling the SNG through normal programming. The Flow Control Valve controller will only allow a volumetric ratio up to 40% SNG to Natural Gas. This ensures that the overall specific gravity will remain below 1.00 (lighter than air), The control system also allows for the SNG volume to adjust as necessary, in a fixed ratio, as the Natural Gas Flow demand changes.

Peak Shaver Controls

Advances in controls technology allows peak shaving operations to be extremely flexible, user friendly and safe at affordable prices. Generally a centralized control station is either a traditional relay based system or more commonly handled via a PLC utilizing either an Ethernet or Data Highway design. Either way, today’s controls allow integration of the entire process — from the bulk storage tanks thru to the gas/air mixing and gas quality measurement and control functions. System design should focus on achieving a coherent operating strategy that ensures a safe, simple and reliable process.

Security Protection

Standard security at an LPG facility should include perimeter fencing and other devices as necessary to keep unauthorized personnel out of the facility. The facility should be restricted to only authorized and trained personnel.

Training and Technical Documentation

System operators must understand the basic properties and associated hazards of LPG. It is important that the differences between natural gas and LPG be understood.

As safety is the ultimate key to success, training and safety measures are fully integrated into the overall SNG Peak shaver proposal.

Feasibility Analysis

Consideration of a peak shaving system requires a feasibility analysis. A practical approach based on knowledge of both natural gas pricing options and SNG technologies is critical.

Conclusion

Natural gas interchangeability strategies can be a tangible investment in both security and flexibility of a gas supply. The natural gas markets of today are not the same as a few decades back. Our growing reliance on natural gas-fired power generation has added a new dynamic to the market. Price variability and seasonal volatility demand the ability to strategically manage shortages of supply as well as pricing issues. Using LPG/air (i.e. SNG) to simulate and replace natural gas can be a good option.

Applications can involve not only peak shaving during high demand periods but can also include off-grid market development (e.g. Pakistan with SNG preceding NG) as well as industrial back-up systems in mature gas markets.

For large scale supply supplementation projects, LNG will retain the upper hand in terms of application. But LNG is not the perfect cure for all scenarios. LNG is also slow and expensive to implement. For many small local markets as well as some regional CityGas opportunities, LPG holds advantages. SNG can be used to supplement natural gas via peak shaving, base-load and back-up fuel applications. SNG can provide an identical or nearly identical Wobbe Index, produce an equivalent amount of energy and require the same amount of combustion air as natural gas. Burners operating on SNG require no pressure adjustments and the measured and observed combustion characteristics show essentially complete acceptance.

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