

# Converting Ammonia Plants to SNG Production

SNG can be useful as a supplemental natural gas replacement in ammonia plants under curtailment due to the energy shortage, despite the higher cost of SNG.

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Substitute natural gas is actually a gaseous fuel consisting primarily of methane plus a few percent hydrogen and small amounts of CO and CO<sub>2</sub>. In some cases, for higher heating value, a gas such as propane or butane may be added to assist in heating value control. The term "SNG" has been used to distinguish this product.

SNG can be made from a wide range of feedstocks running from LPG's through natural gasolines and up to heavy naphthas. Of the process for SNG production, those developed by the British Gas Council has gained greatest acceptance. Prior to 1960 most of the gas used in England came from the old-fashioned coal gasification or manufactured gas plants with their cumbersome technology. With the advent of steam naphtha and steam methane reforming in the ammonia industry, the British Gas Council began research for an efficient process of the same nature to make a suitable town gas. This work produced their basic process entitled the "CRG" (Catalytic Rich Gas) process based on liquid hydrocarbon feedstocks. Subsequently, a large number of plants were built and in general such catalytic town gas processes were adopted throughout England replacing the earlier, and very expensive, coal gasification processes.

The British Gas Council has continued to actively research this field while, at the same time, coordinating the operating activity of gas boards throughout England. As a need for SNG in the United States became apparent, they embarked on an overseas licensing arrangement through English contractors and in a few cases directly with American firms. Pritchard has always been active in the gas industry, and obtained the first direct license with the Gas Council for SNG work. We performed a great deal of operations research on the process coming up with some beneficial adaptations, and have now embarked on an engineering and construction program. The knowledge obtained through direct license is sufficient for Pritchard to do lump sum contracting with complete guarantees.

In the above activity Pritchard has been impressed with the similarity between SNG work and our past activity in ammonia, hydrogen and methanol. Where SNG is to be made, we reasoned that there would be a substantial reuse of equipment in idle ammonia plants. It is evident that the offsites and going concern value of the ammonia plants should be very valuable in SNG service. This idea now in material form is the source of two current projects and this article.

## CRG Process for SNG

A simplified flowsheet of the British Gas Council's CRG process is shown in Figure 1, along with Pritchard's adaptation of it.

Basically, the reaction in the CRG reactor is quite similar to that in naphtha reforming for ammonia, and approaches

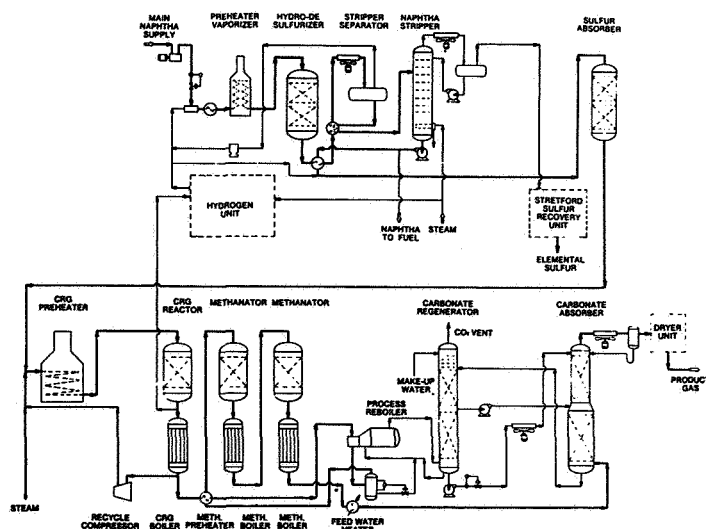


Figure 1. Simplified flowsheet of the CRG process.

**Table 1. Possible equipment conversions.**

Primary Reformer	→	{ Vaporizer-Hydrodesulfurization Preheater-CRG Steam Boiler
Secondary Reformer	→	CRG Reactor
High Temperature Shift	→	Hydrogasification Reactor
Low Temperature Shift	→	Methanator
Methanator	→	Hydrodesulfurizer
CO <sub>2</sub> System	→	CO <sub>2</sub> Removal
Miscellaneous Items	→	{ Drying Tower Blowdown System Catalyst Reduction Unit
Synthesis Compressor	→	Product Compressor (new cylinders)
Refrigeration Compressor	→	Recycle Compressor
Steam/Gas Controls	→	Feedstock/Steam Controls
Waste Heat Boiler	→	Waste Heat Boiler
Steam Power Water Instrument Air	} →	{ Steam Power Water Instrument Air

**Table 2. Portions of ammonia plant used in SNG.**

	Idle Ammonia Plant, Usable Portion of Front End	SNG Plant Portion By <u>Conversion</u> <u>New</u>	
Plant Site .....	100%	75%	25%
Buildings .....	75%	100%	—
Foundation .....	75%	75%	25%
Structures .....	50%	75%	25%
Vessels .....	80%	70%	30%
Furnaces & Boilers .....	60%	70%	30%
Exchangers .....	30%	20%	80%
Cooling Water .....	60%	100%	—
Mechanical Equipment .....	70%	70%	30%
Instruments .....	50%	80%	20%
Piping .....	50%	50%	50%
Electrical .....	60%	80%	20%
Insulation .....	50%	50%	50%
Painting .....	20%	10%	90%
Catalysts & Chemicals .....	—	—	100%

the same chemical equilibrium as found in secondary reformers, but at much lower temperature levels. The CRG reactor, the hydrogasifier, and the methanator are merely a series of three steps, each to establish a lower temperature steam-methane and water-gas equilibrium at successively lower temperature levels.

Only one major difference exists in the catalyst operation in the CRG and hydrogasification reactors in comparison to the secondary reformers with which the ammonia industry is familiar. Both are adiabatic catalyst beds in that no heat is added or subtracted, and both experience a rise in temperature through the beds. The rise in the case of the secondary reformer, is more due to combustion; whereas, the rise in the CRG reactor is due primarily to the formation of methane via methanation at the lower temperature levels. The major difference lies in the temperature profile.

In the CRG reactor, only a small zone of the catalyst is active at any one time, perhaps 19 in. in a 96 in. depth. The catalyst slowly deactivates at the rate of something like 1/8 in./day, and the active zone moves downward through the body of the catalyst gradually over a period of four to six months. At the end of the operating period, feedstock "breaks through" at the bottom of the bed. Afterwards, in the hydrogasification reactor, the catalyst is regenerated by treatment with hydrogen for a period of 24 hours. Upon returning to service, the temperature profile is returned to the top portion of the bed and again proceeds to fall through the catalyst during the operating cycle.

#### Methanator Performance

There is a difference in the methanator performance in SNG work as compared with methanation in an ammonia or hydrogen plant process. In ammonia or hydrogen work, methanation is used to extinguish small amounts of carbon oxides in a large excess of hydrogen. If, during an upset, large amounts of CO<sub>2</sub> pass into the methanator, there is ample hydrogen fuel for complete methanation producing a dangerously high sudden temperature rise. Methanation in an SNG process seeks to extinguish small remaining levels of hydrogen and carbon monoxides in a large excess of methane to raise heating value. The amount of hydrogen is limited to a few percent so that, in case of an upset, larger amounts of carbon dioxide have nothing with which to react. Thus, methanation in SNG is a tame beast. In SNG, methanation operates in a different range requiring an improved and different methanation catalyst.

The basic CRG catalyst used in SNG work is much more reactive than conventional steam methane reforming catalyst, and has a far greater metallic content exceeding 60% in many cases. The shape and form is more like that of methanator catalyst common in the ammonia industry.

Quite a bit of equipment in an ammonia plant can be used to make SNG, as indicated in Table 1. For purposes of illustration, we can look at this comparison in terms of the cost accounts used in our engineering estimates, showing the portion that can probably be used in SNG work. If the ammonia plant is in good serviceable condition, the cost picture may be as shown in Table 2.

The offsite values in an ammonia plant generally will normally support a far larger SNG plant than the "specific battery limits equipment." This enhances SNG values in future periods.

#### Operating Costs

The cost of SNG is predominantly controlled by feedstock cost. A portion of the feedstock is used for heat required in CO<sub>2</sub> removal and in the generation of steam for the basic steam-feedstock catalytic reaction. Thus, process variations are available to handle different carbon-to-hydrogen ratios on an efficient basis. The two most common processes for conversion are the regular CRG process and a version of it known as "hydrogasification." The primary differences arise from the fact that the regular process has only a CRG reactor, while the other has separate CRG and hydrogasification reactors. In the hydrogasification process, the second reactor receives one-half of the hydrocarbon feed. Thus, the combination of excess steam and hydrogen from the first reactor helps control carbon deposition in the second reactor as it received one-half of the feedstock. This, of course, saves in steam providing some gain in efficiency. The biggest difference between these two processes lies in the better exchange of low level heat permitted with the hydrogasification process in the case of lighter feedstocks.

Table 3 shows relative operating cost as compared with the new plant costs for a specific 250 ton/day conversion. This shows that the converted plant can produce pattern advantage with the new plant of the same size and within reasonable reach of the cost of a new and much larger installation. This, of course, assumes the ammonia plant has been shut down and is of no immediate direct value.

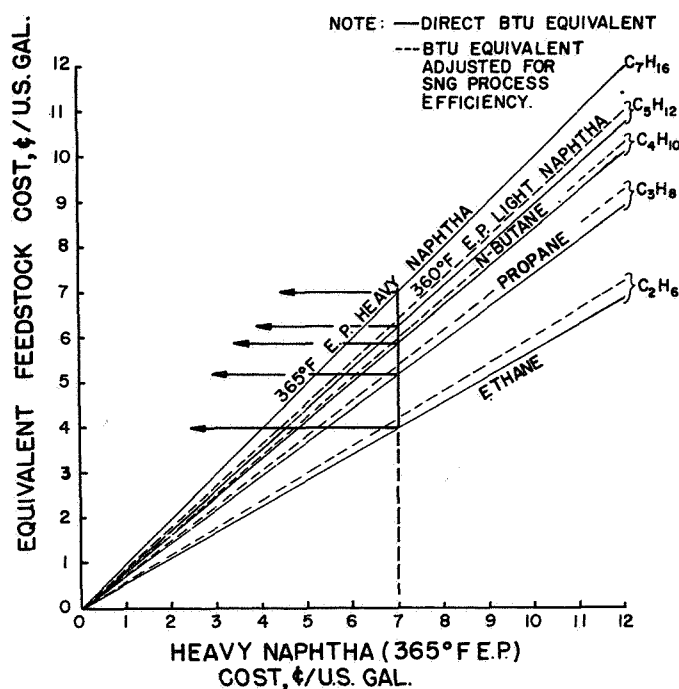


Figure 2. Equivalent cost of alternate SNG plant feedstock relative to a 365°F E.P. naphtha.

Table 3. Comparative SNG production costs: 250 ton/day NH<sub>3</sub> plant vs. new SNG plants.

	Conversion to 35 MMSCFD		SNG New Plants	
	SNG		35 MMSCFD	100 MMSCFD
<b>Investment</b>				
Battery Limits .....	\$3,000,000		\$ 7,000,000	\$15,000,000
Outside Battery Limits .....	1,500,000		7,000,000	10,000,000
Total	\$ 4,500,000		\$14,000,000	\$25,000,000
<b>Production Capacity</b>				
MM of MSCF/Yr. ....	12.2		12.2	34.5
<b>Labor</b>				
Operating .....	\$ 215,000/yr.		\$ 215,000/yr.	\$ 215,000/yr.
Maintenance (staff) .....	145,000		145,000	145,000
Supervision .....	62,000		62,000	62,000
<b>Utilities</b>				
Power .....	(2,700 kw.) 235,000	(1,000 kw.) 87,000	(2,000 kw.) 75,000	
Water Cooling .....	(13 Mgpm) 140,000	(13 Mgpm) 40,000	(30 Mgpm) 320,000	
Water Makeup .....	(130 gpm) 21,000	(130 gpm) 21,000	(400 gpm) 60,000	
<b>Maintenance</b>				
Material (total) .....	\$ 170,000/yr.		\$ 170,000/yr.	\$ 480,000/yr.
Labor (contract) .....	105,000		105,000	335,000
Operating Supplies .....	90,000		90,000	170,000
Financial (15% Burden) .....	670,000/yr.		2,100,000/yr.	3,750,000/yr.
Annual Total	\$ 1,853,000/yr.		\$ 3,135,000/yr.	\$ 5,712,000/yr.
<b>Annual Unit Costs - SNG</b>				
Plant Above .....	15.2 ¢/MSCF		25.5 ¢/MSCF	16.6 ¢/MSCF
Catalyst .....	4.6		4.6	4.6
Fuel 8% of 90 ¢/MMBtu. ....	7.2		7.2	7.2
Feedstock .....	90.0		90.0	90.0
Royalty (Running) .....	0.4		0.4	0.4
SNG Cost	117.4 ¢/MSCF		127.7 ¢/MSCF	118.8 ¢/MSCF

### A Case-by-Case Approach

Each ammonia plant has to be examined on a case-by-case basis. The most significant items in this regard are:

1. Design of the CO<sub>2</sub> system and the extra margin in it can be illustrated by the case of a 400 ton ammonia plant, which could be converted into a 72 million std. cu. ft./day facility.

2. Operating pressure — In order to get the product SNG into existing distribution systems, it is usually necessary to utilize some of the shutdown compression equipment. Quite often the syn gas compressors can be simply altered with replacement cylinders to do this work. The power to perform this compression is a burden on the process and, thus, the higher the front end pressure rating of the ammonia plant the better. At pressure levels of 200 lb. and upward, the power for product compression is not a significant operating cost factor.

3. In the conversion, it is generally useful to shift from

amine CO<sub>2</sub> recovery systems into carbonate systems to get greater efficiency. Actually, there is no need to remove CO<sub>2</sub> into the part per million level customary in ammonia plants. Thus, we can often convert amine systems into carbonate systems utilizing existing apparatus.

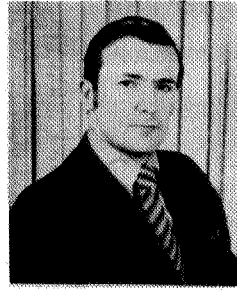
4. It is usually necessary to add feedstock storage to the plant conversion cost. This is generally a substantial item as a part of the offsites facilities.

### In Summary

SNG can be useful as a supplemental natural gas replacement in ammonia plants under curtailment due to the energy shortage, even though the cost of the SNG is much higher than that of natural gas. In a "production-limited" situation, the higher fuel cost can easily be justified on an incremental expense-profit balance. An SNG unit ahead of an ammonia plant performs the same function as the front end designed naphtha process. The units to do this can be very simple and need not process all

the way to SNG since feed can be taken into the ammonia plant right out of CRG reactor containing CO<sub>2</sub>, hydrogen, CO, and methane. We envisioned these units as simple, skid-mounted, prepiped mini plants.

The foregoing information merely serves as a background for production of SNG in shutdown ammonia, hydrogen or methanol facilities. Each installation needs to be looked at on the basis of individual merit, and often there may be unexpected advantages. From our extensive background in the ammonia and hydrogen industry, it is often possible to spot these situations and make a quick evaluation without any significant estimating work. #



**M. J. VAN SICKLES**



**E. J. NOBLES**

## **DISCUSSION**

**Q.:** Is sulfur removal by absorption or a recovery unit?

**NOBLES:** Yes. The removal of sulfur is based on desulfurization, but not with the usual "Stretford" unit. We propose using zinc oxide as an absorbant instead. Now this is a little bit inefficient costwise in the small capacities.

Once you reach 50 MMSCFD, it will pay to use the Stretford form of desulfurization, or a Claus process, or some other method of taking the sulfur out in an actual elemental form.