CARBON DIOXIDE FROM AMMONIA PLANTS – AN EXCELLENT REVENUE SOURCE SERVING AN INTERESTING & DIVERSIFIED MARKET

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Background

As today, without the deployment of new merchant CO2 plants, there are about 23 standing CO2 plants today which are fed by ammonia by-product raw gas. This represents about 21% of the total number of ammonia plants serving the merchant sector. The total number of merchant CO2 plants is around 111 in the United States. Further, numerous additional CO2 plants are under consideration, or possible, as facilities to be built alongside future ammonia ventures. Globally, the merchant CO2 market is over 20 million tons annually; and North America is over 10 million tons in merchant demand.

All ammonia, and CO2 source ventures should take a fresh look at CO2 as an excellent opportunity for future revenue developments. Monetizing the CO2 is probably the primary reason for recovery and marketing the product. The second reason, of course is environmental. In due time, cap and trade or some scenario for emissions reduction will take hold in the U.S.; so this will be a factor which will make the ammonia project so much greener, and environmentally acceptable. On a daily schedule, over 75 million tons of CO2 are emitted globally, of which some 66% of this greater estimate is not sequestered by natural means (oceans, soils, photosynthesis, etc); and this value may be

growing every day. Increasingly more CO2 is being dumped into the atmosphere, particularly by the strong economies of BRIC countries, especially China.

Markets are key to making a commercial CO2 project work, unless the aim is simply a form of sequestration, where carbon credits of the future, or tax incentives, or other government incentives make these efforts work economically. On the other hand, all of the approximate 23 CO2 plants from ammonia in the United States have one form of a market or another; and revenues from the sale of CO2 to the right or best suited markets can mean a steady stream of income for decades ahead. The need to bring in money from all viable by-products in an ammonia project is more important than ever, for long term sustainability. Further, since the U.S. and global markets have consolidated so much, taking a strong look at directly entering the markets makes sense more than ever.

CO2 Market Opportunities – Should it be Wholesale Raw Gas or Direct Marketing to Consumers?

Some decades back, in the United States, some of the source (i.e. ammonia, reformer/refinery) plant operators and owners were and are the same parties who owned operated the CO2 plant near the raw gas source operation. Today, only a very few independents which recover and market CO2 thrive in the United States, as direct sales to consumers. As mentioned before, most of the CO2 independents have been acquired by the majors. As it goes for the time being, and the future, the time is right for new CO2 independents to rise and take advantage of market

opportunities for the sale of CO2 direct to the markets. Since the emergence, and growth of the major gas companies, most of the raw CO2 is actually sold to the major corporate industrial gas refiner - which is also generally the marketing operation for the merchant CO2. What is needed today in North America, are more direct CO2 marketing schemes, since the independents in the CO2 business have largely been acquired by the majors. This scheme, as direct sales from the ammonia plants to the markets, can be found outside of the United States in some cases; which prosper greatly from the CO2 revenue income.

One fact supporting direct sales of CO2 by the ammonia, or other CO2 sourcing firm to a limited merchant or niche market, is a large margin difference between the raw gas price to a refiner/gas company. In the US, raw gas prices range from $5 to $25/ton v. consumer market prices usually averaging around $90 to $120/ton; and in some higher priced markets with little regional competition or no local supply can be $200 to $300/ton. It will be necessary to evaluate the costs of production, distribution, and overhead, initially to consider wholesale raw gas sales or direct markets. Further, once markets are understood, and the costs & requirements for producing CO2 for the merchant trade is known, along with distribution; then potential risks for direct marketing can be properly evaluated. Numerous cases exist, where a niche market or a specific region would make the most sense, in terms of directly marketing the commodity – and a true opportunity to produce much stronger revenues.

CO2 has a Wide Variety of Uses – and Always Growing

In developing economies, the lion's share of CO2 is dedicated to beverage carbonation, with some sold to welding shops and as a cylinder gas for fountain service, and fire abatement. This was also the nature of the merchant or commercial CO2 markets in America some time back. Years ago, there was a great deal of CO2 which needed to be sold by the gas companies, and which was simply being vented by a large number of industries. This was an impetus for developing more markets for the product. What emerged ahead in due time was the application for CO2 liquid in food processing environments – this was largely the use of liquid, stored on site at a food plant, and used for so-called IQF or individually quick frozen, that being a food product laid out to freeze well, which would not stick together in a cryogenic freezer - on a straight thru, multiple pass, or spiral type configuration. Other freezers using CO2 exist, such as a tumble freezer, for products such as pizza toppings, and using CO2 liquid injected into a blender or grinder, which then uses the cold nature of this liquid, which is 'flashed' at atmospheric pressures into a fine CO2 'snow'. The nature of refrigeration and cryogenic freezing is often calculated by a BTU value which would have to be removed to achieve a temperature to simply cool, crust freeze; or freeze completely. These values are calculated during planning stages, in order to closely estimate CO2 usage, dwell time in a freezer, and freezer size. CO2 is delivered via insulated piping from storage vessels into the freezer, blender, grinder, etc, via insulated piping; however sometimes the

liquid CO2 is vaporized for a gas flush or a so-called modified gas environment – intended to preserve the food product, and yield an improved appearance, and reduce the bacteria count. Such CO2 applications probably amount to 40% of the average developed economy's usage of the commodity at large; where some very large plants can use hundreds of tons of CO2 daily for food processing. Thus, if a plant is dedicating their CO2 product to a region which has many such food plants – this represents a captive market of sorts. Of course the soft drink carbonation requirements for CO2 are straight forward in terms using CO2; and some breweries which do not recover sufficient CO2 via fermentation, may then require merchant product to supplement this need – and some large breweries use the gas to backpressure their system, thus not to actually directly enter their product. In many developed economies, such as the U.S., the food and beverage applications for the product can be some 70% of all merchant product sold. This excludes captive use for making commodity or specialty chemicals, numerous industrial uses, enhanced oil recovery, and niche markets of a unique nature, such as recovering natural gas molecules from coal bed seams, and replacing this natural gas with CO2.

The next broad sector, outside of food and beverage applications for CO2, would be a large industrial sector. In most cases, one grade of CO2 is produced at most merchant plants. This standard grade is a high quality product, usually meeting beverage standards, should the plant sell any product to the beverage industry; this is known as ISBT grade. So, outside of a captive enhanced oil recovery

application for CO2, the beverage grade will suit all parties. The only exception to this is a very small market, essentially a specialty gas, a USP grade, meeting pharmaceutical and medical usage standards. This is for respiratory stimulation in emergency room and similar settings. The USP grade is produced in specific plants, and is usually not the concern of smaller players, or even some of the major suppliers.

As for the industrial sector of CO2 markets, this includes the application of CO2 for water treatment – processes and municipal plants using the product in water softening plants, and for Ph reduction – thus carbonic acid which is a weak, environmentally friendly acid, when in water – under given pressures and temperatures. The use of CO2 for Ph reduction has also been a safe acid replacement material in the paper and pulp industries, as well as effluent from chemical plants, and food processing facilities – where an alkaline stream requires treatment. Use of CO2 in fire extinguisher settings is as old as the industry happens to be. The same for many uses of CO2 in cylinders for the welding industry, the soda fountain industry, and similar small usage requirements. Use of CO2 has been popular in some metallurgical settings, as a stirring medium for large molten metal processes, and for use in some foundries, as a coolant. The application of CO2 in rubber and rubberized - belt manufacturing and some plastics manufacturing plants has been around for some time. Using CO2 to control insects in sealed grain elevators, holds, and ships has been popular in warm climates, in lieu of numerous chemical agents – often those which are harmful to the health. CO2

in the form of dry ice is popular in a wide variety of settings, which sells for many more times than a liquid product, generally speaking. Of course dry ice is used in huge quantities for food preservation & shipment and the food processing industry. Dry ice has many uses as a portable coolant, which sublimates as it cools, and of course has a limited life. Dry ice has grown in popularity in so – called 'blast cleaning' applications – whereby the product is manufactured or pressed to form very small 'rice' like pellets, which are literally blasted under pressures, sometimes near 1,500 psig, and are used in a wide range of settings to remove paint, grease, ink – anywhere from printing presses to refineries, and beyond. This is an environmentally friendly application. The application is ever – growing in all types of markets. Further to CO2 applications, this can include a move from the old time dry cleaning solvent 'perc' to CO2; eliminating a hazardous and environmentally unfriendly chemical from the scene – this is essentially a solvent – based application. Other solvent applications include extracting under pressure with CO2 essential oils, and like substances in lieu of using hydrocarbons. CO2 has a huge market in natural gas 'frac' or fracturing applications, given the location, geology, etc; and a whole separate niche market is EOR or enhanced oil recovery – that being CO2 applications for recovering oil which would have not been recovered by primary means – this CO2 technology is usually described as secondary or tertiary oil recovery. This is specific to the oil producing regions – however, a good opportunity for specific settings where a niche market could be created and served, usually for decades. The uses

for CO2 are growing all the time, and today, since carbon sinks and sequestration is a hot topic, using CO2 in large greenhouse operations to enhance the growth of plants, is a popular topic; and the use in tomorrow's future for next generation biofuels – that being CO2 usage for algae growth is a truly environmentally friendly carbon sink, which will grow indefinitely – and applicable to renewable energy. Numerous applications are underway in test phases, which are diverse, and again, very environmentally friendly.

What to do - Direct Markets or Wholesale Options?

Above I have outlined some of the considerations such as evaluating the costs and requirements to produce CO2 for the markets, and understand the downstream requirements and costs surrounding direct sales to the markets. Of course, there is a huge difference between selling prices of a delivered merchant product; and the price to a refiner or gas company for a raw gas. With a full evaluation of markets; along with plant and operating costs and requirements understood – then weighing this against raw gas sales, which usually will have to be negotiated up from the initial offer – will yield a sense of which direction one should take. One consideration today, is to understand the merchant CO2 industry is supplied by a very few, very large gas corporations, and there is an opportunity to look at direct sales to the markets, unlike any time in recent decades. Practically all of the major independents in the CO2 industry have been acquired by the majors, so there is room for new parties to enter the industry.

There are niche settings, or markets which are not served well by local production, or lack local production. These are excellent examples of such opportunities, which an ammonia project could capitalize on when marketing the CO2 directly to the consumers, and sometimes they can literally make a fortune. The first step is understanding in depth the feasibility behind the direct market for the CO2, or wholesale – raw gas options.

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