ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

Commissioning a Nitrogen Generator in China

Dr. Craig Seidelson

Abstract*—*China is the world's largest consumer of industrial N_2 [1]. China's highest executive body, the State Council, has committed to cutting carbon emissions by 40 – 45% of GNP before 2020[2]. One might assume, given the environmental and financial benefits of on site N_2 generation, the process is encouraged in China. However, generating N_2 requires construction to install generators and electricity to power them. Both sectors are heavily regulated in China. This paper defines the benefits of on site N_2 generation for a factory in China and approvals needed to realize them.

***Index Terms*—Nitrogen Generation, China Manufacturing Regulations.**

I. INTRODUCTION

Due to nitrogen's (N_2) inertness, it is used to prevent oxidization in the manufacture of metals, electronics, pharmaceuticals, and beverages. Some factories buy their N_2 in liquid form, store it on site, and convert it to gas as needed. Others generate their own N_2 directly from the air. Reported benefits of on site generation include reduced carbon footprint and 40 – 80% savings on N_2 bills [3].

II. NITROGEN GENERATION PROCESS

To generate N_2, compressed air is first passed through carbon molecular sieves. The 99.5% pure N_2 gas is then cryogenic cooled to distill off remaining oxygen (O_2). The result is 99.999% pure N_2. If the N_2 consuming plant is located far from the generation station, N_2 gas is liquefied for truck delivery. Liquefying involves successive compressions followed by cooling expansions until a temperature of -195° C is reached. Factories store their liquid N_2 in insulated tanks. As needed, the liquid is pumped out of tanks and through evaporators to convert N_2 back into a gas.

III. NITROGEN GENERATION BENEFITS

As the above process indicates, 2 factors primarily affecting the price (and carbon intensity) of N_2 generation are transportation and electricity. In this study the consuming plant receives 500 metric tons of liquid N_2 monthly from a supplier 200 kilometers away. Thirteen times per month two 20 metric ton tanker trucks make deliveries. The average price for tanker delivery in this part of China is \$2.5/km. It, therefore, costs the N_2 supplier \$13,000/month in transportation to satisfy the plant's demand. To produce 500 metric tons of N_2 gas per month requires generating 548 N_2m^3/hr as calculated in (1).

$$\frac{500{,}000 \, {}^{kg}\!/\!_{mo}}{730\,\frac{hrs}{mo} * 1.2506\, {}^{kg}\!/\!_{N_2m^3}} \tag{1}$$

0.5 kilowatts are needed to produce 1 N_2m^3/hr. Since the price of electricity in China averages \$0.1/kwh, the N_2 producer spends \$20,000 in electricity per month to satisfy the plant's demand as calculated in (2).

$$\frac{548 N_2m^3}{hr} * \frac{0.5kw}{N_2m^3/hr} * \frac{\$0.1}{kwh} * \frac{730hrs}{mo} \tag{2}$$

Of the \$110/tonne the plant pays the N_2 producer, transportation and electricity costs account for 60% of the price. If, however, the plant operates a 1000 N_2m^3/hr capacity generator on site, it costs approximately \$20,000/month in electricity and \$25,000/month in equipment rental to satisfy N_2 demand. This is a 20% savings (i.e. \$120,000/yr) verses purchasing liquid N_2. When allowing for design and construction costs to prepare the site for the generator, payback is approximately 2 years. Since basic rental fees do not change up to the maximum capacity of the generator, potential savings are as high as 40%. In terms of carbon footprint improvement, on site N_2 generation eliminates the need to truck liquid N_2. Using 2.35 liters/km for fuel efficiency and 0.73kg of carbon per liter of diesel [4], the plant in this study stands to reduce carbon intensity by 8.58 metric tons /month as calculated in (3).

$$\frac{2.35 liters}{km} * \frac{0.73kg}{liter} * \frac{200km}{delivery} * \frac{25 deliveries}{mo} \tag{3}$$

Realizing N_2 generation's environmental and financial benefits, however, depends on navigating an extensive governmental approval process.

IV. REGULATION OF NITROGEN GENERATION IN CHINA

Commissioning a N_2 generator in China requires writing 5 assessment reports, receiving 2 permits, and ultimately obtaining approvals from 13 governmental bureaus. Approval starts with submitting a *feasibility report* to the local Economic Development Bureau (EDB). The report must be written by an EDP "approved" firm and provide details about equipment operation, utilities requirements, and installation design. The EDB assesses whether N_2 generation as described in the report fits its interpretation of national policy and local industrial policy written by the EDB. If the *feasibility report* is approved, 4 additional reports are needed. An *energy assessment report* quantifies

N_2 generation's energy needs. The EDB compares these needs against its interpretation of local, regional, and national energy policies. A safety assessment report is provided to the Municipal Administration of Work Safety Bureau. Safety and reliability analysis cover N_2 generation equipment, operation, and installation. Hazard factors such as N_2 asphyxiation, compressor noise, piping gas under pressure, and handling cryogenic fluids are detailed and risk levels assessed. An environmental impact assessment report (EIA) is provided to the local Environmental Bureau (EB). The EIA evaluates potential impact of N_2 generation on the local environment, society, and economy. For example, the EIA outlines how compressor noise levels, waste water disposal, and liquid O_2 removal will meet local and national standards. Assuming each assessment report is approved, a geological investigation report is done for the site of the proposed generator. Topographical maps are made. Past uses of the land are investigated. And, soil tests (i.e. strength, contaminants, minerals, hydrology, etc.) are performed. The installation designer is now in a position to stamp its government issued license number on drawings and associated Bill of Materials (BOM). Designs, geological report, and proof of land ownership are then provided to the local Planning Bureau. The Planning Bureau performs a preliminary design review. If approved, 2 permits are issued. One is for land use and the other is for construction. At this point the N_2 generation equipment manufacturer and installation designer must submit their designs to the Municipal Construction Bureau and Drawing Audit Centre for further reviews. If approved, designs are provided to 6 additional bureaus for review:

1. Fire Bureau
2. Water Bureau
3. Power Bureau
4. Work Safety Bureau
5. Quality Administration Bureau
6. Urban Administration Bureau

If each bureau approves, designs are provided to the Provincial Planning Bureau to apply for a construction permit. If a permit is issued, a construction contractor can be selected. To perform work of this scope, the contractor must have at least a class "B" license issued by Province Government Construction Management Bureau. Typically a supervision company is employed to oversee construction methods, materials, quality of workmanship, and schedule achievement. To perform these tasks, a supervision company must have at least a class "C" license issued by the local Government Construction Management Bureau. In addition to a supervision company, an audit company (with at least a class "B" license) is typically used to prepare construction bid documents and verify the final installation matches what is on the drawings. After construction has met with audit company approval, the supervision company arranges follow up inspections by the Fire, Water, Power, Safety, Quality Admin., and Urban Admin Bureaus. Each bureau's approval stamp is put on file with the local government documentation office. After which, a municipal survey is done in order for the Provincial Property Bureau to issue a land use certificate.

V. CONCLUSION

Assuming all reports, approvals, permits, and inspections are approved without delay commissioning an N_2 generator in China takes approximately 1.5 years. Table I breaks this timing down [5].

Table I Project Timing to Set-Up a Nitrogen Generator

Document	Approver	Days to Approve
Feasibility Report	EDB	30
Preliminary Design	Factory Engineer	20
Energy Assessment Report	EDB	25
Safety Assessment Report	Municipal Admin. Of Worker Safety	20
EIA Report	EB	25
Geological Investigation Report	Local Planning Bureau	30
Final Design	Factory Engineer	30
Local Land Use & Construction Permits	Local Planning Bureau	30
Installation Design Review	Local Planning Bureau	80
	Municipal Construction Bureau	
	Municipal Drawing Audit Center	
	Fire Bureau	
	Water Bureau	
	Power Bureau	
	Municipal Admin. Of Worker Safety	
	Quality Admin. Bureau	
	Urban Admin Bureau	
Provincial Construction Permit	Provincial Planning Bureau	30
Construction	Supervision Company	20
Post Installation Review	Local Planning Bureau	180
	Municipal Construction Bureau	
	Municipal Drawing Audit Center	
	Fire Bureau	
	Water Bureau	
	Power Bureau	
	Municipal Admin. Of Worker Safety	
	Quality Admin. Bureau	
	Urban Admin Bureau	
Survey Report	Local Planning Bureau	30
Provincial Land Use Permit	Provincial Planning Bureau	30

For the factory in this study, the proposed generator requires 500 kw of additional transformed power. Even though the factory stands to reduce both its N_2 bill by 20% and carbon footprint by 8.58 metric tons/month, local officials look unfavorably on the project. Two reasons are given. Energy intensive liquid nitrogen suppliers in the region have excess capacity. The local government views on site N_2 generation as energy inefficient based on its interpretation of national industrial policy. For example, as of 2011, the China Electricity Council reports at the national level a 3 – 5% total peak electricity deficit [6]. In addition to supply problems, electricity demand in terms of consumption per-unit output in China remains two times developed countries [7]. In response, China's 12th five year plan challenges local government officials to reduce energy intensity per unit of GDP by 16% [8]. Since N_2 generation at the factory requires more power without more manufactured output local officials decide N_2 generation is an inefficient use of electricity supply. Upon appeal, the feasibility report writer explains officials failed to consider energy efficiency in terms of the entire N_2 supply chain. Generating N_2 gas on site uses 2/3[rd] less electricity than purchasing N_2 as a liquid and then converting it back into a gas. As a result, for the same manufactured output, on site N_2 generation reduces electricity consumption by 400,040 kwh each month (as calculated in (4)).

$$\left(\frac{548N_2m^3}{hr} * \frac{1.5kw}{N_2m^3/hr} * \frac{730hrs}{month}\right) - \left(\frac{548N_2m^3}{hr} * \frac{0.5kw}{N_2m^3/hr} * \frac{730hrs}{month}\right) \quad (4)$$

After a 3 month delay, local officials allow the installation to continue. This paper brings to light three key structural weaknesses in China's approvals process. One, local agencies approve assessment reports and those authorized to write them. This has potential for inflated report prices and corruption. Two, since the local EDB writes industrial policy for the region and approves all feasibility reports in the region, the local EDB has absolute control over investment. Three, with 13 bureaus of narrowly defined responsibility approving reports, approval time is much longer than if fewer agencies of broader responsibility are involved. These 3 weaknesses result in: excessive power of local authorities, political pressure on decision makers, and questionable competency of participants [9]. Future research in this area would be to compare the approvals process for N_2 generation in different provinces and local autonomous regions in China.

REFERENCES

[1] "Markets & Industries" (2012). Available from: http://www.potashcorp.com/investors/markets_industries/industrial/ [Retrieved 10 June 2012].

[2] MacLeod, C. (2009) "China Sets Goal to Reduce Emissions" Available from: http://www.usatoday.com/news/world/2009-11-26-copenhagen_N.htm [Retrieved 25 Aug 2012].

[3] Humphreys, P. (2011) "On-Site Nitrogen Generation Benefits for Pharmaceuticals Processing" Available from: http://www.pharmpro.com/articles/2011/01/manufacturing-and-capabilities-On-site-Nitrogen-Generation/ [Retrieved 20 May 2012] .

[4] Stevens, P. (2012) "How to Calculate Your Trucking Carbon Footprint" Available from: http://www.chemicaltransportation.com/transportation-resources/how-to-calculate-your-trucking-carbon-footprint [Retrieved 20 June 2012].

[5] Seidelson, C. "Commissioning an Industrial Waste Water Treatment System in China" International Journal of Latest Research in Science and Technology Vol.1, Issue 2: Page No.76-79, July-August 2012.

[6] "China's Appetite for Electricity Is about to Outstrip Production and Trigger Brownouts" (2011) Available from: http://articles.businessinsider.com/2011-11-01/markets/30345000_1_china-electricity-council-coal-prices-gigawatts [Retrieved 12 June 2012].

[7] Xinhua (2004) "China Severe Energy Shortage Warned" Available from: http://www.energybulletin.net/node/604 [Retrieved 1 June 2012].

[8] Ma, Damien (2011) "How Should China Solve Its Energy Problems?" Available from: http://www.theatlantic.com/international/archive/2011/03/how-should-china-solve-its-energy-problems/72716/ [Retrieved 18 June 2012].

[9] "Criticizing the Chinese EIA System" (2011) Available from: http://speakupforscience.wordpress.com/2011/09/18/chinaeia2/ [Retrieved 22 June 012].

AUTHOR'S PROFILE

Dr Craig Seidelson is the Timken Company's Chief Engineer for Manufacturing Advancement in China. In academia, he serves as a: Sr. Visiting Research Fellow at the University of the West of England (UK), an adjunct professor at Washington State University (USA), and an honorary professor at Changsha Univ. of Science & Technology (China). Dr. Seidelson's teaching & research interests involve sustainable manufacturing in China.