

# ORIE 4820: Spreadsheet-Based Modeling and Data Analysis

## Team Project

### Spring 2013

## LIQUAIR-PRO\*

---

\* This case is a variation of *Liquair-Pro*, originally written by Professor Peter L. Jackson, School of ORIE, Cornell University

### **Background**

Liquair-Pro is a provider of liquid air products to industrial customers. Its products include liquid oxygen, nitrogen, helium, and other gases extracted from the air. The two principal costs to be managed in this business are the cost of power usage for the production processes and the cost of distributing the products to the customers.

Liquair-Pro's customers are small to medium-sized businesses whose consumption rates average anywhere from 100 to 10,000 gallons of liquid gas per week. To provide service, Liquair-Pro installs tanks at customer sites and makes truck deliveries to replenish the supply in the tanks, according to the customers' consumption rates (which are monitored on a daily basis). With this type of service model, the assets and the replenishment schedule are completely vendor-owned and managed. That is, Liquair-Pro owns the tanks as well as the product in the tanks, and Liquair-Pro is responsible for making sure that the tanks do not run dry. Each customer pays only for the quantity of product used, as it is used. A multi-year contract is established between Liquair-Pro and the customer that specifies a fixed price per gallon that the customer will pay for the product over the contract period. Contract lengths can range from one year up to five years.

Although most of Liquair-Pro's customers renew their contracts with Liquair-Pro when their contract periods expire, the air products business is fiercely competitive. History has shown that the faster a Liquair-Pro salesperson can make a competitive quote to a customer, the more likely it is that the customer will choose Liquair-Pro over one of its competitors. Therefore, the length of time that it takes a Liquair-Pro salesperson to establish a quote for a customer is critical, as is the accuracy of the underlying cost assessment of providing the product to the customer. Ideally, the salesperson will be able to quote a price that includes just enough profit margin to ensure that Liquair-Pro earns an adequate return. If the quoted price is too high, then an opportunity exists for one of Liquair-Pro's competitors to steal the customer away with a lower quote.

### **Air Product Production and Distribution**

In order to manage the cost of power usage for production, Liquair-Pro has negotiated long-term contracts with its local power suppliers. These power supply contracts ensure that Liquair-Pro's manufacturing costs are relatively stable over time, so that the cost of each product type that Liquair-Pro produces can be accurately reflected by a simple "dollars per gallon" figure.

On the other hand, the distribution cost that Liquair-Pro incurs in order to provide product to a particular customer depends upon many factors and is significantly more complicated to determine. For a given customer, the total cost of distribution includes ***three inter-related components***: the cost of providing a tank for use at the customer's site, the cost of maintaining an inventory of product in the tank (recall that the customer does not pay for the product until it is

used), and the cost of transporting the product from Liquair-Pro's manufacturing facility to the tank at the customer site.

The decisions that drive each of the distribution cost components hinge directly upon the customer's anticipated product consumption over the contract period. Before making a price quote to a customer, it is critical that the Liquair-Pro salesperson determine reasonably accurate consumption rate estimates. In the case of an existing customer who is already using an air product, the salesperson can review the customer's historic consumption data, and any additional information provided by the customer, to determine what the average weekly consumption rate(s) will be moving forward. If a customer is new to air products, then the consumption rate is more uncertain. In this case, the salesperson will work with the customer to estimate both the weekly consumption rate for the first year, as well as the annual demand growth rate.

### Tank Costs

Liquair-Pro has three standard tank sizes that it installs at customer sites: LA-1 (1,000-gallon capacity), LA-3 (3,000-gallon capacity), and LA-6 (6,000-gallon capacity). Salespeople currently use a simple rule for choosing a tank size that is based solely on an estimate of the customer's peak demand rate for the product over the next five years.

All tanks are built to last for twenty years, but they must be refurbished at the five, ten, and fifteen-year points in their useful lives. When a tank is removed from a customer site for refurbishment, it will be held in storage until it can be placed into service again at another customer site. Refurbishment costs, which increase with the age of the tank, are treated as capital improvements for accounting and tax purposes.

Once a new or refurbished tank is placed at a customer site, Liquair-Pro will leave it in place for five years unless: (1) it becomes operationally necessary to switch or remove it before then, or (2) the customer's contract ends prior to the five-year point, and the customer chooses *not* to renew their contract with Liquair-Pro.

If a tank is removed from a customer site *prior* to a scheduled refurbishment, then Liquair-Pro incurs the cost of an *early removal*, which is an additional operating expense, and *not* a capital improvement. Early removals are costly, and Liquair-Pro tries to avoid them if possible. As a safeguard to its profit margin, Liquair-Pro factors the cost of an early removal into all new customer contracts that are less than five years in length. New customers who commit to five-year contracts, however, are rewarded with a "loyalty discount" (i.e. Liquair-Pro leaves out the early removal cost when quoting the five-year price). Existing customers who renew their contracts are also given the "loyalty discount," even if their contract lengths are less than five years.

### Inventory Costs

The inventory level of product in a tank roughly follows a saw-tooth pattern over time. The particular pattern for any given customer is determined by the rate at which the product is consumed, the frequency with which the product is replenished, the amount of product delivered with each replenishment, and the amount of product left in the tank at the time of replenishment. (The last three of these elements are entirely Liquair-Pro decisions.) With respect to the last of these, Liquair-Pro monitors its customer consumption levels closely and is, therefore, able to schedule a delivery for a customer just before the customer's tank runs dry, so that little or no safety

stock is needed. A tank does not have to be filled completely by a delivery, but the tank size obviously limits the maximum amount of inventory that can be held at any one time. For a given consumption rate, therefore, the choice of tank size inherently places a lower bound on the number of replenishment deliveries that Liquair-Pro must make to that customer in a given year.

The specific saw-tooth pattern determines the *average amount of inventory* that Liquair-Pro holds at the customer site over time. Holding this inventory implicitly ties up capital and must be taken into account when assessing costs. In addition to the cost of financing the inventory, there is a significant per gallon-year cost of *cooling* the inventory in the tank.

### Transportation Costs

Estimating the transportation costs that Liquair-Pro incurs in providing a product to a customer is a more difficult matter. Typically, a truck will make deliveries to more than one customer on each trip. Strictly speaking, an accurate delivery cost estimate would require detailed routing information, which is not available at the time of making a quote to a customer. Instead, the transportation cost per delivery is approximated using a common model for delivery systems.

For a particular customer, the *full truckload cost* is defined to be the cost of sending a full truck the distance from the manufacturing facility to the customer site and back again. If the amount to be delivered to the customer were exactly a full truckload, then this would be an accurate assessment of the transportation cost per delivery. Since trucks typically make multiple deliveries per run, however, an approximation is used to allocate an appropriate fraction of the full truckload cost to the customer. Specifically, the transportation cost per delivery to a particular customer is estimated to be the *full truckload cost multiplied by the square root of the fraction of a full truckload used for that customer's delivery*. For instance, if the average delivery amount to a customer is equivalent to half a truckload, then the transportation cost per delivery to the customer will be approximated as  $\sqrt{0.5} = 70.7\%$  of the full truckload cost for that customer. This inflated percentage accounts for route inefficiencies caused by adding a customer to a delivery schedule.

A previous economic study examined the costs of trucks and drivers and derived an equivalent *full truckload cost per mile*. Liquair-Pro uses this figure (making any necessary adjustments to account for the current price of gasoline) in computing the full truckload cost for a particular customer. Hence, for a particular customer, the full truckload cost is equal to the *full truckload cost per mile multiplied by the roundtrip distance to the customer location (in miles)*. For the same customer, the average annual transportation cost is simply the transportation cost per delivery multiplied by the number of deliveries per year.

Observe that the factors and decisions that determine the average delivery amount to a customer (average demand rate and tank size) also drive the average delivery frequency and the average annual inventory holding and cooling costs. In turn, the average delivery frequency and the average delivery amount drive the annual transportation costs. *Therefore, both for price quoting purposes and for operational purposes, it is essential for Liquair-Pro to be able to determine, for any prospective or existing customer, the tank size and average delivery amount combination that jointly minimizes the total annual distribution cost for that customer.* That is, the combination that minimizes the sum of:

- (1) the annual cost of providing the tank;
- (2) the annual inventory carrying (i.e., holding and cooling) costs; and
- (3) the annual transportation cost.

## Additional Considerations

A follow-up interview with Liquair-Pro's Vice President has yielded some important additional information about the company's air product distribution:

*Q1: The data we have indicate that your tanker trucks hold 5,000 gallons. If a customer has an LA-6 tank (which has 6,000-gallon capacity) and you want to make a delivery that is more than 5,000 gallons, how do you accomplish this? Do you make multiple deliveries?*

*A1: "I am glad you mentioned that. While the majority of our tankers have 5,000-gallon capacity, we do have some tankers that have 9,000-gallon capacity. For customers with LA-6 tanks, we use the 9,000-gallon trucks to make deliveries. For LA-1 and LA-3 deliveries, we generally use the 5,000-gallon trucks."*

*Q2: Is there a difference in costs between the 5,000-gallon trucks and the 9,000-gallon trucks?*

*A2: "Yes. The 9,000-gallon trucks are more expensive to operate due to their size and the weight of the loads they carry. The current Full Truckload Cost per Mile for the 9,000-gallon trucks is \$4.40 per mile (as opposed to \$3.80 per mile for the 5,000-gallon trucks). Of course, these numbers change periodically."*

*Q3: When you make a delivery to a customer, what is the level of granularity you use for the amount to deliver? For instance, would you deliver 2,349 gallons to a customer?*

*A3: "We only make deliveries in amounts that are multiples of 100 gallons. So we will deliver 2,300 gallons or 2,400 gallons to a customer, but not 2,349 gallons."*

*Q4: When you quote a price to a customer, what level of granularity do you use? Do you just compute a price per gallon and then round to the nearest cent?*

*A4: "Because of the volumes we deal with in this business, a one-cent-per-gallon price differential can be significant. The difference between \$0.55 and \$0.56 per gallon can sometimes mean the difference between gaining and losing a contract. When we make a quote to a customer, we typically round up to the nearest cent at the 1,000-gallon level. For example, if we compute a price per gallon of \$0.5730088, then we would issue a quote of \$0.57301 per gallon, or \$573.01 per thousand gallons."*

## Project Mission

The Vice President of Distribution for Liquair-Pro has commissioned your team to ***develop a user-friendly decision support tool that can be used by salespeople to prepare competitive on-the-spot price quotes for both new and existing customers***. According to the VP: "None of our competitors currently has the ability to do this. If we can develop a tool that works well, then this could be a real competitive advantage for Liquair-Pro!"

## **Project Teams**

You may select your own project teams. Teams must consist of 3 or 4 individuals, but no more and no less. A designated member of your project team must let me know (via email) who the members of your project team are by **12:00 pm on Friday, April 5<sup>th</sup>**. Otherwise, you forfeit the right to select your own team. In any case, I reserve the right to reform project teams and/or to assign additional members to teams in order to ensure that every team has 3 or 4 individuals.

## **Deliverables**

There are two deliverables for this project: a ***decision support tool***, and a ***self-contained slide deck***. The tool should be stand alone, well documented, and should adhere to the specifications described in the next section. The slide deck, which should be easily understood by a Liquair-Pro salesperson, should: (1) describe ***how to use the tool***, (2) convey the ***key elements of the underlying cost and pricing analysis***, and (3) illustrate the features (and potential limitations) of the tool by making ***recommendations for a specific set of customers***, whose information will be provided to you in due course. Note that:

- Slide decks should have a ***maximum length of 20 slides***, not including the title slide.
- While the functionality and soundness of your tool and your conclusions are of foremost importance, ***a heavy emphasis will be placed on the clarity, conciseness, organization, and overall quality of your work.***
- Your project is ***due by Friday, May 3<sup>rd</sup>, 12:00 pm EDT.*** *One designated member of your project team should submit all deliverables.* Do not have different team members submit materials in a piecemeal fashion.
- Your peer evaluation is ***due by Sunday, May 5<sup>th</sup>, 12:00 pm EDT.*** *Everyone is required to submit a peer evaluation.*

## **Tool Requirements**

The tool should focus on pricing a single product for a new or existing customer.

### **Customer-Specific Input Parameters**

If the customer is a *new customer with no consumption history available*, then *four additional input values* should be required from the salesperson:

- An estimate of the customer's average weekly consumption of the product during the *first year* (gallons/week);
- An estimated *annual growth rate* of the customer's consumption over the next five years (%);
- The *distance* of the customer's site from Liquair-Pro's manufacturing facility (miles);
- The desired *contract length* (i.e., the number of years for which the quoted price will be fixed). This should be an integer between one and five.

If the customer is an *existing customer* or a *new customer with consumption history available*, then up to *nine additional input values* should be required from the salesperson:

- An estimate of the customer's average weekly consumption of the product during *each of the next five years* (gallons/week).
- The *distance* of the customer's site from Liquair-Pro's manufacturing facility (miles).
- The desired *contract length* (i.e., the number of years for which the quoted price will be fixed). This should be an integer between one and five.
- For existing customers, the *current tank size* and the number of years until the *next scheduled tank change*. (This will be an integer between one and five.)

#### Required Output and Functionality

**For new customers**, the tool should display (either automatically or by pressing a button) the following information for each possible choice of tank size (LA-1, LA-3, LA-6):

- Whether or not the tank size is *feasible* for the customer for each of the next five years.
- If the tank size is feasible for a given year, an estimate of the total cost for that year. In determining this estimate, the transportation and inventory carrying costs should be based upon the *cost-minimizing average delivery quantity* for that year. The 20-year annual equivalent cost should be used for the tank cost.
- If the tank size is feasible *for the entire five-year horizon*, then the tool should provide a *breakeven price-per-1,000-gallon quote* that is just sufficient to recover all costs associated with producing and distributing product for the customer *over the length of the contract*, including the early removal expense, if applicable. This price should be based on a discounted cash flow analysis using Liquair-Pro's after-tax hurdle rate.
- Among those tank sizes that are feasible *for the entire five-year horizon*, the tool should clearly distinguish the *optimal tank size for the customer* (i.e., the lowest-cost feasible option for Liquair-Pro) and the *corresponding price-per-1,000-gallon quote* for the customer over the length of the contract.

**For existing customers**, the tool should display (either automatically or by pressing a button) the following information for the current tank size:

- Whether or not the current tank size is *feasible* for the customer for each of the next five years.
- If the tank size is feasible for a given year, an estimate of the total cost for that year. In determining this estimate, the transportation and inventory carrying costs should be based upon the *cost-minimizing average delivery quantity* for that year. The 20-year annual equivalent cost should be used for the tank cost.
- An alert if the current tank size will become *infeasible* before the *next scheduled tank change*.
- If the current tank size will remain *feasible* until the *next scheduled tank change*, then:
  - If the time until the next scheduled tank change is *greater than or equal to* the desired contract length, then the tool should simply provide a *breakeven price-per-1,000-gallon quote for the current tank size* that is just sufficient to recover all costs associated with producing and distributing product for the customer *over the length of the contract*.
  - If the time until the next scheduled tank change is *less than* the desired contract length, then a scheduled tank changeover will occur in the middle of the contract period, and Liquair Pro has the opportunity to change the tank size for this customer. In this case, the tool should price out all tank sizes that are expected to be feasible after the tank change and should

indicate if a tank size change would result in a lower price quote for the contract length. For instance, suppose an existing customer that is due for contract renewal currently has LA-3 installed, with one year left until the next scheduled tank changeover. Then if that customer wants a three-year price contract starting now, the tool should determine whether a switch to LA-6 or LA-1 after one year would be better than remaining with LA-3.

For new and existing customers, a module should be provided that allows the salesperson to conduct sensitivity and/or probabilistic risk analysis on key input parameters. (More details to follow.)

Finally, the tool itself should contain sufficient instructions and documentation for a salesperson to begin using it immediately, without any prior training beyond knowing the general purpose of the tool. The tool should be well laid out and may contain multiple worksheets. All calculated values (whether intermediate or final) should be clearly labeled.

### Modeling Assumptions

In building the decision support tool, you may make the following assumptions:

- The planning horizon for *pricing* purposes should be the desired contract length.
- The customer will remain a Liquair-Pro customer throughout the planning horizon.
- For purposes of computing depreciation tax credits, storage tanks belong to the 5-year MACRS property class. Tank refurbishing costs count as capital improvements and are afforded the same tax treatment as a new 5-year MACRS property of the same cost.
- For purposes of estimating inventory carrying costs (of product held in the tank), you may assume a *constant rate of consumption* by the customer over the course of the year. You may also assume that the working capital investment in inventory is equal to its manufacturing cost.
- For purposes of estimating the average delivery frequency, you may assume a *constant rate of consumption* by the customer over the course of the year.

### Default Parameter Values and Tank Information

The default parameter values are given in the following tables, along with the attributes of the three tank types that Liquair-Pro currently installs at customer sites. ALL values should be changeable by the user, although you may assume that LA-6 tanks will always use the larger truck size for replenishment while LA-1 and LA-3 tanks will always use the smaller truck size:

Model Parameters	Default Value
Production Cost per Gallon	\$0.50
Full Truckload Capacity (Gallons)	5,000 and 9,000
Full Truckload Delivery Cost Per Mile	\$3.80 and \$4.40
Marginal Income Tax Rate	34%
After-Tax Minimum Attractive Rate of Return	12%
Customer Consumption Weeks Per Year	52
Maximum Deliveries Per Year	156

<b>Tank Attributes</b>	<b>LA-1</b>	<b>LA-3</b>	<b>LA-6</b>
Capacity (Gallons)	1,000	3,000	6,000
Acquisition Cost	\$15,000	\$22,000	\$30,000
Refurbishing Costs:			
At 5 years	\$2,000	\$3,000	\$4,500
At 10 years	\$2,500	\$4,000	\$6,000
At 15 years	\$3,500	\$5,500	\$7,500
Early Removal Expense	\$1,000	\$1,200	\$1,500
Cooling Cost (per Gallon-Year)	\$2.00	\$2.05	\$2.20

## **Grading**

The project is worth 25% of your overall course grade. Team members will receive the same base score for the tool and the slide deck, although the final score an individual receives for the project will reflect the results of the team peer evaluations.

**GOOD LUCK!!!**