



Praxair plant in Utah with argon, nitrogen and oxygen storage tanks.

Photo credit: Ted Kawalerski

# Praxair:

## Making our planet more productive

**For more than 100 years, Praxair has taken something as fundamental as air** and turned it into ways to make food taste better, processes operate cleaner and breathing easier – in short, to make all our lives better by fulfilling our mission of making our planet more productive. As a Fortune 300 company, we develop products and technology that impact more than 20 different industries. You see our work every day, often without realizing it. We provide oxygen for respiratory therapy, hydrogen to help purify crude oil into gasoline, carbon dioxide to add the fizz in our beverages and argon to enhance the robotic welding systems that build new automobiles.

We provide products to our customers through three primary supply modes: large process plants, cryogenic liquid and packaged gases.

Large process plants: For our largest customers, such as refineries and steel mills, we design, build and operate large process plants adjacent to their facilities. These plants act as a vital utility to those customers, similar to electricity and water, and provide an uninterrupted supply of industrial gases to support their operations. As a result, a high degree of automation and data analytics is needed to ensure that we continuously maintain safe, reliable and efficient operation.

By Larry Megan and  
Kristin Bruton

# All About the Roundtable

Cryogenic liquid: Medium-volume customers, such as hospitals and universities, typically have liquid storage located at their facility, which is then used to provide product throughout their operations. We monitor their inventory in real time and then deliver product using our tanker truck fleet, all without the customer needing to place an order. This proactive, vendor-managed service model provides high reliability for our customers while enabling us to effectively manage our costs. As with large process plants, this service model requires a variety of analytics, from optimizing assets to scheduling daily deliveries.

Packaged gases: We sell a wide variety of smaller packaged gases to laboratories, hospitals and other customers. These products can range from a cylinder of nitrogen to specialty gas mixtures needed for emissions testing, advanced manufacturing and semiconductor fabrication. We also offer a variety of services such as embedded regulators and telemetry. We also own the cylinder assets, which helps ensure continuous supply to our customers. Packaged gases are a very transaction-intensive business with many distinct products, which leads to many opportunities to use analytics to manage the supply chain, understand margins and better target the sales force.

## Culture Drives Strategy

The core of Praxair's business model is a culture of productivity – continuous improvement across all aspects of our business, including how we operate our plants, how we deliver our products, how we manage our business processes and how we collaborate with our customers. This culture pervades all levels in the organization. We have a longstanding history of effectively deploying tools such as Lean and Six Sigma, but as our productivity model has matured, it has become much more challenging to find the low-hanging fruit in productivity. As a result, our current efforts to sustain our productivity momentum are focused on three key areas: innovation, digitalization and advanced analytics.

Praxair's Global Analytics team plays a key role in this evolving productivity strategy. We support Praxair's mission by making our people more productive – developing the decision support systems needed to enable our business clients to make better decisions faster. We provide a wide variety of systems that improve our different business functions regardless of where they are on the analytics maturity curve, from descriptive and diagnostic systems that help Praxair's businesses more effectively manage and share

The Roundtable consists of the institutional members of INFORMS with member company representatives typically the overall leader of O.R. activity. The Roundtable is composed of about 50 organizations that have demonstrated leadership in the application of O.R. and advanced analytics. The Roundtable culture is peer-to-peer, encouraging networking and sharing lessons learned among members.

The Roundtable meets three times a year. Roundtable goals are to improve member organizations' OR/MS practice, help Roundtable representatives grow professionally and help the OR/MS profession to thrive. Further information is available at <http://roundtable.informs.org>.

The Roundtable also has an advisory responsibility to INFORMS. According to its bylaws, "The Roundtable shall regularly share with INFORMS leadership and advise the INFORMS Board on its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities." The Roundtable meets with the INFORMS president-elect each spring to discuss practice-related topics of interest to him or her, and with the entire INFORMS Board each fall to discuss topics of mutual concern.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today.

their data, to predictive and prescriptive systems that optimize operations, logistics and sales. Our wide variety of skills enables us to meet our customers wherever they are on the continuum of analytics, and positions them to meet ever more challenging business needs.

## Global Reach, Local Impact

In industrial gases manufacturing, the majority of the products sold are manufactured roughly 200 miles of where they are produced. This high degree of localization leads to a business model where P&L (profit and loss) responsibility lies with geographical business units to ensure that the company best meets the needs of its local customers. The Global Analytics team reflects this strategy – we have a hybrid global/local organization designed to balance centralized development while embedding key technical capabilities within the regional business units.

The centralized corporate team is organized into Advanced Analytics and Visualization, Business and Supply Chain Optimization and Smart Operations functions. Its portfolio includes simple visualization tools that help business leaders effectively manage data across heterogeneous data sources so they can get quick insights into their business performance; complex optimization models to manage strategic, tactical and operational decisions in our supply chains; and sophisticated algorithms to manage all aspects of plant operation, from automating startup to maximizing and sustaining efficiency during normal operation. To ensure alignment with business priorities, we are a shared organization between R&D and Global Operations, which allows us to have development flexibility while being close to business needs.

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**Global Analytics team**  
plays a  
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**Praxair**  
has a  
**long history**  
of working  
with  
**leading**  
**researchers**  
in  
**operations**  
**research**  
and  
**process**  
**systems**  
to develop  
**platforms**  
for  
**future**  
**innovations.**

Complementing the corporate teams are local teams in China, India and Mexico. These local business teams integrate corporate-level applications into local needs. Many of our applications require customization based on differences in the local business climate and regulatory statutes. These local teams enable fast and impactful replication of solutions to those geographies. These teams, which have similar skill sets as the corporate team, solve local issues that would previously have been invisible at the corporate level. They identify problems and solutions for their local customers and to quickly meet their needs. Often these local solutions have been subsequently leveraged for replication globally.

Besides this horizontal integration across the business, the entire team works to apply analytics across all business functions including our on-site, merchant liquid and packaged gases businesses, and a broad range of business processes including sales, product management and customer service. Some recent examples of our programs follow.

### **Broad Reach**

In our on-site plants, predictable production reliability is critical to our business. We have deployed several programs using advanced analytics to better increase our predictive reliability. Cryogenic air separation plants, which produce oxygen, nitrogen and argon, require compressors driven by large electric motors. The unexpected failure of one of these machines is very disruptive to our operations and supply chain. Our programs utilize advanced statistics and visualization to monitor several hundred machines worldwide and alert the operations staff when a machine is at risk for a potential failure. This provides the local team with the insight they need to effectively manage their maintenance programs. Furthermore, the data from all the machines is sent back to a centralized control center so that subject matter experts can assist local operations to manage issues. Future machine learning applications will help us better identify patterns across multiple data sources to better identify at-risk machines.

Managing the merchant liquid supply chain is a second example. These liquid plants, while all making the same basic set of products, often vary in capacity and efficiency. As merchant liquid customers may receive shipped product from multiple locations, continuously optimizing this supply chain can be challenging. External factors,



**Praxair's goal is to give its people the opportunity to work through the entire lifecycle of a problem.**

Photo credit: Ted Kawalerski

such as varying customer demand and time-of-day electricity prices, make the system quite dynamic. Through the development of sophisticated forecasting tools and large mixed integer linear programming models, we can determine optimum operating scenarios on a continuous basis and share these with our logistics and production teams. The sophisticated planning tools, which plan over a weekly time horizon, then guide the operational tools designed for minute-to-minute optimization of the plants and logistics.

Finally, on the business side, the team has significantly impacted Praxair's revenue management strategies over the past several years. For example, in our packaged gas business, we've developed cooperative game theory methods to allocate shared distribution and production costs to determine product cost at the SKU level and service cost at the order level. This solution adopts linear programming models to determine the cost to serve for existing customers as well as machine learning algorithms to estimate costs for new customers. The deliverables help us better manage business and productivity decisions. For example, understanding cost differences among different locations provides additional insight into our supply chain optimization.

### **Our People**

As with any organization, our people are our most valuable asset. To develop our staff, our goal from day one is to give them the opportunity to work through the entire lifecycle of a problem. This includes working with our business partners on the value proposition, leading a cross-functional team from initial development through beta testing, and working with the business to deploy tools in the field to bring value. Such opportunities help our

people develop strong leadership, communication, business and project management skills, in addition to technical skills. At our core, we're very strong in technical areas such as data visualization, advanced statistics, linear and nonlinear optimization and advanced process control. Our strength is in our breadth as we must be ready to solve a wide variety of business problems from the simple to the complex.

We also recognize the need for strong external partners. We have a long history of working with leading researchers in operations research and process systems to develop the platforms for our future innovations. Strong relationships with SUNY-Buffalo, Carnegie-Mellon, McMaster University and UT-Austin, among others, keep us as at the leading edge of academic research while providing an opportunity for our staff to engage and mentor graduate students. As an example, we have recently been working with several institutions under Department of Energy funding to demonstrate a state-of-the-art industrial scale steam methane reforming plant. As a team, we installed a new visual monitoring system, developed a new control strategy to operate the plant, and demonstrated a cloud-based solution

for decision deployment. Going forward, we will have substantial engagement with the DOE's new Clean Energy Smart Manufacturing Innovation Institute to further Praxair's mission and drive innovation generally within the manufacturing industry.

### What Does the Future Hold?

This is an exciting time to be engaged in advanced analytics. The digitalization of manufacturing is a key trend for future growth, and we are excited to be at the leading edge of that in the process industries. In the next few years, we will be developing cutting-edge applications that leverage "big data" infrastructure to solve key challenges in machine reliability and fleet safety, using new technologies to deliver real-time information and collaboration capabilities to people in the field, and delivering new tools to help optimize our supply chains on a global scale. While the industrial gases industry is more than 100 years old, there is plenty of room left for innovation. **ORMS**

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# HEALTHCARE 2017

## OPTIMIZING OPERATIONS & OUTCOMES

*INFORMS Healthcare 2017 brings together academic researchers in "healthcare analytics" & industry stakeholders who are applying & sharing research to improve the delivery of effective healthcare.*

### KEYNOTE SPEAKERS

#### Dimitris Bertsimas

Operations Research Center, Massachusetts Institute of Technology

#### Brian Denton

Department of Industrial & Operations Engineering, University of Michigan

#### Dr. Eric de Roodenbeke

CEO, International Hospital Federation

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