# Industry White Paper

*Optimizing Capacity Deployment and Reducing Capital Investment*

*Going Beyond Basic Supply Chain and Manufacturing Optimization in the Process Industries*

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## Introduction

Supply Chain Planning and Network Design concepts became popular in the mid 1990's and have provided significant benefits to many of today's leading manufacturers. Companies that invested in supply chain and production improvement projects have experienced reduced costs and improved efficiencies. The process industries, including pharmaceutical, chemical, food and other related industries, have enjoyed some of these benefits. Demand planning and logistics initiatives have had significant paybacks in these industries. However, the typical production optimization methodologies and tools, built around concepts specific to the discrete industries, have limited the benefits achieved by process companies.

The process industries require a different approach to optimization. The nature of the production processes are not modeled and simulated well using typical constraint-based approaches. A fundamentally different approach is required in order to address the complexity and unique requirements found in process plants and supply chains. This white paper will review these unique requirements and discuss an alternative approach. Additionally, this paper will review the history of one large process company that employed this approach and identify how they achieved dramatic reduction in costs and eliminated or postponed the need for significant capital investments.

## Process Markets

The bottom line is that the process industries have to reduce their capital investments in order to protect their shrinking margins. This is challenging because the nature of process manufacturing requires significant investment in capital equipment for process plants. To remain competitive, companies must ensure that this investment is optimized, expenditures provide the right payback, and investments are timed appropriately to meet operational objectives with the least requirement for capital deployment. Production plans must also be optimized. Process plants, particularly those that run a continuous process, are highly dependant on proper capacity utilization for profitability. The product mix must be continuously adjusted in order to meet current market demands with the highest return possible.

Given current economic conditions and a large number or mergers and acquisitions, many process manufacturers are faced with a significant challenge. The parameters and constraints for process supply chains and production are continuously shifting because of market changes such as demand fluctuations, global economic changes and the changing make-up of the supply chain. While traditional supply chain optimization has helped with some improvements, it has not been enough to handle the continuously shifting planning requirements of the process industries. Companies have already achieved much of what they can accomplish, but not what they need to accomplish, with generic tools. Leading companies will have to adopt a new approach in order to right-size and redesign their supply networks to remain competitive and provide adequate returns on their investment in capital equipment.

## Typical Challenge Faced by a Leading Process Company

The challenges faced by one batch and continuous chemical company, a leader in the crop protection industry, provide an excellent example of the challenges faced by many process companies. This global company was experiencing a number of challenges, and the solutions identified to address them were often conflicting. The company needed to reduce their investment in capital equipment, but at the same time they needed to rapidly ramp up production capacity for a new product in order to gain market share. To make matters more complex, the company recognized that the challenges they were facing were not static. While their initial goal for the new product was to ramp up production quickly to gain market share, the goal changed with the phase of the product lifecycle they were analyzing. The priority after the initial market penetration phase was to quickly reduce the cycle time and cost of producing the item, allowing them to take advantage of the leadership position they would develop through rapid production introduction. At the same time they were addressing these issues, they recognized that they had a need to consolidate and reduce overall production capacity to meet the reality of current market demands. The optimal solution would require the ability to increase the throughput of existing facilities, increase the productivity of current production across multiple plants and geographies, and also allow them to meet their new product introduction goals for their new product. Given complex production processes and products that were processed partially in multiple plants, the company had a challenge.

Fortunately, the company had previous experience with some leading supply chain tools, and had seen some good success in past optimization efforts. This time, however, their efforts to right-size the plants and delay capital investment for the new product were not producing plans that would meet the company's objectives. The supply chain environment was too dynamic, and attempts to pinpoint and optimize constraints using Theory of Constraints techniques were proving to be impractical. Resulting plans and schedules were not only sub-optimal - they were not even feasible. The company realized that they were going to need a more holistic approach to the problem, to deal with the supply chain systemically as opposed to solving point problems individually. Their current tools and techniques were not able to accommodate this approach.

## The Need to Address Dynamics in Supply Chain

In order to provide feasible plans and schedules, let alone optimal ones, supply chain approaches must take into account the reality of dynamic environments. When product-mix changes frequently in process plants, the bottlenecks can move from one operation or piece of equipment to the next. If one operation is constrained and a solution is generated, the problem can merely move to another operation. If that operation is then constrained, the problem can move again. Planning in dynamic environments does not lend itself to modeling and simulation techniques that attempt to identify and plan around key constraints, because the problem simply reappears elsewhere.

The dynamic nature of the manufacturing environment is further complicated by the multiple trade-offs that must be considered in planning. The typical optimization decisions have too many interdependencies to be properly modeled in a linear fashion without sub-optimizing one optimization goal for another. Traditional tools are not well suited to address these trade-offs. These tools are even less suited to address the trade-offs when they change over time, for example to meet the changing objectives for the new product over the course of its product lifecycle.

## Traditional Solutions Don't Address Process Supply Chains

In addition to being dynamic, process supply chains are different by the very nature of the materials they work with and by the inherently connected nature of materials that move between operations in pipes and tanks instead of on forklifts. Process production is fundamentally a more complex problem than for discrete items. Process planning is well known by supply chain experts for the challenges brought about by disassembly processes as opposed to the typical assembly process, variability of materials, difficult changeover and sequencing rules, product aging and volume-based planning required for tanks. The following table highlights some of these challenges and the implications for process manufacturing.

| Process Challenge | Implication |
|---|---|
| Inverted Bills | Producing products to fulfill demand generates other products that must be sold or further processed. By-products, co-products and waste must be taken into account and matched to existing demand or used to meet other demands. Waste products consume capacity to be recycled or disposed of. |
| Multiple Recipes | Products can be made in multiple ways, and often with different ingredients depending on what is available and what current costs are. This leads to multiple trade-off scenarios to produce a single item. |
| Multi-Level Planning | Production of the bulk material must be planned concurrently with packaging operations. Demand for products often comes for different packaging configurations. When fixed or economical batch sizes are produced, this amount of bulk material typically does not exactly match packed demand, so inventory must be stored in tanks, packed off in product or intermediate containers, sold in bulk or disposed of. |

| Process Challenge | Implication |
|---|---|
| Variability | Materials used and produced in process manufacturing often has variable qualities based on their chemistry and structure. Organic products, in particular, are often difficult to procure or produce in consistent composition, and planning must take into account this unpredictability on both a proactive and reactive basis. |
| Push-Pull | When bulk materials are produced, they must be packaged, further processed, sold, or disposed of. Push-pull scenarios can come from an integrated plant that continuously provides feedstock that must be processed, inverted bills leading to by-products, co-products or waste, organic material that comes available seasonally, unexpected products or material grades from difficult to control processes, transition products, or other sources. |
| Changeovers / Sequencing | Process plant productivity is very sensitive to product transitions, and properly sequencing these transitions is extremely important to improving yields and reducing changeovers. Cleanups and wash-downs must be taken into account, and product wheels and transition matrixes provide critical planning criteria when planning product mix and sequencing. Some process plants can not effectively be shut down between products and produce transition products or batches during changeover. These transition products are variable based on sequencing, and must be handled as "push" scheduled products. |
| Tanks / Silos | Inventory and work in process for process materials is often stored in tanks or silos. Planning for production in tanks and silos must not only address the time required for the operation, but the volume of material. The inflow from one operation and the outflow to the next dictate when the tank is available, and upstream and downstream operations have to be scheduled synchronously to ensure that tanks do not overflow or that a process does not produce a material that must be stored when there is no tank capacity available. |

Other challenges specific to some process industries are aging and maturation periods, among others not listed here. A final note to add is that many process plants experience a combination of many of the challenges listed above, making the overall problem more complex. These challenges are in addition to the normal challenges of accurately predicting demand and other standard supply chain planning difficulties.

## A New Concept: Combining Dynamic Simulation and Multi-Criteria Optimization

Dynamic markets, which are extremely common in the global process industries, and the additional complexity of process manufacturing environments itself, have led to the need for new approaches in network and production optimization. Planning models that address only a portion of the production problem, or that attempt to abstract the supply chain problem into a small set of constraints, are not effective. In order to properly dynamically simulate the process supply chain of today, a holistic modeling approach is required. The holistic approach demands that all constraints are modeled and optimized concurrently. This is true not only for detailed production planning and sequencing within a plant, but also across plants and the supply chain. This thorough approach to modeling the supply chain provides optimized solutions that match the reality of the production environment.

A multi-tiered modeling approach can greatly help manage the potential complexity of this comprehensive supply chain model. While the detailed analysis of the production processes are highly relevant to optimizing the supply network and decided where capacity should be adjusted from a capital equipment standpoint, there are other issues that must be considered at the same time. To address this, the plant model could be seamlessly incorporated underneath the supply network model. In this approach, the details are being considered to ensure that a real, feasible solution is being generated. At the same time, the planner does not suffer from having to interact with an overwhelming level of detail when they are working at a higher level. This multi-level approach allows for simulation and optimization that is solidly rooted in actual production processes, but available to be viewed at the level required to provide the answers to high-level or lower-level supply chain questions as needed.

The holistic model, coupled with a modeling environment that matches the realities of the process industries, will offer process manufacturers the deeper benefits that they have not yet achieved with traditional approaches and solutions. It will allow for dynamic simulation based on the realities of the capabilities of the production equipment and processes to allow the next level of benefits to be achieved by process companies.

## Leading Company, Leading Approach

The crop protection company described earlier decided to employ the new approach just discussed. The manufacturer had several supply chain decisions in front of them, and decided to take a multi-tiered approach to addressing them. In order to make the higher-level decisions, the company first decided to address the plants and develop working models of two of their primary plants. These models were put to immediate use in improving the operations of the plants themselves to make additional capacity available for the new product they were launching. Once the detailed models were completed and validated with real results, the company moved on to improving the capacity and throughput across the two plants, while minimizing capital investment. Once completed, the manufacturer began solving their new product introduction challenge using those models to allow additional volume for the new product as it began to reach higher market demand levels. The final step was to re-optimize across all of the plants in order to provide further capital reductions and process efficiencies to reduce costs.

## Optimizing the Plants

The company initiated a series of projects to improve their supply chain. In a pragmatic approach, each of the projects had it's own objectives and provided it's own payback. The first project was to improve the productivity of one of the primary plants that would be used in producing the new product. In order to increase the capacity for the new product, existing production was modeled and reviewed to find production efficiencies and improve planning capabilities. This was a tactical project that was a part of a longer-term, strategic program. The first plant produced approximately fifty different products on multi-purpose equipment. Genetic algorithms, along with other optimization techniques, were used to optimize the production across multiple production lines and an outsourced production facility. The company reported a 15% gain in productivity and an associated 15% reduction in working capital for materials from the resulting supply chain model and processes, translating to significant savings and additional capacity for the new product. The same approach was used for the second plant, and similar results were achieved in throughput. These results were gained primarily by modeling all of the constraints, and modeling and dynamically simulate them accurately using tools and techniques designed exclusively for the process industries.

## Optimizing Across the Plants

After the plants had been optimized within their own boundaries, the company moved to optimizing production across the plants. The plants shared production for many products, and products produced in one were used as inputs to processes in the other. To achieve this, the two existing plant-level models were used to ensure that the details of the production processes were kept intact in the model. An overlay model that planned across these plants, using the detailed models of the plants in the individual models, was developed. The model described alternative routes for the current products as well as multiple possible routes for the new product. This model also included production options that would be achievable only if capital investments were made in the plants, and those associated investments became a part of the model. The trade-offs between the potential capital projects and the resulting improvements in throughput were optimized, resulting in an additional throughput of 4,550 tons of product from the two plants with only minor capital investment, and providing tens of millions of dollars worth of investment savings. This improvement came in addition to the increased throughput gained from better planning in the individual plants. This additional capacity allowed for the new product to be introduced, using the "found" capacity to produce the required volumes. By employing the multi-tiered, holistic modeling approach, the multi-plant model ensured that the individual plant-level savings was retained, and that the development of the cross-plant model would provide feasible results that could be implemented because they matched the reality of the plant situation.

## Optimizing the New Product

In time, the company was seeing adoption of the new product in the market and the associated increased demands. The initial goals of meeting product scale-up had been met, and the company turned their attention to reducing the cost of production. Again, the company focused on modeling the production processes in detail across the plants and looking for production alternatives. Multiple routing and process options were identified and evaluated on a "what-if" basis. The different options and the associated trade-offs were evaluated and an optimal approach determined. The resulting improvements in production processes and scheduling resulted in an additional 25% reduction in cycle time, effectively reducing the product cost and allowing for more growth in market demand for the product without the need for additional capital investments to increase capacity.

## Optimizing Across the Manufacturing Network

The last step in the process was to pull all of the models together and analyze the entire supply chain. By modeling the entire supply chain, additional improvement opportunities and scheduling improvements were identified. By looking at the supply chain holistically, and with full access to current and potential production processes in the detailed models, the company was able to identify additional cycle time reductions for their products. By reducing the cycle time, they were also able to reduce the need for transferring products between plants, resulting in additional savings in logistics expense and product lead-time. With these savings, the company was able to meet the new product market demands for years into the future, with less than one million dollars worth of capital expense. By delaying the capital investment, they were able to save significantly on their capital expenses and increase their associated ROI. In an interesting development, the combined market for the new product and the other products did not meet predictions from marketing, and the investment was not only deferred, but avoided. Instead of simply putting off the need to buy new capacity, they avoided building new capacity that would have cost them not only to produce the plant capacity, but then also to dispose of it in an additional right-sizing event.

## A Leading Approach - A Leading Partner

The crop protection company discussed in this paper used the holistic approach and used methodology and tools designed for the process industry. They brought to the project knowledge of traditional planning techniques and tools, and the need to produce significant results. What they needed was a partner that had the appropriate modeling and optimization methodologies and tools. More importantly, they needed a partner that had the knowledge of their industry and how to address supply chain requirements for process. The company chose to work with a thought-leader in apply new tools and approaches to planning in the process industries. Brightrivers, their chosen partner, was chosen based on their knowledge and direct experience in the process industries. By selecting a company with the right experience and that was willing to partner with them, they were able to meet and surpass their expectations. Process companies choosing a company like Brightrivers, with proven experience including large process companies like DuPont, Nestle, Roche, Syngenta, Novartis, UCB, Shell, Dow, Atofina, Rhodia and others, will have a key advantage in achieving their unattained supply chain goals.

## Conclusion

Supply chain optimization and network design have not produced the significant results that the process industry had hoped for. While successes have been achieved, deeper savings have not been reached because of inadequate modeling techniques and tools. A new approach, that encompasses a holistic modeling approach and accurately models the reality of the process environment, is required. This approach has proven valuable across multiple projects for a leading crop protection company, and appears very well positioned to provide a deeper level of value in supply chain optimization for the process industries.

## About the Author

Jim Brown has over 15 years of experience in management consulting and application software focused on the manufacturing industries. Jim is a recognized expert in software solutions for manufacturing and has broad experience in applying enterprise applications such as Supply Chain Management, Product Lifecycle Management, CRM and ERP to improve business performance. Jim created his consulting firm, Tech-Clarity Associates, to make the value of technology clear to business.

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