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A Guide for Expanding Manufacturing Capacity

Best Practices for New Plants, Expansions, or Re-purposing Existing Facilities

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Introduction

COVID-19 has quickly demonstrated the dangers of depending too heavily on imports for products critical to the health and safety of U.S. residents. The fast-evolving threat to both individual and economic health has placed a renewed focus on the advantages of reshoring manufacturing capability to the United States.

According to the Reshoring Initiative (www.reshorenow.org) a few significant reasons that companies re-shore include shorter lead times, higher product quality and consistency, minimal intellectual property risks, and the image of being 'Made in USA'. Add to that compelling economic reasons like strengthening the U.S. economy, creating good jobs, and helping to balance trade and budget deficits, and it seems likely that in 2020 many companies will begin focusing on opportunities to expand their manufacturing capacity in the United States.

For manufacturing leaders investigating the best options for expanding manufacturing capacity in the United States it's important to investigate known best practices for starting a new facility or re-starting an existing facility.

COVID -19 has probably shined the brightest spotlight on supply chain weakness in the pharmaceutical and medical supplies industry. At risk are over-the-counter and prescription drugs, equipment, and supplies required to minimize loss of life and to combat exposure to future pandemics. The U.S. federal government is focusing on purchasing goods made in America, and other manufacturing plants deemed "essential" will be expanding here in the U.S. In early April, Larry Kudlow, Director of the United States National Economic Council, said the U.S. government is considering literally paying companies to move manufacturing back from China. (Forbes, April 10, 2020)

For manufacturing leaders investigating the best options for expanding manufacturing capacity in the United States it's important to investigate known best practices for starting a new facility or re-starting an existing facility – best practices which will ensure the plant starts operations effectively and efficiently, and continues operating at designed capacity at the lowest risk and total cost of ownership (TCO).

As much as 80% of a plant's total lifecycle cost is determined during the design phase, so early decisions have a dramatic impact on the total cost of ownership. The following figure shows the complexity and number of functions that influence the TCO and the owner's return on investment. Each element in the figure below needs to be carefully considered. Many of the functions are not mutually exclusive, and focusing on one element can impact several of the other

Manufacturing Drivers for Total Cost of Ownership

elements. For example, lowering indirect materials cost could increase operations and maintenance cost due to lower quality and performance of a material.

To achieve the lowest total cost of ownership, the timing of the activities for each element is also critical. For example, choosing equipment that is only able to use solvent-based paint (versus water-based) could increase disposal costs, risks, and liabilities for the life of the facility. This decision can only be made at the beginning during the design phase of a plant.

Selecting the Optimal Approach to Expand Manufacturing Capacity

Common requirements for any expansion
At a high level, the process for starting a new plant, large capital expansion, or re-purposing an existing facility includes common requirements:

- Some amount of capital investment
- Developing an integrated master plan
- Creating an operational risk-readiness schedule
- Using a checkpoint process
- Developing an asset management strategy
- Designing the organizational culture

- Designing for reliability, commonality, and maintainability
- Establishing a MRO and spare parts strategy
- Developing a sustainable supply chain
- Managing engineering, construction and procurement
- Designing and developing work processes
- Hiring and training employees
- Pre-startup commissioning and testing
- Launch plan and schedule
- Planning for decommissioning and disposal cost, O&M waste streams, and equipment end-of-life

But there are major differences in the approaches, activities, and timing for project strategy.

New Plant: Advantages and Disadvantages

A new plant or green-field project offers the best opportunities to achieve the lowest total cost of ownership because it lacks the barriers of expanding at an existing site or re-purposing an existing facility. Although this approach allows the owner to develop strategies that can minimize TCO, in most cases it requires the largest amount of initial capital and the longest schedule. Historically, new manufacturing facilities have received the largest amounts of state incentives to help offset capital investments and workforce costs such as employee selection, hiring, and training. Critical location requirements can also be optimized by siting a new manufacturing facility.

Advantages of a new plant:

- Highest state and local incentive programs
- Proximity to clients for lower delivery cost, faster or just-in-time delivery
- Along optimal transportation and logistics routes such as highways, rails, ports
- In or near Free Trade Zones for export out of the U.S.
- Ability to choose region with best workforce selection and market compensation

Other potential advantages include:

- New operating philosophies and culture
- Potential for more automation
- Higher throughput and quality
- New equipment and warranties

Advantages need to be weight against potential disadvantages including:

- Higher capital costs
- Slower time to market – typically longer development schedule due to site selection, site preparation, permitting, construction, and infrastructure development
- Risks, construction and equipment schedules, weather slowdowns
- New workforce - employee hiring and training
- Economic and market changes due to longer schedules

Plant Expansion:
Advantages and Disadvantages

Expanding an existing facility or plant is another option for owners who already have operating plants in the U.S. This is a possibility if the plant footprint can absorb new capacity requirements, i.e. utilities infrastructure, local workforce, and other requirements to accommodate the planned expansion.

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Advantages of a plant expansion could include:

- Lower capital cost than a new site/building
- Time to market
- Existing plant infrastructure, i.e. management, procurement, HR, accounting, administration
- Existing systems infrastructure
- Existing workforce
- Established Operations and Maintenance work processes
- Existing HSE policies and procedures
- Plant culture

Disadvantages could include most of the above, depending on how well the existing plant is performing, as well as other risks such as:

- Capacity overload – can the existing infrastructure absorb the new requirements?
- Risks of having too much capacity in one location and subject to weather, pandemic, or employee-related shutdowns
- Risks of impeding current production as a result of resource constraints or other unforeseen conditions
- Inherent barriers to achieve lowest total cost of ownership, such as the workforce quality, existing plant layout, supply chain, existing culture, and existing work processes

Repurposing an Existing Facility:
Advantages and Disadvantages

When American manufacturers moved manufacturing offshore, many facilities were decommissioned and equipment moved to the new offshore locations, sold to other ventures, or in some cases, simply sold for scrap value. However, there are factories and facilities that could be repurposed and reopened. The advantages to this scenario are an existing building, facility infrastructure, and in some cases, skilled employee base. Depending on the size and infrastructure requirements of the owner's manufacturing processes, some investors have also erected new generic facilities on speculation that are suitable for light manufacturing. This also will require some due diligence to determine if the pre-built facility will meet the infrastructure requirements and long-term business goals and objectives for the business. (For additional information on evaluating an existing facility, see this paper's appendix: Facility and Equipment Condition Assessment.)

Advantages of an existing facility can include:

- Lower capital cost – some existing facilities can be acquired for pennies on the dollar
- Time to market
- Existing facility infrastructure
- Transportation access
- Existing workforce
- Existing equipment that could be re-purposed
- Possible state incentives to re-open a manufacturing facility

Disadvantages could include most of the above, depending on how well the existing plant was decommissioned and mothballed, as well as other risks such as:

- Condition of the facility and infrastructure
- Cleaning and restoration of the facility
- Risk of environmental hazards
- Removal and disposal of equipment and other items not required in the new process
- Condition of equipment that may be re-purposed in the new process
- Restoration timing and estimates for used equipment to meet new manufacturing requirements
- Barriers to achieve lowest TCO, such as facility footprint and production line layout options

Evaluating Scenarios (Manufacturing Decision Process and Planning)

The decision to build a new plant, expand an existing plant, or re-purpose an existing facility requires a careful assessment of the advantages and risks of each approach. The following figure outlines an approach to evaluate scenarios when considering how to expand your manufacturing capacity in the U.S .

Manufacturing Decision Process & Planning

Preparing for Operational Readiness (Things to consider to start up as quickly as possible)

Develop an integrated master plan

Once you have selected your manufacturing capacity expansion approach, there are some very specific best practices to consider so that you can start up as quickly as possible. Your plan should be tailored for the type of project that best meets your business goals and objectives. The integrated master plan is a living document focused on tying all of the plant, people, operations, and maintenance activities into the engineering, procurement, construction, and commissioning schedules and milestones. Each project is unique, and there is a window of opportunity to get some specific activities completed that will be gone once the project team, equipment suppliers, engineers, and other key personnel leave the project. One of the largest potential risks is optimum knowledge transfer from the project team to the plant operating team. Being proactive with an integrated master plan ensures plant personnel have been properly trained to operate and maintain the equipment and processes before the project team disappears.

Create an operational risk-readiness schedule

Anything that can impact your capacity expansion investment's ability to successfully achieve business objectives is a risk. Most operational risks are well understood and recognized. Companies can accurately assess and efficiently mitigate such risks. In fact, well-mitigated risks can actually become opportunities. By minimizing operational risks, companies are rewarded with superior operational performance, greater margins, and a significant competitive advantage in the marketplace.

Operational risks typically are related to:

- Slow production ramp-up
- Poor quality or non-compliance
- High operational costs
- Untrained or underprepared workforce
- Poor safety, health, environmental performance
- Poor capacity utilization
- Excessive raw material waste
- Low energy inefficiency
- Excessive downtime due to failure and time to repair
- Sub-optimized design
- Voided OEM warranties
- Lack of emergency spare parts

Failure to address operational risks can jeopardize the performance of new capacity expansions. Some expansions never achieve the level of performance specified in their business plans because they fail to identify, assess and mitigate operational risks. In extreme cases, the company and its reputation can be destroyed as a result.

By minimizing operational risks, companies are rewarded with superior operational performance, greater margins, and a significant competitive advantage in the marketplace.

Understanding the risks and when they are most likely to occur is critical to being able to identify, assess, and mitigate them. A risk register should be used to record and track risks throughout the project. Risks change throughout the project, as do the opportuni-

ties to properly mitigate risk impacts. A best practice is to start an initial risk register at the beginning of the project and develop a cadence of periodic risks reviews and updates based on the expected timing of the risk life cycles. In the beginning, the risk reviews may only be performed every couple of months. Once design, construction, procurement, and start-up commence, it may be necessary to review the operational risks as often as weekly as part of the routine project meetings. The consequences of identified risks and the pace of a project should dictate the frequency of the risk review schedule.

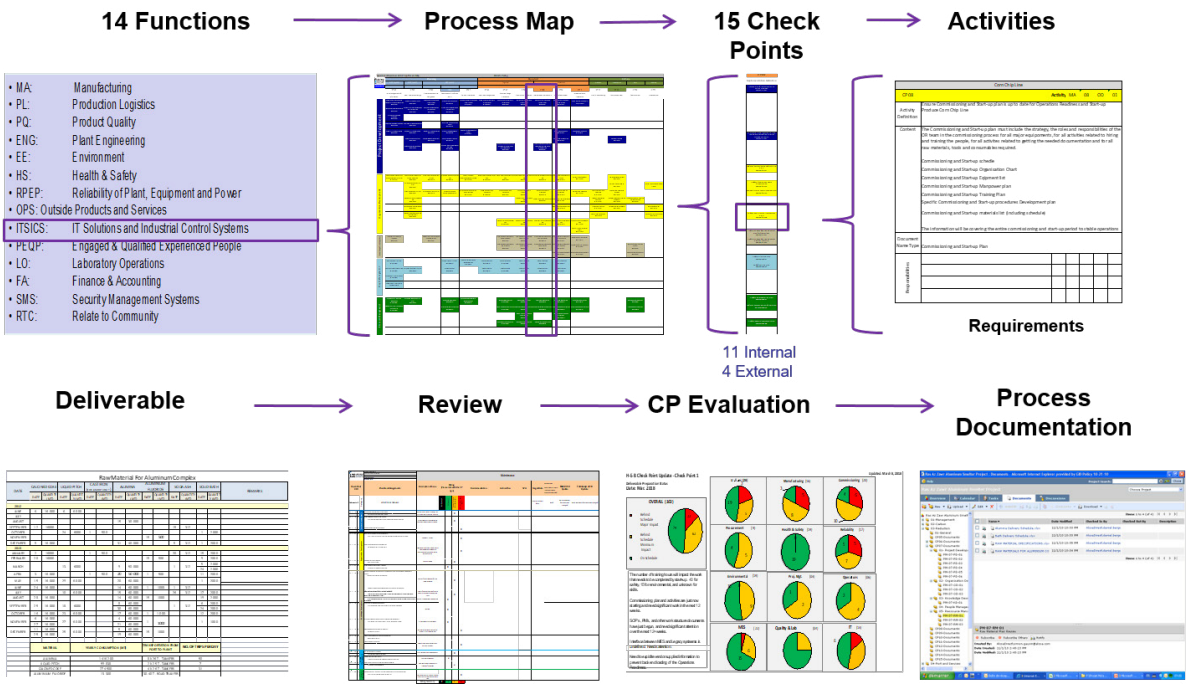
Use a checkpoint process

To ensure a project is delivered within budget, on schedule, and at desired operational performance from the start, over 1,600 activities must be completed. These activities are organized by five areas that are ongoing throughout the delivery of the project:

- Project development
- Organizational development
- Knowledge development
- People management
- Materials management

Each one of the 14 functional areas for a new or expanded site (HR, Environmental, Safety, Operations, Maintenance, etc.) has actions that must be completed at the appropriate time to ensure everything is ready for start-up. A check point process provides a roadmap that validates deliverables at multiple points throughout the project.

Check Point (CP) Process Flow



Develop your asset management strategy
For a new or re-purposed plant, this is a great opportunity to define how you will manage the entire life cycle of the assets. With skilled labor being scarce, your expansion could be focused on highly automated processes and using more sophisticated equipment or incorporating more Industry 4.0 technology and using data analytics to enhance your production process. Your asset management plan is an important document because it outlines how the critical assets will be managed across their life cycle. This plan will identify the actions necessary to ensure that these assets will deliver the value expected by the various internal and external stakeholders. This plan will document the activities necessary for maintaining and operating these assets at the agreed-upon service levels, while optimizing TCO at an appropriate level of risk. This plan will also provide a financial summary of cost and investment required during the life of the assets.

For a plant expansion within an existing site, this is also an ideal time to challenge results of your current strategy to determine if an upgrade would be beneficial. If a new strategy is not warranted, your existing framework can be used for the new expansion.

For companies that would benefit from having an asset management certification, the International Organization for Standardization (ISO) offers a very structured process as a best practice, ISO 55000. However, if there are no compelling business reasons, an owner does not have to go through the formality of certification to take advantage of the long-term benefits that an asset management plan provides.

Your asset management plan is an important document because it outlines how the critical assets will be managed across their life cycle. This plan will identify the actions necessary to ensure that these assets will deliver the value expected by the various internal and external stakeholders.

Design your organizational culture
Along with your asset management strategy, now is an excellent time to design your organizational culture for the future. Many existing cultures do not attract and retain high-caliber and skilled employees. An article by Michael D. Watkins, "What Is Organizational Culture? And Why Should We Care?" in the May 15, 2013 issue of the Harvard Business Review is a helpful exploration of the importance of the operational culture.

Many traditional work cultures lack the ability to keep employees highly engaged. Studies from Bob Kelleher, the leading expert on employee engagement, estimates that 68% of employees are disengaged. In an excellent YouTube video, "Who's Sinking Your Boat?" Kelleher describes why employee engagement is so important to your organizational culture.

A new organizational culture works best for new plants or for repurposed plants starting with a new workforce. For capacity expansions, changing the culture at an existing plant is much more difficult or even impractical because of the existing culture and inherent barriers such as established compensation models. As manufacturing continues to expand in the U.S. and compete with off-shore manufacturing, finding, selecting, hiring, and retaining a highly engaged workforce will become much more difficult. An organizational culture focused on employee engagement could help a company remain competitive.

Design for reliability, commonality and maintainability

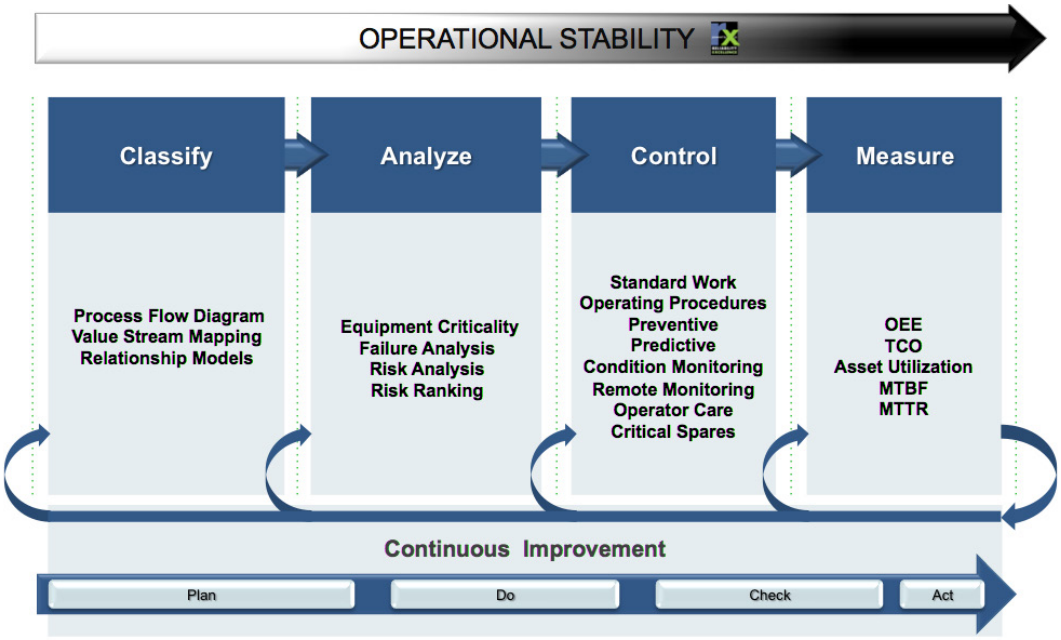
Designing for reliability, commonality, and maintainability is a best practice for all three strategies. Designing for reliability ensures that the equipment and process remain stable and reliable. Designing for commonality ensures that you use common equipment and components when possible to eliminate excessive spare parts, training, and special tools and rigs. Designing for maintainability ensures that critical equipment items are accessible in the plant layout and have the necessary isolation and safety components to quickly and safely isolate equipment for maintenance and repairs.

Your design for reliability, commonality, and maintainability should maximize the following objectives:

1. Asset productivity
2. Asset sustainability
3. Asset lifecycle
4. Regulatory compliance
5. Cost and capital rationalization
6. Measurement and learning

The following figure illustrates a risk-based approach to maximize these objectives.

Risk Based Asset Management (RBAM)



Establish a MRO and spare parts strategy
One common mistake made during a new project is simply accepting the OEM's documentation, training, and recommendation for spare parts. Procurement specifications should require OEM documentation to be electronic and in a form you specify to quickly and efficiently load into your document management and asset management systems. This should include all 3-D drawings of equipment and parts. Training requirements and documentation should be focused on ensuring proper knowledge transfer and not simply the OEM conducting a training class or delivering a training manual. Once the POs are let to the suppliers, it is often too late to get what plant personnel really need to operate and maintain the plant effectively and efficiently. The results from your design for reliability, commonality, and maintainability processes should dictate what critical spare parts you should order and when, based on the risks identified during commissioning and your equipment maintenance plans for steady-state operations developed during the RBAM assessment.

Develop a sustainable supply chain
COVID-19 has uncovered unexpected vulnerability in many U.S. manufacturing supply chains. With the closing of many businesses and factories, initially overseas, many companies were starved for materials and parts that were critical to sustain their manufacturing capacity. The use of just-in-time inventory management strategies has decreased the storage of extra materials and supplies to absorb any kind of disruption. Now, with overseas companies starting production, materials and parts are arriving before the U.S. plants can open. Ports are becoming overwhelmed and companies are scrambling for extra warehouse space.

Even before engineering and construction of a new or expanded plant begins, supply chain strategies need to be developed and risk and scenario planning should be conducted to determine the best sources of raw materials, components, and supplies.

Even before engineering and construction of a new or expanded plant begins, supply chain strategies need to be developed and risk and scenario planning should be conducted to determine the best sources of raw materials, components, and supplies. If suppliers are unknown, proper due diligence should be performed to ensure a reliable supply of quality materials can sustain expected production requirements and growth. The article "Supply Chain Lessons from Covid-19: Time to Refocus on Resilience" by Olaf Schatteman, Drew Woodhouse, and Joe Terino, (www.bain.com, April 27, 2020) explains why supply networks designed for low-cost and minimal inventory pose a risk.

Manage engineering, construction, and procurement

Most capacity expansion projects will require civil, electrical, and mechanical engineering along with facility, process, and possibly equipment engineering. In the case of a new plant or a capacity expansion at an existing facility, a new building will need to be erected, so construction and procurement are critical components that are typically outsourced to an EPC contractor. As indicated in the above section on the integrated master plan, the EPC schedule will most likely dictate the schedule for the expansion project. Working with the EPC project schedule and milestones is critical to ensuring a smooth and synchronized start of the process. In addition, the checkpoint process will help you ensure that all of the activities of the EPC contractor as well as key equipment suppliers and your on time and in the proper sequence for a successful launch.

Design and develop work processes

In conjunction with the EPC activities and in alignment with your asset management strategy, the plant administrative, procurement, operations, and maintenance work processes need to be developed and documented. A technology transfer team is a best-practice method to document the procedures needed by the broader workforce. Once documented and validated, they should be entered into a management control system with a management-of-change process that ensures consistency in procedures across the business enterprise. This is not only a best practice; it's also a requirement if you are seeking ISO certification or performing a regulated production process. Many of these work processes need to be highly integrated and cannot be developed independently from other work processes. The following figure shows an example of potential work processes that need to be developed, documented, and managed.

Hire and train employees

Employee selection, hiring, and training are crucial to the success of any expansion. Using information developed in previous sections, you need to develop a comprehensive staffing and training strategy. This strategy uses previously developed information

to determine attributes of the employees best suited to the culture you are trying to develop, as well as the knowledge and skills required to operate and maintain the new process or plant. Once you have a knowledge and skill inventory, you will need to determine the amount of work to be done and how the work will be divided into job categories. The number of shifts will also be used to help determine the number of personnel required to fill the number of jobs needed, taking into account attrition, vacation, and sick leave. Your staffing strategy will also reflect your outsourcing strategy for highly technical or seldom-performed jobs for which it may not be cost-effective to have and maintain a full-time or expensive resource on your payroll.

Once you have your criteria and the number of jobs you need for each role, you can start the selection process. For new manufacturing jobs, many states offer incentives to help you select and hire operations and maintenance personnel. States also offer basic training on manufacturing and maintenance activities.

As mentioned above, you need to hire soon enough to take advantage of the equipment and process-specific training the OEMs can provide during installation, startup, and commissioning, but you do not want to hire them too early and absorb extra cost. It is a best practice to have a multifunctional, technology transfer team assigned to each section of the process or plant. These teams are typically made up of operators, maintenance, and engineering personnel. The technology transfer team is responsible for developing all the process procedures and team members become subject-matter experts on their part of the plant and/or process. They will also be responsible for training the remaining workforce prior to startup and steady-state operations.

It is imperative that your integrated master plan shows when specific roles will be hired and ready for the OEM training and actively participate in the equipment installation, commissioning testing, and startup of the equipment.

Pre-startup commissioning and testing

Typically the EPC and OEMs will conduct the pre-startup commissioning and testing of the equipment and processes. As mentioned earlier, your employees need to be hired and have received their basic, plant, and process overview training prior to the commissioning and testing of the equipment and processes. It is imperative that your integrated master plan shows when specific roles will be hired and ready for the OEM training and actively participate in the equipment installation, commissioning testing, and startup of the equipment. The opportunity to document information about the installation, com-

missioning, and startup could be lost if the technology transfer teams are not in place prior to commissioning and startup activities. The check point process will also help to ensure that all pre-requisite activities have been completed prior to the commissioning, testing, and start-up.

Conclusion

COVID 19 has reinforced the benefits of strengthening supply chains and reshoring manufacturing to the United States where feasible. For manufacturing leaders investigating the best options for expanding manufacturing capacity in the U.S. it's important to apply best practices for starting a new facility or re-starting an existing facility – best practices which will ensure the plant starts operations effectively and efficiently, and continues operating at designed capacity at the lowest risk and total cost of ownership (TCO).

Regardless of the approach, adding capacity is a challenging and risky process. The above recommendations provide only high-level guidance into some of the best practices that should be considered. A few larger U.S. companies have started up new plants and expanded their manufacturing capacity and have knowledgeable people and well-defined processes based on experience and lessons learned. Even with this experience, some choose to use a third party at a relatively low cost to audit their internal plans for managing operational risk.

Other companies with less experience expanding capacity on a disciplined, reliable schedule may want to find a partner who has the knowledge, experience, and tools to guide them, starting as early in the process as practical to avoid costly mistakes and deliver the new capacity with the lowest total cost of ownership.

If you seek a partner with deep experience strengthening the performance of U.S. manufacturers, please reach out to us at info@LCE.com.

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Appendix: Facility and Equipment Condition Assessment

To repurpose an existing facility, an additional best practice should be implemented. Before making an offer to purchase an existing facility, you need to complete thorough due diligence. Like a home inspection before purchasing a house, the assessment is relatively low cost and will typically pay for itself many times over. An assessment should include an environmental study to identify any hazardous wastes that have or could contaminate the property or would be harmful to the employees. Some properties will have already performed the study and are certified clean prior to a sale, and you may determine that there is little or no risk of environmental hazards.

In addition to the environmental assessment, a Facility Condition Assessment (FCA) – including any equipment such as HVAC, chillers, compressors, and switch gear components that will be used to support the new manufacturing processes – should be completed to ensure that the facility is suitable or can be restored to a suitable condition for the new operation.

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For equipment that might be used for production, Equipment Condition Assessment & Restoration (ECAR) is an assessment methodology designed to evaluate physical equipment condition, production process operation and capability, and production losses critical to business goals. ECAR can be used to accomplish the following business objectives:

- Restore production capability and capacity
- Restore equipment condition and process operation to industry standard
- Restore equipment and process operation to compliance with EH&S regulation
- Reduce Total Cost of Ownership (O&M phase)
- Extend asset life to meet a business need

Methods and tools used in the ECAR process are based on individual site needs and may include conducting visual equipment walkdowns, using condition assessment technologies, failure modes and effects analysis, and design reviews.

The resulting ECAR assessment report can be used to negotiate the terms and price of the existing facility based on empirical data on the condition of the facility, grounds, and equipment and will provide you with a defined level of effort and cost estimate to bring the existing facility up to your production requirements.