Alternative Energy Commercialization: Challenges...and Solutions

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BACKGROUND

Alternative energy is a very broad term covering many sources of usable energy intended to replace fossil fuels and (depending on how you feel about it) nuclear power. Common examples of alternative energy technologies include wind power, water power, solar, biofuels, geothermal, and fuel cells.

Environmental concerns, global energy demand forecasts, and long-term price trends for fossil fuels are driving growth in alternative energy sources in the early years of the 21st century. Alternative energy technologies are not "Star Wars" fantasies. The technologies are real but their costs are often considerably higher than that of fossil fuels. Consequently, the deployment of alternative energy technologies has been frozen by the low prices of crude oil, coal, and natural gas.

Alternative energy technologies must be *commercialized* in order to be truly competitive with existing fossil fuel power sources. Commercialization is full of risks in technology, people, markets, and finance. Most if not all of these technologies will require new manufacturing processes and supply chains.

Fortunately, solutions to the operational and manufacturing aspects of the commercialization problem can be found in an existing industry…automotive. In the last thirty years, there have been dramatic improvements in the cost, quality, and reliability of cars and light trucks. Alternative energy technologies must replicate this success, but on a much shorter time line.

Concurrent with the growth in alternative energy, the domestic auto industry is experiencing a dramatic and likely permanent contraction. Adam Smith's invisible hand is re-allocating human capital and intellectual property to other sectors of the economy. Some of this talent and knowledge will be applied to alternative energy commercialization.

This paper outlines the "automotive" operations engineering methods that will be used to successfully commercialize alternative energy technologies. The winners in this high stakes poker game will utilize operational excellence to reduce costs, increase reliability, and become truly competitive with other power generating alternatives.

COMMERCIALIZATION ISSUES

Unlike "dotcom" digital technologies, alternative energy commercialization will require industrial production: things must be made and likely in large quantities for an adequate return on investment. Only $25 million in venture capital money was required to launch Google. Orders of magnitude more will be required to commercialize alternative energy technologies.

Regardless of the technology, all alternative energy companies will be faced with pressure to increase quality and reduce costs while ramping up volumes. Material suppliers and installation contractors will be under similar pressures. Here are some examples of common manufacturing challenges:

- Improve reliability while simultaneously increasing performance
- Improve integration of product design / engineering and manufacturing / installation
- Develop "lean" assembly and installation processes to reduce costs, improve production process controls, increase throughput, and reduce lead times

- Develop a global supply base capable of manufacturing increasingly sophisticated components and sub-assemblies
- Remove supply base bottlenecks while simultaneously reducing the cost of purchased parts
- Improve transportation and supply chain logistics

OPERATIONS ENGINEERING SOLUTIONS

Automotive is perhaps the most competitive consumer durable goods industry on the planet. Companies must compete not only on product, but also on process. When these hard lessons are taken out into other sectors of the economy, the value proposition is very good. Five "automotive" operations engineering tools and methods are directly applicable to alternative energy commercialization issues:

- Theory-of-Constraints (systemic problem solving)
- Industrial Engineering / Lean Thinking (basic blocking and tackling to reduce the seven wastes)
- Value Stream Mapping (visualizing the seven wastes)
- Quality Systems (statistics and robust processes)
- Manufacturing / Business Process Simulations (predicting future operational and financial results)

Theory of Constraints

Theory-of-Constraints is a proven process to solve business problems. T-O-C views an organization as a chain of dependent activities or functions all working towards a goal. The constraint is the weakest link in the chain…the link that most severely limits the organization's ability to achieve the goal. In business, the goal is usually to make more money both now and in the future.

Eliyahu Goldratt outlined the following five step process to improve organizational performance in his first book on Theory-of-Constraints, *The Goal*:

- Step 0: Define the system. In this context, the "system" includes both the goal and the activities and functions that deliver the goal: Who and what contributes to production and cash flow?
- Step 1: Identify the system's constraint. Finding the constraint in a large, complex organization can be a challenge. A simple rule of thumb: If a link in the chain is "blocked" then the constraint is downstream. If a link is "starved" then the constraint is upstream.
- Step 2: Decide how to exploit the constraint. How can we get the most out of the constraint: Approve overtime? Reduce setup times? Improve scheduling? Increase in-coming inspection?
- Step 3: Subordinate everything else to the decisions made in Step 2. What can non-constraints do to ensure that the constraint is as productive as possible: Cross-train people? Improve quality? Perform extra inspections? Take lunch and breaks at different times?
- Step 4: Elevate the system's constraint. Add capacity if and only if the constraint's performance has been truly maximized.

- Step 5: If a constraint is broken in Step 4, go back to Step 1. Repeat the process on the next constraint until the organization's goal has been met. If the goal is open-ended (e.g., make more money), then this process never ends.

Industrial Engineering / Lean Thinking

Once the constraint is identified, industrial engineering and lean thinking can be applied to increase throughput at the constraint and reduce operating costs at non-constraints. Industrial engineering is the discipline of utilizing inputs in the most efficient way possible to achieve planned outputs. Lean thinking is a management philosophy focused on the reduction of the seven wastes:

(1) Over-production (making more than customer demand)

(2) Motion (human or machine)

(3) Waiting (human or machine)

(4) Conveyance (movement from one location to another)

(5) Over-processing (making features not valued by the customer)

(6) Inventory (raw materials or finished goods)

(7) Correction (scrap and rework)

The principles of lean manufacturing started with Henry Ford and were refined into what is known today as the Toyota Production System (TPS). When a delegation from Toyota visited the United States after World War II, they concluded that mass production was not suitable in post-war Japan. They were, however, inspired by a supermarket's simple but elegant process for re-stocking shelves.

TPS is a process-driven, long-term philosophy of continuous improvement and waste reduction. It is based on a "pull" system to avoid over-production and minimize inventories, a culture of getting quality right the first time, standardized work, and visual control.

Many costs are assigned when a product is designed. Companies are now applying lean thinking to reduce waste in product development: standardized parts, modular components, design review checklists, etc.

Both manufacturers and service providers incur significant wastes as material moves into, through, and out of their operations. Applying lean thinking up front to packaging design, container density, internal material flows, and external logistics can reduce total costs.

Quality Systems

Automotive quality and reliability has improved dramatically in the last thirty years. Dr. W. Edwards Deming introduced statistical process control to Japan after World War II. These principles were incorporated into lean thinking and the Toyota Production System. More recently, Six-Sigma has continued to refine the application of statistical methods to improving quality.

ISO 9000 is a comprehensive standard that can be used to assess the robustness of a company's quality system and operating practices. With just ten questions from the standard, a far-reaching quality audit can be performed:

(1) Management Responsibility: What is the quality policy?

(2) Customer Satisfaction: How is customer satisfaction measured and tracked?

(3) Contract Review: How are all customer requirements verified before order acceptance?

(4) Quality Planning: How is the quality of new products and/or new services ensured?

(5) Purchasing: How is the quality of purchased products and/or services ensured?

(6) Process Control: How are production, inspection, and maintenance activities controlled?

(7) Inspection and Test Status: How are defective materials and parts identified and segregated?

(8) Corrective and Preventive Action: How are quality problems identified, corrected, and prevented?

(9) Handling, Storage, Packaging, Preservation, and Delivery: How are products protected?

(10) Training: How are training needs assessed and delivered?

Value Stream Mapping

Value Stream Mapping (VSM) is a method to illustrate the seven wastes and to identify their sources. A VSM is a comprehensive view of all the actions, value-added and non-value added, required to bring a product or service to a customer. A VSM includes product flows as well as information flows. In addition to illustrating process logic, a VSM organizes key data for each process step: cycle times, change-over times, lot sizes, uptimes, scrap rates, inventory levels, inventory delays, transport times, shipping frequencies, etc.

A VSM is a good first step in thinking systemically. Taking a value stream perspective ensures working on the big picture and therefore helps to avoid local optimization. VSM's are equally valid for manufacturing, service, and administrative processes. Once a current state VSM is completed, it provides managers and employees an effective tool to find constraints and discuss alternative actions to reduce waste.

Software programs have been developed to facilitate the development of value stream maps. While nice to have, they are not essential. VSM's on brown paper covered with sticky notes are just as valid.

Manufacturing and Business Process Simulation

While a VSM is a good first step in thinking systemically, the method has one significant limitation: it is a static snapshot, not a moving picture.

A simulation provides a dynamic view of the value stream as well as the ability to run "what-if" experiments to predict future operational and financial results. As such, simulation is a very powerful and versatile tool to maximize investment efficiency and mitigate risk in both manufacturing and business processes.

Discrete event simulations are built by connecting modeling elements (machines, conveyors, buffers, parts, people, etc.) in the process flow logic. Next the performance of each element is described with variables such as cycle times, downtimes, changeover times, conveyor min/max/floats, buffer sizes, shift hours, etc. By happy coincidence, most of the data required to build a discrete event simulation has already been organized on the Value Stream Map…

Uncertainty in any performance variable can be captured by fitting a probability distribution around a mean value. By using a different random number stream for each probability distribution, the events in the model are independent of each other…just as in the real world. At the end of a run, the simulation software collates the results and generates reports. What-if experiments are easily performed by making changes to the input data set, re-running the model, and then comparing the results.

Many manufacturing and business processes share resources in complex ways. In such cases, finite capacity simulations can create multi-product, multi-process production schedules for improved customer service, reduced inventories, and better utilization of resources. Finite capacity simulations are equally applicable to manufacturing and service organizations and can be interfaced with shop-floor and human resource systems. Finite capacity simulations have similar dynamic what-if capabilities. What if a shipment of parts is running late? What if a machine is down for the day?

For over two decades, discrete event simulations and finite capacity simulations have proven equally adept in finding constraints and testing strategies to break them per the Goldratt five-step process.

CONCLUSIONS

A combination of these five "automotive" operations engineering tools can address the manufacturing related commercialization challenges facing all alternative energy technologies. The systemic perspectives provided by Theory-of-Constraints and value stream mapping will ensure that functional interfaces and hand-offs are considered. Lean thinking and quality systems will squeeze out waste and improve customer satisfaction. Simulations will find bottlenecks and reduce the risk and uncertainty around capacity investments. First adopters of these operations engineering tools in the alternative energy industry will achieve dominant market positions, greater economies of scale, and superior financial returns.

ABOUT THE AUTHOR

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Steve came to PMC from the Ford Motor Company. During his twenty years at Ford, Steve guided North American assembly and stamping plants through the ISO 9001 registration process, developed a total plant simulation process, and assembled cross-functional / multi-national teams to model enterprise profitability.

Steve holds a BSME from Massachusetts Institute of Technology, an MBA from Indiana University, and is a Professional Engineer. Steve is a member of the Society of Automotive Engineers, the Turnaround Management Association, and the Association for Corporate Growth.

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