Pilot vs. Commercial Plant – part 1

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To the casual observer, pilot and demonstration plants seem to look and behave like large-scale commercial plants. Indeed, both types of plants need to be designed and fabricated in accordance with federal and local codes and standards, both use the same engineering principles, and both have similar looking electrical and control systems. However, it is a misconception that they should be designed with the same equipment using the same specifications. Contrary to the intuition of many engineers, commercial-plant specifications should not be applied to pilot plants. In fact, following this line of thinking is a trap that will deliver subpar research results and incur unnecessary expenses.

Design Criteria for Pilot Plants

Design specifications for pilot plants are primarily driven by the need for flexibility and representative data collection. Flexibility allows the order of operations to be reconfigured, new unit operations to be added, and a range of operating conditions to be tested. Other drivers of design specifications for pilot plants include the following:

- complete design and fabrication quickly to minimize time to market
- maintain the accuracy of small-scale metering systems and measurements
- minimize the layout space of the plant
- represent process conditions accurately
- ensure the system is safe

These drivers are often very different from those for commercial plants, which underlines how misguided it is to apply commercial specifications to pilot plants.

The Objectives of a Pilot Plant

Pilot plants and commercial plants have different objectives (Table 1). Pilot plants are designed and built to learn more about a specific process in order to make decisions regarding new technologies or other process configurations. Data collection is central to achieving this goal, as it provides process engineers with boundary conditions for scale up.

Pilot plants are also meant to expose potential problems so that possible solutions can be engineered and tested before continuing to scale up or transfer technology to full-scale operation. This means that pilot plants are designed to operate intermittently for one to thirty days per campaign, allowing for adjustments and experimentation, while a full-scale commercial plant will be expected to run continuously with only a few weeks of shutdown per year.

Table 1. Pilot-Plant and Commercial-Plant Objectives

Pilot-Plant Objectives	Commercial-Plant Objectives
• collect data as part of scale up	• produce product to maximize revenue and minimize costs
• accurately model the full-scale process at a smaller scale to obtain representative results	• create consistent and reproducible product quality
• expose problems and test alternative solutions	• prioritize efficient operation
• assess the effect of impurities buildup in recycle streams	• use assets efficiently
• test multiple configurations and operating conditions to optimize the process	• reduce costs through preventive maintenance
• design flexibility for frequent reconfigurations	• run continuously
• prioritize easy start up and shutdown	• troubleshoot without shutting down
• run intermittently	

A pilot plant needs to be flexible and adaptable so operators can quickly make modifications, test configurations, and establish optimal operating conditions. Notably, owners of pilot plants are concerned more with proof of concept than with efficiency of operation. For example, a pilot plant will focus on the critical issue of controlling reactor temperature and spend little or no time trying to recover heat from hot streams.

The Objectives of a Commercial Plant

Commercial plants are built to produce a set volume of a well-defined product of consistent quality to maximize profit. Underlining any design choice, then, is a cost consideration. Unlike the pilot plant, a commercial plant will design methods of cost control into the system, including recycling solvents and gases, recovering heat from effluent streams, and recovering the energy value of waste gases.

Commercial plants are built to achieve economies of scale. The plants are large and require a high capital investment, which incurs high fixed operating costs in the form of depreciation. In order to maximize the value of the assets and control costs and protect profit margins, they must operate at high utilization. Because quality is an important component of high utilization, standard procedures that break tasks down into discrete, reproducible, and uniform steps are the focus of any design.

Unlike pilot-scale operations, preventive and predictive maintenance is paramount in a commercial-scale plant because maximizing uptime is a major objective. Where plant layouts are sprawling, then, an aspect of the design may be using smart devices (such as control valve positioners) to alert personnel when replacement is required.