A Simulator Acquisition Strategy

For Limited Training Budgets

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Table of Contents

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The Three Things

There are three things that every plant and training manager desires, but very few have:

1. **Well-trained, competent, and accessible operators.**
2. **A plant that runs at peak efficiency** and is continually being assessed; consequently establishing new operational benchmarks.
3. **An affordable method** to attain the first two.

It is more critical today than ever before to plan for the ever-increasing demands created by the attrition of experienced operators and the ever-escalating costs of power production. Never before has there been a greater return for investments in these areas.

In an ideal world, everyone would readily recognize the benefits of a well-trained staff, and there would be no organizational obstacles in funding an operations training program. But how do you get there when your training budget is limited?

First, you must confirm the need for training.

Does Your Staff Need Training?

How does your plant stack up?

Are the following statements true for your plant?

- ❑ **The plant's thermal performance** has increased over time and compares favorably with plants of similar design.
- ❑ **There are fewer** forced outages due to equipment damage.
- ❑ **The plant's availability** has increased with time.
- ❑ **Component life** has been sustained since there are fewer trips and pressure/temperature excursions.
- ❑ **Fines** have not been levied against the plant for operator failure to maintain environmental limits.
- ❑ **There is no evidence** of current or future attrition of experienced, essential operations staff.

If most of these statements are *not* true for your plant (and your plant maintenance is not an issue), **then the answer to the question is yes — your staff needs training**, and you should be considering additional operations training.

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Advantages of Simulator Training

Figure 1: Generic simulators can replicate the look and feel of the control room

Plant operators "have immediate and continuous impact on plant systems and components" and often "have the least formal training and technical preparation of any other generation support staff."[1]

After operators have been properly instructed in power plant fundamentals and plant systems training, reinforcement in plant operation pays big dividends in improved plant performance and the development of a cadre of well-trained operators. There is no substitute for the practice of procedural plant operations with simulator training's hands-on maneuvering of plant controls and monitoring the resulting plant responses.

Some advantages of simulator training:

- **There is no impact** on plant availability or power production.
- **Operator errors** have no plant consequences.
- **Training** can be performed in a structured or self-paced environment.
- **Critical start up and shut down procedures** can be followed.
- **Normal plant maneuvers** can be performed.
- **Responses to transient abnormalities** can be tested.
- **Trip and malfunction recoveries** can be exercised.
- **Plant performance improvement** (e.g., heat rate, environmental constraints, and fuel costs) can be practiced.
- **Reduction in plant startup time** is usually achieved.

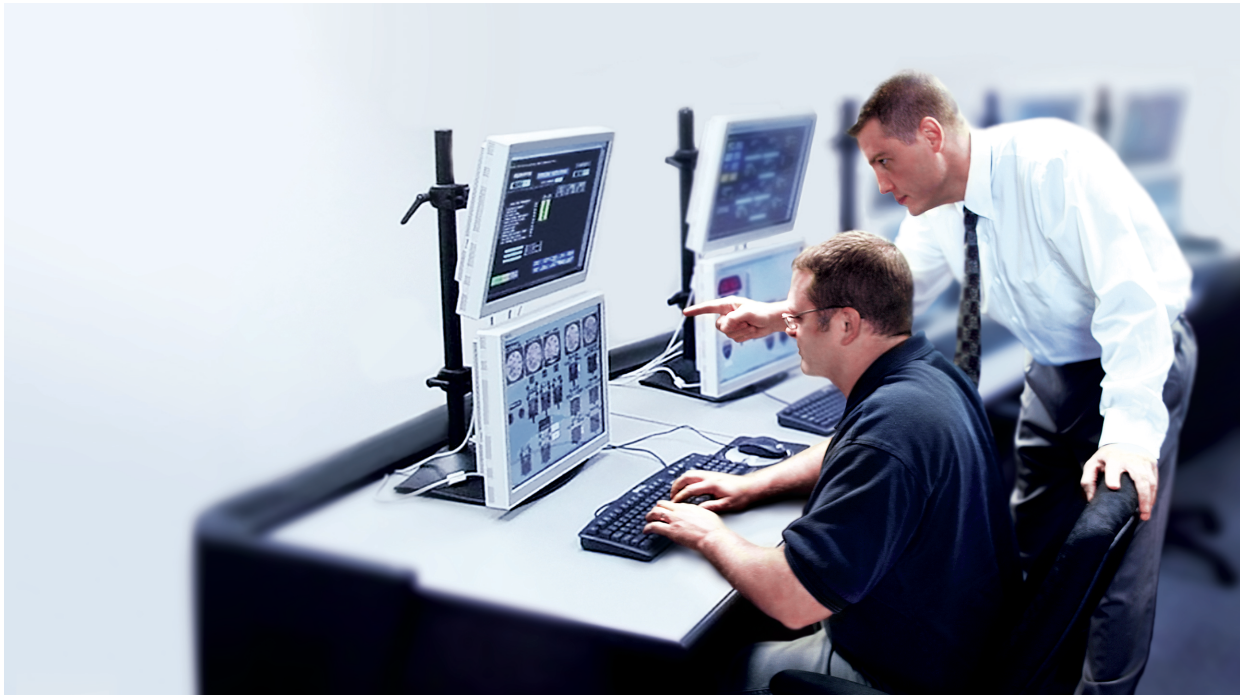

Figure 2: A simulator setup mimicking the control room

Simulator Training ROI (Return on Investment)

Over ten years ago, Electric Power Research Institute (EPRI) performed a conservative cost benefit analysis for full-scope, high fidelity fossil plant-specific simulators. This study[2] showed a payback period of five years when factoring in the costs of the simulator, training program development, instructor and operator training time. These costs were offset by:

1. **The avoidance of operator error that would result in forced outages and trips**
2. **Plant startup time reduction**
3. **Fuel cost reduction**

The report also showed that after ten years the benefit savings were three times the costs, with a continual savings of over $600,000/year. This study assumed a simulator cost of $1,250,000 (mid '90s dollars), which far exceeds the prices available today from several simulator vendors; however, the cost of plant operation has increased significantly, thus reducing the payback time for a full-scope, high fidelity training simulator. Today the payback period is more likely to be two or three years for an even higher quality and more reliable simulator than was considered in the EPRI study.

If there are doubts about achieving this level of simulator payback for an organization, then some very low-cost alternatives permit "kicking-the-tires" before making any major expenditure. The human-machine-interface (HMI) in Figure 3 illustrates an example of the systems available for training with a generic training simulator.

Figure 3: Generic Simulator "overview" HMI indicates the variety of plant systems available for operator training.

Low-Cost Simulator Options

There are a number of power plants that share common designs. They have the same boiler vendor and, often, the same engineering constructor. These plants are likely also to share many operational similarities; therefore, a simulator for a plant of comparable design (i.e., a generic simulator) offers a great deal of training value. This value can be achieved without going to the expense of developing a plant-specific simulator. In addition, many plants have upgraded their plant controls from hard panels to Distributed Control Systems (DCS) where the operator interface becomes a set of operator workstation monitors. This arrangement is even more appropriate to duplicate with a PC-based computer network that replicates the control room environment. Any remaining hard panel controls can also be included effectively with quality PC graphics emulation.

The cost of a generic simulator is a small percentage of the cost of a plant-specific simulator; for that reason, the payback period is indeed quick. Even with considerable customization of the generic

simulator (to make it more like the owner's plant), it would be only a small fraction of the simulator cost identified in the EPRI study.

Both a plant-specific and a generic simulator use the same:

- **Low-cost PC-based computer platform**
- **Instructor Station software**
- **Learning curve for running the simulator.**

What can be accomplished by generic simulator customization?

- **Operating data modifications can adjust the:**
  - Power level
  - Temperature and pressure levels for various plant components
  - Many other plant characteristics associated with physical data in the simulator model (these operations can be performed by the end-user or the simulator vendor).

- **Model modifications can:**
  - Change the number of components such as valves, pulverizers, pumps, etc.
  - Add components, plant systems (e.g. scrubbers, bag houses, etc.).
  - Perform "what-if" studies for component changes.

- **Control interface modifications are able to:**
  - Customize hard-panel emulation to have the "look-and-feel" of owner's plant
  - Adapt plant-specific HMI displays to the generic plant process model
  - Adapt plant-specific control logic to generic plant process model.

- **Simulator cabinetry and training rooms** can be selected to replicate the control room environment.
- **Interactive "assisted learning" features** can be added to the simulator to provide trainee guidance.

Customization options for a generic simulator should be designed so that modifications can be re-used for a future plant-specific simulator. This is one more instance where the generic simulator investment is preserved.

Figure 4 is a typical HMI display for a major plant system; many more HMIs are used to control the plant simulation, as in the plant.

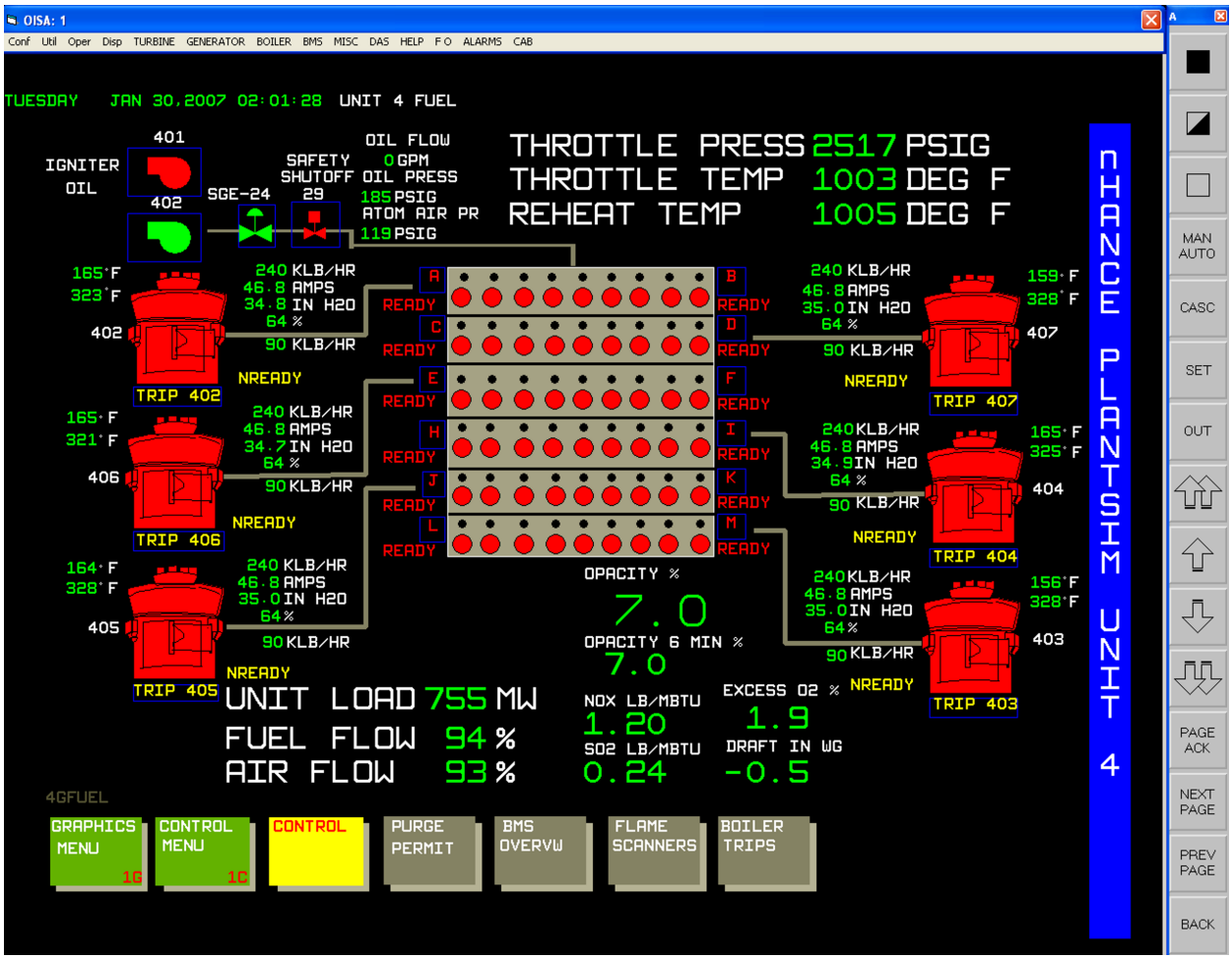

Figure 4: Fuel Overview screen with Control Menu and Toolbar.

There is, of course, a point where the extension of generic model customization may rival developing a plant-specific model. Even so, the same PC-based computer platform can be used for both. The same simulator executive software used by the plant staff will operate both the generic and the plant-specific simulator, and any customization associated with hard-panel and/or HMI emulation should be transferable to a plant-specific simulator.

Process of Selecting a Generic Simulator

Select a plant simulator similar to your own plant, preferably one capable of being upgraded – particularly for specific plant components and controls of training interest for the plant's operations staff. Any simulator selected should be based on first principles modeling of the plant's dynamics with a full-scope of system components that can run at least in real-time, and faster than real-time for slow moving plant operations.

A full-featured instructor station should be included. It will provide the simulator a runtime executive that is used to control the simulator events and trending graphics for observing the training session.

This interface should require minimal training for an instructor, allowing the focus to be on the process of training rather than navigating the simulator system.

The instructor station basic functions should include:

- **Capability to freeze and restart (run)** the simulator execution
- **Selection of initial condition (IC)** from a set of ICs for various plant situations and previously saved simulator states
- **Ability to take snapshots of the simulator state**, either manually or at some specified interval, with no noticeable indication to trainees
- **No limitations on saved files** beyond available disk storage
- **Time scaling ability** to execute either faster or slower than real-time
- **Initiation of malfunctions from pre-set lists** and the ability to easily develop new malfunctions. An example of a pre-set list:
  - Unit trip
  - Loss of turbine boiler feed pump
  - Loss of FD fan
  - Loss of ID fan
  - Loss of air heater drive
  - Loss of pulverizer
  - Partial loss of circulating water flow to the condensers
  - Reheater temperature problem
  - Superheater temperature problem
  - Loss of AC power
  - HP feedwater heater tube leak
- **A Trainee Proficiency Review utility** that allows the instructor to set operating bounds for key plant parameters therefore training operators to maintain the unit within design limits
- **A graphics utility** for trending and displaying plant variables in real-time.

The operator station is the trainee's interface to the simulator that uses emulated HMI graphics for the DCS operator stations and animated graphics for hard-panel controls. Both types of emulations are displayed on Windows-based PCs. The generic simulator should support expandability from a single PC to a network of PCs capable of replicating a control room environment. If the simulator software can be supported on a single PC, i.e., a laptop or desktop, it will bolster the training program and could support self-paced training. The trainee could then exercise his own initiative in a self-training process.

After establishing the level of simulator customization, decide how the user community should access it. One capability allows logging on over the Internet or the company's Intranet. This new form of accessibility offers the flexibility of training anywhere, anytime, over the Internet.

Additional benefits of Internet/Intranet-based simulator training include:

- **Cost effectiveness** – no operator, instructor, or vendor travel and living costs
- **No simulator maintenance responsibility**
- **Portability of training** to multiple locations
- **Advanced technology** to keep trainees' interest
- **Easy access** via Internet.

Users have reported simulator responsiveness over the Internet to be as good as or better than many on-site training simulators. The simulator supplier, with directions from the operations staff on plant changes, can maintain the simulator model to synchronize it with the plant. Usage of the simulator can be scheduled to suit the trainees' timetable. This mode of training alleviates the need for the company to dedicate additional technical resources from their staff for simulator maintenance.

Before adopting Internet-based simulator training, determine the answers to the following:

- **Is there simulator technical support from either the supplier or in-house staff?**
- **What are the hours and costs for technical support?**
- **Are basic user instructions provided?**
- **Is a startup procedure provided?**
- **Who trains the in-house instructor to use the simulator and at what cost?**

Decision Time

Now that you have examined many of the options for improving your operations staff's training, have you decided which direction to take? Generic simulators provide a low-cost introduction into the "world of simulator training." Instead of making an expensive commitment with limited knowledge of the technology, a step-wise procurement is possible. For example, a generic simulator may be run on a single laptop, desktop, or a dedicated network of PCs to capture the control room "look-and-feel." If a future decision is made to upgrade this system to a full-scope, plant-specific simulator, the same PCs and network equipment can be used. The experience gained using the simulator functions, such as those found in the instructor station, would be applicable to both generic and plant-specific simulators. Any customization of a generic simulator should be transferable to a plant-specific simulator. Experience using a generic simulator prior to the acquisition of a plant-specific simulator will give the organization the advantage of inexpensively steering through the simulator technology learning curve. This acquired knowledge sorts through the multitude of simulator specifications to those requirements that have real training value and helps achieve the three things that every plant and training manager desires:

1. **Well-trained, competent, and accessible operators.**
2. **A plant that runs at peak efficiency** and is continually being assessed; consequently establishing new operational benchmarks.
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