Powersmiths

PowerWorld Corporation
The Visual Approach to Analyzing Power Systems

PowerWorld and Powersmiths

- PowerWorld and Powersmiths have teamed up to develop OPS-X, a new concept in electric power system training
- OPS-X training Exercises utilize the new time step simulation feature of PowerWorld Simulator on a simplified PowerWorld platform

About OPS-X Training

- Powersmiths International has developed NERC approved Continuing Education training for system operators based on simplified PowerWorld Simulator time step simulation software.
- This training is highly simulator based and is targeted at the NERC Emergency Operations requirement and topics that are recognized under the new NERC System Operator credential program.
- One objective of OPS-X is to place the operators out of their comfort zone, in unfamiliar circumstances, with a skinny power system at faster than real time to develop and test instincts and reactions.

OPS-X will lower system operating costs

- OPS-X Training is hands-on, simulation based training. As such it drives home the concepts of economic dispatch, load and generation balance, line loading and voltage control as no other training can.
- A fundamental understanding of these concepts will lower system operating costs in a number of ways and in some cases actually increase revenues.

1. By experiencing surge impedance loading first hand, operators understand the relationships among line loading, VAR consumption and voltage control. Operators understand how proper voltage control can lower line loadings thus reducing losses.
2. Proper voltage control also reduces transmission congestion and leads to a more economic dispatch.
3. Proper voltage control also keeps customer equipment working at its most effective operating point and maximizes revenues as customer load is a function of voltage or voltage squared.
4. System operators want the most effective training available. It is the best use of their time. An OPS-X training program will show your system operators that the company values their time and their dedication. This will increase operator retention and reduce the costs of hiring new staff.

OPS-X training is one of the most effective cost cutting measures a company can implement.

Analogy to Flight

- The simulator training is patterned after military flight simulators
- OPS-X is designed to teach and test operators to anticipate and think proactively.
- Using the flight simulator analogy, OPS-X teaches you how to fly the power system under emergency conditions as opposed to teaching the theory of flight.

Analogy to Flight

- Pilots could be taught how to handle life threatening scenarios solely through manuals, check lists and lectures. But they are not.
- This would leave out one critical element, that being that the pilot must determine the proper action and implement it in a TIMELY fashion all under an environment of increasing stress measured by his altimeter.
- To accommodate the element of time and the accompanying stress, pilots undergo much of this training in flight simulators.

Analogy to Flight

- The same is true for power system operators therefore we need to put the element of time and urgency into power system training and for this we need a clock and the equivalent of an altimeter.
- For this we turned to PowerWorld's new feature in power system simulation called time step simulation (TSS). This feature allows us to change power system conditions with time. We can implement contingencies much like a flight simulator throwing varying situations at the operator making him think under stress.

Analogy to Flight

- We put several read-outs on the one-line diagram; ACE, voltage via color contouring and line loadings via pie charts. These are the equivalent of the altimeter and the air speed indicator. Now with time marching on and conditions deteriorating if no action is taken, the operator is faced with making the right decision in a timely fashion. If he does not, he crashes.

Analogy to Flight

- OPS-X is very much about power system fundamentals but it is also about critical thinking and decision making.
- Critical thinking and decision making under stress are acquired skills that must be practiced regularly.

OPS-X

- The basic OPS-X training is structured in 5 training modules for a total of 40 NERC CEU's.
- The topics are as follows:
  - AC Systems (8 CEU's)
  - EHV Operations (8 CEU's)
  - Congestion Management (8 CEU's)
  - Power System Restoration (8 CEU's)
  - Transmission System Operations (8 CEU's)

NERC Credential Requirements

- The expanded (2006)NERC Operator Certification program has the following requirements:
  - Reliability Operators—200 CEU's
  - Combined Transmission/Balancing and Interchange—160 CEU's
  - Transmission Operator-140 CEU's
  - Balancing and Interchange Operator—140 CEU's

NERC Credential Requirements

- 30 CEU's must be on the NERC Standards and
- 30 CEU's must be achieved through some form of simulation exercise
- Additionally, each transmission operating company has a requirement for 32 hours of Emergency Operations training

NERC Credential Requirements

- These are not additional requirements in that if the training course is properly structured it can meet more than one or all of these requirements
- The following table shows how OPS-X meets the credential requirements

OPS-X Credential Requirements

OPS-X Module	NERC CEU's	Standards Hours	Simulation Hours	Emergency Ops Hours
AC Systems	8	2	7	8
EHV Ops	8	6	6	8
Congestion Management	8	4	6	8
Power System Restoration	8	4	5	8
Transmission System Operations	8	1	7	8
Totals	**40**	**17**	**31**	**40**

AC Systems I and II (8 CEU's)

- Power Flow
- Reactive Power
- Voltage Regulation
- Generation Control
  - **NERC Standards BAL-001, BAL-005, BAL-006**

EHV Operations I and II (8 CEU's)

- ACE Disturbance Control Performance-
  - NERC Standard BAL-002
- Contingency Analysis- BAL-002
- Operating Reserves-BAL-002
- Reactive Reserves- NERC Standard VAR-001
- System Operating Limits (SOL) and Interconnection Reliability Standards (IROL)- NERC Standards IRO-004, IRO-005

Congestion Management (8 CEU's)

- Economic dispatch and marginal cost generation
- Loop flows
- Transmission Loading Relief (TLR)-
  - NERC Standard IRO-004, IRO-005, IRO-006
- Available Transmission Capacity (ATC)
- Power Transfer Distribution Factor (PTDF)
- Interchange Distribution Calculator (IDC)

Power System Restoration (8 CEU's)

- NERC Standards EOP-005, EOP-006, EOP-007
- A reference document by the NERC Operating Committee “Electric System Restoration.”

Transmission System Operations (8 CEU's)

- Relay action
  - Overvoltage
  - Undervoltage
  - Differential
  - Distance (Zones 1, 2 and 3)
- NERC Standards TOP-001, TOP-004, TOP-006, TOP-007, TOP-008, PRC-001, PRC-002
- System faults
- Transmission system relief
- Partial System Restoration
- Transmission congestion

Typical OPS-X Training Module

- Each module contains one or more simulator Exercises. In each Exercise, the operator will interact with the power system in faster than real-time to experience first hand the concepts of the training topic.
- Each module is supported by a narrative explaining the Exercise fundamentals and objectives.
- Multiple Exercises:
  - Some exercises are static in time. In this case, conditions are not changing. The operator can make changes to the power system to determine their impact.
  - Most exercises are dynamic. Conditions are constantly changing and the operator must react to those changing conditions providing for a "real life reaction" environment.
- A dynamic exercise will serve as the final exam for each lesson.
- The operator will be graded on their response to the dynamic changing system conditions.

Operator Interaction

- The operator may interact with the power system by clicking on breakers to change the status (open or closed) of transmission lines, loads, capacitors and generators.
- The operator may also change the generation output by clicking on the up/down arrows.
- The generators marked “on AGC” are automatically dispatched to minimize generation costs. If the operator re-dispatches a generator, it is taken off AGC until the operator puts it back on by clicking the “off AGC” graphic

Displays

- The status of the Exercise is shown on a dynamic one-line diagram
- Multiple forms of display provide immediate information
  - The color contour displays the voltage profile
  - Pie charts show line flows as a percentage of rating
  - Numerical displays show load, generation, ACE, generation costs, SOL’s and spinning reserve.

OPS-X Design

- The OPS-X exercises are specifically designed to include a limited number of buses and lines for two reasons:
  - In a training environment, it is difficult to monitor more than a few buses and lines
  - Limited buses and lines allow the operator to experience and respond to system emergency conditions that occur as a result of single and double contingencies.
  - OPS-X places the operators out of their comfort zone, in unfamiliar circumstances, with a skinny power system, at faster than real time to develop and test instincts and reactions.
  - While the system may not be "realistically" complicated, it requires realistic reactions to real life situations that are possible on the actual power system.
  - It is under these conditions that operator reactions and instincts are most critical

OPS-X Philosophy

- The OPS-X simulator approach to training is designed to impart new information and re-enforce concepts previously learned.
- Learning is re-enforced by:
  - Narrative explanations,
  - Hands-on user interactions in a fast paced simulation,
  - Multiple forms of data presentation –visual learning
  - Blackouts-Real learning is painful
  - Feedback (test)
- OPS-X is designed to be free standing (no internet connection required)
- OPS-X can be used for independent self study or used as the basis for classroom team sessions

OPS-X Summary

- OPS-X is structured into 5 focused subject modules
- Each module is approved for NERC Continuing Education Units
- The fast paced simulation OPS-X Exercises increase the participant interest and greatly improve the retention of the material
- Interactive OPS-X Exercises improve real time decision making and develop instinctive reactions
- OPS-X can be customized to include portions of the customer's system

Module Description

Module I, **AC Systems**, presents the basics of AC power systems:

- Control Area operation
- load and generation balance
- ACE
- NERC Standard BAL-002, BAL-005, BAL-006
- Disturbance Control Performance
- voltage regulation
- reactive power and real power flow
- VAR generation
- surge impedance loading
- load and transmission line modeling

AC Systems

- Module I is divided into two parts
- **AC Systems Part I** consists of Exercises 1-4. It demonstrates the principles of AC systems utilizing a system with two buses and two transmission lines.
- **AC Systems Part II** consists of Exercise 5 and 6 and demonstrates the principles of AC systems using a more complex system configuration with the addition of a third line and a third generator.

EHV Operations

In this module, the topics of :

- Power flow
- Power transfer
- Reactive power transfer
- Real and reactive power reserves
- Contingency analyses
- ACE
- NERC Standard BAL-002
- DCS
- Operating Reserve –BAL-002
- Reactive Reserves-VAR-001
- System Operating Limit (SOL) and Interconnection Reliability Operating Limit (IROL)
- IRO-004, IRO-005
- This module builds on the lessons of Module I particularly those related to voltage control and line loading. The power system is the same for consistency

EHV Operations

- Exercises 1-3 address contingency analysis for a single contingency and concentrate on operating the system so that an SOL/IROL is not violated in the no contingency state and that Operating Reserves are maintained. Also, the NERC DCS is revisited.
- Exercises 4-6 concentrate on contingency analysis for a second contingency and reconfiguring the system so that an SOL/IROL is not violated following a first contingency and Operating Reserves are maintained.

Congestion Management

- In this module, the system has been expanded from that of Module II to include a third bus.
- Congestion exists on the system in that transmission line ratings limit the ability of the cheapest power to reach all of the load.
- The basics of economic dispatch and marginal cost generation are covered.
- Also, scheduled power transactions create loop flows on the system that impair the ability to transfer power within the Control Area.
- Operators must configure the system so that ACE DCS is not violated, voltage profiles are maintained and lines are not overloaded.
- Transmission Loading Relief (TLR), Available Transmission Capacity (ATC), Power Transfer Distribution Factor (PTDF) and the Interchange Distribution Calculator (IDC) are discussed.
- NERC Standards IRO-004, 005 and 006 are presented covering TLR's

System Restoration

This module addresses the basics of re-establishing a power system from a blacked out state. It is based upon NERC Standards EOP-005, EOP-006 and EOP-007 and a reference document by the NERC Operating Committee "Electric System Restoration."

- In this module, the operator is placed in an islanded and blacked out system. The requirement is to re-energize the transmission system, make generation available for synchronization and restore load.
- The power system simulated is more extensive than that of the first three modules. An understanding of the basics presented in the first three modules is required.

Transmission System Operations

This module builds on the lessons of the four previous modules.

- It addresses the following concepts of as well as the concepts of NERC Standards BAL-002, VAR-001 previously presented but this time in the context of a more complex power system.
- NERC Standards TOP-001, TOP-004, TOP-006,TOP-007, TOP-008, PRC-001 andPRC-002 are also presented
- Relay action
- System faults
- Transmission congestion
- Transmission system relief
- Partial system restoration

OPS-X Training Structure Options

- Traditional classroom
- Train-the-Trainer
- Supervised self-guided simulations
- Team based simulation exercises
- Classroom mixed options
- Independent study

In closing

- Traditional OTS training teaches operators to handle specific system circumstances. This is proper and necessary training.
- We are supplementing that training by teaching principles that can be applied broadly to prevent many different specific events.
- Beyond that, we are teaching a thinking process that involves simultaneously managing several changing elements where failure is not an option.

Perspective

- "Multi-tasking"—managing more than one task at a time
- "Dynamic multi-tasking"—managing more than one continually changing task at a time
- "Critical dynamic multi-tasking"—our business is really life and death.