JORDANIAN TRANSMISSION BENEFITS FROM ARIZONA PUBLIC SERVICE TRANSMISSION EXPERIENCE

APS Transmission Experts Share "Best Practices"
with the National Electric Power Company of Jordan (NEPCO)

by Jason Hancock, Senior Program Coordinator, United States Energy Association

NEPCO Managing Director Ahmad Hiyasat receives a Hopi (Native American) Kachina doll from Robert Smith, Director Energy Delivery, Asset Management and Planning at APS as a token of friendship between the two utilities.

Delegates from **Arizona Public Service (APS)** traveled to Amman, Jordan to meet with their counterparts at the **National Electric Power Company (NEPCO)** of Jordan. Ross Hagan, Director, Energy Office, USAID/Jordan welcomed the delegation and made opening remarks to commence the second executive exchange visit for NEPCO. The exchange visit was conducted October 3-11, 2009 in Amman, Jordan, was aimed at improving transmission system reliability, improving transmission system planning and operations, and accelerating the integration of renewable energy into Jordan's transmission grid. The NEPCO Partnership Program is sponsored by the **United States Agency for International Development (USAID)** and organized by the **United States Energy Association's (USEA) Energy Utility Partnership Program (EUPP)**.

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org

BACKGROUND

The purpose of the program with NEPCO is to develop long-term cooperative relationships between U.S. transmission experts to transfer U.S. experience in market-based, environmentally sustainable energy production, energy transmission, and energy distribution to NEPCO.

The partnership seeks to address four specific topic areas:

- Improving the reliability and stability of the transmission grid system;
- Accelerating the integration of renewable energy into the grid;
- Improving transmission system planning and operations; and
- Introducing advanced techniques for operating the Jordanian electricity market and handling cross-border electricity exchange.

THE NATIONAL CONTROL CENTER (NCC)- NEPCO'S OPERATIONS DIVISION

NEPCO's Operational Division, otherwise known as the National Control Center (NCC) was established in the late seventies to monitor and control the National Grid of Jordan. The NCC is comprised of four departments, the Communications System Department; the Control System Department; the System Operations Department; and the Operations Planning Department. NEPCO's NCC coordinates the operation of the electrical system that belongs distribution companies JEPCO and IDECO, and the transmission interconnections with neighboring countries.

As the electrical system of Jordan continues to grow, NEPCO has found that it is necessary to upgrade and modernize its National Control Center in order to improve the efficiency and overall integrity of the system. To this end, NEPCO has begun construction of a new facility to house its new NCC which is currently scheduled for completion in January 2010.

NEPCO's current control center

NEPCO's new control center scheduled for operation in January 2010

DISPATCH CONTROL CENTER DESIGN AND DISPATCHER TRAINING

The Control Systems Department at NEPCO is responsible for maintaining and operating NEPCO's Supervisory Control & Data Acquisition System (SCADA). SCADA refers to a system that collects data from various sensors throughout the transmission network and then sends this data to a central control center. The control center then uses the data to manage and control the transmission network. The Control Systems Department has undergone many upgrades and additions as NEPCO's transmission system has grown and as technology has advanced. Currently, the Operations department is in the final phases of its largest transformation since its inception.

NEPCO's National Control Center will be moving from its original location to a newly constructed facility designed to house the new equipment of a modern control center. The design of the new control center is similar to the designs of the control centers at APS and Duke Energy that the NEPCO delegation visited in April-May 2009. NEPCO has added an observation gallery similar to the one in use at APS overlooking the control center floor that allows visitors to observe the workings of the control center

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org

without interfering with the operations of the dispatchers. Additionally NEPCO plans to adopt layouts for the dispatchers' desks based on the layouts of APS and Duke Energy.

The new NCC will include a state-of-the-art digital projection displays that will replace the wall board system map of the current control center. The new digital display screen will show system changes as they happen which are updated in real-time by the SCADA system. The analog board in the current NEPCO control room must be manually updated by control room operators to show changes in the network. In addition the display NEPCO will also be replacing its RANGER control software with ABB's Network Manager.

TRAINING

Mark Hackney, APS

Mark Hackney, Section Leader, Transmission Service Trading at APS introduced control center operations and operator training practices at APS. One of the key differences between NEPCO and APS is that at NEPCO, the control center is operated by engineers. At APS the control center operators are typically linemen and substation operators who have decided to come in from the field to work in an office environment. The APS operators are then supported by a team of engineers who work normal hours rather than round-the-clock as the operators do. Hiring linemen and substation operators rather than engineers at APS is more a response to the scarcity of engineers in the U.S. than to engineers being unwilling to perform the work. As such, APS takes the training of its control center operators very seriously.

Training for control center operators in the U.S. is conducted as on-the-job training with very little classroom-style training. Operators train for one year, usually achieving operational competency within six months, before they begin a one year apprenticeship with an existing operator who will act as a mentor to the trainee. After the two year training requirement is fulfilled, the operator is tested to determine his or her capabilities and is then certified to perform specific operations based on the results of the examination.

U.S. Control center training goes beyond the initial training required to gain operator status. Operators must complete 200 hours of continuing education every three years in order to maintain their certification. APS control center supervisors determine which training meets adequate criteria for continuing education credit and also create and offer in-house training courses designed to meet the 200 hour requirement.

NEPCO has expressed interest in adopting the APS control center operator training curriculum. This will be a key focus area of the partnership program during future exchange visits.

NEPCO audience learns APS approach to transmission system planning

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org

INTEGRATING RENEWABLE ENERGY INTO THE TRANSMISSION SYSTEM

Transmission planning has always been an important consideration for NEPCO. However, due to mandates by the Ministry of Energy in Jordan to wind energy from one percent to nine by 2020 it has become even more critical. As NEPCO begins to face the realities of grid-integration of large-scale wind energy, 200 megawatts of which is scheduled for completion by 2013, it must take a careful look at its transmission network and control systems to ensure they are up to the task.

John Lucas, APS

John Lucas, Manager of Transmission Planning and Engineering of APS discussed transmission system planning acknowledged the difficulty in planning for the integration of renewable energy due to the significant monthly and seasonal variation in both wind and solar generation. John said that the uncertainty and variability of renewable resources must be considered in load forecasting, but doing this is extremely difficult.

Wind generation in particular is extremely variable in both the long-term and short-term. Wind can peak with the system peak or it can peak in the middle of the night during low peak periods. Additionally, when wind speeds are too high, wind generation shuts down.

Solar generation peak output typically follows the peak load, but it can be difficult to determine output on a day-ahead basis. APS is working on a Concentrated Solar Power (CSP) facility that incorporates molten salt storage which is capable of generating electricity after the sun sets. Molten salt storage can extend generating periods by four to six hours beyond sunset.

APS commented on the fact that there seems to be a need for more planning for solar generation in Jordan. NEPCO states that although Jordan has ideal conditions for solar generation the equipment required to do so is too expensive to implement. APS, which owns and operates **Solar Test and Research Center (STAR)** in Tempe, Arizona, is considered a leader in solar research. The STAR Center is one of the world's premiere solar research facilities and has been testing and evaluating solar energy products for more than twenty-five years. APS urged NEPCO to reconsider the issue of solar integration as cost continues to drop but more importantly, the load curve in Jordan almost identically matches the output curve of solar generation. APS uses its solar generation to even up its base load, but even with sufficient wind to integrate with solar, the variability would make it less than ideal for base load.

NEPCO delegation inspects photovoltaic arrays at the APS Solar Test and Research (STAR) facility in Tempe, AZ. From left to right: Majed Jabri, Assistant Managing Director for Operations; Amin Zaghal, Manager, Operations Planning Department; Jason Hancock, Senior Program Coordinator, USEA; Ayed Abu Snobar, Assistant Managing Director; and Dr. Allan Khalil, Manager, Department for Coordination of Electricity Affairs.

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org

Enclosed capacitor bank at Amman South Substation

APS delegation examines the Amman South Substation yard.

NEPCO shows the APS delegation their latest relays

SUBSTATION MAINTENANCE

Robert Smith, APS

Robert Smith, Director Energy Delivery, Asset Management and Planning of APS introduced U.S. transmission system maintenance procedures. One of the most critical steps in establishing a maintenance program is the need for benchmarking. Benchmarking is the act of comparing the maintenance practices of your utility with the maintenance practices of other utilities in order to find areas in which your own practices can be improved.

Typically, maintenance is performed for any of the following reasons:

- General Maintenance- routine maintenance performed at regular intervals;
- Performance-based Maintenance- maintenance performed due to a specific problem; or
- Compliance-based Maintenance- maintenance mandated by a regulatory or other oversight agency.

Additionally, in the United States, maintenance is also performed based on the results of studies by the Electric Power Research Institute (EPRI), an independent, non-profit company performing research, development and design in the electricity sector for the benefit of the public and the directives established under the Transmission Maintenance and Inspection Plan (TMIP) from the Federal Energy Regulatory Commission (FERC).

In the course of its general maintenance routine, APS regularly schedules both minor and major maintenance. Minor maintenance is performed more frequently than major maintenance and usually consists of visual inspections and external readings; and any work that can be done without substantial downtime. In the course of performing minor maintenance, larger problems can be found which would then trigger major maintenance. Major maintenance requires substantial downtime for a piece of equipment and can include replacement/retrofitting of major components.

FREQUENCY OF MAINTENANCE

During the maintenance discussions, NEPCO discussed the frequency of some of its maintenance procedures. The APS delegation commented that NEPCO appeared to be performing maintenance routines more frequently on specific types of equipment than they are performed on the same type of equipment at APS. APS stated that each utility will have unique factors that determine maintenance requirements There is a greater economic efficiency when the intervals between regularly scheduled maintenance can be extended to the maximum duration without impairing system reliability. However,

judging how often maintenance should occur is difficult. If maintenance is scheduled too frequently then the utility spends money without real benefit. If maintenance is scheduled too infrequently then equipment fails causing potential loss of revenue. in order to overcome this difficulty, APS has turned to a software-based solution.

APS introduced NEPCO to a maintenance scheduling and tracking software program from Insert Key Solutions, Inc. The software products that APS is currently using include Power Delivery IQ, ER Dashboard and IQ Review. These tools allow APS to track maintenance procedures throughout its transmission system. The software allows APS to see at a glance the maintenance integrity of a whole section of its system, or they can focus on a specific piece of equipment. The software tracks the number of operations for specific piece of equipment which can lead to maintenance being performed earlier than may have otherwise been scheduled. The software also logs test results, maintenance procedures performed and provides space for the operator/maintenance worker to leave notes on unique issues for a specific piece of equipment. By providing both a large picture view of system integrity and the ability to focus on individual pieces of equipment, APS is able to better judge the proper interval between scheduled maintenance.

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org

NEXT STEPS

The Second Executive Exchange Program for NEPCO continued the success of the first exchange visit. In addition to the material presented and the information exchanged, the program also helped solidify the burgeoning partnership between APS and NEPCO and influenced the direction of future partnership activities. USEA will continue to work with NEPCO and APS to facilitate:

- NEPCO's implementation of its newly designed load dispatch control center and the training of its dispatchers;
- NEPCO's transmission planning requirements to introduce renewable energy resources into its transmission grid; and
- NEPCO's evaluation and possible implementation of equipment maintenance procedures and maintenance tracking methodologies/software programs as practiced and implemented by APS.

USEA is currently planning a follow up visit to APS in Phoenix, Arizona in March 2010.

From left to right: Jason Hancock, USEA; Robert Smith, APS; John Lucas, APS; Mark Hackney, APS

APS EXECUTIVE EXCHANGE VISIT PARTICIPANTS

1. Robert Smith, Director Energy Delivery, Asset Management and Planning
2. John Lucas, Manager of Transmission Planning and Engineering
3. Mark Hackney, Section Leader, Transmission Service Trading

NEPCO EXECUTIVE EXCHANGE VISIT RESULTS

The NEPCO Executive Exchange Visit gave the three delegates from APS the opportunity to interact with their peers at NEPCO to discuss matters pertaining to transmission system operation. This visit provided a hands-on look at the transmission system of Jordan which resulted in the following:

- APS discussed the configuration of its dispatch control centers and introduced its training methodologies of APS dispatchers. APS will continue to work with NEPCO to further assist in the development of its new dispatch control center;
- APS discussed the importance of transmission planning both in the near-term and long-term including the need for system redundancy to maintain grid integrity in failure situations;
- APS suggested ways to integrate renewable generation resources; and
- APS introduced its maintenance procedures including the use of a maintenance software suite from Insert Key Solutions, Inc. that allows APS to carefully monitor its equipment integrity and plan predictive and preventative maintenance in the most cost effective manner.

United States Energy Association, 1300 Pennsylvania Avenue, NW Suite 550 Box 142 Washington, DC 20004-3022
Telephone (202) 312-1230; Fax (202) 682-1682; website: http://www.usea.org