TRANSMISSION COMPANY OF JORDAN LAUNCHES PARTNERSHIP PROGRAM WITH USEA

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

by Jason Hancock

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.

The **National Electric Power Company (NEPCO)** of Jordan completed the first in a series executive exchange visits 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 inaugural executive exchange visit for NEPCO was conducted April 25 to May 8, 2009 in Washington, DC; Charlotte, North Carolina; and Phoenix, Arizona. 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)**.

BACKGROUND

The purpose of the partnership with NEPCO is to develop long-term cooperative relationships between U.S. transmission experts that will provide a mechanism to transfer experience in market-based, environmentally sustainable energy production, energy transmission, and energy distribution from an transmission company perspective to NEPCO. The partnership seeks to address four specific topic areas:

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

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WASHINGTON, DC: MEETINGS WITH FERC, ISO NEW ENGLAND, PJM INTERCONNECTION AND EEI

Seated from left to right: Sarah McKinley, FERC; Dr. Alan Khalil; Amy Crowley, ISO New England, Majed Jabri, Amin Zaghal, and Ayed Abu-Snobar

John Gdowik of PJM Interconnection discusses the use of Locational Marginal Pricing (LMP) as a method of calculating wheeling charges with the NEPCO delegation.

In Washington, DC, the NEPCO team met with **Sarah McKinley** of the **Federal Energy Regulatory Commission** where they were given an overview of bifurcated nature of the U.S. electricity regulatory system (state and Federal) and FERC regulatory jurisdiction within that dual system.

The NEPCO team also met with two Regional Transmission Operators (RTOs) represented by **Amy Crowley of ISO New England** and **John Gdowik of PJM Interconnection**. NEPCO is very interested in improving its tariff structure to adequately calculate and assess wheeling charges for electricity that is sent across their transmission system from one neighboring country to another.

Both ISO New England and PJM calculate wheeling charges through a process called Locational Marginal Pricing (LMP). LMP is a market pricing approach that was established to efficiently manage a transmission system at times of congestion. LMP takes congestion into consideration by calculating the price at various locations called "nodes" thought out the transmission network. The price at the various nodes may vary from time to time throughout the day based on system congestion at that geographic location. Wheeling charges are then calculated for the specific time and system conditions that power was "wheeled" across the network.

The NEPCO delegation was initially very intrigued by the concept of LMP, but found the investment required to establish the infrastructure to report real-time congestion monitoring at hundreds of locations throughout their system to be daunting. Rather than adopt LMP, the NEPCO delegation felt that more traditional methods of calculating wheeling charges would be more applicable in their situation.

While in Washington, DC, the NEPCO delegation also met with the **Edison Electric Institute (EEI)**, the association of U.S. shareholder owned utilities. NEPCO was a former member of EEI and is considering the possibility of renewing its membership with EEI. At EEI, **John Easton, Raj Patel, Matthew Hastings, Tony Ingram and Christopher Eisenbrey** discussed how U.S. utilities collaborate in planning and operating transmission grids throughout the United States.

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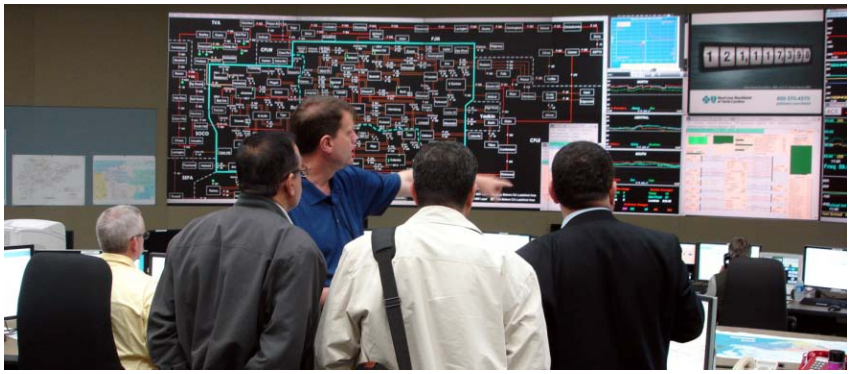

Kale Meade of Duke Energy points out various functions of the Duke Energy Control Center.

NEPCO delegation at Duke Energy tap changer with Bobby Messer.

MEETINGS WITH DUKE ENERGY, CHARLOTTE, NORTH CAROLINA

Duke Energy is a vertically integrated electric and gas utility that serves retail and wholesale customers in portions of Indiana, Kentucky, North Carolina, Ohio and South Carolina. The majority Duke Energy's load is centered around Charlotte, North Carolina. Duke Energy generates the majority of its electricity from nuclear and fossil plants and operates a 20,900 mile electric transmission network.

The NEPCO delegation was given an in depth overview of Duke Energy's dispatch control center and the procedures used by Duke Energy in its dispatch process. Of particular interest was Duke Energy's approach to cyber-security for dispatch control, something that NEPCO is looking at carefully as it prepares to redesign its own load dispatch center.

CYBER-SECURITY: DUKE ENERGY'S APPROACH

Duke Energy separates its dispatch control centers computer functions into two separate systems: one that is dedicated to internal SCADA communications and another for external communications including both internet and intranet. This separation ensures that the SCADA system cannot be controlled from commands coming from outside the closed, dedicated network. In order to maintain communications with the rest of company, Duke Energy maintains a second system that is able to access a copy of the data from the SCADA control network without actually being connected to the system directly.

To further enhance security, Duke Energy requires its employees to log in using both a password and a "token." The token that Duke Energy has chosen to use is manufactured by RSA. It is a small key fob device that generates a new multi-digit number every minute that synchs with a code on the main server. This dual-security login process consists of something the user knows (password) and something the user has (key-fob token) and ensures that a stolen password cannot function by itself.

NEPCO will be evaluating and implementing security features into its own control center in the coming months. The cyber-security approach by Duke Energy, including the use of passwords and tokens to identify and limit user access is something NEPCO will carefully consider.

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MEETINGS WITH ARIZONA PUBLIC SERVICE (APS), PHOENIX, ARIZONA

APS serves 1.1 million customers in 11 counties in Arizona with a service territory of 34,645 square miles. APS has 411 substations; 28,022 distribution line miles (12.47 kV); 5,234 transmission line miles and 54 generation units. APS is the fourth largest employer in Arizona. The majority of APS generation is from coal (38%) followed by natural gas (31%) and nuclear (27%). APS only has 2% renewable generation and 2% new energy efficiency (energy savings from energy efficiency programs that is then expressed as a megawatt value).

NEPCO found that APS, as a utility, was very similar to the energy sector in Jordan, both in number of customers served and system size as well as in geography and climate. NEPCO was particularly interested in APS approach to renewable energy and it use of energy efficiency programs to shift peak load.

Northwind Phoenix, LLC District Cooling circulation pumps

Northwind District Cooling tour from left to right: ***APS****: Robert Smith, John Lucas, Moe Sakkijha, Peter Krzykos;* ***NEPCO****: Amin Zaghal; Allan Khalil, Ayed Abu-Snobar;* ***Northwind Phoenix, LLC:*** *Robert Martin.*

SHIFTING PEAK LOAD THROUGH ENERGY EFFICIENCY - NORTHWIND PHOENIX, LLC (DISTRICT COOLING PROJECT)

In 2000, APS began a diversification process in which it began to acquire non-utility type investments. This trend continued for several years but was later discontinued. **Northwind Phoenix, LLC**, a district cooling project was one of the APS acquisitions during this time. Pinnacle West, the APS holding company still owns Northwind Phoenix, LLC.

Northwind Phoenix, LLC is a district cooling plant that has two plant locations in downtown Phoenix, one at Arizona State University and a cogeneration facility in Tucson. The NEPCO delegation toured Plant One in downtown Phoenix which provides cooling for the Convention Center and several other office buildings and hotels in the Phoenix downtown area.

The cooling process at Northwind Phoenix is quite simple. Utilizing off peak electricity, purchased at a discounted rate, Northwind uses electricity to run standard industrial heat pumps that are used to remove the heat from a massive 25 foot deep pool of glycol. The glycol is chilled to seventeen degrees Fahrenheit and then pumped through steel pipes that are arranged vertically in large tanks of water. The chilled glycol causes ice to form around the pipes.

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The ideal ice build does not create a solid block of ice, but rather a series of ice tubes that provides optimum flow for the remainder of the water in the tank. As the water flows past the ice on the tubes, it is chilled to a temperature of thirty-four degrees Fahrenheit. In the winter, an ice build can last up to two weeks. In the hotter days of the Phoenix summer however, the ice build can last as little as eight hours.

As the working day begins, Northwind uses pumps to send the chilled water to its customer's water lines. The water from Northwind meets with the customer's water at an exchanger that is similar to an automobile's radiator only rather than only having a single input and return it has two separate, inputs and returns that are entirely closed from one another, one running on one side of the exchanger's surface and the other on the opposite side. The Northwind chilled water can reduce the temperature of the customer's water as low as thirty-seven degrees Fahrenheit, but typical cooling applications require chilling the customer's water only to forty-five degrees Fahrenheit. The temperature of the customer's water can be controlled very precisely by using automated, computer controlled valves that limit the flow of Northwind's chilled water through the exchanger. The two separate systems allows customers to maintain ownership of all of the equipment on its side of the exchanger while Northwind owns and maintains all of the equipment up to and including the exchanger.

Northwind Phoenix, LLC District Cooling water circulation pipes. Blue pipes carry chilled water to client and green pipes return warm water to be chilled again.

Glycol storage tank.

Northwind Phoenix, LLC District twenty-five foot deep glycol pool.

The district cooling process does have a definite MWh savings, but these figures were not available at the time of this program. The main benefit, in addition to the MWh savings is that it shift air conditioning load on the APS system from peak times to off peak times. Initially, the NEPCO delegation was skeptical of the application of district cooling in Jordan, citing the lack of water resources. However, after touring the Northwind facility and seeing that it was closed system that did not rely on continuous water resources they began to feel that such a system could be quite beneficial in Amman as cooling becomes an increasingly large portion of the electric load on the Jordanian energy system.

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STAR Center photovoltaic cell array featuring solar cells from various manufacturers

The NEPCO delegation inspects a utility controlled disconnect on a demonstration residential solar installation at the STAR Center.

SOLAR GENERATION: THE APS APPROACH TO TRANSFORMING AN ABUNDANT ARIZONA RESOURCE INTO AN ASSET

During the exchange program the NEPCO delegation toured the APS **Solar Test and Research Center (STAR)** in Tempe, Arizona. 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.

The STAR facility offers the international solar industry a testing grounds where new technologies for transforming solar energy into electricity can be developed. The STAR Center tests many different types of photovoltaic cells from multiple manufacturers in multiple cell arrays. The STAR Center long-term testing has given APS the ability to determine most efficient mounting solutions as well as the level of gradual degradation in efficiency of actual solar cells in the field thereby determining the most cost effective solutions for various installations.

In addition to the solar panel arrays, the STAR Center also maintains several residential rooftop installations with various solar cell configurations. These rooftop installations help APS evaluate consumer installed units and also server to train APS technicians to work safely in an environment where solar energy can energize a line that has been disconnected from the traditional grid. In order for any consumer to install a grid connected generation source, they must also install a disconnect device that can be operated by their utility

MEETING RENEWABLE ENERGY MANDATE: JORDAN TO INCREASE RENEWABLE ENERGY FROM 1% TO 9% BY 2020

The Ministry of Energy in Jordan has mandated an increase in renewable energy from the current level of one percent to nine percent by 2020. There are very few wind or water resources in Jordan and the majority of this renewable energy will have to come from solar resources. It is extremely important that Jordan implement the most cost effective solar technologies as they strive toward their renewable energy goals. To this end, the NEPCO delegation has asked APS and the STAR Center for guidance as they begin their evaluation process.

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NEXT STEPS

The NEPCO Executive Exchange Program was quite successful. In addition to the material presented and the information exchanged, the program also helped outline the direction for future partnership activities. USEA will continue to work with NEPCO and its U.S. counterpart utilities to help facilitate:

- NEPCO redesign of its load dispatch control center;
- NEPCO's requirement to introduce renewable energy resources into its transmission grid; and
- NEPCO to adopt evaluation and selection methodologies and procedures for accurately calculating wheeling charges for energy transferred across its system.

USEA is currently planning a follow up visit to NEPCO in Amman, Jordan in October 2009.

NEPCO EXECUTIVE EXCHANGE VISIT PARTICIPATING ORGANIZATIONS

- The Federal Energy Regulatory Commission
- ISO New England
- PJM Interconnection LLC
- Edison Electric Institute
- Duke Energy
- APS

NEPCO EXECUTIVE EXCHANGE VISIT PARTICIPANTS

1. Abu Snobar, Ayed, Assistant Managing Director, NEPCO
2. Jabri, Majed, Assistant Managing Director for Operations, NEPCO
3. Khalil, Allan, Manager, Department for Coordination of Electricity Affairs, NEPCO
4. Zaghal, Amin, Manager, Operations Planning Department, NEPCO

NEPCO EXECUTIVE EXCHANGE VISIT RESULTS

The NEPCO Executive Exchange Visit gave the four delegates from NEPCO the opportunity to interact with their peers in the United States to discuss matters pertaining to transmission system operation. This initial visit provided overviews of the U.S. electric industry and highlighted the different regional approaches to energy transmission in the United States stemming from load centers, type of generation, geography, etc. Additionally, the NEPCO delegation was able to focus on specific issue areas they are currently facing which resulted in the following:

- NEPCO evaluated the use of Locational Marginal Pricing (LMP) with ISO New England and PJM Interconnection as a potential method of calculating wheeling charges;
- NEPCO discussed the configuration of the dispatch control centers and training methodologies of the dispatchers of Duke Energy and APS and has requested additional help from both utilities to further assist NEPCO in its development of its new dispatch control center;
- NEPCO was provided with documents on the use of the APS Northwind district cooling project as a method of shifting air conditioning load from peak hours to off-peak hours; and
- NEPCO met with representatives of the APS Solar Test and Research (STAR) facility to discuss strategies to integrate of solar generation into the energy sector of Jordan, STAR staff have agreed to continue working with NEPCO to assist in the selection of a cost effective solar generation solution for Jordan.

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