PAKISTAN STUDIES U.S. ELECTRICITY GRID OPERATION & PLANNING BEST PRACTICES

EXECUTIVE EXCHANGE IN WASHINGTON, DC & PORTLAND, OR

OCTOBER 2014 – The U.S. Energy Association organized an eight-day executive exchange for nine senior managers from Pakistan's National Transmission Despatch Company (NTDC) to review best practices in transmission operations and planning, as well as renewable energy integration, with their U.S. counterparts.

The executive exchange visit was funded by the U.S. Agency for International Development (USAID) Energy Policy Program (EPP) through Advanced Engineering Associates International (AEAI). The Energy Policy Program is a multi-year USAID-funded initiative to increase power generation, decrease losses and increase cost recovery in Pakistan's power sector by working with selected energy infrastructure and facilitating Government of Pakistan reform efforts with technical assistance and new technology.

*Delegation with **Bonneville Power Administration** executive Mike Staats. From left to right: Sadia Murshad, Kirn Zafar, Sahar Anum, Zahra Fatima, Mike Statts of BPA,Aziz Ullah Khan, Muhammad Zahid, Shahzad Butt, Anees Goojar and Anique Ahmed.*

EXECUTIVE EXCHANGE HIGHLIGHTS

Over the course of eight days, the Pakistan executives met with their U.S. counterparts to examine best practices for managing open-access transmission service and monitoring high voltage transmission. Topics included improving transmission system planning and operations to increase efficiency and reliability, grid technologies that support renewable energy integration, dispatch of non-firm power and harmonization of regional transmission planning to facilitate additional renewable energy.

The Pakistan delegation met with a variety of entities in Washington, DC and Portland, OR to discuss transmission operations and planning including:

- Schiff Hardin
- Alstom Grid
- Covanta
- PJM Interconnection LLC (PJM)
- Potomac Electric Power Company (PEPCO)
- Federal Energy Regulatory Commission (FERC)
- U.S. Department of Energy (USDOE)
- Edison Electric Institute (EEI)
- Bonneville Power Administration (BPA)
- Northwest Power Pool (NWPP)

The delegation toured the Alexandria, Virginia **municipal-waste-to-energy Covanta Energy power facility**. The facility's three, 325 ton-per-day furnaces process 975 tons of solid waste, generating up to 23 MWs of

Meetings highlighted best practices in:

- Asset management
- Planning
- Data collection and modeling
- System reliability and transmission standards (grid codes)
- Operations and maintenance
- Wheeling mechanisms
- Congestion management
- Ancillary services
- Transmission scheduling and power dispatch
- Renewable integration

BACKGROUND ON PAKISTAN'S POWER SECTOR

Pakistan's power sector is confronted by significant challenges, including limited availability of reliable and affordable electric power, aging and inadequate transmission and distribution networks, and utility policies and practices that lag those of advanced utilities. For distribution utilities in Pakistan, these deficiencies translate into levels of financial performance that are not self-sustaining. Yet financial self-sufficiency is critical, as Pakistan's power industry is undergoing sweeping changes, including transitioning from government-owned utilities to fully autonomous companies that will engage in power generation, transmission, and distribution under the government's reform agenda. A similar industry structure exists and functions smoothly in many other countries today. In Pakistan, however, outdated policies, procedures and work practices, as well as low investment in infrastructure, are barriers to a successful transition.

Background on National Transmission & Despatch Company (NTDC)

National Transmission & Despatch Company (NTDC) Limited was incorporated on 6th November, 1998 and commenced commercial operation on 24th December, 1998. It was organized to take over all the properties, rights and assets obligations and liabilities of 220 KV and 500KV Grid Stations and Transmission Lines/Network owned by

Pakistan Water and Power Development Authority (WAPDA). NTDC operates and maintains twelve 500 KV and twenty nine 220 KV Grid Stations, 5077 km of 500 KV transmission line and 7359 km of 220 KV transmission line in Pakistan. NTDC was granted Transmission Licence No.TL/01//2002 on 31st December 2002 by National Electric Power Regularity Authority (NEPRA) to engage in the exclusive transmission business for a term of thirty (30) years, pursuant to Section 17 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

Pakistan delegation with Dr. Lawrence Jones and Mrs. Martyna Kurcz-Jenn of **Alstom Grid.**

RENEWABLE INTEGRATION TO TRANSMISSION GRID

Integrating renewables and intermittent resources is a large concern for NTDC as Pakistan begins to develop wind. Participants discussed the successful integration of renewables with BPA, Covanta and Alstom Grid and how it impacts operations.

The delegation toured the Alexandria/Arlington Resource Recovery Facility, a waste-to energy-plant connected to a local utility's transmission grid that began commercial operation in February 1988. The facility has three 325 ton-per-day waterwall furnaces with reverse-reciprocating grates and ash handling system that process 975 tons of solid waste, generating up to 23 megawatts of renewable energy that is sold to Dominion Virginia Power Company. The facility also has its own substation connected and metered at 230 kv to the Dominion Power network. **Covanta** owns and maintains its own substation although it does sometimes contract out some of the more dangerous work.

The waste-to-energy plant reduces the volume of garbage by 90% and the weight by 75% and results in a one ton reduction of CO2 for each ton of garbage used. The delegation questioned why only 7% of U.S. garbage is used for waste-to-energy given the clear benefits. Covanta explained that siting is a key issue as the plants need to be near where the waste is generated to reduce transportation costs and the site footprint is 23 acres, so a lot of land is needed.

BPA has over 5,000 MW of wind on its system through independent power producers (IPP) and is continuing to add wind. BPA stressed that if wind is to continue to grow, it cannot be done by one utility. It really needs to be a regional effort to help offset the variability. They also stated they made a mistake when they did not require 10% onsite storage as there is a great need for generation that can be brought up to deal with demand increases. To ensure reliability with the wind, BPA created operational controls (DSO 216), which holds an amount of capacity aside for balancing and will take over operational control if an IPP takes too much. The IPPs are not penalized for not generating what they say as long as they scheduled according to what they thought they would have – there is no penalty for an incorrect forecast.

Dr. Lawrence Jones of **Alstom Grid** discussed the role of smart grid and grid modernization with a focus on integrating renewable energy. He stated unequivocally that power grids can be operated with large amounts of intermittent renewable energy on the system but that they must be designed differently. In particular, he mentioned Denmark that has 33% of power consumed from wind power as of 2013 and in January 2014 had 62% of its demand met by wind with no operational issues. Dr. Jones highlighted the need to integrate forecast data in planning and operations and some enabling technologies that facilitate intermittent renewable integration such as sensors, measurements, grid analytics, advanced controls, intelligent devices, integrated solutions, big data analytic, HVDC to allow greater flexibility, and SynchroPhasors.

TRANSMISSION GRID OPERATIONS

A key topic of the exchange was how U.S. utilities operate the transmission grid. Discussions with PEPCO, BPA and focused on equipment controls and system software like SCADA.

PEPCO executives outlined their Emergency Management System (EMS) and Supervisory Control and Data Acquisition (SCADA) applications and how they interact and work together. PEPCO uses the EMS to run contingencies and models to determine if they can shut down equipment for maintenance. The delegation questioned whether EMS only works if you have SCADA at all substations. PEPCO said SCADA is not needed at all substations – instead, a state estimator can fill the holes in data. PEPCO uses the EMS applications to also control radial load bus voltage by controlling transformer LTCs to maintain adequate substation voltage and uses a distribution VAR dispatch program to maintain adequate power factor by controlling distribution capacitors. The delegation asked a lot of questions about power factor. PEPCO also relies on static VAR compensators to regulate voltage, power factor and harmonics to stabilize the system.

The delegation met with **PEPCO** executives (left) on SCADA and EMS systems.

The delegation continued the conversation on VAR control and overcurrent relays with **PGE**. PGE has been forced to set its overcurrent relay to 150% of the emergency rating to ensure it never trips on overcurrent unless absolutely necessary. All generation in PGE's system must give VARs at 95% leading/lagging, including those near load centers. The delegation expressed their belief that this is a very narrow band and stated theirs is 85% and generators are lagging at 90%. PGE emphasized that the 95% is at the point of interconnection, not at the generator itself, as sometimes there is 5-10 miles of line that have a step up transformer. Historically, BPA provided VAR support but now if 97% power factor is not maintained, BPA has a charge because you are leaning on the system so BPA charges for excessive VARs.

TRANSMISSION GRID PLANNING AND DESIGN

Participants met with representatives of PJM, BPA, the Northwest Power Pool, and EEI to discuss transmission grid planning. All stated that a lot of the planning is performed by the regional transmission system operator like PJM and NWPP but the actual construction of the lines is voluntary.

BPA provided the delegation with an overview of its asset management system. Equipment groups are divided with individual strategies and plans. Evaluations are based on a risk curve of failure and items are replaced before they get too high on the curve. The Pakistan delegation stated that they are experiencing difficulty assessing prioritization for part replacement. BPA recommended to NTDC that they communicate the process when determining criticality - this will lead to an improved information sharing and help with assessment. The delegation questioned conditions are used for determining criticality. BPA replied that they look at what happens to the system when you take the equipment out and determine criticality based on what has the greatest impact.

Representatives from the **Northwest Power Pool** and **PGE** reviewed the transmission line process to plan and build transmission lines in the Northwest. The process can take up to seven years to build a major transmission line in the U.S., so the planning horizon is very important and you must project out for a longer time period. The group stated that in Pakistan they must look out 5-7 years for major lines. In planning new transmission, the load forecast and

transmission usage are very important. The delegation questioned what types of techniques are used in the U.S. for load forecasting. NWPP and PGE stated that most U.S. utilities use a straight line approach and extrapolate the historical, which is a crude method but demand is only growing 2% a year. Now they are looking at it from a more spatial view to determine where load is going to grow. Customers have been estimating their future use high so BPA had to rationalize and tighten the parameters on what they accepted on load forecast because the bright future didn't materialize and they were over building.

A discussion then ensued on the technical specifications of the transmission network. NWPP and PGE recommended using HVDC to connect two countries so you can island when their system trips and protect your system. The Pakistan delegation stated that some distribution utilities are not properly setting the trip levels so NTDC gets its circuit breakers tripped. They stated that coordination is the big problem in Pakistan and the issue is not at the transmission level (220kv and up) as Pakistan.

Pakistan delegation at the **U.S. Department of Energy** in Washington, DC.

A key topic discussed by **PGE** was voltage stability studies. PGE stated that Q-V curves (reactive power injection and receiving end voltage) are the most useful planning tool to determine reactive requirements as they give you good idea if you have a voltage collapse problem. Q-V curves give the reactive mvar margin at bus, where reactive could be added, and can determine capacitor sizing, and the critical voltage where a bus voltage collapse occurs. However, the Q-V curves do not tell you how far from the voltage collapse point you are so you should use P-V (transmitted power and receiving end voltage) and Q-V together.

TRANSMISSION GRID OVERSIGHT AND POLICY DEVELOPMENT

Oversight was a key topic mentioned throughout all the meetings. The delegation heard about FERC orders 888 and 2000 that greatly changed the U.S. electric industry from executives at **Schiff Hardin**.

The **Federal Energy Regulatory Commission (FERC)** is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC discussed how it regulates the transmission and wholesale sales of electricity in interstate commerce, protects the reliability of the high voltage interstate transmission system through mandatory reliability standards, monitors and investigates energy markets, and enforces FERC regulatory requirements through civil penalties and other means. The delegation asked how the standards are developed. FERC stated that the industry usually creates the standard and it goes through member and FERC review before being finalized. Once it is final, it is mandatory and enforceable. Violations of standards or market manipulations can result in fines that are based on a matrix that grades the violation based on if it impacted or risked the system's reliability and the severity of the violation. The delegation mentioned Pakistan has standards but no one follows them and there are no penalties because the utilities are state-owned. FERC emphasized the importance of penalties and enforcement to ensure reliability.

The **U.S. Department of Energy (USDOE)** also discussed reliability and how it interacts with the electric utilities. USDOE focuses more on research than enforcement and has conducted studies on lines for reliability and reviews those written by the regional transmission operators and the North American Electric Reliability Council (NERC). The USDOE also conducts a national congestion study every three years and can designate national interest corridors if it sees an urgent need for a transmission line. FERC has backstop authority to permit the line in a national interest corridor if the state commissions do not make a decision within one year. USDOE also coordinates the construction

of transmission lines when they have multiple jurisdictions or go over federal land. USDOE also highlighted Mexico is a nation with similar issues to Pakistan and discussed their constitutional reform to privatize generation and transmission.

RESULTS

The Pakistani delegation discussed transmission operations with their counterparts for seven days. As a result of this program, the delegates learned:

- **Build a market incrementally like PJM did with a cost-based balancing market**. Doing a full complete deregulated market overnight like California leads to disaster.
- The **transmission operator should be a facilitator,** not a participant in a market.
- The **wind forecast should be integrated in the control room** and used in power flow analysis.
- **Implementing under voltage load shedding relays** might be the easiest and cheapest thing to do to address voltage issues.
- You need an **emergency rating of about 15% above the normal rating** to give you time to get back to normal. The emergency rating is based on a 30-minute rating and should be sized to the weakest link, keeping other equipment such as line switches in mind.
- **Line shunt reactors on a line help reduce overvoltage of long lines**.
- A **limit of 5% change in voltage** is used as a standard when switching a reactive device for bus voltage control applications.

PAKISTAN NTDC EXCHANGE PROGRAM PARTICIPANTS

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