ENERGY RESILIENCE:
RISK MANAGEMENT FOR NATURAL DISASTERS IN MEXICO’S ELECTRICITY SYSTEM
Main natural disasters with potential effects on Mexico’s Electricity System:

- Hurricanes
- Cold Fronts
- Fires
- Tornados
- Earthquakes
Hurricanes
Hurricanes

Preventive Measures:

- Track hurricane routes
- Process formal emergency procedures
- Prepare procedures in those facilities within the potentially affected area
- Define the electricity system’s prior operational conditions (via studies to determine the power flow in transmission corridors to minimize disturbance impact)
- Implement power generation conditions and fuel stocks
- Prepare electricity system’s control and operation (dispatch of generation and transmission flows)
- Estimation of multiple contingencies
- Restoration strategies for the electricity grid
**Measures prior to event:**
- Operational policies
- Estimation of likely multiple contingencies
- Track of reserves: operational, spinning, cold
- Blocking of re-closings
- Locate and operate remedial actions schemes
- Electricity grid segmenting
- Quality control of frequency
- Voltage regulation
- Control of electricity flows

**Measures during the event:**
- Security Assessments - Real time operational security
- Generation re-dispatches in real time
- Recovery Procedures for load and electricity grids
- Human Resources Management; Operational Staff
- Reports of conditions and updates
Measures after the event:

- Status report of the electricity grid’s main elements
- Stabilize key variables: frequency, power flows, voltage
- Apply SEP’s operational procedures and practices
- Recovery of priority loads
- Recovery of connecting lines
- Recovery of communication links
- Synchronization of islands
- Final report of the event
Cold Fronts
Preventive measures:

• Track cold front routes
• Prepare procedures in those facilities within the potentially affected area (verify SF6 pressure and oil levels across the incumbent elements in the Transmission Grid)
• Define the electricity system’s prior operational conditions

• Implement power generation conditions.
• Availability of fuel stocks.
• Prepare electricity system’s control and operation (dispatch of generation, transmission limits, preparation of rotating load cuts and provision of personnel in strategic facilities).
• Estimation of multiple contingencies.
• Restoration strategies for the electricity grid.
Cold Fronts

Measures during the event:

• Monitoring of weather conditions and its effects on the electricity system.
• Electricity flows control on the transmission grid based on the behavior of the demand and generation losses.
• Execution of real time studies to assess the operational conditions upon potential contingencies.
• Execution of rotating cuts.
• Restoration strategies for the electricity grid.
Measures after the event:

- Recovery of the affected load
- Normalization of the Transmission Grid.
- Normalization of the generation.
- Report of the event.
Fires
Factors to be considered in case of fire:

- Burning of pasture and cane.
- Meteorological factors.

Supervision:

- Field personnel is informed or detects the burning of pasture or cane and informs the Control Center to take the corresponding provisions.
- The variables of ambient temperature, wind speed and relative humidity are supervised.
Measures during fires:

- Assessment of the transmission grid conditions.
- Evaluation of potential contingencies in the transmission grid.
- Blocking of the monopolar re-closing or opening of the equipment as determined by the Operator based on the severity of the fire.
- Establishment of operational strategies (adjustments on the dispatch of generation or the segmenting of the grid if necessary).
- The operational condition of alert or emergency is declared depending on the impact on the electricity system.
- Monitoring of the fire evolution and determination of potential damages to the equipment in coordination with the Operator’s personnel and civil protection.
Measures when controlling the fire:

- The Operator in coordination with civil protection determine that the fire is controlled.
- The operational condition of the equipment is normalized.
- The operational condition of the electricity system is normalized if adjustments in the dispatch of generation or the segmenting of the grid were required.
- The normal operational condition of the electricity grid is declared.
- A report of the contingency is done.
Tornados
The Interinstitutional Commission for the Analysis of Severe Tornados and Storms (CIATTTS, in its Spanish acronym), created following the tornado in Piedras Negras in 2007 and by the initiative of The Coordination General of Civil Protection and the National Center for Disaster Prevention (CENAPRED) of the Ministry of Interior (SEGOB).

Most of the tornados that occur in Mexico are known as weak tornados or non-supercell tornados (approximately 90%).

In Mexico most tornados occur between the months of May and June, taking place mainly in the central area of Mexico, nevertheless in the northern area is where the strongest tornados occur.
Tornados are unpredictable on their formation and magnitude, their follow up depends on the atmospheric conditions that allow for the possibility of their creation, according to the National Oceanic and Atmospheric Administration (NOAA) the following categories are presented:

**Categorías de Riesgo de Tormentas Severas**

<table>
<thead>
<tr>
<th>Tormentas (sin categoría)</th>
<th>1 - MINIMO (MIN)</th>
<th>2 - LEVE (LEV)</th>
<th>3 - ELEVADO (ELEV)</th>
<th>4 - MODERADO (MOD)</th>
<th>5 - ALTO (ALTO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se esperan tormentas no severas*</td>
<td>Posibles tormentas severas aisladas</td>
<td>Posibles tormentas severas aisladas</td>
<td>Posibles tormentas severas numerosas</td>
<td>Probables tormentas severas de amplia cobertura</td>
<td>Se esperan tormentas severas de gran cobertura</td>
</tr>
<tr>
<td>Amenaza de rayos/relámpagos pueden existir en todas las tormentas</td>
<td>Limitadas en duración/cobertura</td>
<td>De corta duración/ no tan extensas, posiblemente alguna intensa aislada</td>
<td>Más persistentes/ de amplia cobertura, pocos intensas</td>
<td>Larga duración, amplia cobertura e intensas</td>
<td>Muy larga duración, gran cobertura y particularmente intensas</td>
</tr>
<tr>
<td>• Ráfagas de viento de 40 MPH</td>
<td>• Ráfagas 40-60 MPH</td>
<td>• 1-2 tornados</td>
<td>• Algunos tornados</td>
<td>• Fuerte tornados</td>
<td>• Brote de tornados</td>
</tr>
<tr>
<td>• Granizo pequeño</td>
<td>• Granizo de hasta 1”</td>
<td>• Reportes/daños por fuerte ráfagas de vientos</td>
<td>• Reportes/daños por fuertes tornados</td>
<td>• Daños por granizos 1-2”</td>
<td>• Derechos: zona de vientos de carácter rectilíneo y de origen convectivo</td>
</tr>
</tbody>
</table>

*El Servicio Nacional de Meteorología, NWS, define una tormenta severa como: ráfagas de vientos de por lo menos 58 MPH y/o granizo con 1 pulgada de diámetro y/o un tornado. Todas las categorías de tormentas implican rayos/descharges eléctricas y el potencial de inundaciones. Las categorías también están ligadas a la probabilidad de tiempo severa a 25 millas de su ubicación.

Typically, tornados have short duration (between 20-30 minutes), and could reach more than 2 hours. In the northern zone of Mexico is where tornados have the highest intensity due to the effect of the U.S. Tornado Valley.
In case of tornado alerts in the state of Texas, the following actions are carried out:

- Assessment of the transmission grid conditions
- Evaluation of possible contingencies in the transmission grid
- Establishment of operational strategies (adjustments in the dispatch of generation or segmenting of the grid if required) if the tornado occurs.
- In the event of a tornado, alert or emergency conditions are declared depending on the impact on the electricity system
Measures after a tornado:

- Evaluation of the transmission grid damages by the Operator.
- Assessment of the electricity system operational conditions.
- Recovery of the affected load in case of any failure.
- Establishment of operational strategies (adjustments in the dispatch of generation or segmenting of the grid if required)
- Depending on the severity of the damages, maintain the alert or emergency condition, subject to the impact on the electricity system
Earthquakes
As the result of the movement in tectonic plates, earthquakes are highly unpredictable. The National Seismological Network monitors seismicity in those regions in the Mexican territory most likely to present earthquakes.

For the country’s central area, the seismic alert monitors activity of this type in the Oaxaca and Guerrero shores.
An earthquake of 6.2 degrees in the Richter scale occurred on Sunday 21 April 2013 at 20:17, with epicenter 10 km away, south of Lázaro Cárdenas, in the State of Michoacán.

Typical electricity demand development in a regular Sunday

Electricity demand development on Sunday 21 April 2013
During this event an amount of 2,400 MW of generation output was lost (equivalent to 8% of the online generation), thus producing a frequency shift from 60 to 59.295 Hz. Whenever frequency variation events occur the system’s protection scheme goes into operation (81’s).

This scheme entailed the disconnection of 945 MW of load. Because of the earthquake effects, an additional amount of 661 MW were lost, totalling 1,606 MW of lost load. Restoration procedures took place 12 minutes later and were finished after 46 minutes.
Earthquakes

Measures after the event:

- Identify the low frequency level after 1 minute and calculate generation deficit as frequency deviation in dHz * 350. Example for April 21st. Generation deficit = 5 dHz* 350 MW/dHz = 1750 MW.
- Verify whether there are any electric islands. Deployment of frequency comparisons:

- Identify overloaded links or those likely to reach their transmission maximum thresholds.
• Request generation increase = Generation deficit + reserve margin in Automatic Generation Control (AGC)
• Identify the total amount of affected load with support from the graphic showing normal demand patterns

• Verify AGC is in operation
• Request Regional Officies their reports concerning the size of the load effect and the discharged elements during frequency restoration to 60 Hz.
• Restore load in areas with generation surpluses and overloaded links
• Gradually request the synchronization of the amount generation required to restore the load calculated in item 5, without exceeding transmission thresholds.
Earthquakes

- Initiate restoration of affected load without exceeding transmission thresholds while allowing frequency deviations of ± 0.20 hz (59.80 - 60.20 hz). Priority order in areas ORI, CEL, OCC, NES, NTE, NOR, PEN
- Prepare an executive informative note of the event.
- Prepare a full report regarding the event.
The Simulator is one of the most valuable tools for training, as it enables the assessment of incumbent staff in a comprehensive way and highlights the weak areas on which to concentrate.

- Management of layouts for supervision
- Real Time Management of applications and tools
- Knowledge of the power grid
- Knowledge of generation fleet.
- Awareness of operational conditions in the Electricity Power System
- Assertive and effective communications at every hierarchical level.
- Stress management.
Thank you!