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ENERGY RESILIENCE: RISK MANAGEMENT FOR NATURAL DISASTERS IN MEXICO'S ELECTRICITY SYSTEM

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Natural disasters

Main natural disasters with potential effects on Mexico's Electricity System :

Hurricanes

Cold Fronts

Fires

Tornados

Earthquakes

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Hurricanes

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Hurricanes

Líneas en riesgo por paso de huracán Patricia

No.	KV	CLAVE LT	EXTREMOS
1	230	93930	TEPIC DOS (TED)- NUEVO VALLARTA (NVT)
2	230	93950	TEPIC DOS (TED) - VALLARTA POTENCIA (VTP)
3	230	93D20	VALLARTA POTENCIA (VTP) - NUEVO VALLARTA (NVT)
4	230	93490	MANZANILLO (MNZ) - COLOMO (COL)
5	230	93480	COLOMO (COL) - TAPEIXTLES (TPX)
6	230	93530	COLIMA DOS (CMD) - TAPEIXTLES (TPX)
7	230	93550	COLIMA DOS (CMD) - TAPEIXTLES (TPX)
8	230	93540	COLIMA DOS (CMD)- CIUDAD GUZMAN(CGM)
9	400	A3530	TEPIC DOS (TED)- AGUAMILPA (AGM)
10	400	A3550	TEPIC DOS (TED)- AGUAMILPA (AGM)
11	400	A3630	TEPIC DOS (TED) - CERRO BLANCO (CBL)
12	400	A3590	TEPIC DOS (TED) - CERRO BLANCO (CBL)
13	400	A3600	TEPIC DOS (TED) - CERRO BLANCO (CBL)
14	400	A3J00	TEPIC DOS (TED)- MAZATLAN DOS (MZD)
15	400	A3K70	CERRO BLANCO (CBL) - CAJÓN (CJN)
16	400	A3K80	CERRO BLANCO (CBL) - CAJÓN (CJN)
17	400	A3240	MANZANILLO (MNZ)- ATEQUIZA (ATQ)
18	400	A3230	MANZANILLO (MNZ) - ACATLÁN (ATN)
19	400	A3190	MANZANILLO (MNZ) - TAPEIXTLES (TPX)
20	400	A3170	MANZANILLO (MNZ) - TAPEIXTLES (TPX)
21	400	A3J20	TAPEIXTLES (TPX) - MAZAMITLA (MTA)
22	400	A3N00	LA YESCA (LYE) - IXTLAHUACÁN (ITC)
23	400	A3N10	LA YESCA (LYE) - IXTLAHUACÁN (ITC)
24	400	A3K40	CERRO BLANCO (CBL) - TESISTAN (TSN)
25	400	A3K50	CERRO BLANCO (CBL) - TESISTAN (TSN)
26	400	A3K60	CERRO BLANCO (CBL) - TESISTAN (TSN)
27	115	RED COMPLETA	ZONA VALLARTA
28	115	RED COMPLETA	ZONA MANZANILLO
29	115	RED COMPLETA	ZONA SANTIAGO

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

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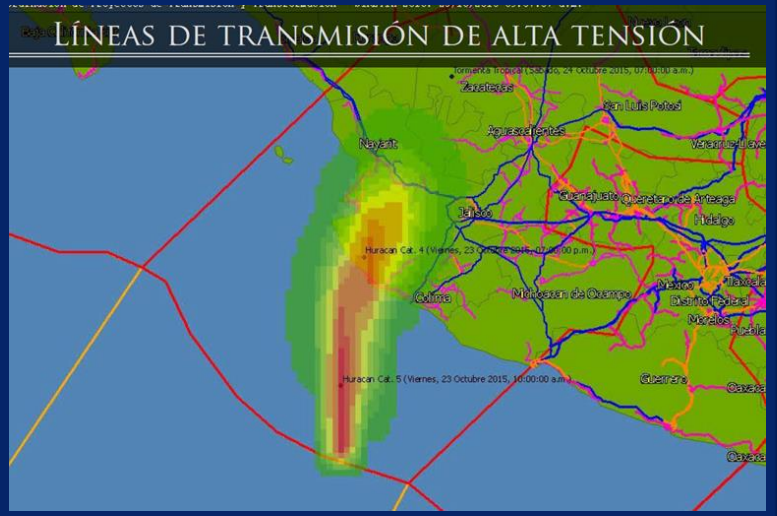
Hurricanes

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*



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Hurricanes

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*

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Cold Fronts

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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.*

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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.*

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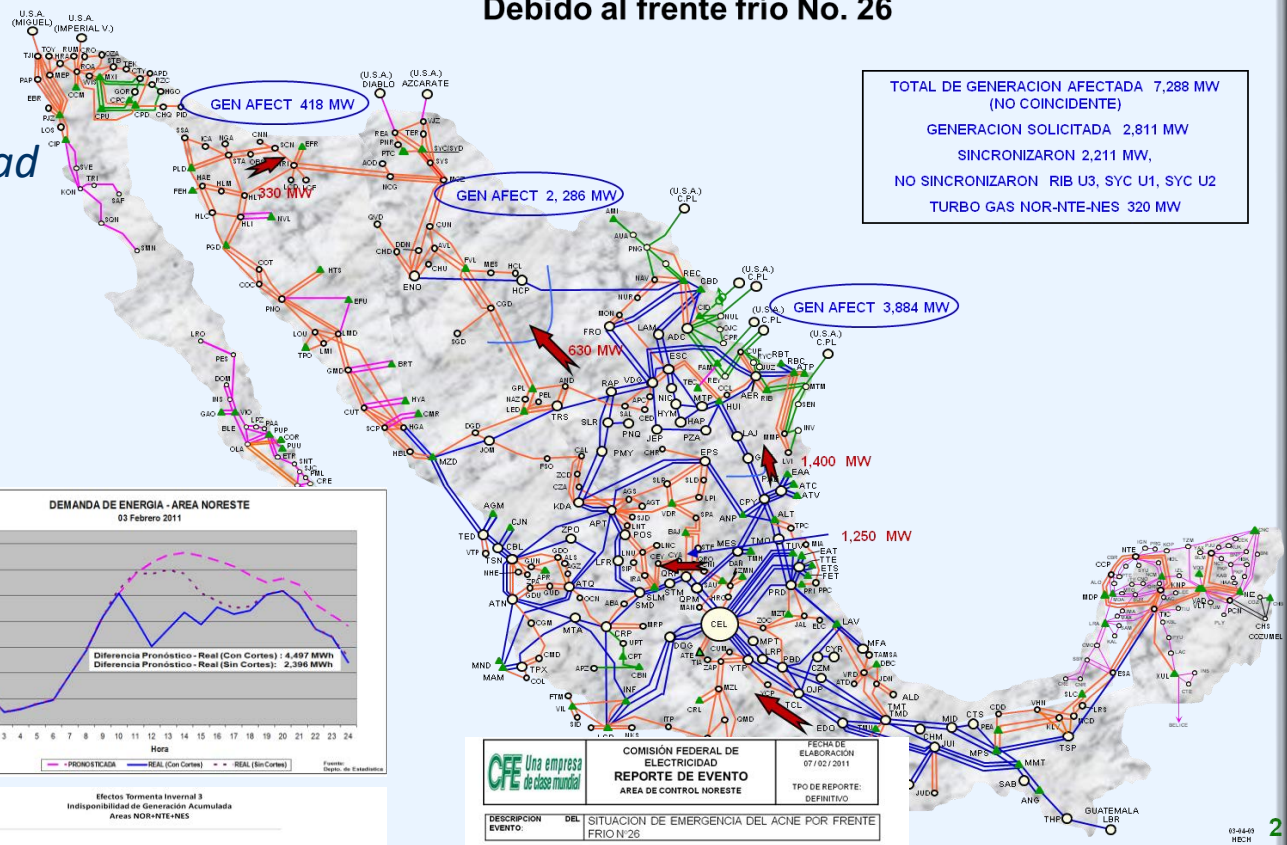
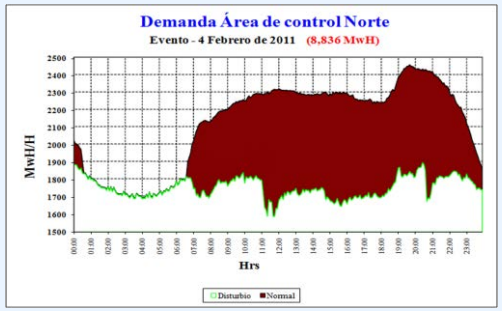
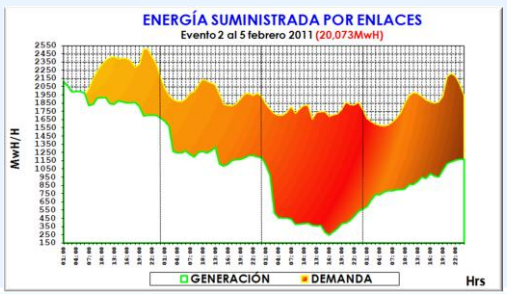
Cold Fronts

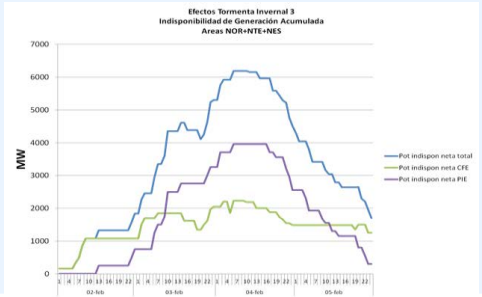
Measures after the event:

- *Recovery of the affected load*
- *Normalization of the Transmission Grid.*
- *Normalization of the generation.*
- *Report of the event.*









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COMISIÓN FEDERAL DE ELECTRICIDAD
REPORTE DE EVENTO
AREA DE CONTROL NORESTE

FECHA DE ELABORACION 07/02/2011
TPO DE REPORTE: DEFINITIVO

DESCRIPCION DEL EVENTO: SITUACION DE EMERGENCIA DEL ACNE POR FRENTE FRIO N°26

1. RESUMEN

DERIVADO DE LAS TEMPERATURAS CONGELANTES EN LA ZONA, SE PRESENTA PERDIDA DE GENERACIÓN ESCALONADA PROVOCANDO ALTOS FLUJOS EN EL ENLACE CPY-GUE.

2. ANTECEDENTES

DIA 02 DE FEBERO DEL 2011

07:26 HRS /22:11 HRS DISPARA CBD U3 CON 212 MW POR PROBLEMAS EN BOMBAS DE AGUA DE ALIMENTACION POR BAJA TEMPERATURA AMBIENTE 4 °C Y UNA HUMEDAD RELATIVA DE 71%../SINCRONIZA AL SISTEMA

12:09 HRS DISPARA ACL U2 CON 81 MW

12:35 HRS ABRE ACL U1 POR FUGA EN CALDERA CON 150 MW

22:34 HRS SALE POR FUGA CDU U2 CON 221 MW

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Fires

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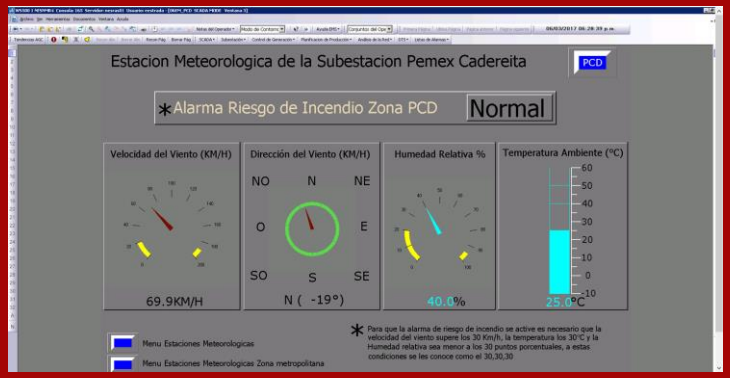
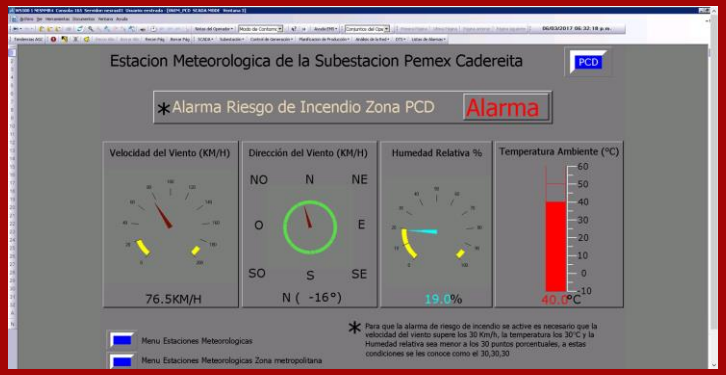
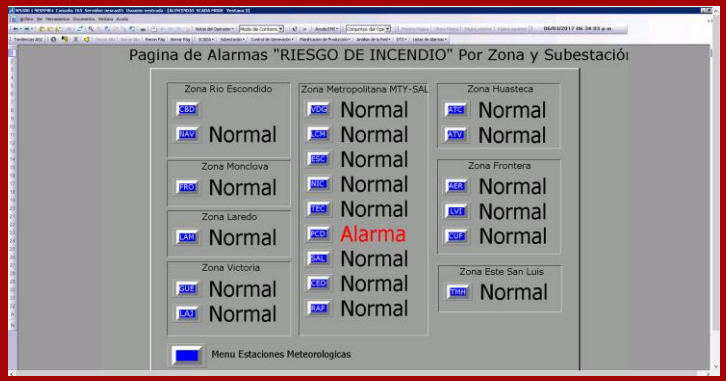
Fires







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.**

Fires

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.

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Tornados

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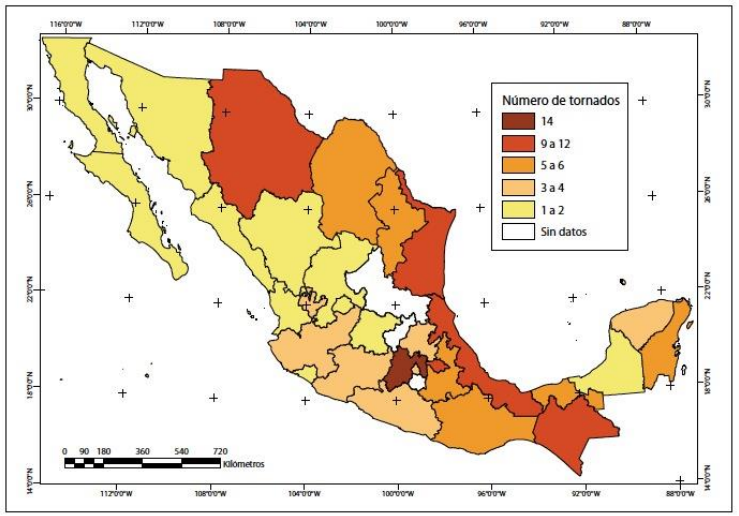
Tornados

- The Interinstitutional Commission for the Analysis of Severe Tornados and Storms (CIATTS, 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.



Fuente: base de datos tornados México, CIESAS-CIATTS.

Figura 2. Número de tornados por estados 2000-2012.

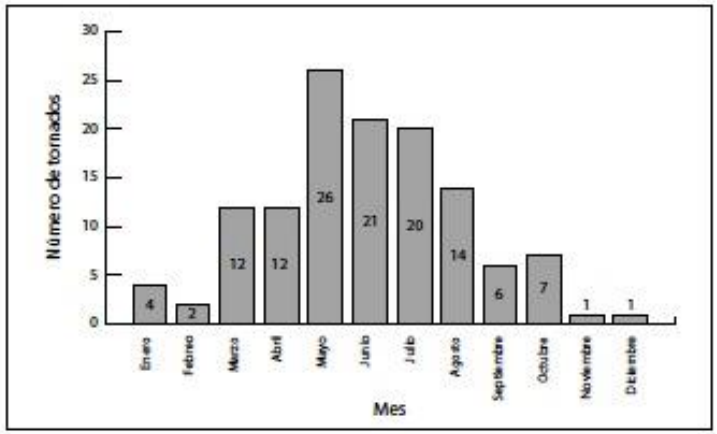


Figura 4. Número de tornados por mes.

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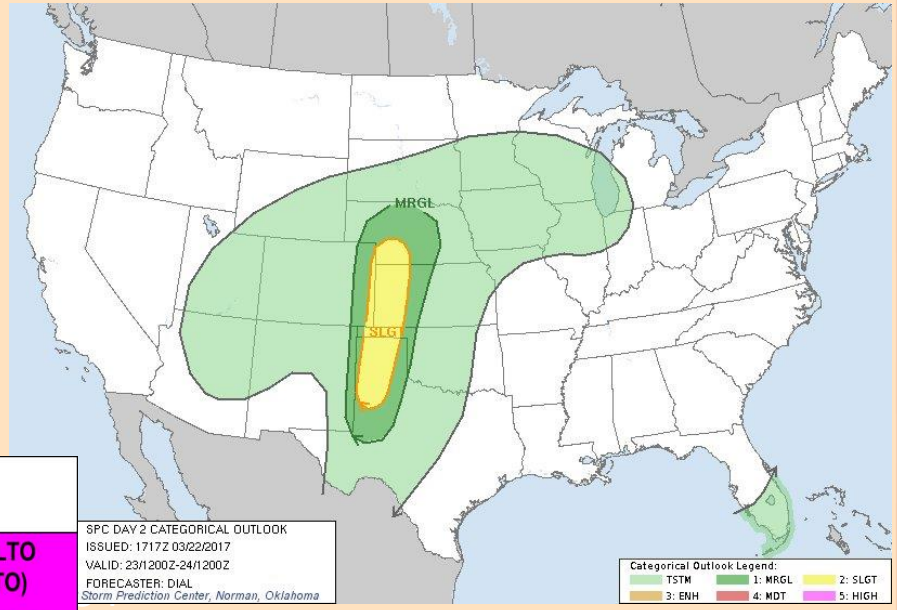
Tornados

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

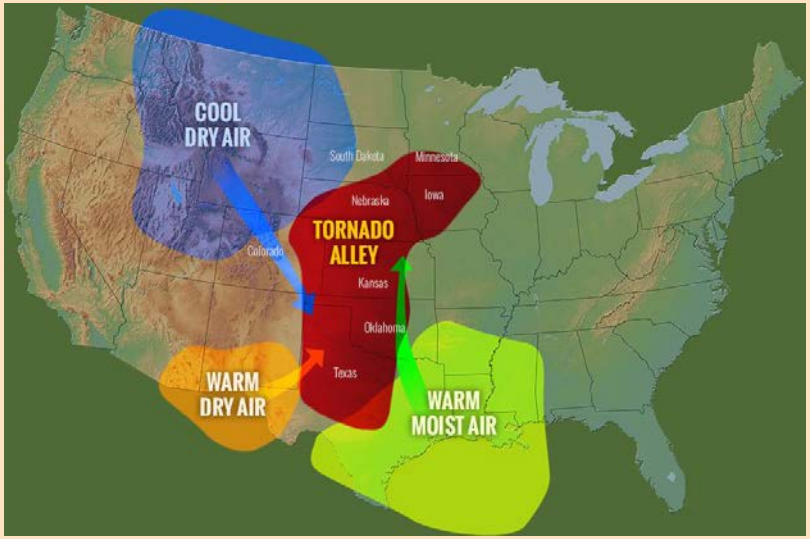
Tormentas (sin categoría)	1 - MÍNIMO (MÍN)	2 - LEVE (LEVE)	3 - ELEVADO (ELEV)	4 - MODERADO (MOD)	5 - ALTO (ALTO)
Se esperan tormentas no severas* Amenaza de rayos/inundaciones pueden existir en *todas* las tormentas	**Posibles tormentas severas aisladas** Limitadas en duración/cobertura/ intensidad	**Posibles tormentas severas aisladas** De corta duración/ no tan extensas, posiblemente alguna intensa aislada	**Posibles tormentas severas numerosas** Más persistentes/ de amplia cobertura, pocas intensas	**Probables tormentas severas de amplia cobertura** Larga duración, amplia cobertura e intensas	**Se esperan tormentas severas de gran cobertura** Muy larga duración, gran cobertura y particularmente intensas
• *Ráfagas de viento de 40 MPH* • *Granizo pequeño*	• *Ráfagas 40-60 MPH* • *Granizo de hasta 1"* • *Riesgo bajo de tornados*	• *1-2 tornados* • *Reportes/daños por fuerte ráfagas de vientos* • *Granizo ~1",alg. de 2"*	• *Algunos tornados* • *Varios reportes de daños por ráfagas* • ***Daños por granizo 1-2"***	• *Fuerte tornados* • *Daños por ráfagas de vientos extensos* • *Granizo destructivo 2"+*	• ***Brote de tornados*** • ***Derechos: zona de vientos de carácter rectilíneo y de origen convectivo***

* 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/descargas eléctricas y el potencial de inundaciones. Las categorías también están ligadas a la probabilidad de tiempo severa a 25 millas de su ubicación.

National Weather Service
www.spc.noaa.gov

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.

Tornados



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

Tornados

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

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Earthquakes

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Earthquakes

As the result of the movement in tectonic plates, earthquakes are highly impredictable. 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.

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Earthquakes

An earthquake of 6.2 degrees in the Richter scale ocurred 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

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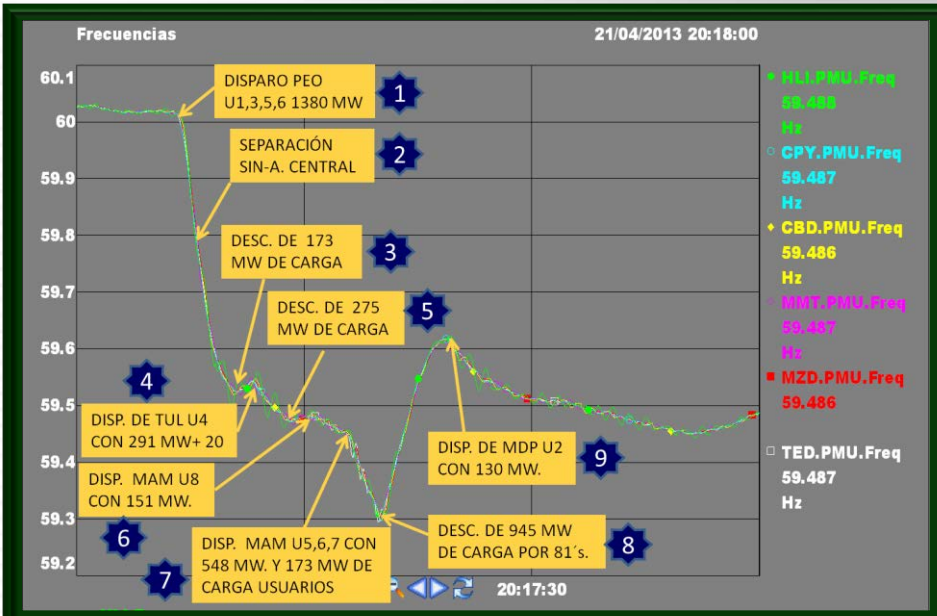
Earthquakes



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

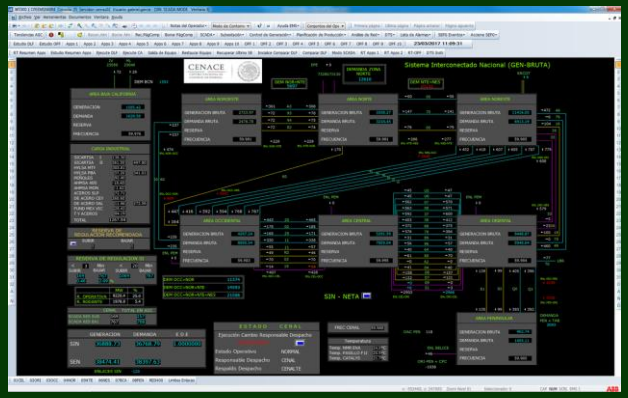
Measures after the event :

- Identify the low frequency level after 1 minute and calculate generation deficit

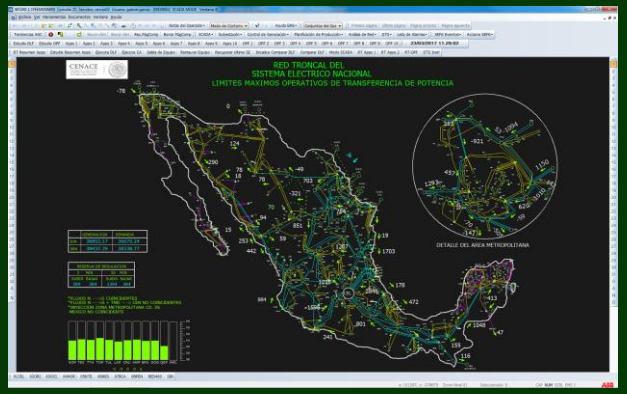
= frequency deviation in dHz * 350.

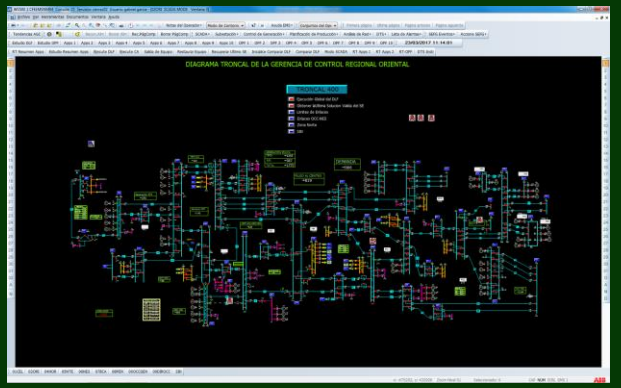
Example for April 21st. Generation deficit = 5 dHz* 350 MW/dHz = 1750 MW.

- Verify whether there are any electric islands. Deployment of frequency comparisons:



- Identify overloaded links or those likely to reach their transmission maximum thresholds





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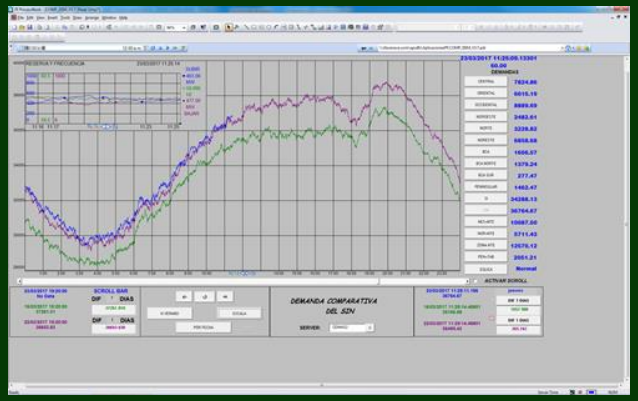
Earthquakes

- Request generation increase = Generation deficit + reserve margin in Automatic Generation Control (AGC)
- Identify the total amount of 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 frecuency 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 exceeeding transmission thresholds.

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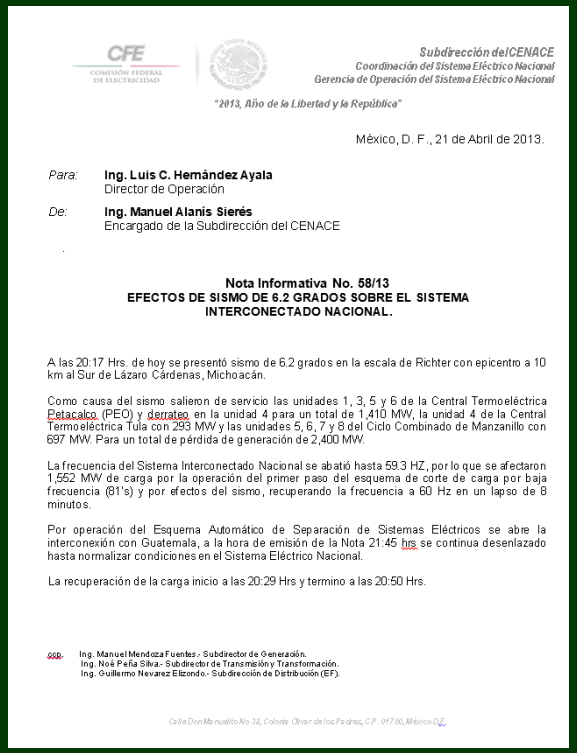
Earthquakes

- Iniciate restoration of affected load without exceeding transmission thresholds while allowing frecuency 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.



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Subdirección del CENACE
Coordinación del Sistema Eléctrico Nacional
Gerencia de Operación del Sistema Eléctrico Nacional

"2013, Año de la Libertad y la República"

México, D. F., 21 de Abril de 2013.

Para: **Ing. Luis C. Hernández Ayala**
Director de Operación

De: **Ing. Manuel Alanis Sierés**
Encargado de la Subdirección del CENACE

Nota Informativa No. 58/13
EFECTOS DE SISMO DE 6.2 GRADOS SOBRE EL SISTEMA INTERCONECTADO NACIONAL.

A las 20:17 Hrs. de hoy se presentó sismo de 6.2 grados en la escala de Richter con epicentro a 10 km al Sur de Lázaro Cárdenas, Michoacán.

Como causa del sismo salieron de servicio las unidades 1, 3, 5 y 6 de la Central Termoeléctrica Petacalco (PEO) y derrateo en la unidad 4 para un total de 1,410 MW, la unidad 4 de la Central Termoeléctrica Tula con 293 MW y las unidades 5, 6, 7 y 8 del Ciclo Combinado de Manzanillo con 697 MW. Para un total de pérdida de generación de 2,400 MW.

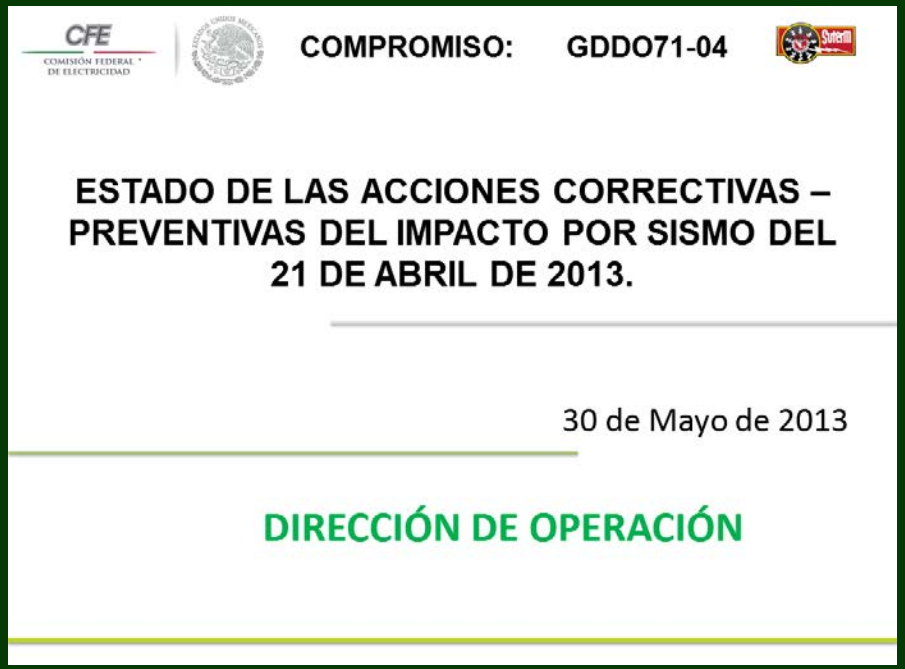
La frecuencia del Sistema Interconectado Nacional se abatió hasta 59.3 HZ, por lo que se afectaron 1,552 MW de carga por la operación del primer paso del esquema de corte de carga por baja frecuencia (81's) y por efectos del sismo, recuperando la frecuencia a 60 Hz en un lapso de 8 minutos.

Por operación del Esquema Automático de Separación de Sistemas Eléctricos se abre la interconexión con Guatemala, a la hora de emisión de la Nota 21:45 hrs se continua desenlazado hasta normalizar condiciones en el Sistema Eléctrico Nacional.

La recuperación de la carga inicio a las 20:29 Hrs y termino a las 20:50 Hrs.

cop. Ing. Manuel Mendoza Fuentes.- Subdirector de Generación.
Ing. Noé Peña Silva.- Subdirector de Transmisión y Transformación.
Ing. Guillermo Nevarez Elizondo.- Subdirección de Distribución (EF).

Calle Don Manuelito No 32, Colonia Olivar de los Padres, C.P. 01780, México D.F.



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COMPROMISO: GDDO71-04

ESTADO DE LAS ACCIONES CORRECTIVAS – PREVENTIVAS DEL IMPACTO POR SISMO DEL 21 DE ABRIL DE 2013.

30 de Mayo de 2013

DIRECCIÓN DE OPERACIÓN

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Training Simulator

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Training simulator

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 Electricty Power System*
- *Assertive and effective communications at every hierarchical level.*
- *Stress management .*

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Thank you!