State of Michigan
ENERGY SECTOR RISK PROFILE

This State Energy Risk Profile examines the relative magnitude of the risks that the State of Michigan’s energy infrastructure routinely encounters in comparison with the probable impacts. Natural and man-made hazards with the potential to cause disruption of the energy infrastructure are identified.

The Risk Profile highlights risk considerations relating to the electric, petroleum and natural gas infrastructures to become more aware of risks to these energy systems and assets.

MICHIGAN STATE FACTS

<table>
<thead>
<tr>
<th>State Overview</th>
<th>Annual Energy Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population: 9.90 million (3% total U.S.)</td>
<td>Electric Power Generation: 108.2 TWh (3% total U.S.)</td>
</tr>
<tr>
<td>Housing Units: 4.53 million (3% total U.S.)</td>
<td>Coal: 53.1 TWh, 49% [12.6 GW total capacity]</td>
</tr>
<tr>
<td>Business Establishments: 0.22 million (3% total U.S.)</td>
<td>Petroleum: 0.3 TWh, &lt;1% [0.7 GW total capacity]</td>
</tr>
<tr>
<td>Annual Energy Consumption</td>
<td>Natural Gas: 21.7 TWh, 20% [12.2 GW total capacity]</td>
</tr>
<tr>
<td>Electric Power: 104.8 TWh (3% total U.S.)</td>
<td>Nuclear: 28.0 TWh, 26% [4.3 GW total capacity]</td>
</tr>
<tr>
<td>Coal: 30,700 MSTN (3% total U.S.)</td>
<td>Hydro: 0.4 TWh, &lt;1% [2.3 GW total capacity]</td>
</tr>
<tr>
<td>Natural Gas: 762 Bcf (3% total U.S.)</td>
<td>Other Renewable: 1.1 TWh, 1% [0.9 GW total capacity]</td>
</tr>
<tr>
<td>Motor Gasoline: 99,800 Mbarrels (3% total U.S.)</td>
<td>Coal: 0 MSTN (0% total U.S.)</td>
</tr>
<tr>
<td>Distillate Fuel: 26,300 Mbarrels (2% total U.S.)</td>
<td>Natural Gas: 130 Bcf (1% total U.S.)</td>
</tr>
<tr>
<td>Crude Oil: 7,400 Mbarrels (&lt;1% total U.S.)</td>
<td>Ethanol: 6,200 Mbarrels (&lt;1% total U.S.)</td>
</tr>
</tbody>
</table>

NATURAL HAZARDS OVERVIEW

Annual Frequency of Occurrence of Natural Hazards in Michigan (1996–2014)

- According to NOAA, the most common natural hazard in Michigan is Thunderstorm & Lightning, which occurs once every 4.2 days on the average during the months of March to October.
- The second-most common natural hazard in Michigan is Winter Storm & Extreme Cold, which occurs once every 5.3 days on the average during the months of October to March.

Annualized Property Loss due to Natural Hazards in Michigan (1996–2014)

- As reported by NOAA, the natural hazard in Michigan that caused the greatest overall property loss during 1996 to 2014 is Thunderstorm & Lightning at $28.1 million per year.
- The natural hazard with the second-highest property loss in Michigan is Tornado at $19.4 million per year.
Electric Power Plants: 231 (2% total U.S.)
- Coal-fired: 33 (3% total U.S.)
- Petroleum-fired: 52 (2% total U.S.)
- Natural Gas-fired: 61 (2% total U.S.)
- Nuclear: 3 (2% total U.S.)
- Hydro-electric: 58 (2% total U.S.)
- Other Renewable: 24 (1% total U.S.)

Transmission Lines:
- High-Voltage (>230 kV): 5,277 Miles
- Low-Voltage (<230 kV): 458 Miles
Electric Transmission

- According to NERC, the leading cause of electric transmission outages in Michigan is **Severe Weather - Thunderstorm**.
- Michigan experienced **42 electric transmission outages** from 1992 to 2009, affecting a total of **7,997,216 electric customers**.
- **Severe Weather - Thunderstorm** affected the largest number of electric customers as a result of electric transmission outages.

### Electric Customers Disrupted by NERC-Reported Electric Transmission Outages by Cause (1992–2009)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Weather - Thunderstorm</td>
<td>2,626,793</td>
</tr>
<tr>
<td>Severe Weather - High Winds</td>
<td>692,998</td>
</tr>
<tr>
<td>Faulty Equipment / Human Error</td>
<td>0</td>
</tr>
<tr>
<td>Severe Weather - Winter Storm</td>
<td>1,061,424</td>
</tr>
<tr>
<td>All Other Causes</td>
<td>3,616,001</td>
</tr>
</tbody>
</table>

Data Source: NERC

### Number of NERC-Reported Electric Transmission Outages by Cause (1992–2009)

- **Severe Weather - Thunderstorm**: 13 incidents
- **Severe Weather - High Winds**: 16 incidents
- **Faulty Equipment / Human Error**: 3 incidents
- **Severe Weather - Winter Storm**: 6 incidents
- **All Other Causes**: 4 incidents

Electric Distribution

- Between 2008 and 2013, the greatest number of electric outages in Michigan has occurred during the month of **June**.
- The leading cause of electric outages in Michigan during 2008 to 2013 was **Weather/Falling Trees**.
- On average, the number of people affected annually by electric outages during 2008 to 2013 in Michigan was **1,292,790**.
- The average duration of electric outages in Michigan during 2008 to 2013 was **7,653 minutes or 127.6 hours a year**.

### Electric Utility Reported Power Outages by Month (2008–2013)

- The leading cause of electric outages in Michigan during 2008 to 2013 was **Weather/Falling Trees**.
- On average, the number of people affected annually by electric outages during 2008 to 2013 in Michigan was **1,292,790**.
- The average duration of electric outages in Michigan during 2008 to 2013 was **7,653 minutes or 127.6 hours a year**.

**NOTE:** # of Incidents – The number within each pie slice is the number of event incidents attributable to each cause.
PETROLEUM

Petroleum Infrastructure Overview

- Refineries: 1 (1% total U.S.)
- Terminals: 49 (3% total U.S.)
- Crude Pipelines: 1,288 Miles (3% total U.S.)
- Product Pipelines: 12,000 Miles (2% total U.S.)
- Bio-Refineries (Ethanol): 5 (2% total U.S.)
Petroleum Transport

Top Events Affecting Petroleum Transport by Truck and Rail (1986–2014)

- The leading event type affecting the transport of petroleum product by rail and truck in Michigan during 1986 to 2014 was Incorrect Operation for rail transport and Miscellaneous/Unknown for truck transport, with an average 4.3 and 8.7 incidents per year, respectively.

Petroleum Refinery

- The leading cause of petroleum refinery disruptions in Michigan from 2003 to 2014 was Operational Upset or Process Problem.
- Michigan's petroleum refineries experienced 25 major incidents from 2003 to 2014. The average production impact from disruptions of Michigan's refineries from 2003 to 2014 is 37.8 thousand barrels per day.
NATURAL GAS

Natural Gas Infrastructure Overview
Gas Wells: 10,858 (2% total U.S.)
Processing Plants: 14 (3% total U.S.)
Storage Fields: 57 (13% total U.S.)
Interstate Pipelines: 10,200 Miles (2% total U.S.)
Local Distribution Companies: 17 (1% total U.S.)
Natural Gas Transport

The leading event type affecting natural gas transmission and distribution pipelines in Michigan during 1986 to 2014 was Corrosion for Transmission Pipelines and Outside Force for Distribution Pipelines, with an average 0.45 (or one incident every 2.2 years) and 2.10 incidents per year, respectively.

Top Events Affecting Natural Gas Transmission and Distribution in Michigan (1986-2014)

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Transmission</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>0.45</td>
<td>0.52</td>
</tr>
<tr>
<td>Equipment Failure</td>
<td>0.13</td>
<td>0.26</td>
</tr>
<tr>
<td>Excavation Damage</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Incorrect Operation</td>
<td>0.16</td>
<td>0.29</td>
</tr>
<tr>
<td>Material / Weld Failures</td>
<td>0.03</td>
<td>0.29</td>
</tr>
<tr>
<td>Miscellaneous / Unknown</td>
<td>0.06</td>
<td>0.23</td>
</tr>
<tr>
<td>Natural Forces</td>
<td>0.10</td>
<td>0.32</td>
</tr>
<tr>
<td>Outside Force</td>
<td>0.24</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Data Source: DOT PHMSA

Natural Gas Processing

Insufficient public data are available on major incidents affecting natural gas processing plants in this state.
Overview Information

- Census Bureau (2012) State and County QuickFacts [http://quickfacts.census.gov/qfd/download_data.html]

Production Numbers


Consumption Numbers


Electricity

- Platts (2014 Q2) Transmission Lines (Miles by Voltage Level)
- Platts (2014 Q2) Power Plants (Production and Capacity by Type)

Petroleum

- Argonne National Laboratory (2012) Petroleum Terminal Database
- Argonne National Laboratory (2014) Ethanol Plants
- NPMS (2011) Petroleum Product Pipeline (Miles of Interstate Pipeline)
- NPMS (2011) Crude Pipeline (Miles of Interstate Pipeline)

Natural Gas

- EIA (2013) Number of Producing Gas Wells [http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm]
- NPMS (2011) Natural Gas Pipeline (Miles of Interstate Pipeline)
- Platts (2014 Q2) Local Distribution Companies (LDCs)

Event Related


*The NERC disturbance reports are not published after 2009.

Notes

- Natural Hazard, Other, includes extreme weather events such as astronomical low tide, dense smoke, frost/freeze, and rip currents.
- Each incident type is an assembly of similar causes reported in the data source. Explanations for the indescribable incident types are below.
  - Outside Force refers to pipeline failures due to vehicular accident, sabotage, or vandalism.
  - Natural Forces refers to damage that occurs as a result of naturally occurring events (e.g., earth movements, flooding, high winds, etc.)
  - Miscellaneous/Unknown includes releases or failures resulting from any other cause not listed or of an unknowable nature.
  - Overdemand refers to outages that occur when the demand for electricity is greater than the supply, causing forced curtailment.
  - Number (#) of Incidents – The number within each pie chart piece is the number of outages attributable to each cause.

FOR MORE INFORMATION CONTACT:
Alice Lippert
Senior Technical Advisor
Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy
email: energyanalysis@hq.doe.gov