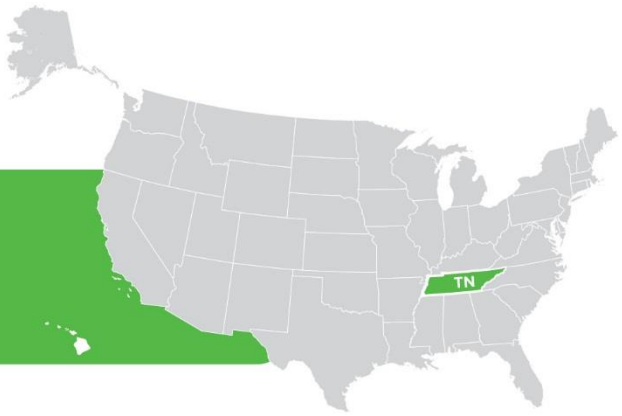
U.S. DEPARTMENT OF ENERGY

State of Tennessee
ENERGY SECTOR RISK PROFILE



This State Energy Risk Profile examines the relative magnitude of the risks that the State of Tennessee'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.

TENNESSEE STATE FACTS

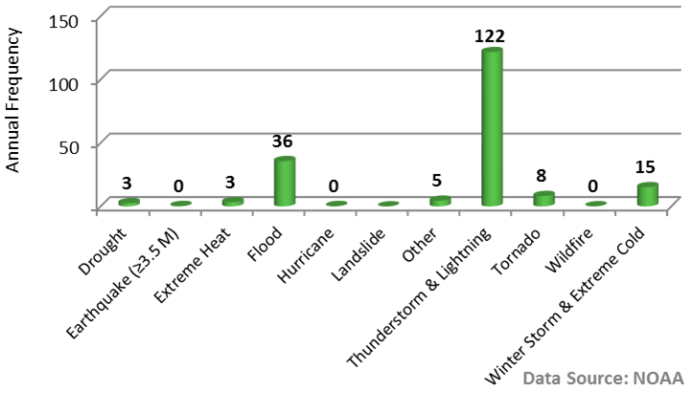
State Overview
- Population: 6.50 million (2% total U.S.)
- Housing Units: 2.84 million (2% total U.S.)
- Business Establishments: 0.13 million (2% total U.S.)

Annual Energy Consumption
- Electric Power: 96.4 TWh (3% total U.S.)
- Coal: 19,900 MSTN (2% total U.S.)
- Natural Gas: 267 Bcf (1% total U.S.)
- Motor Gasoline: 70,800 Mbarrels (2% total U.S.)
- Distillate Fuel: 28,900 Mbarrels (2% total U.S.)

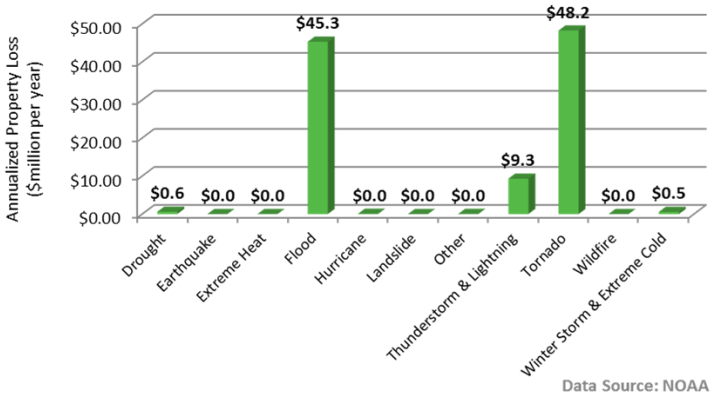
Annual Energy Production
- Electric Power Generation: 77.7 TWh (2% total U.S.)
  - Coal: 35.4 TWh, 46% [9.6 GW total capacity]
  - Petroleum: 0.1 TWh, <1% [0.1 GW total capacity]
  - Natural Gas: 8.1 TWh, 10% [6.4 GW total capacity]
  - Nuclear: 25.1 TWh, 32% [3.7 GW total capacity]
  - Hydro: 8.1 TWh, 10% [4.2 GW total capacity]
  - Other Renewable: 0 TWh, <1% [0.2 GW total capacity]
- Coal: 1,100 MSTN (<1% total U.S.)
- Natural Gas: 10 Bcf (<1% total U.S.)
- Crude Oil: 400 Mbarrels (<1% total U.S.)
- Ethanol: 5,200 Mbarrels (2% total U.S.)

NATURAL HAZARDS OVERVIEW

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



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



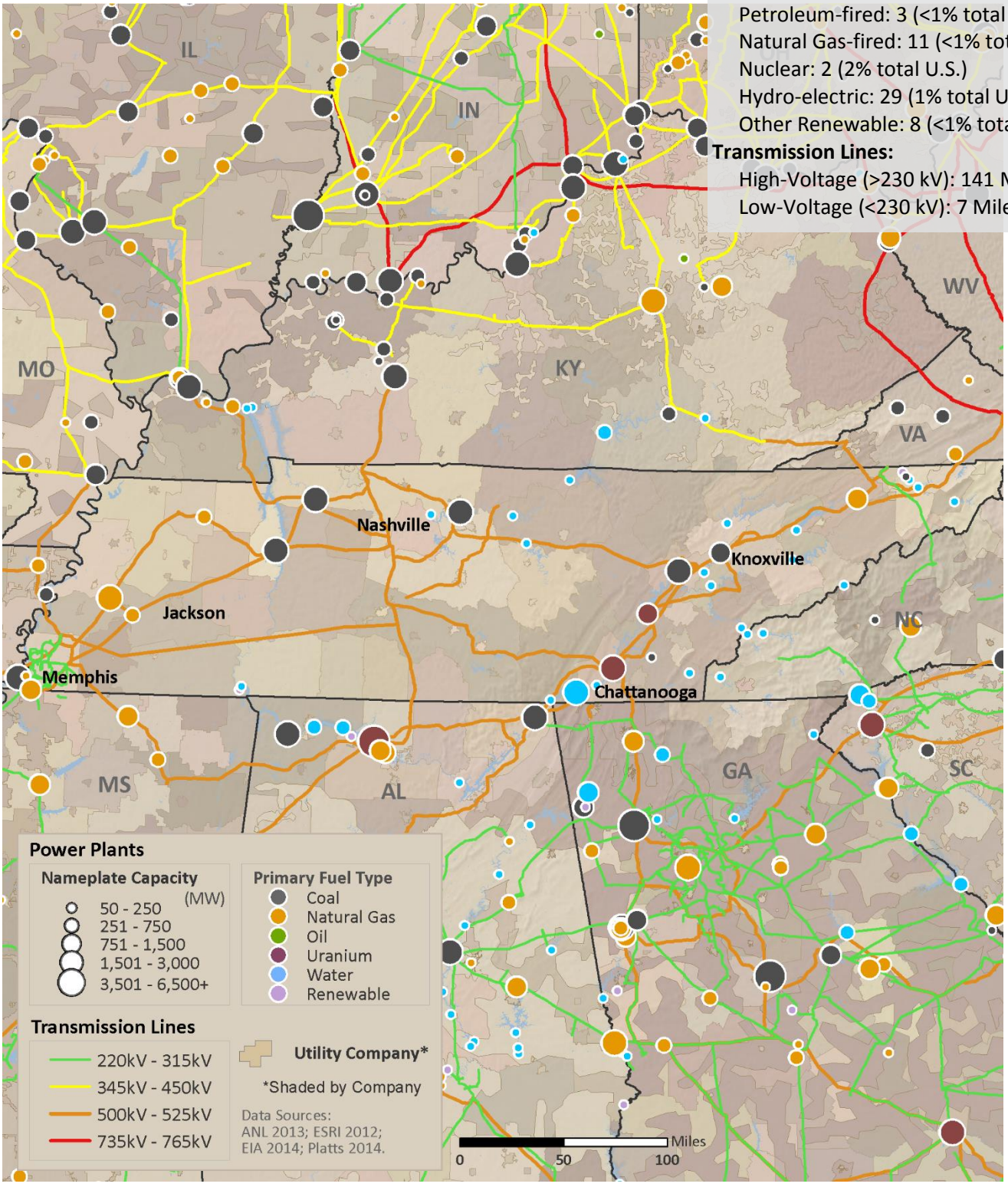
- According to NOAA, the most common natural hazard in Tennessee is Thunderstorm & Lightning, which occurs once every 3 days on the average during the months of March to October.
- The second-most common natural hazard in Tennessee is Flood, which occurs once every 10.2 days on the average.
- As reported by NOAA, the natural hazard in Tennessee that caused the greatest overall property loss during 1996 to 2014 is Tornado at $48.2 million per year.
- The natural hazard with the second-highest property loss in Tennessee is Flood at $45.3 million per year.

Produced by Department of Energy (DOE), Office of Electricity Delivery & Energy Reliability (OE)

ELECTRIC

Electric Power Plants: 63 (<1% total U.S.)
- Coal-fired: 10 (1% total U.S.)
- Petroleum-fired: 3 (<1% total U.S.)
- Natural Gas-fired: 11 (<1% total U.S.)
- Nuclear: 2 (2% total U.S.)
- Hydro-electric: 29 (1% total U.S.)
- Other Renewable: 8 (<1% total U.S.)

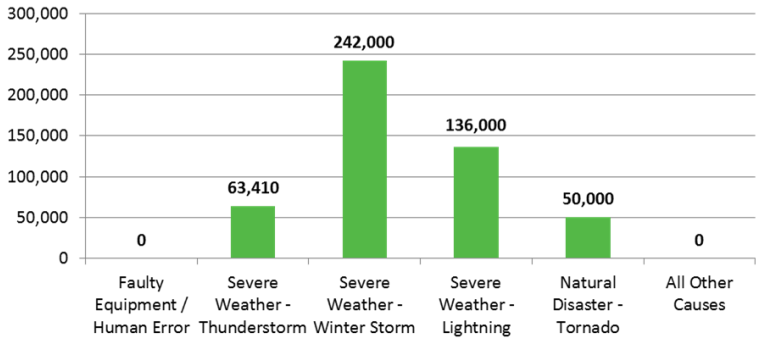
Transmission Lines:
- High-Voltage (>230 kV): 141 Miles
- Low-Voltage (<230 kV): 7 Miles



Electric Transmission

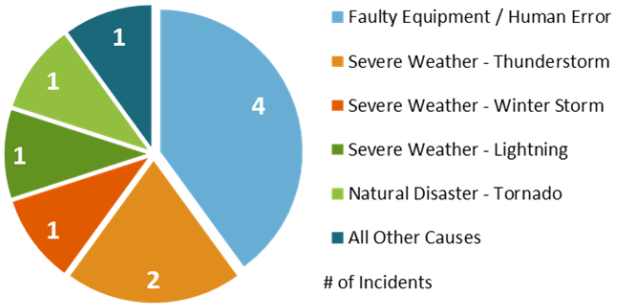
- According to NERC, the leading cause of electric transmission outages in Tennessee is **Faulty Equipment/Human Error**.
- Tennessee experienced **10 electric transmission outages** from 1992 to 2009, affecting a total of **491,410** electric customers.
- **Severe Weather - Winter Storm** affected the 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)



Data Source: NERC

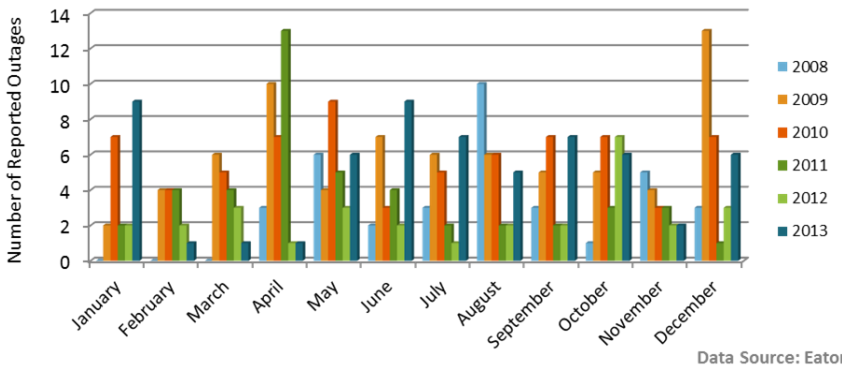
Number of NERC-Reported Electric Transmission Outages by Cause (1992–2009)



Data Source: NERC

Electric Distribution

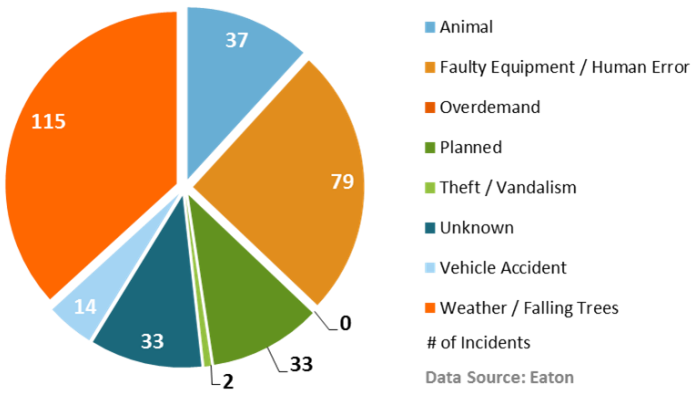
Electric-Utility Reported Power Outages by Month (2008–2013)



Data Source: Eaton

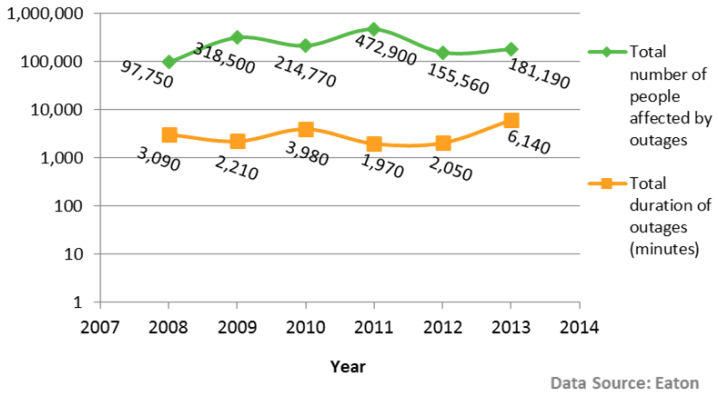
- Between 2008 and 2013, the greatest number of electric outages in Tennessee has occurred during the month of **April**.
- The leading cause of electric outages in Tennessee during 2008 to 2013 was **Weather/Falling Trees**.
- On average, the number of people affected annually by electric outages during 2008 to 2013 in Tennessee was **240,112**.
- The average duration of electric outages in Tennessee during 2008 to 2013 was **3,240 minutes or 54.0 hours a year**.

Causes of Electric-Utility Reported Outages (2008–2013)



Data Source: Eaton

Utility Outage Data (2008–2013)

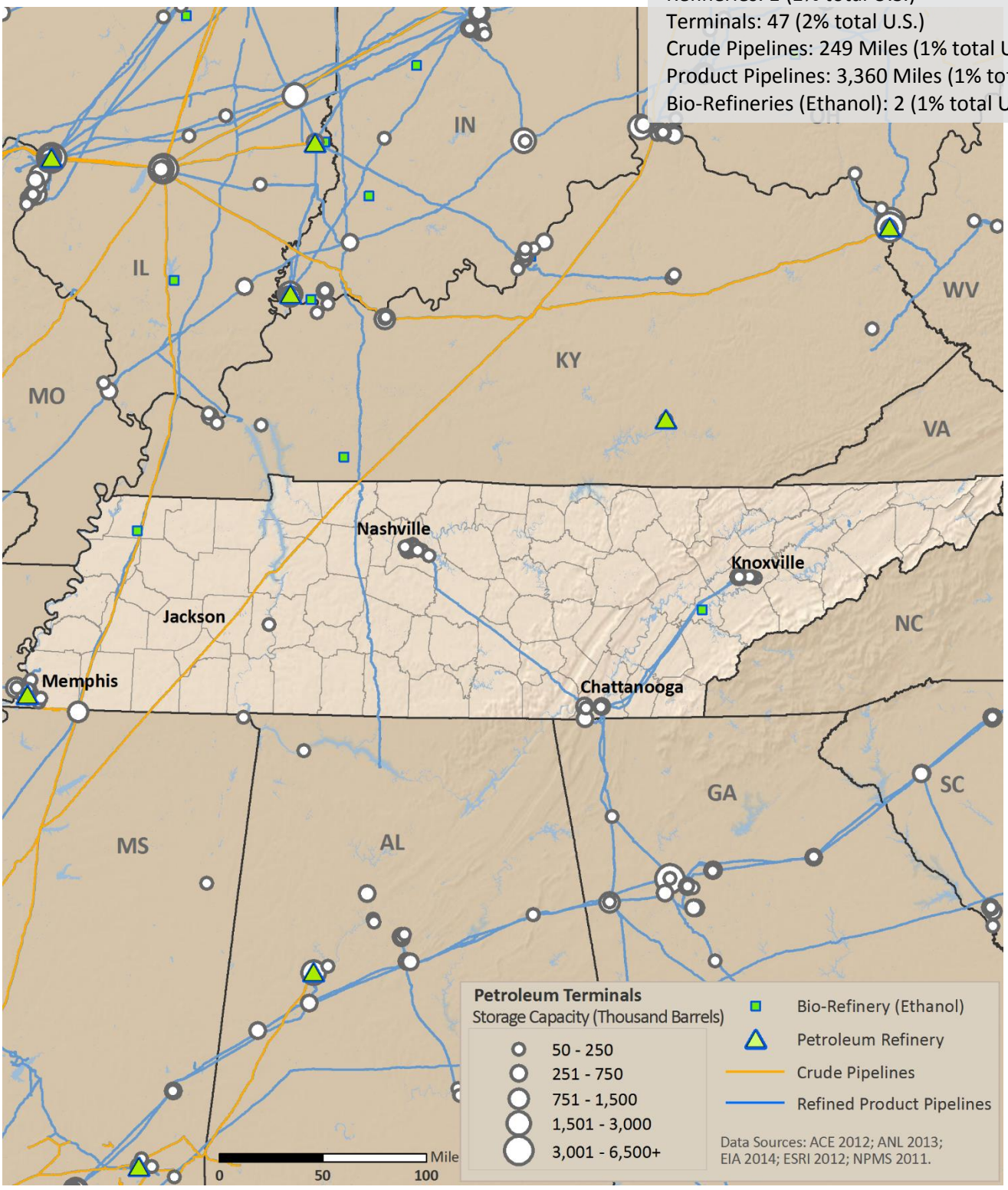


Data Source: Eaton

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

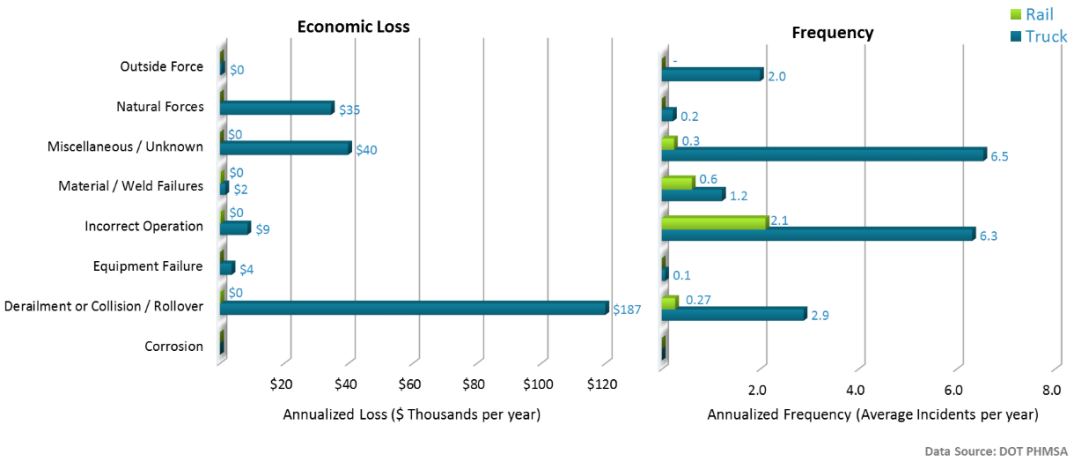
PETROLEUM

Petroleum Infrastructure Overview
Refineries: 1 (1% total U.S.)
Terminals: 47 (2% total U.S.)
Crude Pipelines: 249 Miles (1% total U.S.)
Product Pipelines: 3,360 Miles (1% total U.S.)
Bio-Refineries (Ethanol): 2 (1% total U.S.)



Petroleum Transport

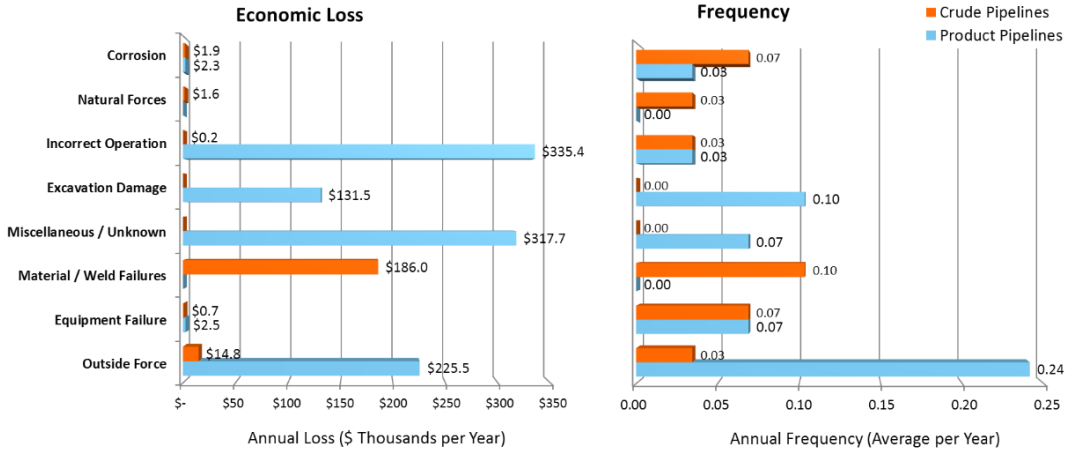
Top Events Affecting Petroleum Transport by Truck and Rail (1986–2014)



Data Source: DOT PHMSA

- The leading event type affecting the **transport of petroleum product by rail and truck** in Tennessee during 1986 to 2014 was **Incorrect Operation** for rail transport and **Miscellaneous/Unknown** for truck transport, with an average **2.1 and 6.5 incidents** per year, respectively.

Top Events Affecting Crude Oil and Refined Product Pipelines in Tennessee (1986–2014)



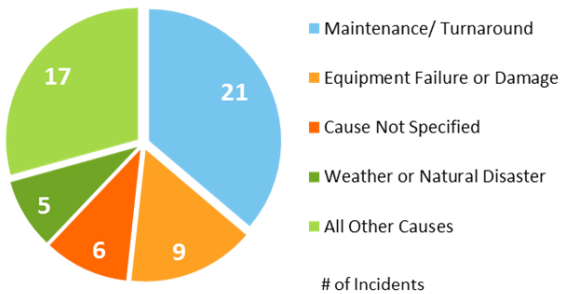
Data Source: DOT PHMSA

- The leading event type affecting **crude oil pipeline and petroleum product pipelines** in Tennessee during 1986 to 2014 was **Material/Weld Failures** for crude oil pipelines and **Outside Force** for product pipelines, with an average **0.1 and 0.24 incidents** per year (or one incident every 9.7 and 4.1 years), respectively.

Petroleum Refinery

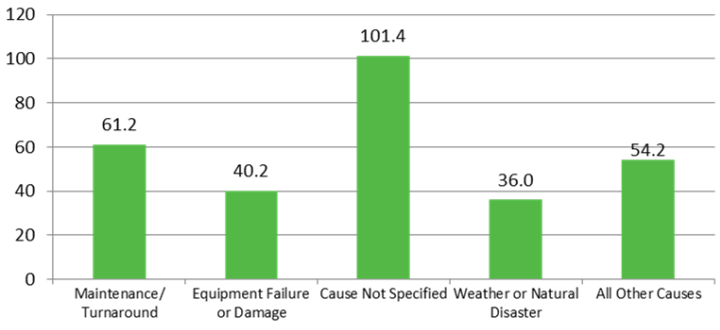
- The leading cause of petroleum refinery disruptions in Tennessee from 2003 to 2014 was **Maintenance/Turnaround**. Tennessee's petroleum refineries experienced **58 major incidents** from 2003 to 2014. The average production impact from disruptions of Tennessee's refineries from 2003 to 2014 is **57.9 thousand barrels per day**.

Top-Five Causes of Petroleum Refinery Disruptions in Tennessee (2003–2014)



Data Source: DOE OE

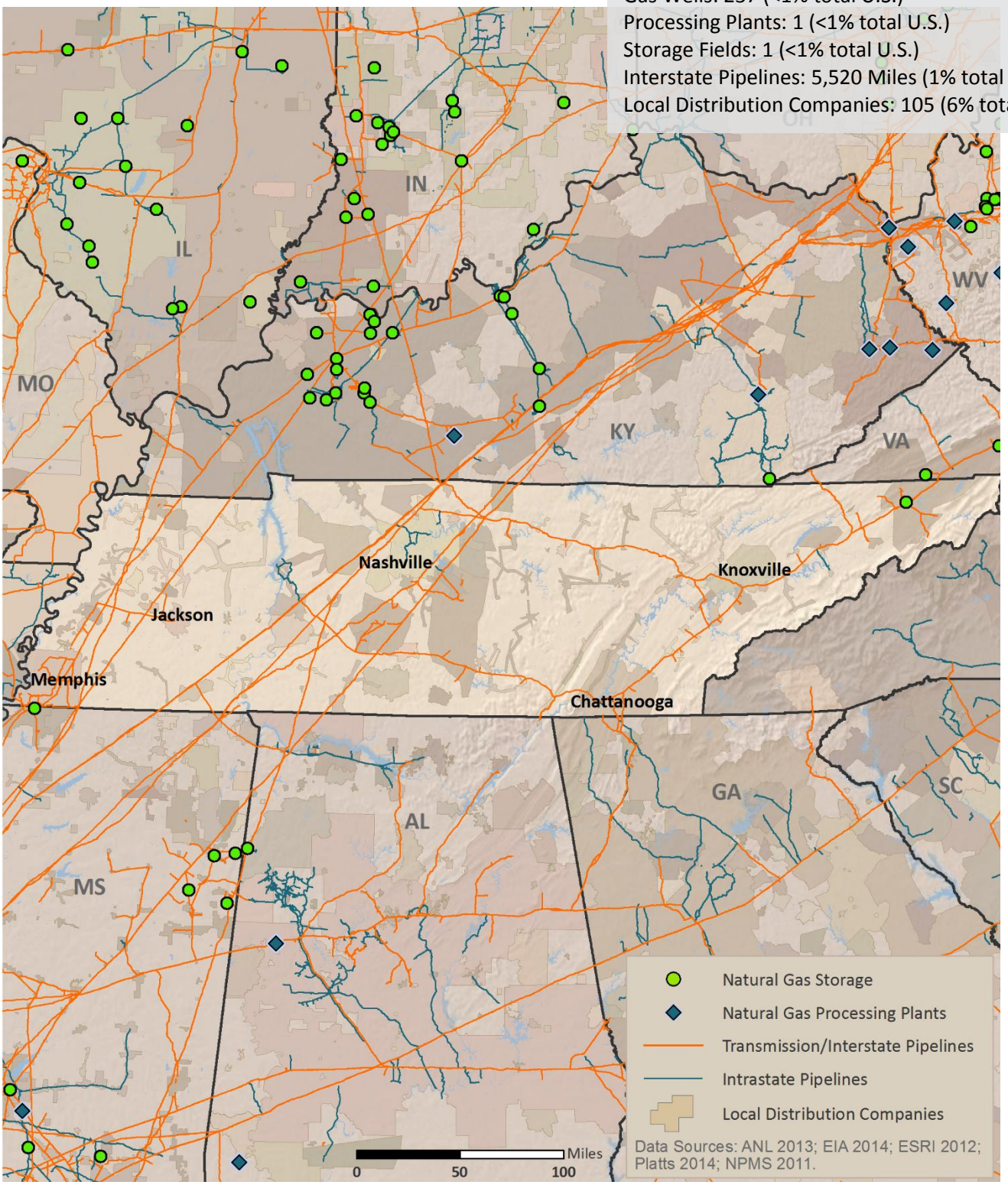
Average Production Impact (thousand barrels per day) from Petroleum Refinery Outages in Tennessee (2003–2014)



Data Source: DOE OE

NATURAL GAS

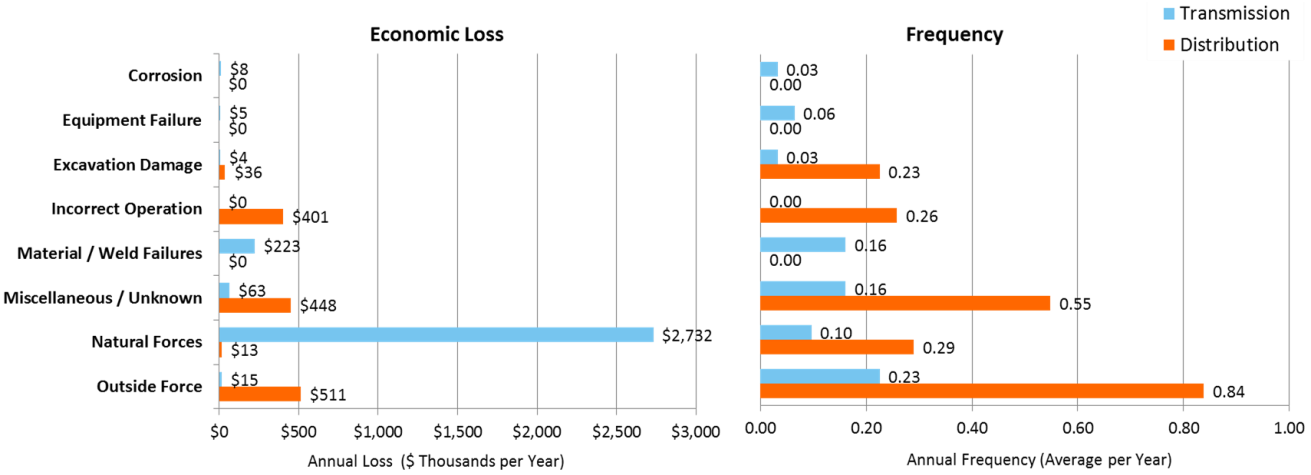
Natural Gas Infrastructure Overview
Gas Wells: 237 (<1% total U.S.)
Processing Plants: 1 (<1% total U.S.)
Storage Fields: 1 (<1% total U.S.)
Interstate Pipelines: 5,520 Miles (1% total U.S.)
Local Distribution Companies: 105 (6% total U.S.)



Natural Gas Transport

- The leading event type affecting natural gas transmission and distribution pipelines in Tennessee during 1986 to 2014 was **Outside Force** for Transmission Pipelines and **Outside Force** for Distribution Pipelines, with an average **0.23 and 0.84 incidents** per year (or one incident every 4.4 and 1.2 years), respectively.

Top Events Affecting Natural Gas Transmission and Distribution in Tennessee (1986–2014)



Data Source: DOT PHMSA

Natural Gas Processing

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

Bcf – Billion Cubic Feet
GW – Gigawatt
kV – Kilovolt
Mbarrels – Thousand Barrels
Mbpd – Thousand Barrels per Day
MMcfd – Million Cubic Feet per Day
MSTN – Thousand Short Tons
TWh – Terawatt hours

DATA SOURCES

Overview Information

- NOAA (2014) Storms Events Database [www.ncdc.noaa.gov/data-access/severe-weather]
- Census Bureau (2012) State and County QuickFacts [http://quickfacts.census.gov/qfd/ download_data.html]

Production Numbers

- EIA (2012) Table P1 Energy Production Estimates in Physical Units [http://www.eia.gov/state/seds/sep_prod/pdf/P1.pdf]
- EIA (2013) Natural Gas Gross Withdrawals and Production [http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGM_mmcf_a.htm]
- EIA (2012) Electric Power Annual, Table 3.6. Net Generation by State, by Sector, 2012 and 2011 (Thousand Megawatt hours) [http://www.eia.gov/electricity/annual/pdf/epa.pdf]
- EIA (2012) Electric Power Annual, Existing Nameplate and Net Summer Capacity by Energy Source, Producer Type and State (EIA-860) [http://www.eia.gov/electricity/data/state/]

Consumption Numbers

- EIA (2012) Electric Power Annual, Fossil Fuel Consumption for Electricity Generation by Year, Industry Type and State (EIA-906, EIA-920, and EIA-923) [http://www.eia.gov/electricity/data/state/]
- EIA (2013) Prime Supplier Sales Volumes [http://www.eia.gov/dnav/pet/pet_cons_prim_dcu_nus_m.htm]
- EIA (2012) Adjusted Sales of Fuel Oil and Kerosene [http://www.eia.gov/petroleum/data.cfm#consumption]
- EIA (2012) Annual Coal Consumption [http://www.eia.gov/coal/data.cfm]

Electricity

- EIA (2013) Form-860 Power Plants [http://www.eia.gov/electricity/data/eia860/]
- 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
- EIA (2013) Petroleum Refinery Capacity Report [http://www.eia.gov/petroleum/refinerycapacity/]
- NPMS (2011) Petroleum Product Pipeline (Miles of Interstate Pipeline)
- NPMS (2011) Crude Pipeline (Miles of Interstate Pipeline)

Natural Gas

- EIA (2013) Form-767 Natural Gas Processing Plants [http://www.eia.gov/cfapps/ngqs/ngqs.cfm?f_report=RP9]
- 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

- DOE OE (2014) Form 417 Electric Disturbance Events [http://www.oe.netl.doe.gov/OE417_annual_summary.aspx]
- DOE OE (2014) Energy Assurance Daily (EAD) [http://www.oe.netl.doe.gov/ead.aspx]
- Eaton (2014) Blackout and Power Outage Tracker [http://powerquality.eaton.com/blackouttracker/default.asp?id=&key=&Quest_user_id=&leadg_Q_QRequired=&site=&menu=&cx=3&x=16&y=11]
- DOT PHMSA (2013) Hazardous Material Incident System (HMIS) [https://hazmatonline.phmsa.dot/gov/IncidentReportsSearch/search.aspx]
- NERC (2009) Disturbance Analysis Working Group [http://www.nerc.com/pa/rrm/ea/Pages/EA-Program.aspx]*
  *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:
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