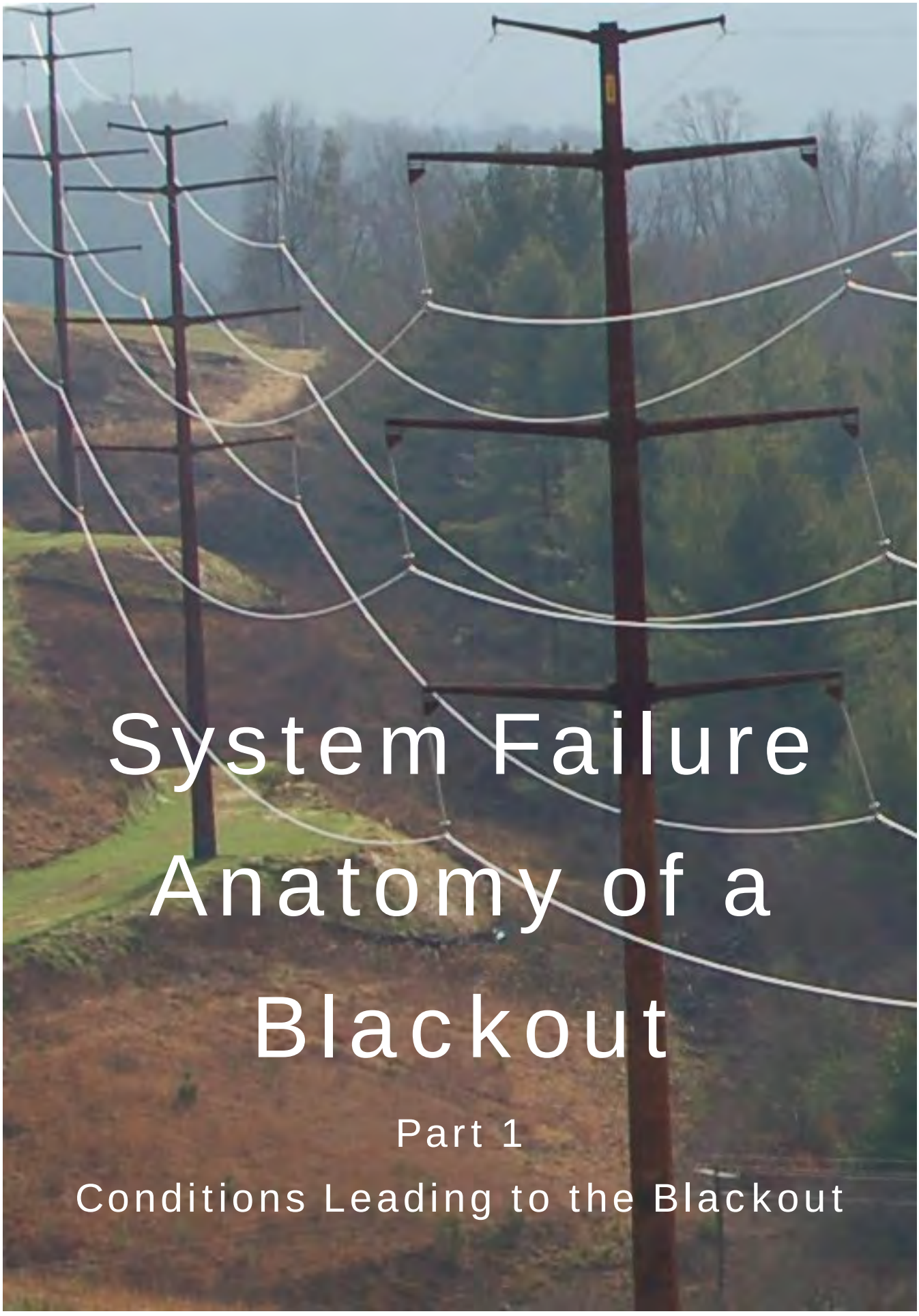
System Failure- Anatomy of a Blackout - Part I

An Online Continuing Education Course for Engineers

Course Number: E-4017

Credit: 4 Hours / 4 PDH / 4 CPD



System Failure Anatomy of a Blackout

Part 1

Conditions Leading to the Blackout

Table of Contents

Preface

On August 14, 2003, just after 4 p.m. Eastern Daylight Time (EDT), the North American power grid experienced its largest blackout ever. The blackout affected an estimated 50 million people and more than 70,000 megawatts (MW) of electrical load in parts of Ohio, Michigan, New York, Pennsylvania, New Jersey, Connecticut, Massachusetts, Vermont, and the Canadian provinces of Ontario and Québec.

Although power was successfully restored to most customers within hours, some areas in the United States did not have power for two days and parts of Ontario experienced rotating blackouts for up to two weeks.

This course looks at the conditions on the bulk electric system that existed prior to and during the blackout, and explains how the blackout occurred. Note that since this report was originally written, several of the companies and organizations mentioned in the report have merged or reorganized.

Immediately following the blackout, NERC assembled a team of technical experts from across the United States and Canada to investigate exactly what happened, why it happened, and what could be done to minimize the chance of future outages. The scope of NERC's investigation was to determine the causes of the blackout, how to reduce the likelihood of future cascading blackouts, and how to minimize the impacts of any that do occur. NERC focused its analysis on factual and technical issues including power system operations, planning, design, protection and control, and maintenance.

This course is Part I of a two part series about the August 14, 2003 blackout. Part I covers the events leading up to the black and gives an overview of the conditions prior to the start of the system failure and describes the conditions for the hours preceding the cascading failure of a large part of the Eastern Interconnect. Part II covers the actual cascading failure and describes how it spread, and finally stopped.

I. Introduction

The August 14, 2003 blackout affected the northeastern portion of the Eastern Interconnection, covering portions of three NERC regions. The blackout affected electric systems in northern Ohio, eastern Michigan, northern Pennsylvania and New Jersey, much of New York and Ontario. To a lesser extent, Massachusetts, Connecticut, Vermont, and Québec were impacted. The areas affected by the August 14 blackout are shown in Figure 1.

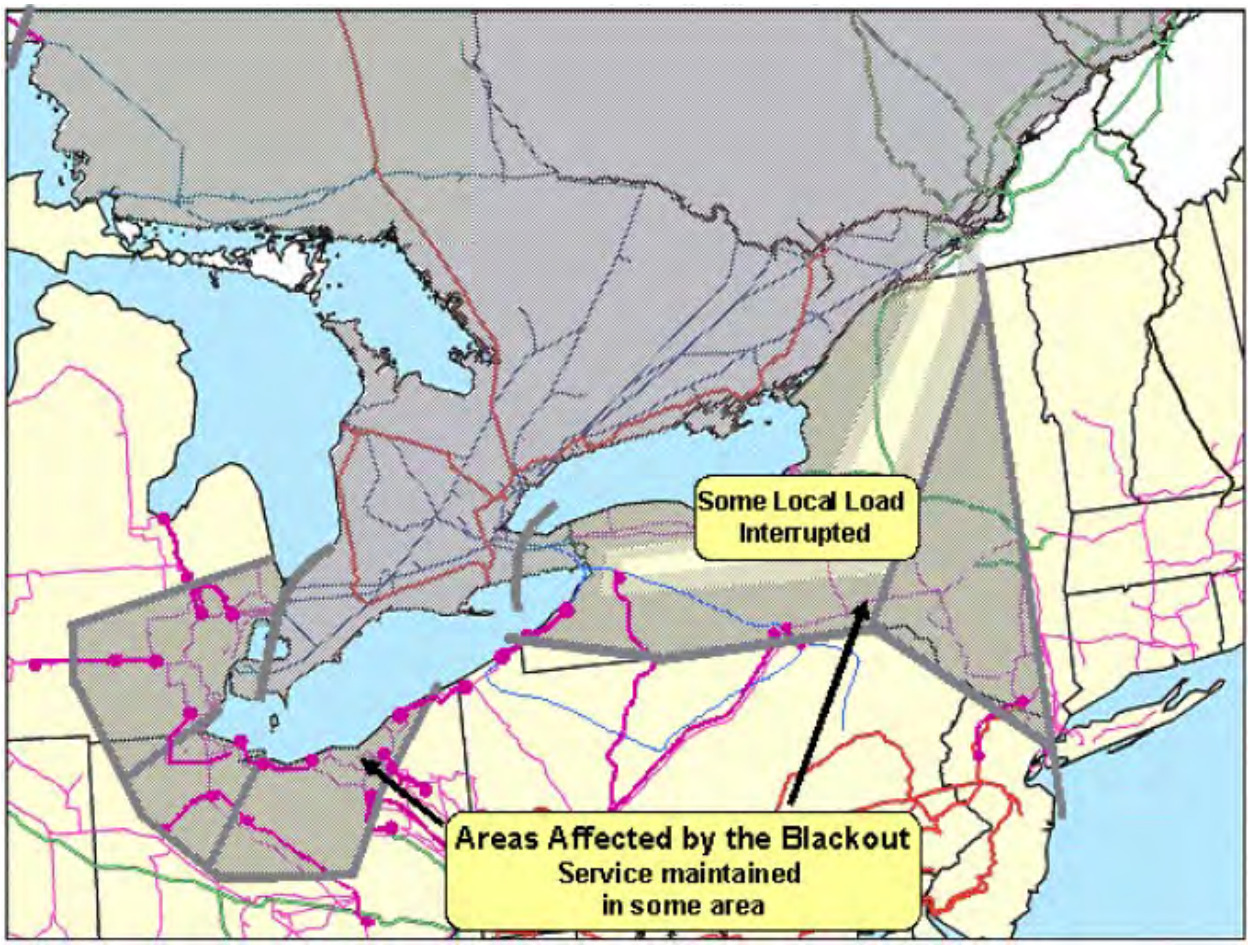


Figure 1 — Area Affected by the Blackout

The power system in Ontario is operated by the Independent System Operator (IMO). The New York system is operated by the New York Independent System Operator (NYISO). The mid-Atlantic area, including the northern Pennsylvania and northern New Jersey areas affected by the blackout, is operated by the PJM Interconnection, LLC (PJM). Each of these entities operates an electricity market in their respective area and is responsible for reliability of the bulk electric system in that area. Each is designated as both the system operator and the reliability coordinator for their respective area.

In the Midwest, several dozen utilities operate their own systems in their franchise territory. Reliability oversight in this region is provided by two reliability coordinators, the Midwest Independent Transmission System Operator (MISO) and PJM.

New England, which is operated by the New England Independent System Operator (ISO-NE), was in the portion of the Eastern Interconnection that became separated, but was able to stabilize its generation and load with minimal loss, except for the southwest portion of Connecticut, which blacked out with New York City. Nova Scotia and Newfoundland were also not impacted severely. Hydro-Québec operates the electric system in Québec and was mostly unaffected by the blackout because this system is operated asynchronously from the rest of the interconnection.

Several of the key players involved in the blackout are described in more detail below.

FirstEnergy Corporation

FirstEnergy Corporation (FE) is the fifth largest electric utility in the United States. FE serves 4.4 million electric customers in a 36,100 square mile service territory covering parts of Ohio, Pennsylvania, and New Jersey. FE operates 11,502 miles of transmission lines, and has 84 ties with 13 other electric systems.

FE comprises seven operating companies (Figure 2). Four of these companies, Ohio Edison, Toledo Edison, The Illuminating Company, and Penn Power, operate in the ECAR region; MISO serves as their reliability coordinator. These four companies now operate as one integrated control area managed by FE. The remaining three FE companies, Penelec, Met-Ed, and Jersey Central Power & Light, are in the MAAC region and PJM is their reliability coordinator. This report addresses the FE operations in northern Ohio, within ECAR and the MISO reliability coordinator footprint.

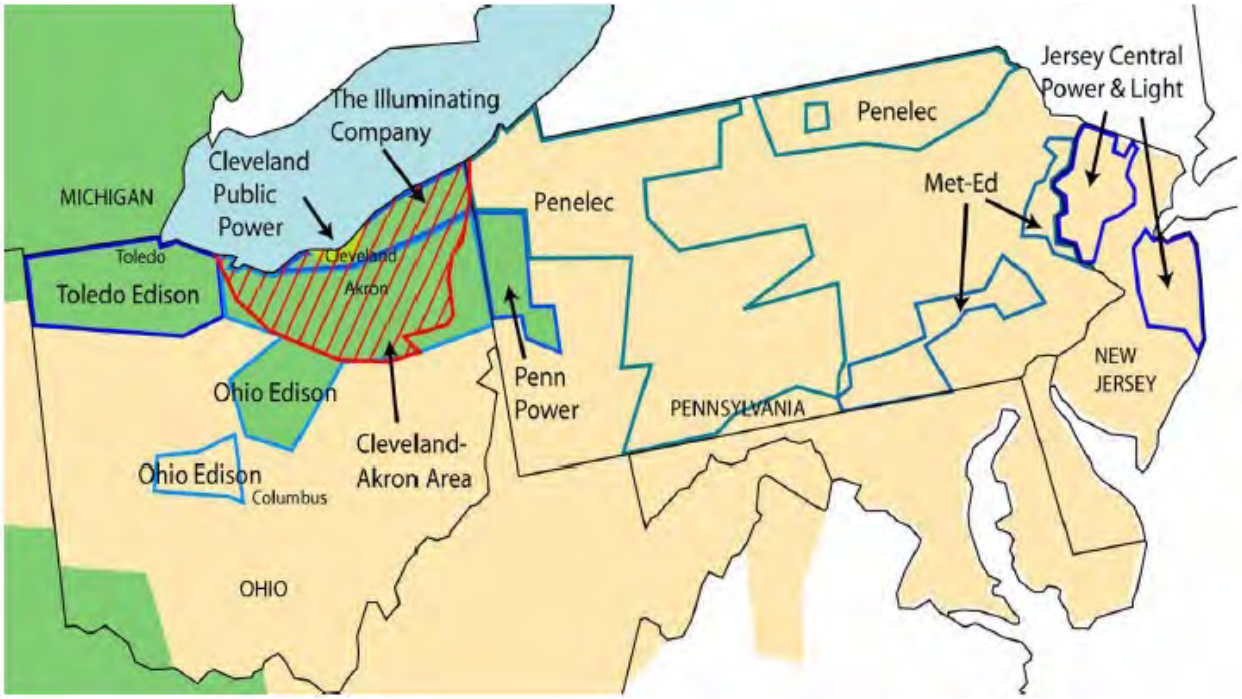


Figure 2 — FE Operating Areas

FE operates several control centers in Ohio that perform different functions. The first is the unregulated Generation Management System (GMS), which is located in a separate facility from the transmission system operations center. The GMS handles the ...gulated generation portion of the business, including Automatic Generati... FE units, managing wholesale transactions ...d managing ancillary services. On August 1 ...ling on automatic reserve sharing when the East...

The second FE control ...MS). The EMS control center is charged with r... ...ontrol area and is managed by a director c... ...s report to the director. The first group ...ond is responsible for transmission operations ...as several dispatchers who perform day-ahead s... ...om.

Within the main control r... ...tors: the Western Desk, which oversees the ...k, which oversees the eastern portion of the s... ...back of the room. There are other desks for c...