ComEd
An Exelon Company

ComEd Outlook

Next Generation Grid Component R&D Program Planning Workshop

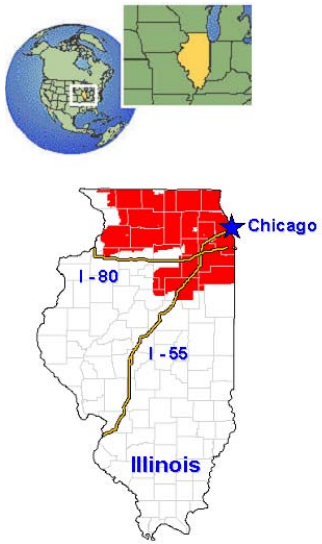
Dale Player
Manager Material Condition

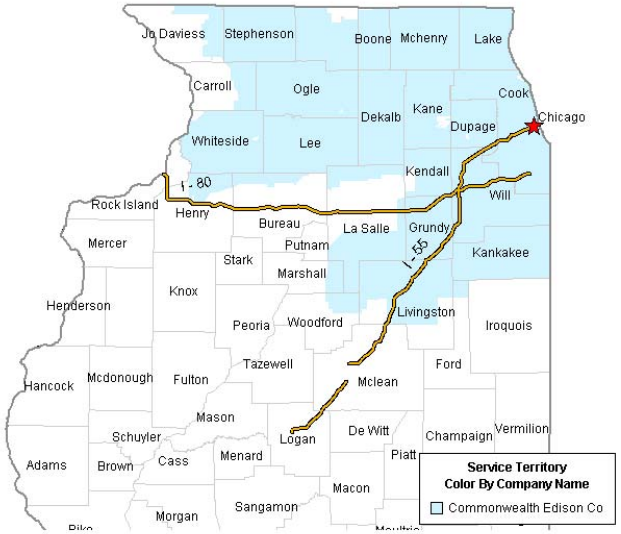
August 2016

ComEd Overview

ComEd service territory covers over 11,000 square miles in northern Illinois including the Chicago metropolitan area.

ComEd is committed to safely delivering reliable electricity throughout the more than 400 municipalities and 25 counties and serves 3.8 million customers which includes the city of Chicago.





ComEd Facts:

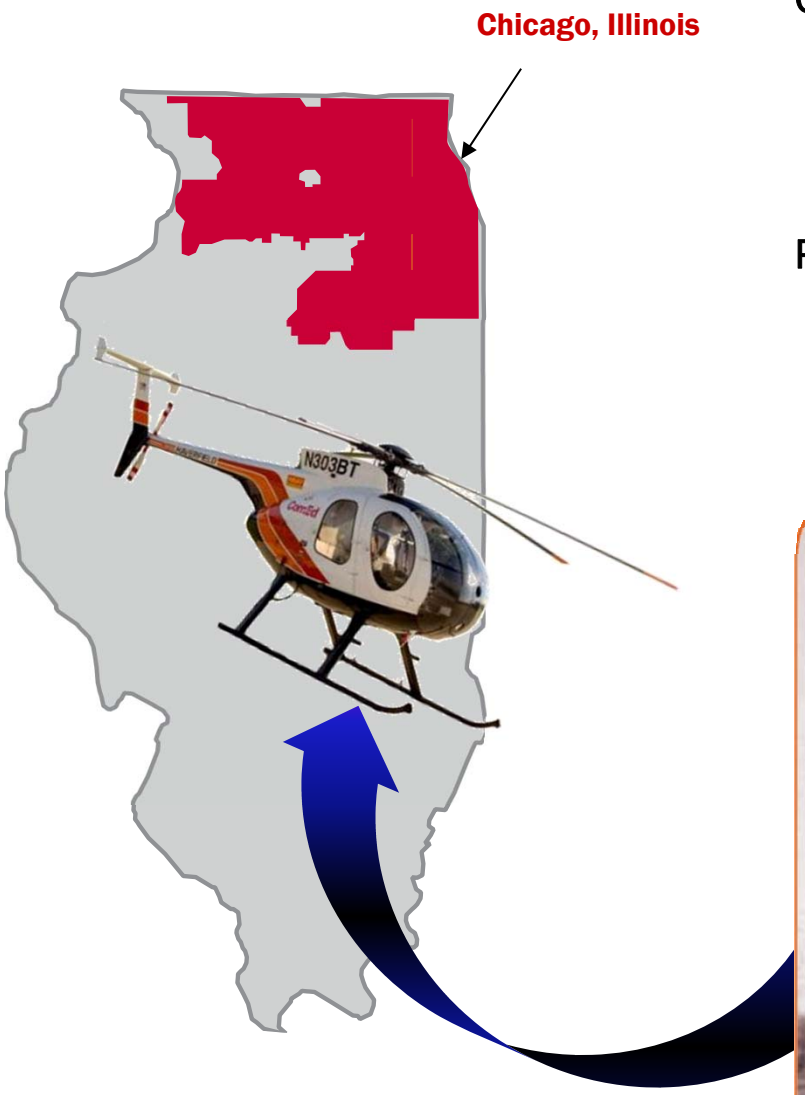
- All-time highest System Summer Peak - – 23,753 MW on July 20, 2011
- Substations – over 2,600
- Distribution Circuits – over 5,400
- Overhead Line Miles* - over 44,400
- Underground Cable Miles* – over 55,000
- Poles – over 1 Million

* Includes service & secondary conductors

System Statistics:

- 3.8 Million Customers
- 70% IL Population

ComEd Overview

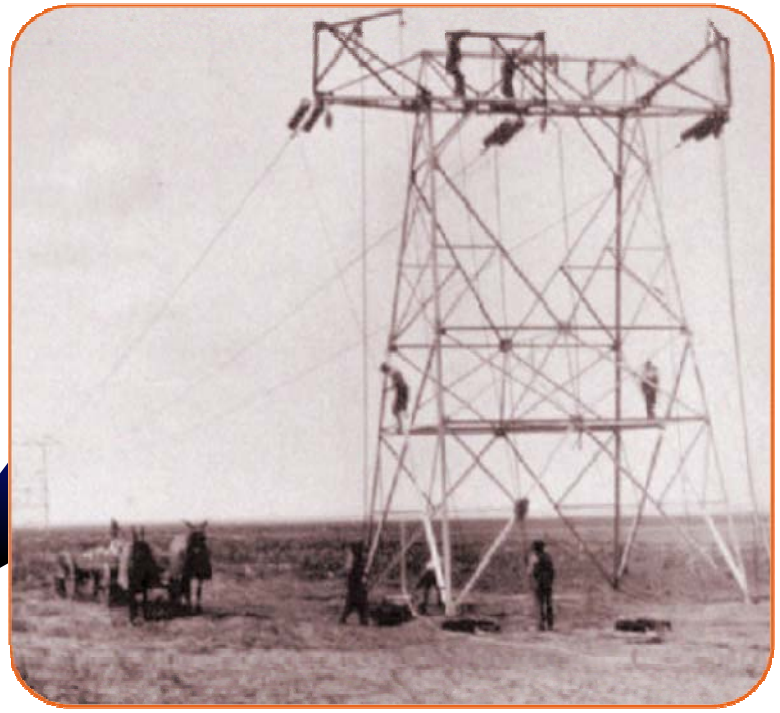


ComEd Overview:

- Employees: ~5,800
- Electric customers: 3.8 million
- Service Territory: 11,300 square miles
- All-Time Peak Load: 23,753 MW

Profile:

- 765kV – 3 Lines, 90 Miles
- 345kV – 151 Lines, 2,657 Miles
- 138kV – 231 Lines, 904 Miles
- 69kV – 15 Lines, 129 Miles



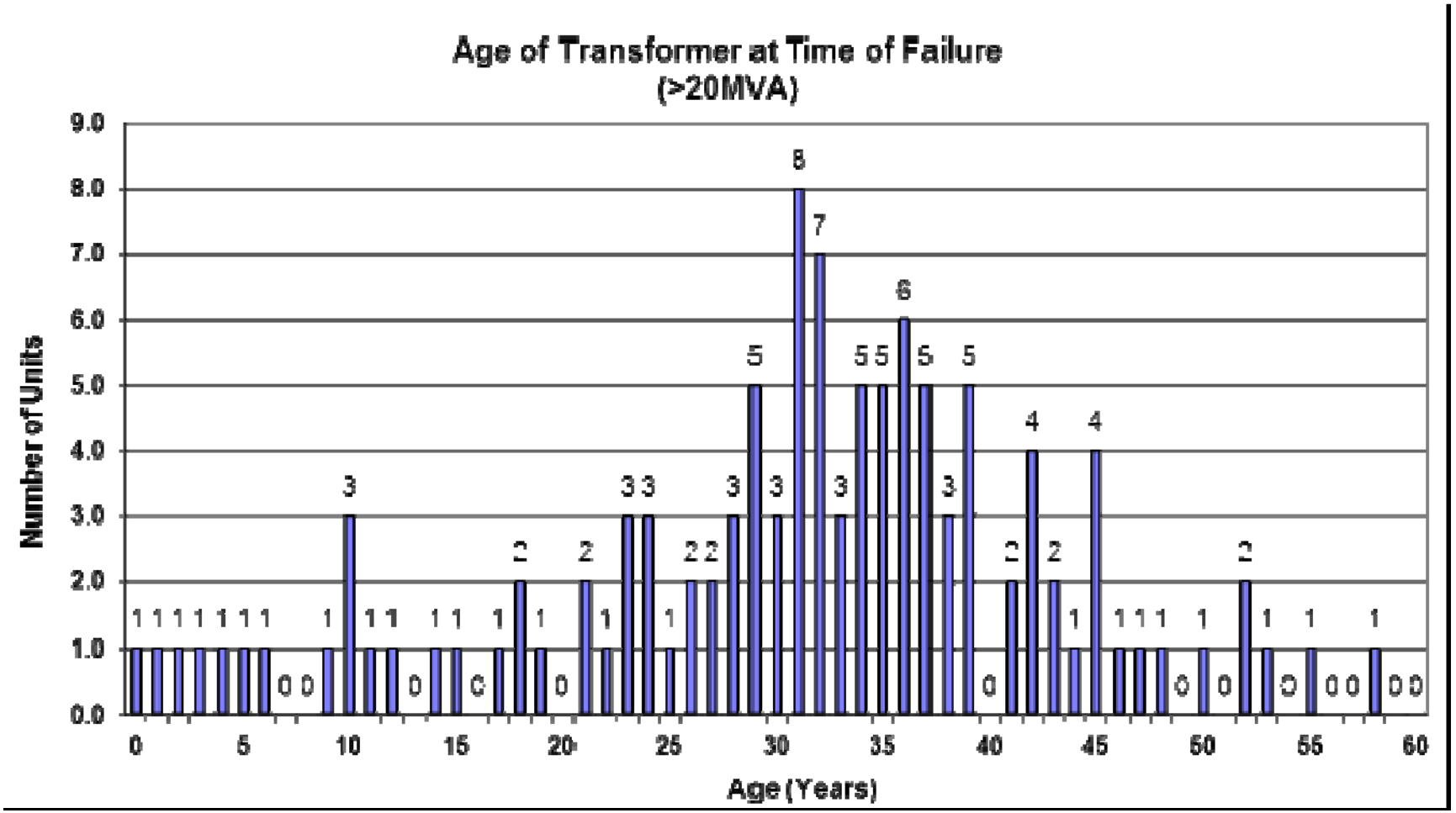
In-service types and voltages (Transmission & Substation)

Type	4 kV	12 kV	34 kV	69 kV	138 kV	345 kV	765 kV	Total
Autotransformer	-	-	-	-	-	87	15	102
Phase Shifter	-	-	-	-	10	-	-	10
LTC Transformer	-	137	575	34	704	-	-	1,452
Dual LTC Transformer	-	-	-	-	13	-	-	13
Power Transformer	-	90	453	2	81	-	-	626
Distribution Transformer	56	107	583	-	-	-	-	746

In-service types and voltages (Transmission & Substation)

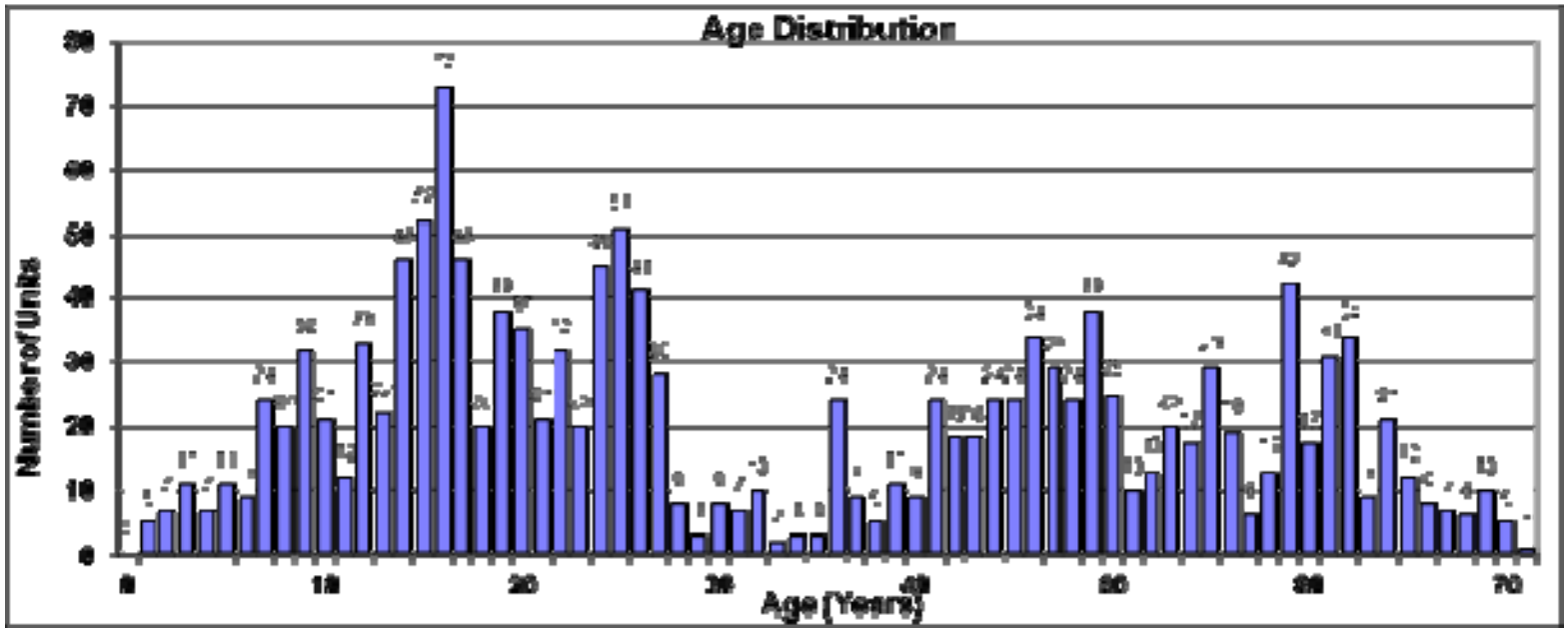
Type	4 kV	12 kV	34 kV	69 kV	138 kV	345 kV	765 kV	Total
Air Blast Breaker	-	-	-	-	-	8	-	8
Air Magnetic Breaker	785	1,719	-	-	-	-	-	2,504
Oil Breaker	-	-	434	104	409	158	-	1,105
Oil Distribution Breaker	671	770	-	-	-	-	-	1,441
SF_6 Puffer Breaker	-	-	233	14	429	188	9	873
SF_6 Two Press Breaker	-	-	-	-	-	-	-	0
Vacuum Breaker	35	356	19	-	-	-	-	410
Vacuum Switchgear Breaker	396	2,545	114	-	-	-	-	3,055
Single Phase Oil Recloser	5	3	-	-	-	-	-	8
Three Phase Oil Recloser	1	45	-	-	-	-	-	46
Single Phase Vacuum Recloser	39	92	-	-	-	-	-	131
Three Phase Vacuum Recloser	17	829	2	-	-	-	-	848

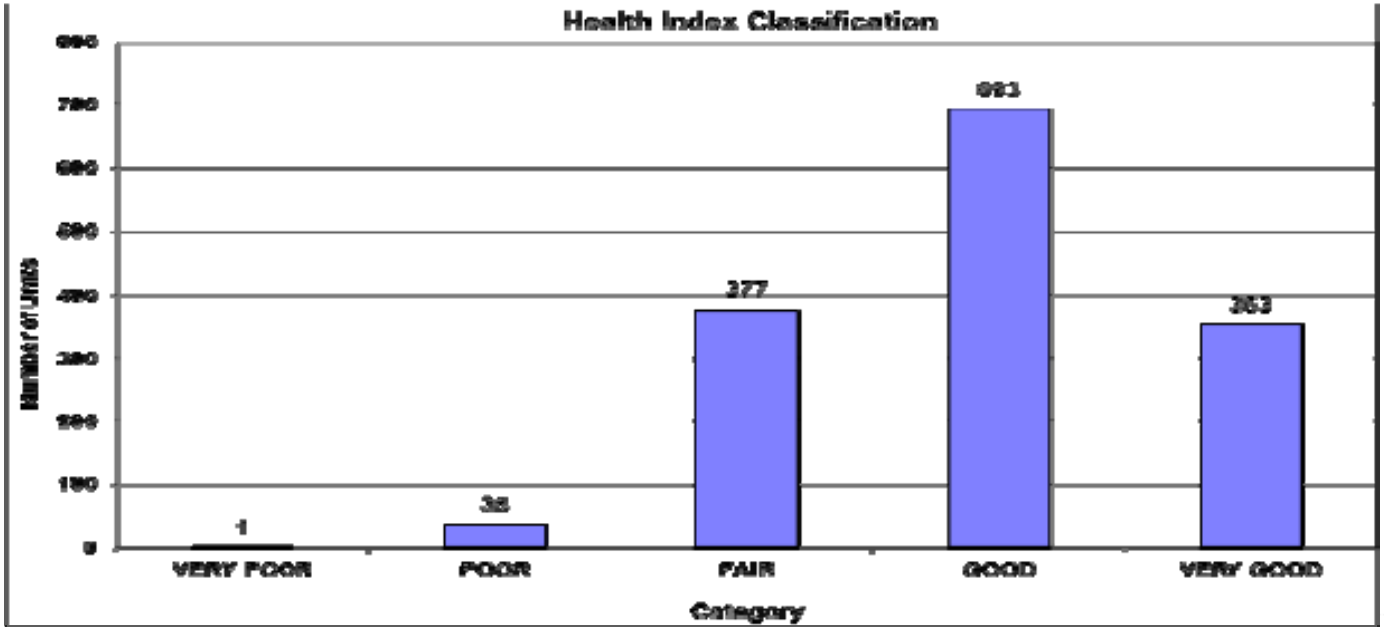
20MVA and larger transformers failure by age



*Data from 2000 - 2015

LTC Transformers (20-75MVA)





Illinois Senate Bill 1585 Amendment

Illinois utilities must be able to accommodate the following:

Renewable Energy Requirement of ComEd's Load by June 1st of each year

2017	**13.0%**
2018	**14.5%**
2019	**16.0%**
2020	**17.5%**
2021	**19.0%**
2022	**20.5%**
2023	**22.0%**
2024	**23.5%**
2025	**25.0%**

By May 31, 2017 the % of total renewable energy must be:
75% Wind, 6% PV, 1% DG

After June 1, 2017 the total % of renewable energy must be a combined 75% of Wind and PV, with "new" MWh requirements. The other 25% shall not be subject to requirements

NEW WIND AND PV REQUIREMENT

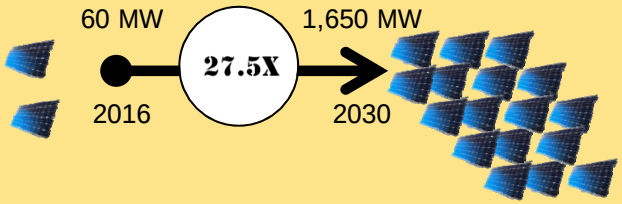
Year	MWh of new Wind	MWh of new PV
2021	**2,000,000**	**2,000,000**
2026	**3,000,000**	**3,000,000**
2031	**4,000,000**	**4,000,000**

* "new" generation means renewable energy project energized after June 1, 2017

RENEWABLE ENERGY SOURCES:
Wind, Solar Thermal Energy, Photovoltaic Cells/Panels, Biodiesel, Anaerobic Digestion, Crops & Organic Waste Biomass, Tree Waste, Hydropower

Assumptions

Illinois Next Generation Energy Plan
Forecasted Impact on ComEd Grid



27.5X increase in Solar DER expected to be connected to ComEd Distribution System by 2030

Strategic Assumptions

Location	Criteria for optimal DER location: • Minimal existing grid impact • DER lowers net cost to customers • DER lowers GHG emissions • DER improves Safety & Reliability Criteria for DER allocation methodology: • Identify type of ComEd customer that adopts DER based on economic potential & interest • Establish inventory of those customers across individual circuits • Allocate quantity of DERs to distinct circuits in proportion to customers w/DER potential
Growth	Assume net affect DER on load growth is minimal since some DER reduces load (storage, solar) and some add load (storage, EV)
Operations	Assume bi-direction current flow will exists on any feeder/substation bus w/DER Assume shifted/unpredictable peak demand due to energy storage Fact: DER hosting capacity is a function of resistance on any circuit Fact: DER hosting capacity increases w/nominal voltage

Assumptions

Operational Assumptions

Communications	• Required to provide safe & secure coverage of grid automated devices • Must be able to support transfer of large amounts of system data • Must allow integration of existing equipment (DA) w/new technology (smart inverters, smart fault indicators) • Utility must be able to track & interact w/DERs to allow operators to react/respond w/actual dispatchable resources; protection schemes must be able to alleviate islanding scenarios by interacting w/DERs ***Estimated Investment Impact: Evaluate expanding existing radio and fiber communication infrastructure or deploying newer technology system to support DER control***
Voltage Control	• Improved voltage control essential to maintain grid reliability & mandated voltage levels ***Estimated Investment Impact: System-wide CVR implementation with/smart distribution capacitors and smart LTC controllers***
Grid Stability	• Circuit investments driven by planning criteria modifications that include mainline reinforcements, conductor/equipment upgrades and 4kV conversion projects • TRs, fuses and substation breakers may require upgrades based on expected DER deployment studies ***Estimated Investment Impact: Upgrade overhead & underground mainlines and substations equipment for DER hosting capacity expansion, convert 4kV to 12kV in projected high-DER penetration locations***
Relays	• Substation bus/feeder/Mid-circuit recloser relays must protect for bi-directional powerflow going forward • Distribution feeder/line reclosing modifications to ensure coordination with DERs ***Estimated Investment Impact: Upgrade protection schemes (DA, feeder, and bus) for projected high-DER penetration locations***
Fault Indicators, Power Quality & Automated Switches	• All fault indicators must be replaced w/bi-directional and smart devices • Additional automated switches are required to enhance grid telemetry to track & manage impact of DERs on grid (high-DER locations may require automated switches on fused taps) ***Estimated Investment Impact: Pilot & install smart fault indicators in projected high-DER penetration locations; replace tapped fuses with automated switches***

Assumptions

Operational Assumptions

Cyber Security	• Secure communications must be used and cyber security capabilities must detect, isolate and reroute as needed • Customer smart invertors must conform to latest cybersecurity standards ***Estimated Investment Impact: IT applications must support latest applicable cyber security standards; potential introduction of new O&M costs to maintain system***
Metrics & Reliability Reporting	• CAIDI, SAIFI, and MAIFI will need to be viewed differently ***Estimated Investment Impact: Limited impact however reliability report will require modifications to accurately reflect utility performance and customer impact due to DER***
Premier Customer Experience Enhancements, Data, Analysis & Software Tools	• Premier Customer Experience enhancements that include: o Customer/Utility information sharing portal w/maps showing DER hosting capacity & locations where EV charging stations will have fewest grid impact o Customer DER application tool to support quick & efficient interconnection enrollment and processing • More accurate forecasting into DER impact must be accounted for in distribution planning process • Grid operations must have insight into distribution line load flow analysis and methods to intercede (remote control) to maintain reliable energy delivery • Back office engineering must analyze grid & identify issues w/DA & substation schemes due to DER ***Estimated Investment Impact: Customer-facing software tools & apps required, distribution planning tool enhancements***
Other Process Improvements	• DER project completion status must integrated into ComEd mapping and planning tools ***Estimated Investment Impact: Evaluate CEGIS to determine if application provides functionality for tracking customer DER project status or identify comparable solution***
People Strategy	• Distribution system will require enhanced level of operation awareness: dispatchers, field personnel, and back office engineering will require new skillsets to operate & analyze system ***Estimated Investment Impact: Training on new tools, potential staffing enhancements to manage and analyze distribution system***

Key Investments

- **Strategy for Investment Prioritization**
  - DER Enablers
    - *Communications Infrastructure & Backbone*
    - *Smart Voltage Control/CVR*
    - *Modern Relay Upgrades*
    - *Software/IT Solutions*
      - *Data sharing portal for DER hosting capacity*
      - *Interconnection enrollment & processing website*
      - *Distribution planning tools that include DER forecasting*
      - *DMS Controller*
  - DER Location Fortifiers
    - *Mainline Cable/Conductor upgrades*
    - *4kV → 12kV Conversions*
    - *Automated Switch Installations*
    - *Fault Indicator Replacement/Installation*
    - *Energy Storage Devices*
    - *Microgrids*
  - Reliability Improvements
    - *Substation TR and CB upgrades/replacements*