Our Company:
- One of six utilities owned by Exelon. (Exelon also owns generation and energy sales businesses.)
- 6,400 Employees
- Service Territory: 11,428 square miles

Our Customers:
- 4 million customers in northern Illinois, including the City of Chicago

Our Grid:
- Peak Load: 23,753 MW (7/20/2011)
- 553,800 distribution transformers
- 66,200 circuit miles of primary distribution
- 53% overhead, 43% underground
- 5,800 circuit miles of transmission
- 93% overhead, 7% underground
Changing Challenges: Climate and Security

Electric utilities typically focus on reliability, or assuring that there is adequate supply under credible contingencies.

In recent years, there is more emphasis on the resilience of the electric grid:
- Greater numbers and impact of major weather events
- Increased salience of physical and cyber-terrorism against energy infrastructure

Broadly speaking, reliability focuses on high-frequency, low-impact events. Resiliency deals with low-frequency, high-impact events.

Resilience: The ability to prepare for, withstand, recover from and reduce the magnitude and/or duration of disruptive events, which includes the capability to prepare for, absorb, adapt to, and/or rapidly recover from such an event.

Source: NOAA
Identify Microgrid Locations to Improve Resilience

- ComEd utilized a holistic data driven approach to evaluate its entire service territory for microgrid pilot installation locations. The approach considered three key drivers:
  - Power delivery infrastructure scope
  - Critical infrastructure
  - Input from external stakeholders

- The approach divided the service territory into one-mile by one-mile sections outside the city of Chicago and into half-mile by half-mile sections inside the city of Chicago.

- In the selection process, ComEd leveraged its partnerships with governmental organizations including the Department of Energy (DOE), Department of Homeland Security (DHS), Illinois Emergency Management Agency (IEMA), and City of Chicago Office of Emergency Management and Communications (OEMC).
The Bronzeville Community Microgrid enables a green, resilient, sustainable neighborhood for consumers.
- 7 MW aggregate load, serving approximately 1,000 residences, businesses and public institutions
- Installation of first utility-operated microgrid cluster powered by DER including solar PV and energy storage
- Demonstration of advanced technologies supported by six grants from the Department of Energy
- These technologies have been developed with partnerships with universities, vendors, and national labs
Installing a Microgrid in Chicago

Green - Dearborn Homes
Blue - IIT
Red - BCM Footprint
Yellow – Phase I Solar Boundary
Demonstrating Cutting-Edge Technologies

- **DOE awarded $4M** to support the use of solar PV, Battery Energy Storage System, smart inverters and microgrid master controller to demonstrate microgrid integrated solar storage technology (MISST)
- **SHINES Project**
- **DOE grant to develop and deploy a foundational blockchain technology** based energy internet and demand response applications
- **Blockchain Technology**
- **DOE grant** to develop and deploy a foundational blockchain technology which will provide coordinated control of different components as well as clustering capabilities.
- **Microgrid Master Controller**
- **Awarded $1.5M from DOE** to develop sensors with advanced features to support DER penetration: Sensors with Intelligent Measurement Platform and Low-Cost Equipment (SIMPLE)
- **SIMPLE**
- **Exploring different applications of distribution PMUs including Distribution Linear State Estimation** to enhance situation awareness as well as system resiliency
- **Distribution Linear State Estimation**
- **High speed fiber-optic communications requirement for distribution applications**
- **PMU**
- **Line Sensors and Predictive Analysis**
- **Communication Assisted DA Schemes**
- **Upgrading communication and increase the number of Distribution Automation (DA) devices to improve grid reliability**
- **Higher speed fiber-optic communications requirement for distribution applications**
- **Material and construction standards for distribution applications**
- **Phasor Measurement Units (PMU) on the distribution system** to provide real-time monitoring and enhanced visibility for operation and analysis
- **Upgrade and increase the number of Distribution Automation (DA) devices to improve grid reliability**
- **Provide real time monitoring** on circuits to decrease CAIDI through the rapid identification of fault location and to reduce patrol time after fault events
Supporting Solar and Storage with SHINES

- $8 million project with $4 Million DOE grant (SHINES). Development and demonstration of integrated, scalable, and cost-effective technologies for solar PV that incorporate energy storage in a microgrid
- Advanced smart inverter technology was tested using PHIL
- Enhanced microgrid controller with solar-storage control was tested with the BCM model

Multi-time scale model
- The model considers the sub-hourly variation of the PV outputs to handle the rapid changes

Robust modelling
- The model considers all possible scenarios to mitigate the forecasting error or uncertainty

Constant hourly aggregated solar-storage output
- The output of the solar-storage system in the proposed model will remain unchanged on an hourly basis even if the PV unit outputs deviate from the forecasted values.

Solar-storage controller high-level architecture
Microgrid Master Controller Architecture

- DOE awarded $1.2 million to ComEd and its partners to develop and test a commercial-grade microgrid controller capable of managing two or more clustered microgrids.
- The MMC utilizes a hierarchical control strategy to ensure reliable and economic operation of the microgrid.
Integrated HIL for Testing Inverter and Controller

PHIL

Communication between MMC and MGMS

Battery Node Vref

CHIL
Advanced Model for Testing Emerging Technology

- Advance modeling capability for hardware in the loop (HIL) test on emerging technology.

NOTES:
1. The vendor and the model number is TBD.
2. 3V represents 3 voltage channels.
3. Comm. interface may need to be adapted.
4. Further details are needed from the vendor.
5. The device model number should be confirmed with the vendor.
6. The MODBUS connection from the DER RTACs to the RTDS is tentative.
7. Each SEL-751 has a separate connection to the RTDS through separate amplifiers.

LEGEND:
- Voltage/Current Amplifier
- Analog output (Low-voltage)
- Secondary voltage/current (out of amplifier)
- Digital I/O
- DNP Ethernet
- Modbus Ethernet
- Voltage/Current Amplifier
- AMP

SCH成本

DNP NET MODBUS 1
DNP NET MODBUS 2
DNP NET MODBUS 3
DNP NET DNP

RTDS
BCM Model

NOTES:
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2. 3V represents 3 voltage channels.
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- Modbus Ethernet
Bronzeville Solar Panels

750 kw of solar PV is being installed on the Dearborn Homes in Chicago.

500 kW/ 2 MWh of battery energy storage has been installed in the BCM.
Simulated Islanding Test

- Simulated islanding on portion of the BCM feeder using portable generation, PV and BESS in preparation for actual island test later in 2019
- Controllable generation is used to maintain the POI flow within the threshold.
- 500 kW battery used to zero out POI power while 2 MW generator used to offset load

Schematic diagram of the Phase 1 test system
ComEd has been granted 2 DOE grants to support penetration of electric vehicles in its service territory

1. Partnering with Virginia Tech to develop and implement a cyber-secure extreme fast charging (XFC) EV charging station within BCM

2. Partnering with Center for Sustainable Energy and the City of Chicago to support installations of EV Charging stations in the Bronzeville neighborhood, serving multi-unit dwellings and curbside residential charging.
Phasor Measurement Unit (PMU): Device that provides and transmits synchrophasor measurements
  - Time-synchronized measurements of voltages and currents representing magnitude, phase angle, and frequency
  - Sample rate is significantly higher than traditional SCADA methods.
Deploying distribution PMUs at substations and in BCM to enhance monitoring and situation awareness of the distribution grid
Exploring different applications of distribution PMUs including a demonstration of PMU based Distribution Linear State Estimation
Demonstrating Technologies in Advanced Labs

- Established Grid Integration and Technology lab with Hardware in the Loop (HIL) capabilities to test enabling technologies
- Control Hardware in the Loop (CHIL) and Power Hardware in the Loop (PHIL) tests through Real Time Digital Simulator (RTDS) provide close to actual system test bed to test and verify emerging technologies in a safe environment
# Metrics to Evaluate Impacts of the BCM

## Areas

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<th>Energy System Resilience</th>
<th>Critical Infrastructure Resilience</th>
<th>Community Resilience</th>
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## Indicators

- Power Delivery Resilience & Performance
- Energy Efficiency Performance
- Emissions Performance
- Reliable Communication & Mobility
- Continuity of Critical Services
- Critical Infrastructure Security
- Community Economic Resilience
- Community Health
- Community Livability and Safety

## Metrics

- Integrated Metrics