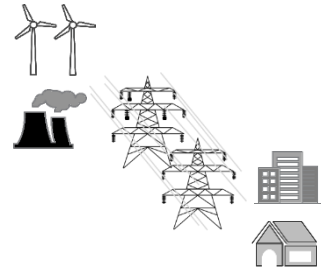


# Power System Fundamentals

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## E-Learning Module



# Power System Fundamentals

## MODULE OBJECTIVES:

- Identify the difference between Bulk Power Transmission vs. Distribution Systems
- Name Physical Components of NYCA Power System
- Explain the Purpose behind Operational Ancillary Services

# Bulk Power Transmission vs. Distribution vs. Retail Load

## ■ Bulk Power Transmission

- NYISO is responsible for controlling the transmission of power across the high-voltage transmission network, which is maintained by the Transmission Owners

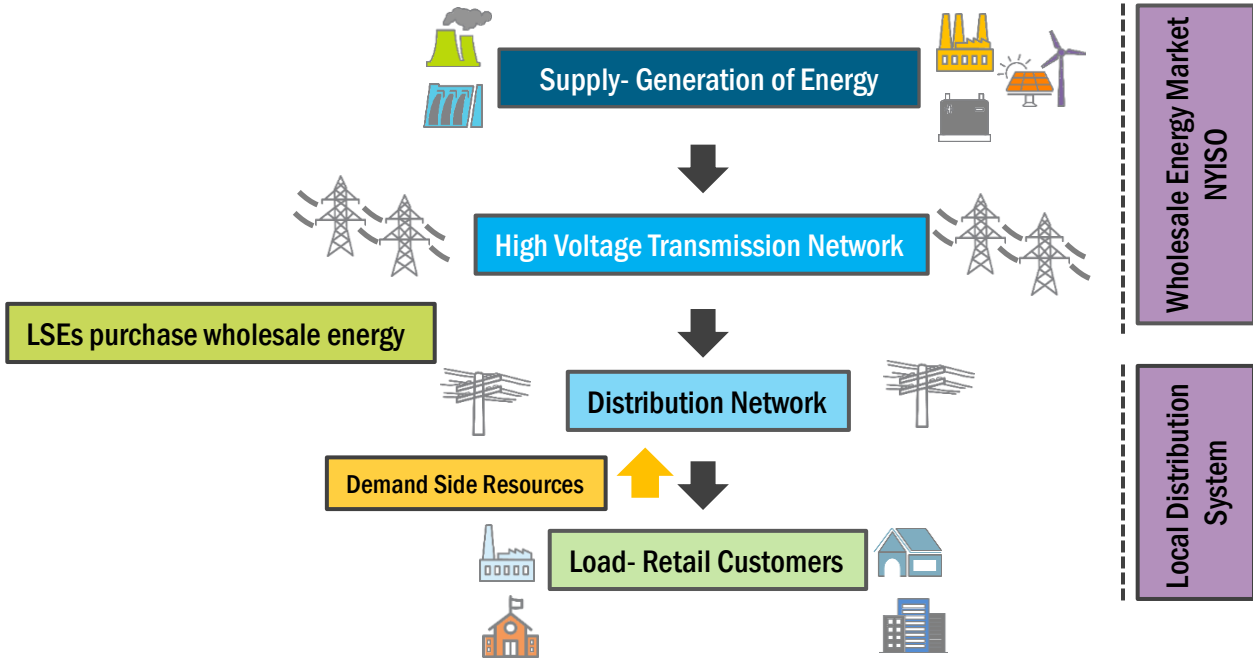
## ■ Distribution System

- Transmission Owners are responsible for distributing power across the lower voltage transmission network to consumers

## ■ Management of Retail Load Consumption

- Load Serving Entities buy power at the wholesale level to sell to consumers at the retail level

# Energy Production and Delivery



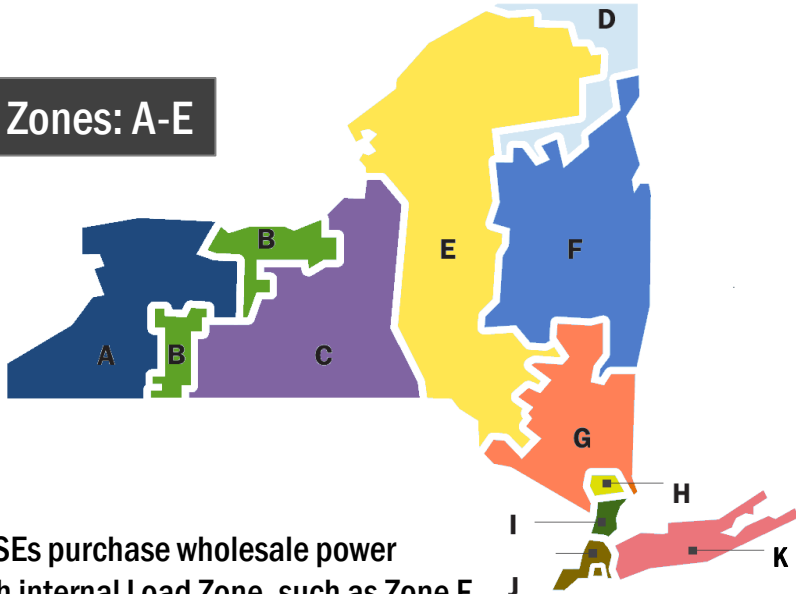
# The New York Control Area

# NYCA Power System

- NYCA Load Zones
- Neighboring Control Areas
- NYCA Transmission Owners

# New York Control Area Internal Load Zones

**Upstate Zones: A-E**

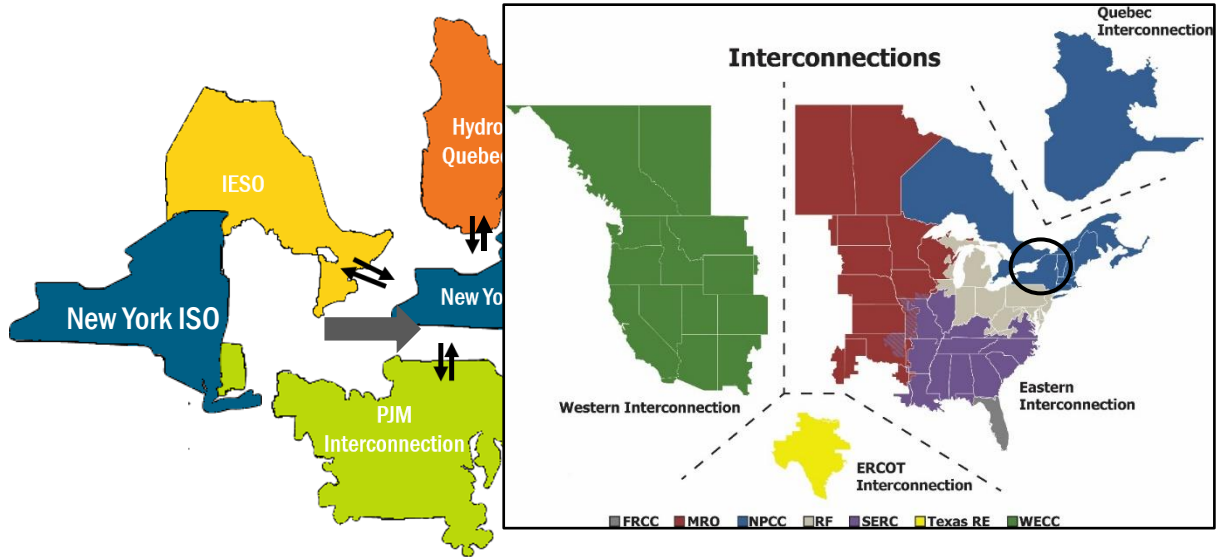


|   |               |
|---|---------------|
| A | West          |
| B | Genesee       |
| C | Central       |
| D | North         |
| E | Mohawk Valley |
| F | Capital       |
| G | Hudson Valley |
| H | Millwood      |
| I | Dunwoodie     |
| J | NYC           |
| K | Long Island   |

Multiple LSEs purchase wholesale power within each internal Load Zone, such as Zone F

**Downstate Zones: F-K**

# Neighboring Control Areas

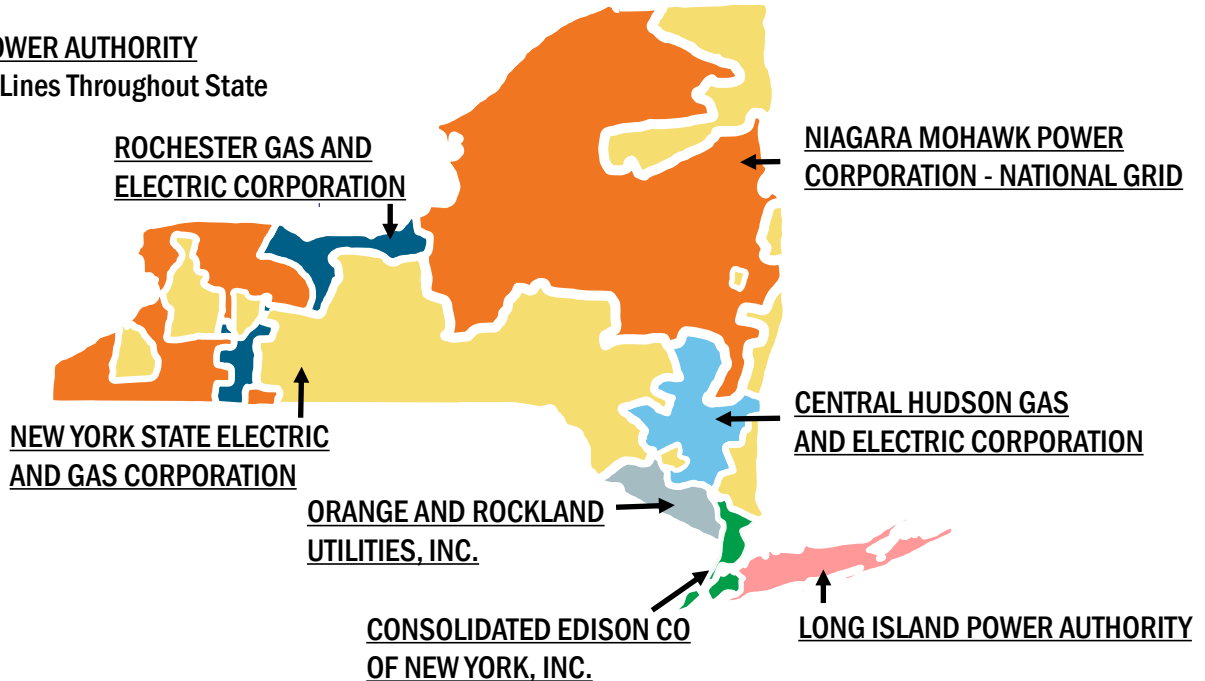




# NYCA TRANSMISSION OWNERS

## NEW YORK POWER AUTHORITY

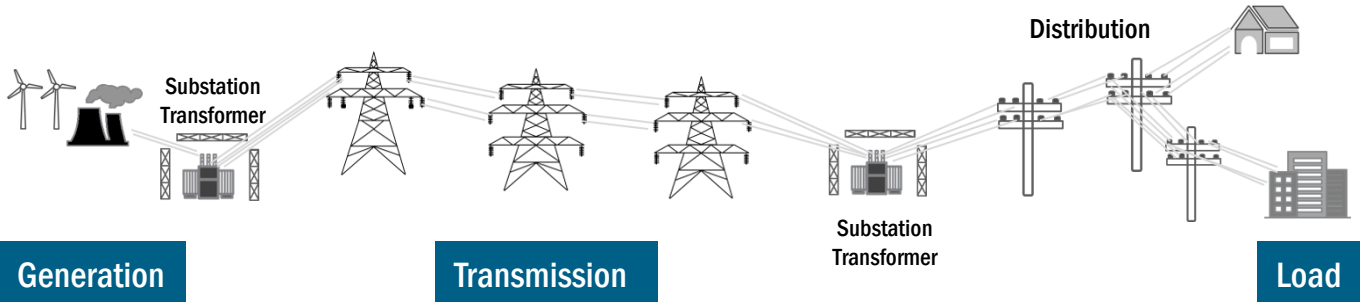
Transmission Lines Throughout State



# Physical Components of the NYCA Power System

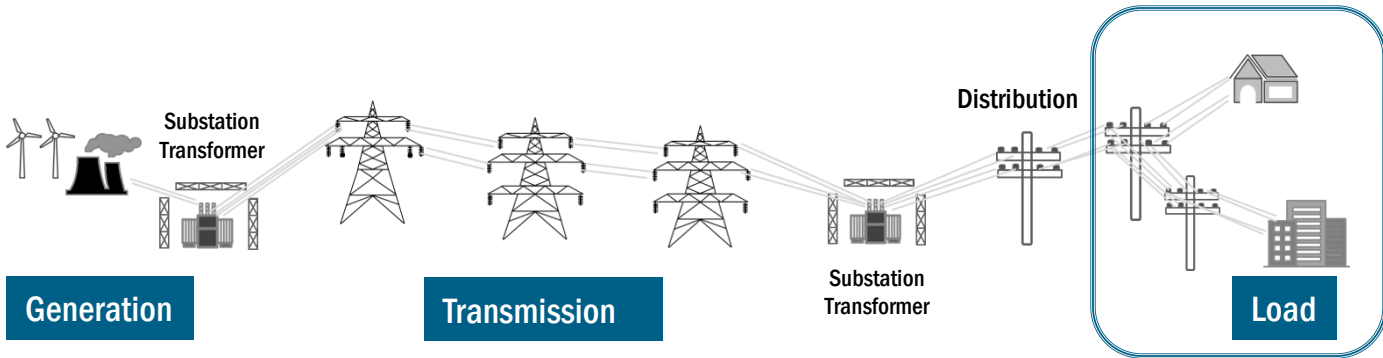
# Physical Components of NYCA Power System

- Load
- Generation
- Transmission

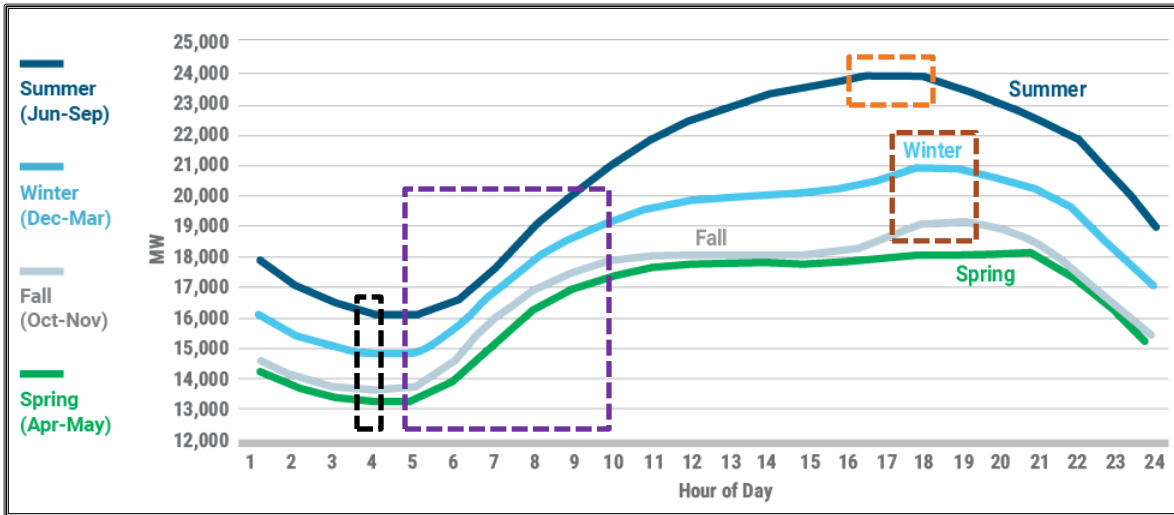


# Load

- Power consumed from NYCA Grid



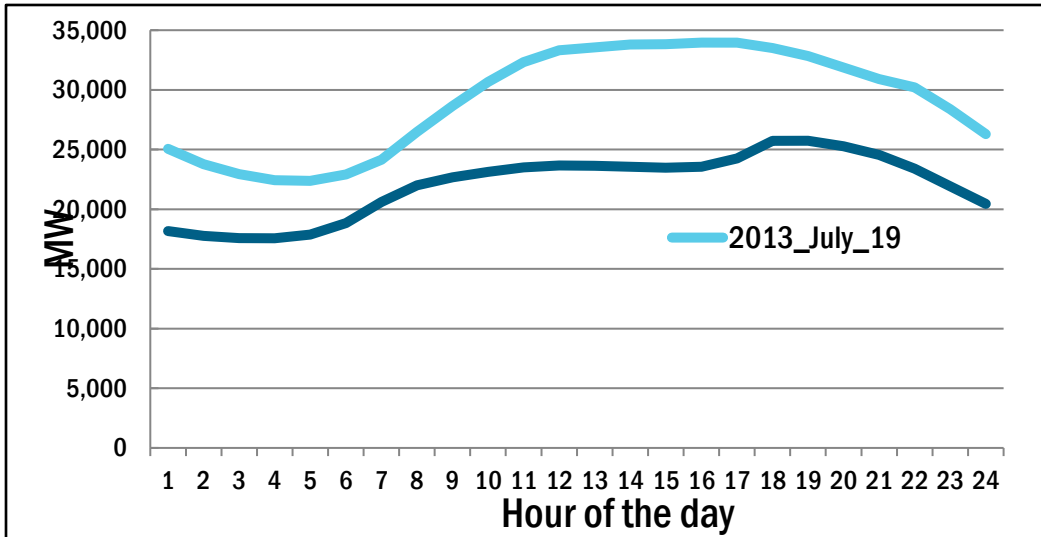
# Illustrative NYCA Load Profile – Seasonal and Hourly



-  Low Points
-  Morning Pickup
-  Summer Peak
-  Fall/Winter Peak

\*\*\*Seasonal Hourly Demand Patterns, Power Trends 2019

# NYCA Load Profile: Record Summer and Winter Peaks

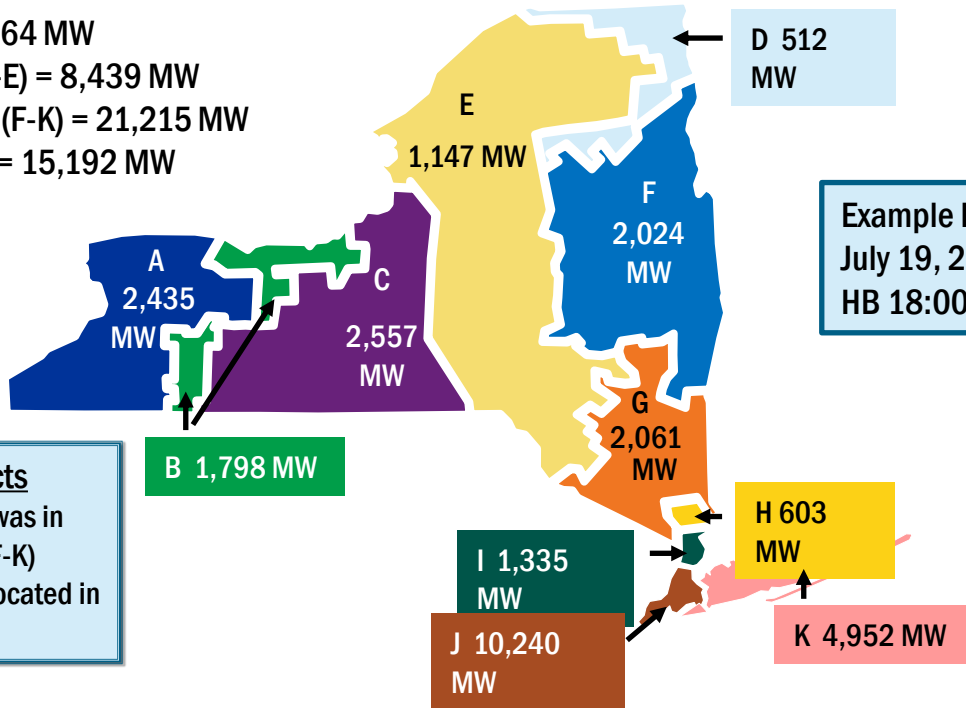


Record Summer Peak  
33,956 MW - 2013

Record Winter Peak  
25,738 MW - 2014

# Load Profile by NYCA Zones

Total Load = 29,664 MW  
 Upstate Zones (A-E) = 8,439 MW  
 Downstate Zones (F-K) = 21,215 MW  
 NYC and LI (J+K) = 15,192 MW



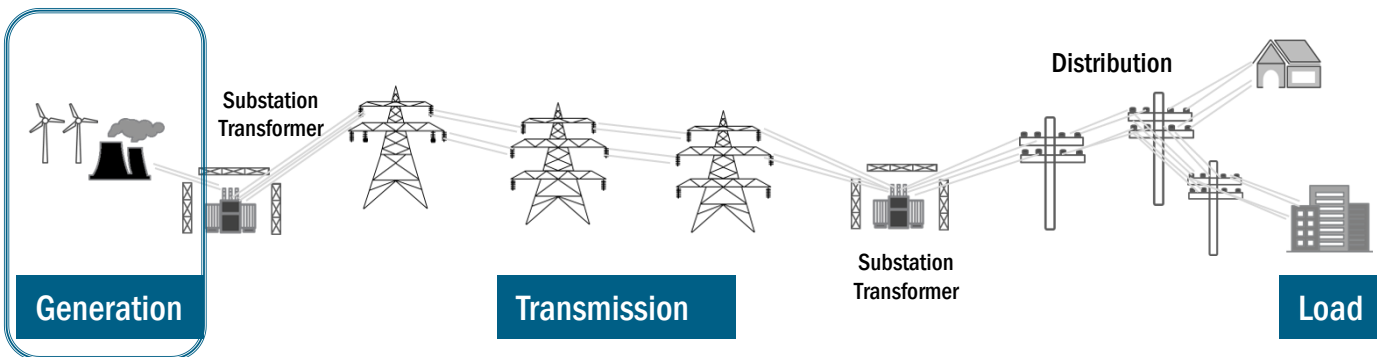
Example Hour:  
 July 19, 2017  
 HB 18:00

**Important Facts**

- 71.5% of the Load was in Downstate Zones (F-K)
- 51.2% of the load located in NYC & LI

# Generation

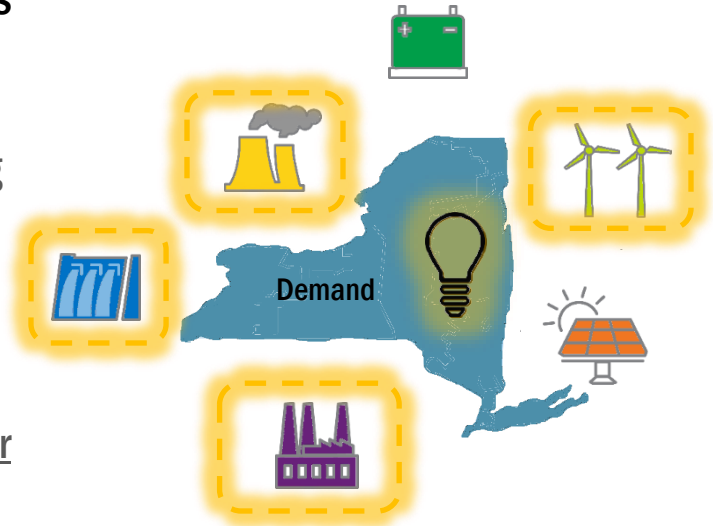
- Electrical energy for load consumption





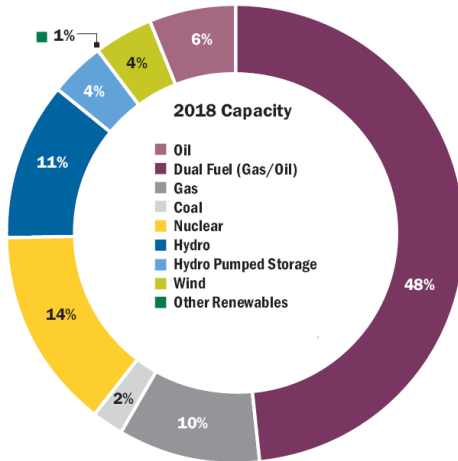
# Capacity vs. Energy

- Two very different commodities
- Capacity – *measured in MW*
  - Refers to the electric power output for which a generating system, plant, or unit is rated
  - Capability to produce power
- Energy – *measured in MWh*
  - Is the amount of energy produced (from capacity) over time

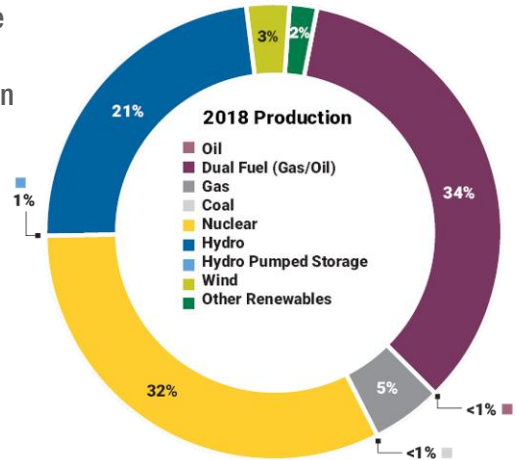


# Generating Capacity vs. Energy

New York Statewide Capacity by Fuel Source: 2018



New York Statewide Energy Production by Fuel Source: 2018

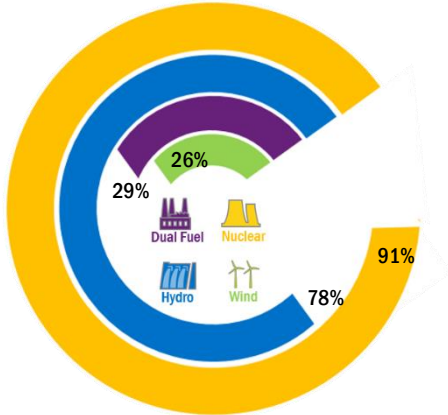


# Generating Capacity vs. Energy

**Capacity Factor: Ratio of Actual Generation to Maximum Generation Potential**

For one example hour in 2018,

|                | <u>Capacity</u>   | <u>Capacity Factor</u> | <u>Energy</u>     |
|----------------|-------------------|------------------------|-------------------|
| <b>Nuclear</b> | 14%<br>(5,402 MW) | 91%                    | 32%<br>(4,916 MW) |



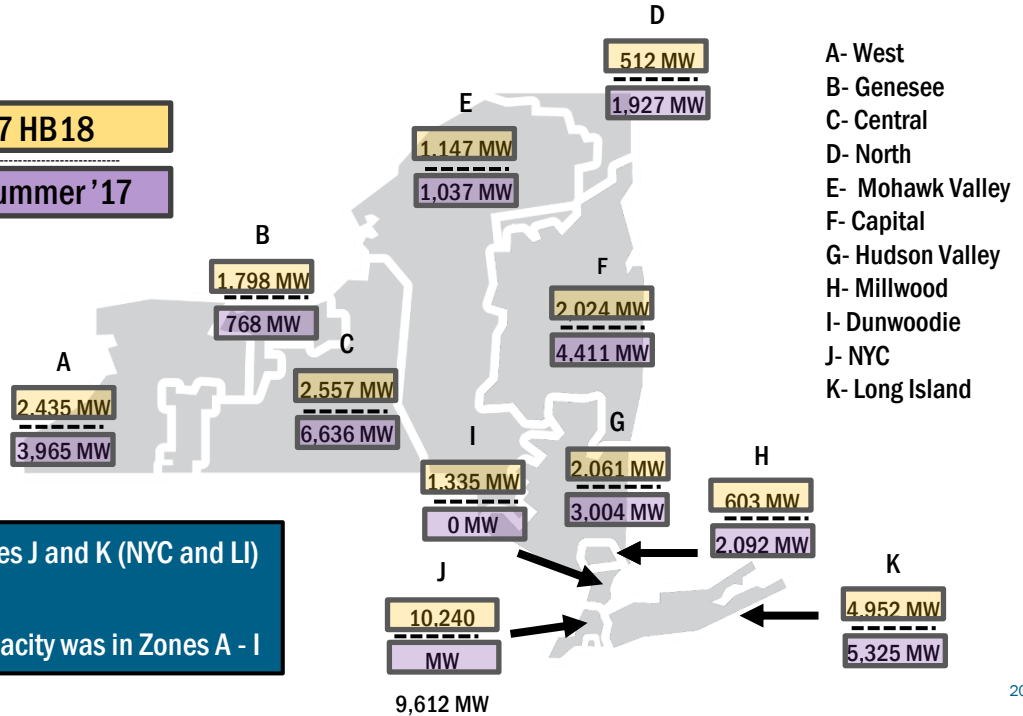
2018 Annual Capacity Factors

# NYCA Load vs. Generation

Representative day

**LOAD 7/19/17 HB18**

**GEN CAPACITY Summer '17**

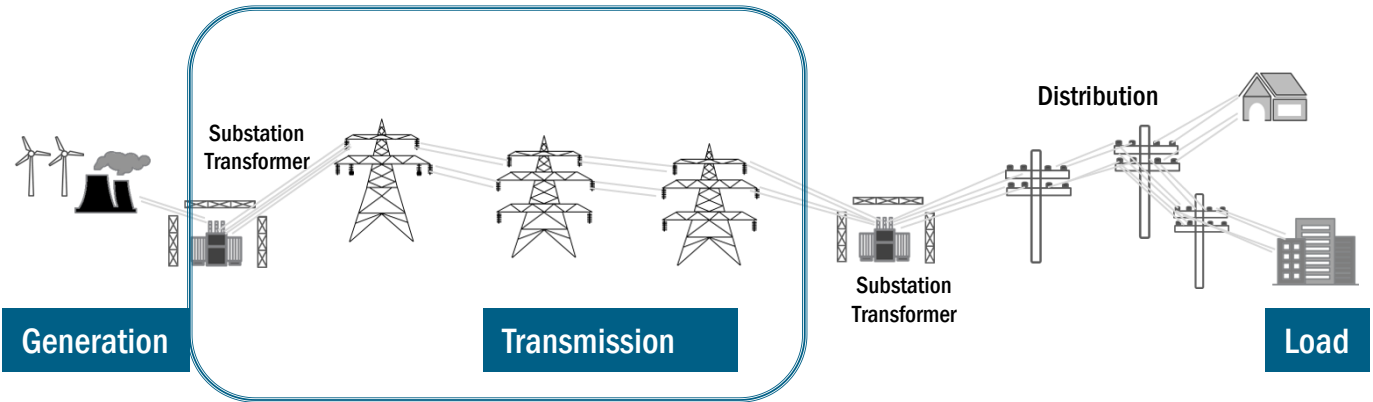


51% of NYCA load was in Zones J and K (NYC and LI)

62% of NYCA Generation Capacity was in Zones A - I

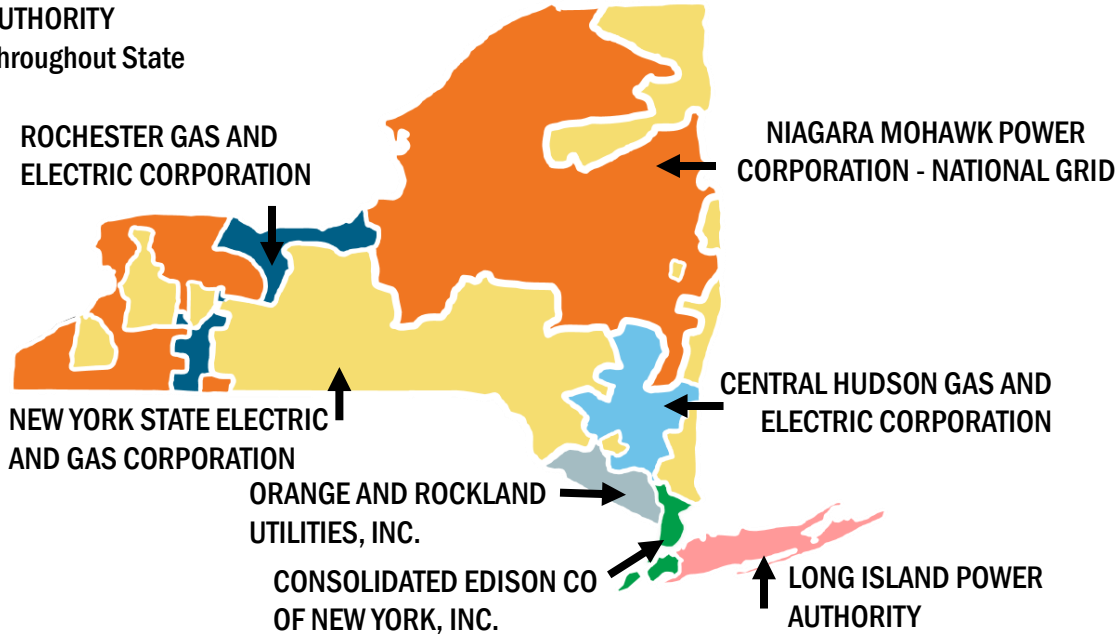
# Transmission

- Bulk transfer of electrical energy



# NYCA Transmission Owners

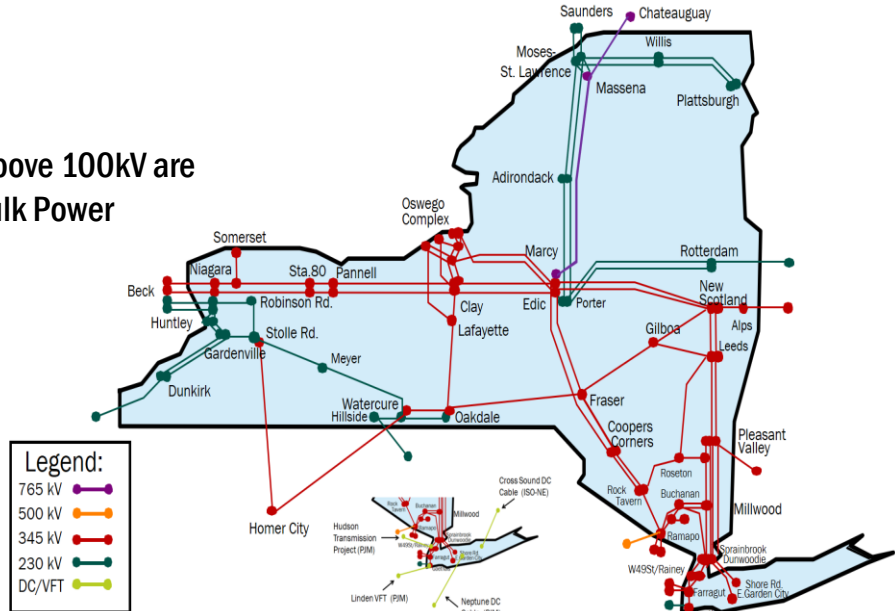
**NEW YORK POWER AUTHORITY**  
Transmission Lines Throughout State



# NYCA Transmission System

## Bulk Transmission

Note: All transmission lines above 100kV are now considered part of the Bulk Power System



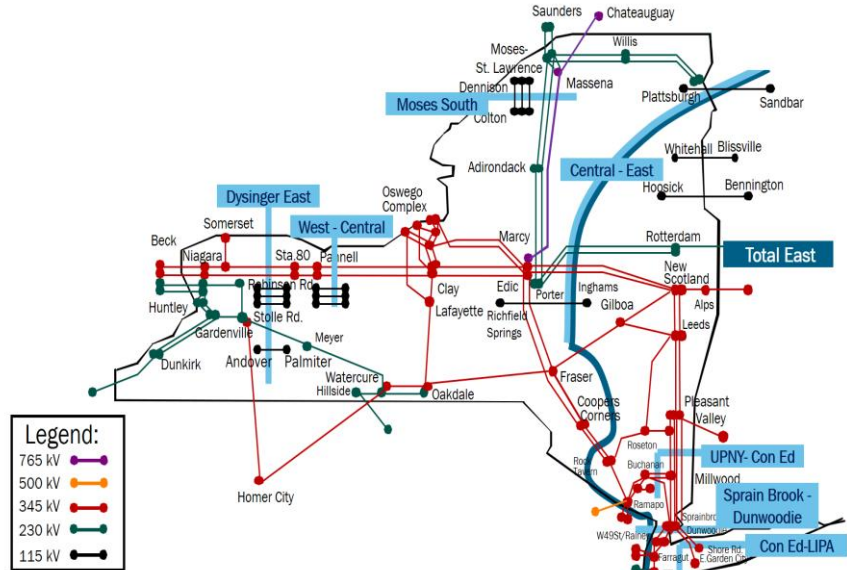
# Transmission Interfaces

- **Definition of Interface**
  - A defined set of transmission facilities that separate Load Zones and that separate the NYCA from the adjacent Control Areas
- **Internal Interface**
  - Obey transfer limitations across the internal interface to deliver generation to load within NYCA
- **External Interface**
  - Comply with transfer limitations across the external interface to import or export scheduled power transactions between RTO/ISOs



# NY Internal Transmission Interfaces

- Multiple transmission lines make up an interface
- Interface limits can create constraints on the flow of power
- Some interfaces are more impacting on the flow of power



\* Not all NYCA internal interfaces are shown

# Interface Transfer Limits

- Transfer limits create constraints on the flow of energy
- Types of Transfer Limits
  - Thermal Limits
  - Voltage Limits
  - Stability Limits

**Total Transfer Capability = Min(Thermal Limit, Voltage Limit, Stability Limit)**

- Real time transfer limits vary with system conditions and are posted at the 5 minute level, both positive and negative limits

# Operational Ancillary Services

# Operational Ancillary Services

Ancillary Services support the transmission of energy from generation resources to loads, while maintaining reliable operation of NYS Power System

Voltage Support Service

Regulation and Frequency  
Control

Operating Reserves

Black Start Service

# Voltage Support Service

Voltage: Force that moves electricity through transmission lines



Garden Hose: Transmission cable

Water flowing through hose: Electrical current flow

Water pressure: Voltage

↓ Water Pressure → ↓ Water flow

↓ Voltage → ↓ Electricity flow

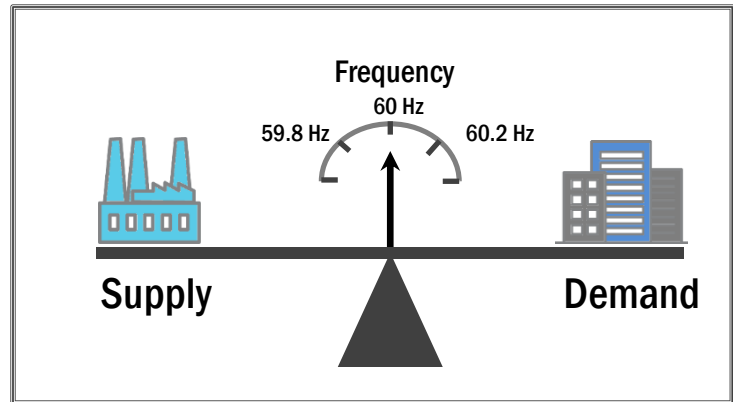
- Voltage Support is needed to:
  - Transfer power from the generation to the load
  - Prevent equipment damage from high voltages
  - Prevent voltage collapse during high load periods

# Voltage Support Service

- **System Voltage Control is a Continuous Process**
- **System Voltage Control is provided by the Voltage Support Service providers on a voluntary basis**
  - **Includes:**
    - **Generators**
    - **Synchronous Condensers**
    - **Static VAR Compensators**
    - **Shunt Capacitor banks**
    - **Static Compensators**
- **Transmission Owners (TO) are responsible for Local Control within their Network**

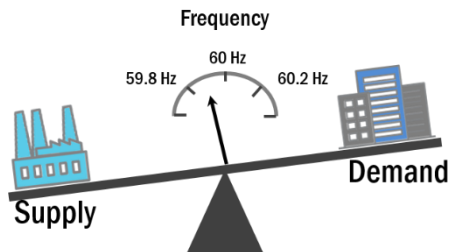
# Regulation and Frequency Control

- Regulation and Frequency control service
  - Is necessary for the continuous balancing of resources with load
  - Assists in maintaining scheduled Interconnection Frequency at 60 Hz

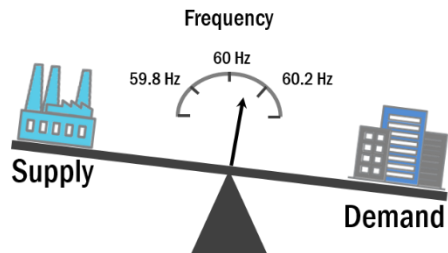


# Regulation and Frequency Control

## System Frequency Changes



Load Increases without Generation Increase



Generation Increases without Load Increase





# Operating Reserves

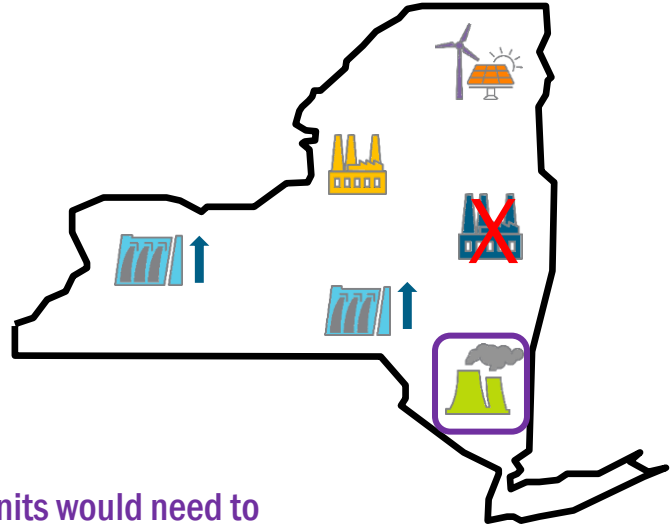
- **Backup Generation in the event of a System Contingency**
  - **NYSRC Total Operating Reserve Requirement:**
    - **Must Procure  $\geq$  to 1.5 x times the Largest Single Contingency (in MW)**
      - Largest Single Contingency is 1310 MWs
  - **NYISO Procures 2 x Largest Single Contingency**
    - **2 x 1310 = 2,620 MWs of Total Reserves each Market Day**
      - Regional/Locational Requirements
      - Time/Product Type Requirements

# Example: Operating Reserve Pickup

1. If there is a large and sudden loss of generation

2. The Operating Reserves being held for the Market Day would be dispatched to make up the shortfall

3. New reserve units would need to be selected to maintain Operating Reserves



# Black Start Service

- Generators capable of starting without an outside electric supply, following a system-wide blackout
- Identified by NYISO as part of the Restoration plan
- 14<sup>th</sup> August 2003 – Most recent use of Black Start units



# Summary – Power System Fundamentals

- NYISO Responsible for NYCA Bulk Power Operations
- Three Primary Components to Power System
  - Load, Generation, & Transmission
- Operational Ancillary Services in place to meet the following System Requirements:
  - Maintaining power transfer capability of the transmission system (Voltage Support)
  - Maintaining balance between Generation and Load (Regulation and Frequency Support)
  - Securing System for Contingencies & Constraints (Reserves)
  - System Restoration (Black Start Service)

# Additional Resources

- **Tariffs – MST and OATT**
- **Transmission & Dispatching Operations Manual**
- **Day Ahead Scheduling Manual**
- **Transmission Services Manual**
- **Ancillary Services Manual**
- **Market Participant User's Guide**
- **Technical Bulletins**

# Questions?

For any future assistance, please contact NYISO Stakeholder Services at [stakeholder\\_services@nyiso.com](mailto:stakeholder_services@nyiso.com) or by phone at (518) 356-6060