# Power System Elements

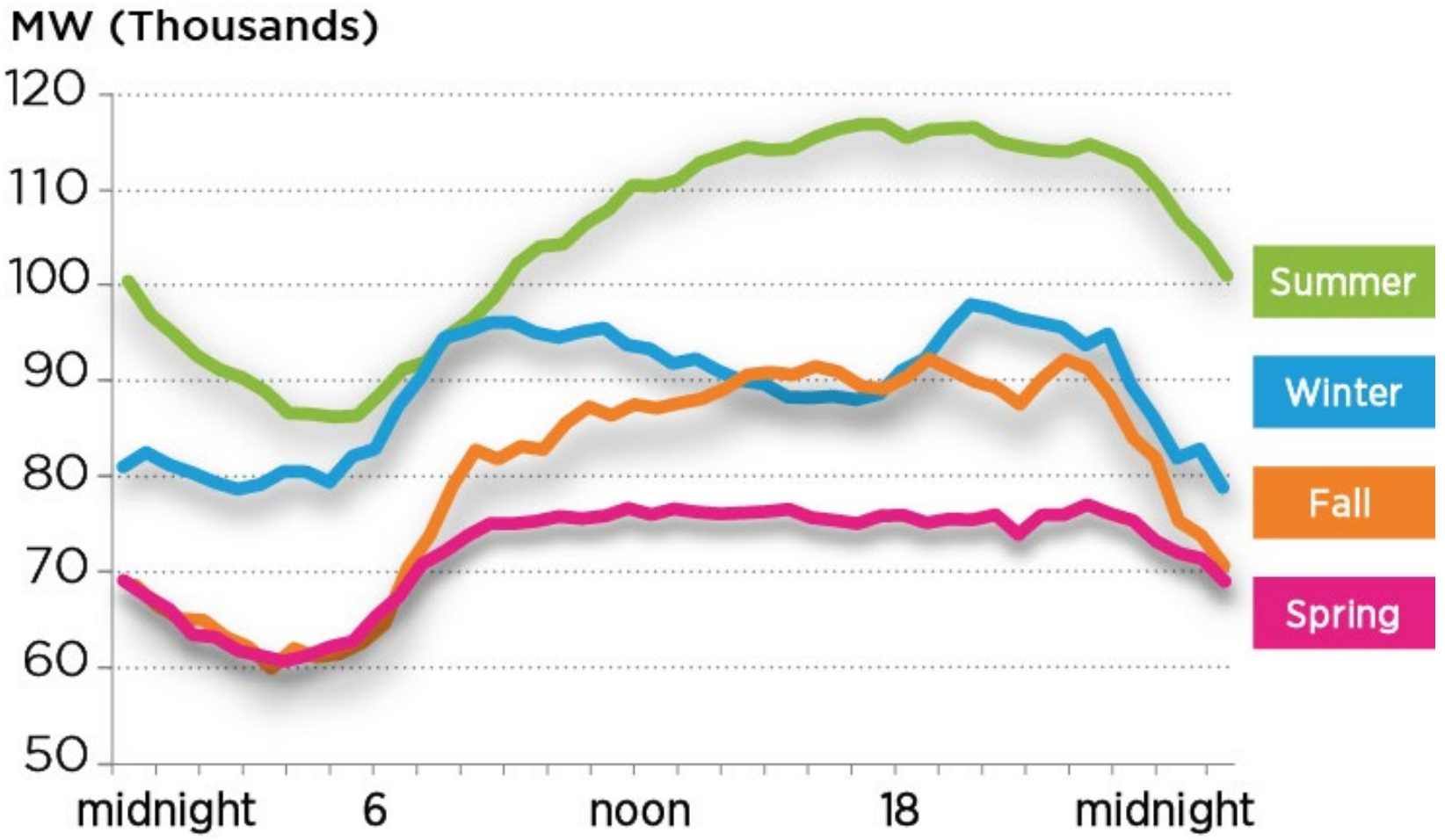
## System Loads

PJM State & Member Training Dept.

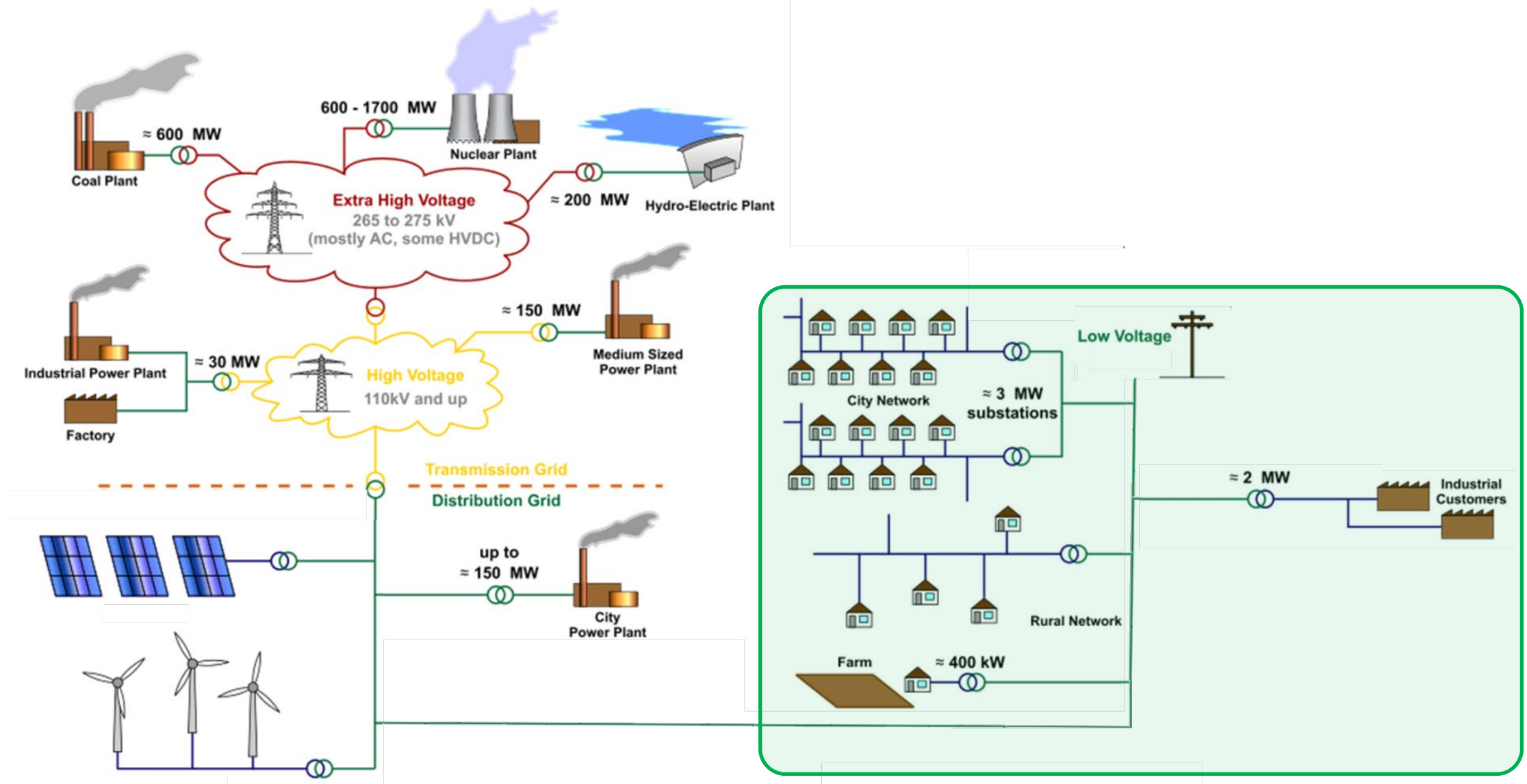
# Objectives

- Identify the different types of general load on the power system
- Describe the characteristics of non-motor load on the power system
- Describe the characteristics of the motor loads on the power system
- Describe the effects of changing voltage on the different load types

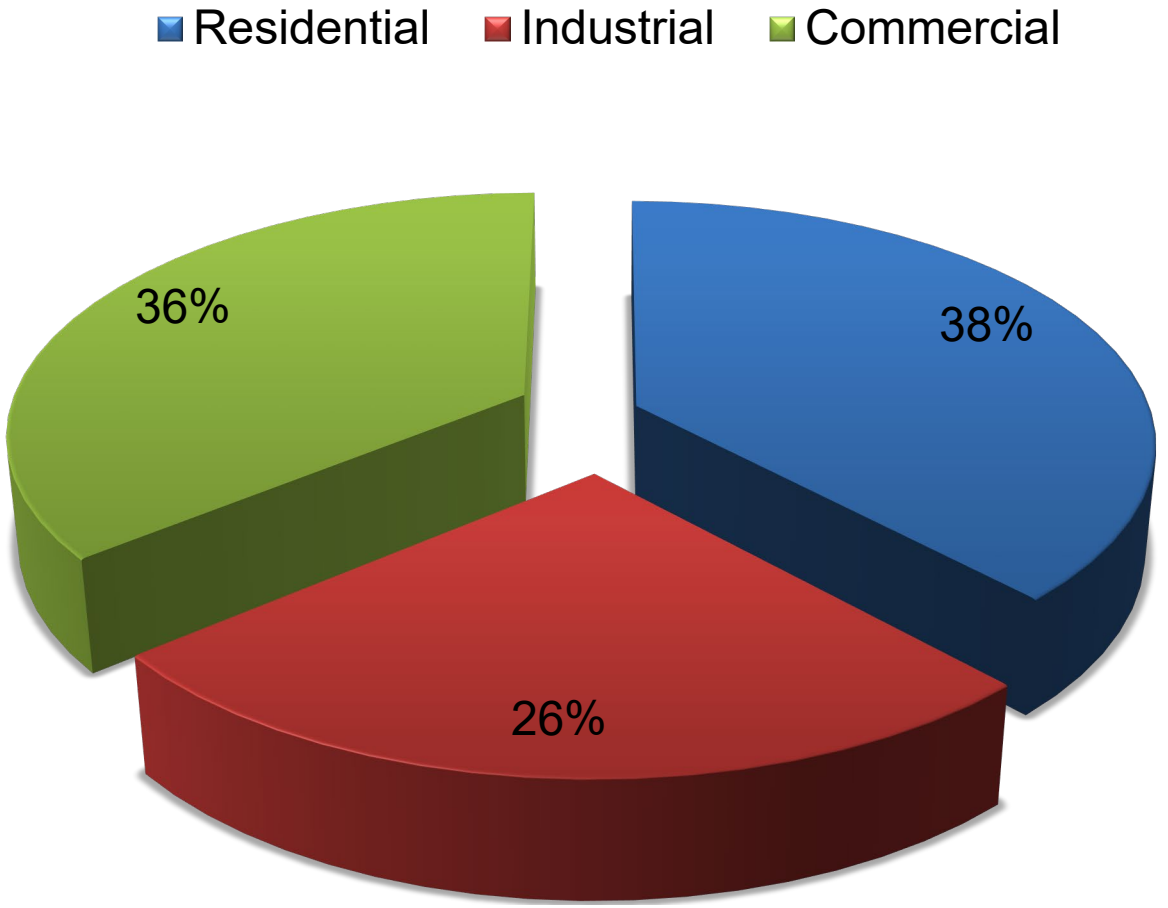
# Load Curves


MW (Thousands)
120
110
100
90
80
70
60
50
midnight
6
noon
18
midnight
Summer
Winter
Fall
Spring

# System Configuration

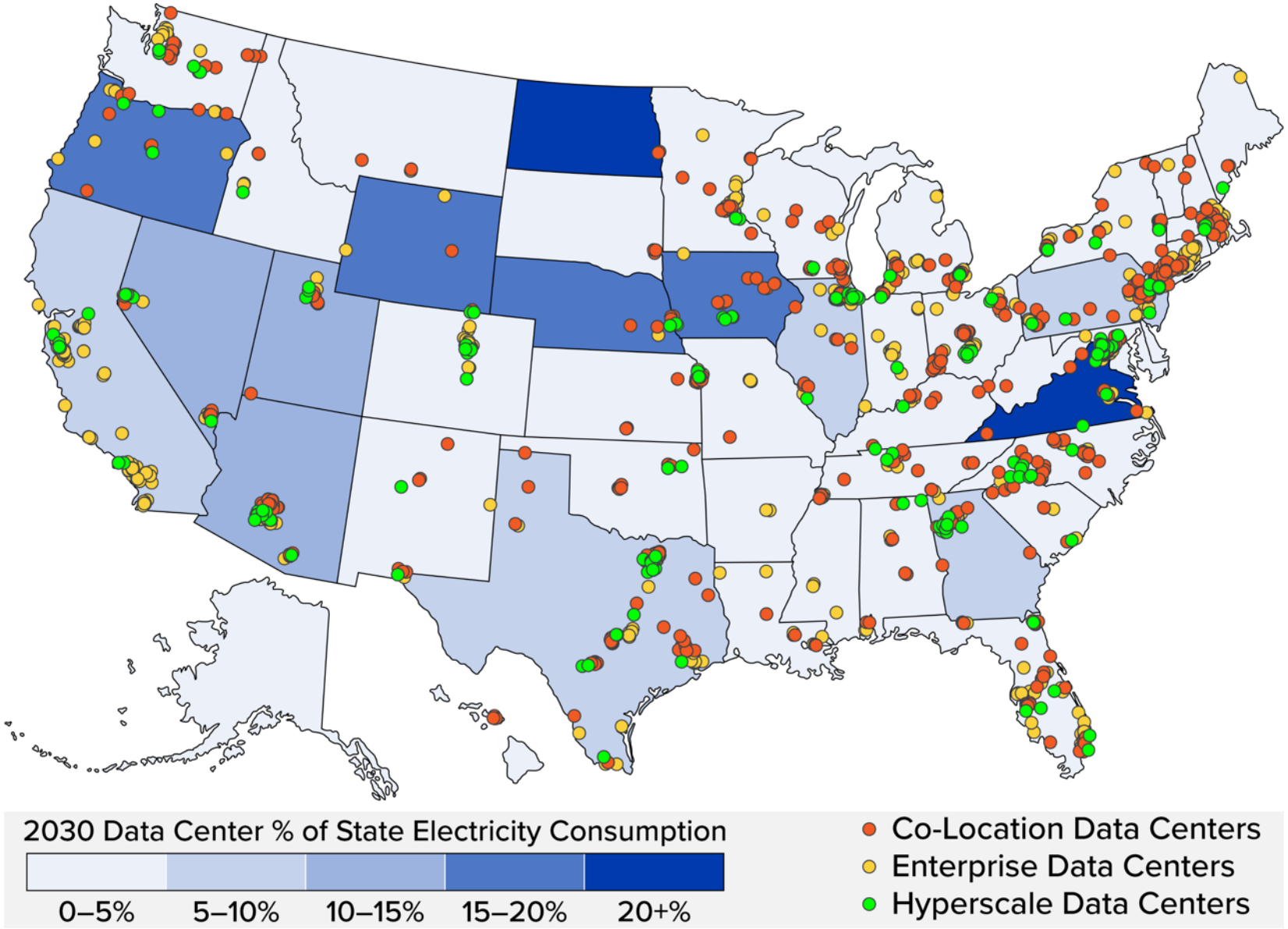


# PJM's Load Profile*




*load profile is the average across the RTO as of January 2023

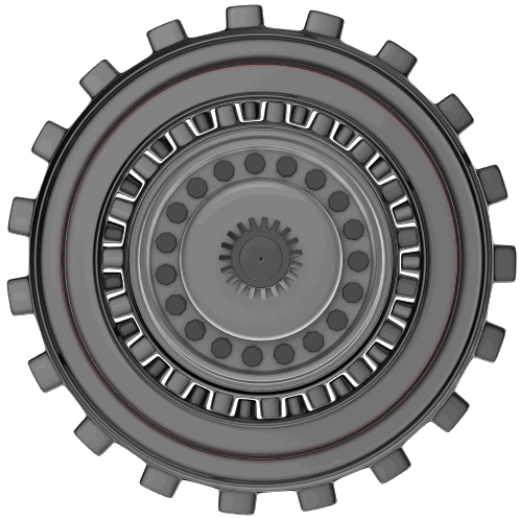
# Existing Data Centers and Projected 2030 Demand




Read the full report (3002028905)

# General Types of System Loads

- **Motors**
  - Induction
    - Most popular type
    - Air Conditioners, freezers, washers, fans, pumps, etc.
  - Synchronous



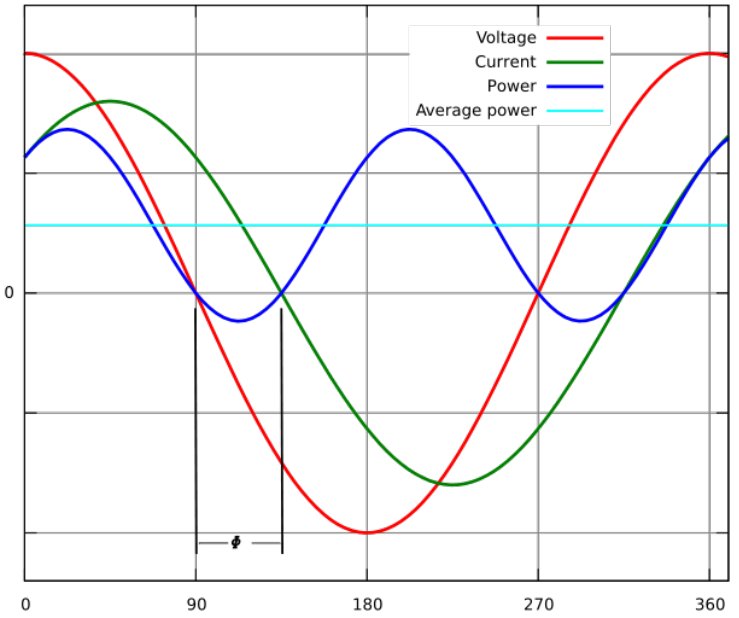
# General Types of System Loads

- **Non-Motor**
  - Lighting
    - Incandescent, fluorescent, etc.
  - Heating
    - Water heating, resistance heating. etc.

# Motor Load

Motor Load – makes up a large portion of total load **(typically 40% to 60%)**

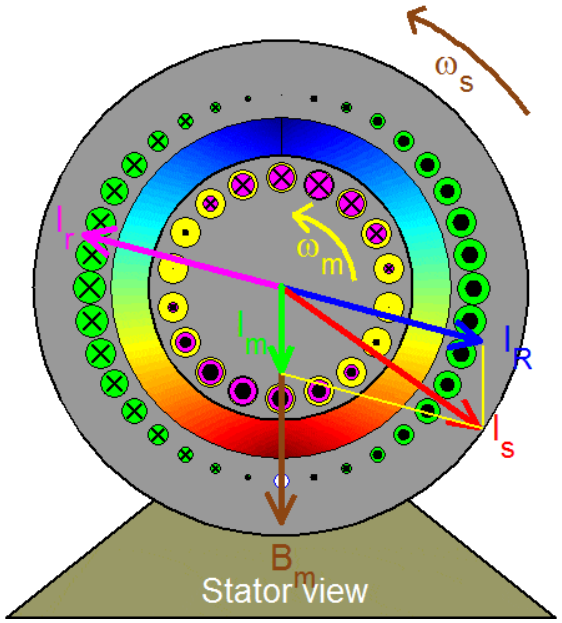
- Classified as **Constant Power Load**
- Often motors are of the induction type
- Favored due to simplicity and ruggedness
- Requires large amount of reactive power to start




http://www.overunityresearch.com

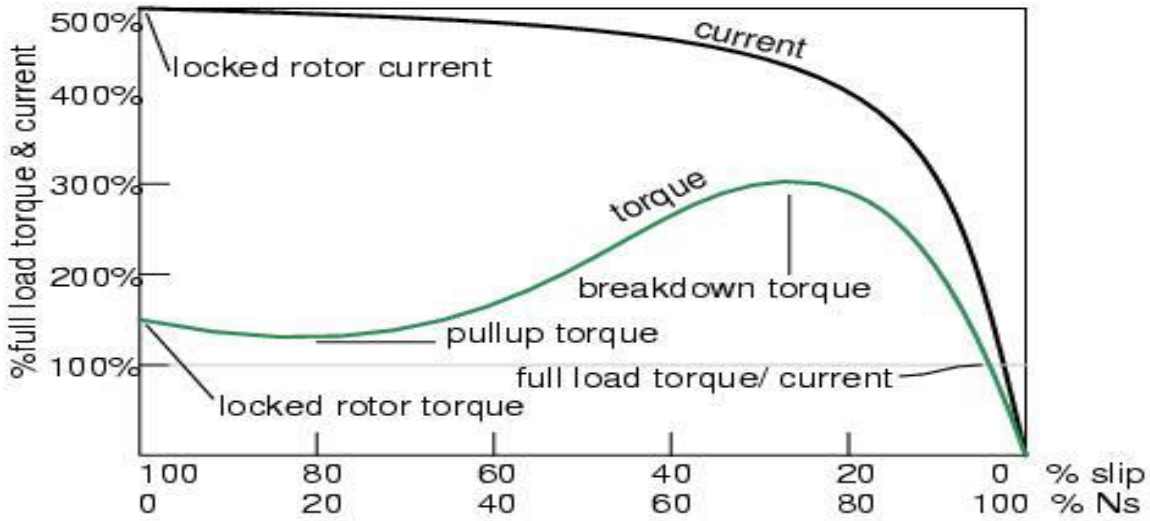
# Motors

- Stator windings are distributed around the stator
- Three-phase AC voltages are applied to the stator windings
- An electric current is induced in the rotor bars
- Magnetic field of the stator drags the rotor around
- Rotor falls behind or “slips” as the field rotates



# Characteristics of Motors

- Induction motors at rest appear just like a short circuited transformer
- Draws a very high current called **“Locked Rotor Current” (LRC)** when started
- The LRC of a motor can be as high as 500% of full load current (FLC)



# Characteristics of Motors

The current drawn by a motor has two components:

1. **Reactive (magnetizing current)** – dependent on stator voltage
   - Can vary from as low as 20% of FLC to as high as 60% of FLC
2. **Active (working current)** – directly proportional to the load

# Characteristics of Motors

- Motor load does not significantly vary with voltage magnitude
  - Tries to maintain the same power output as voltage drops
- If voltage drops to 80% or less of rated there is a chance motors will slow down or “stall”
- Combined reactive power draw of numerous stalled motors could prevent system voltage from recovering

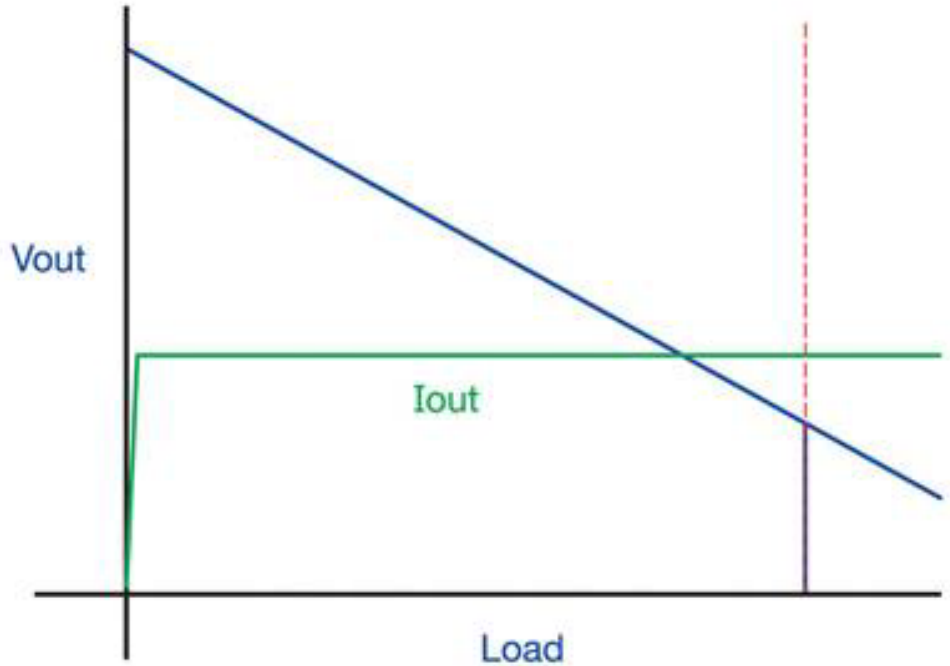
# Non-Motor Load

Load magnitude varies with voltage magnitude

- Two general classifications
  1. **Constant Current Load**
     - Varies directly with the voltage
  2. **Constant Resistance/Impedance Load**
     - Varies with the square of the voltage

# Non-Motor Load – Constant Current Load

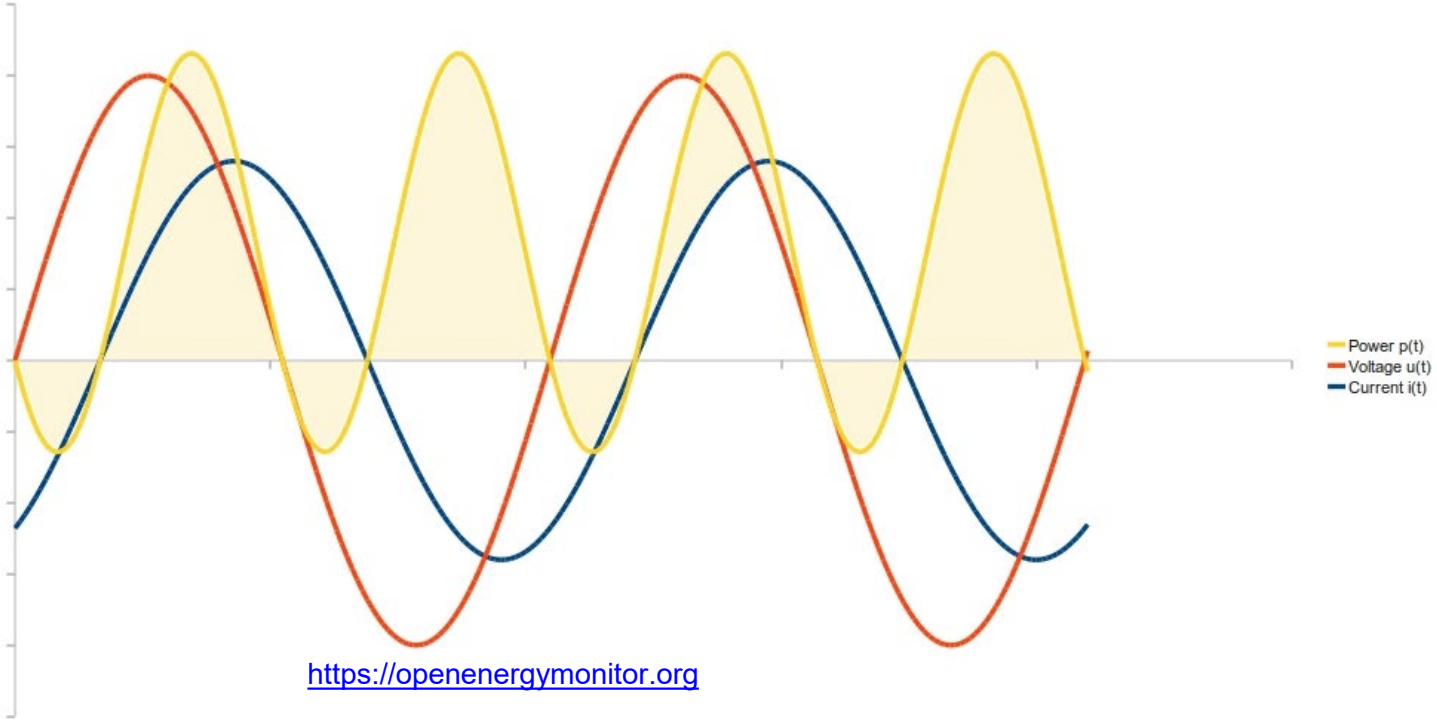
- Current remains constant with fluctuations in voltage so Power is variable
- This is a rare load on the system
  - Custom designed circuitry for loads that require a constant current




http://www.digikey.com/

# Non-Motor Load – Constant Resistance/Impedance Load

- Impedance remains constant as current or voltage changes
- Most non-motor loads on the system appear as constant impedance
  - However every load has slightly different characteristics




https://openenergymonitor.org

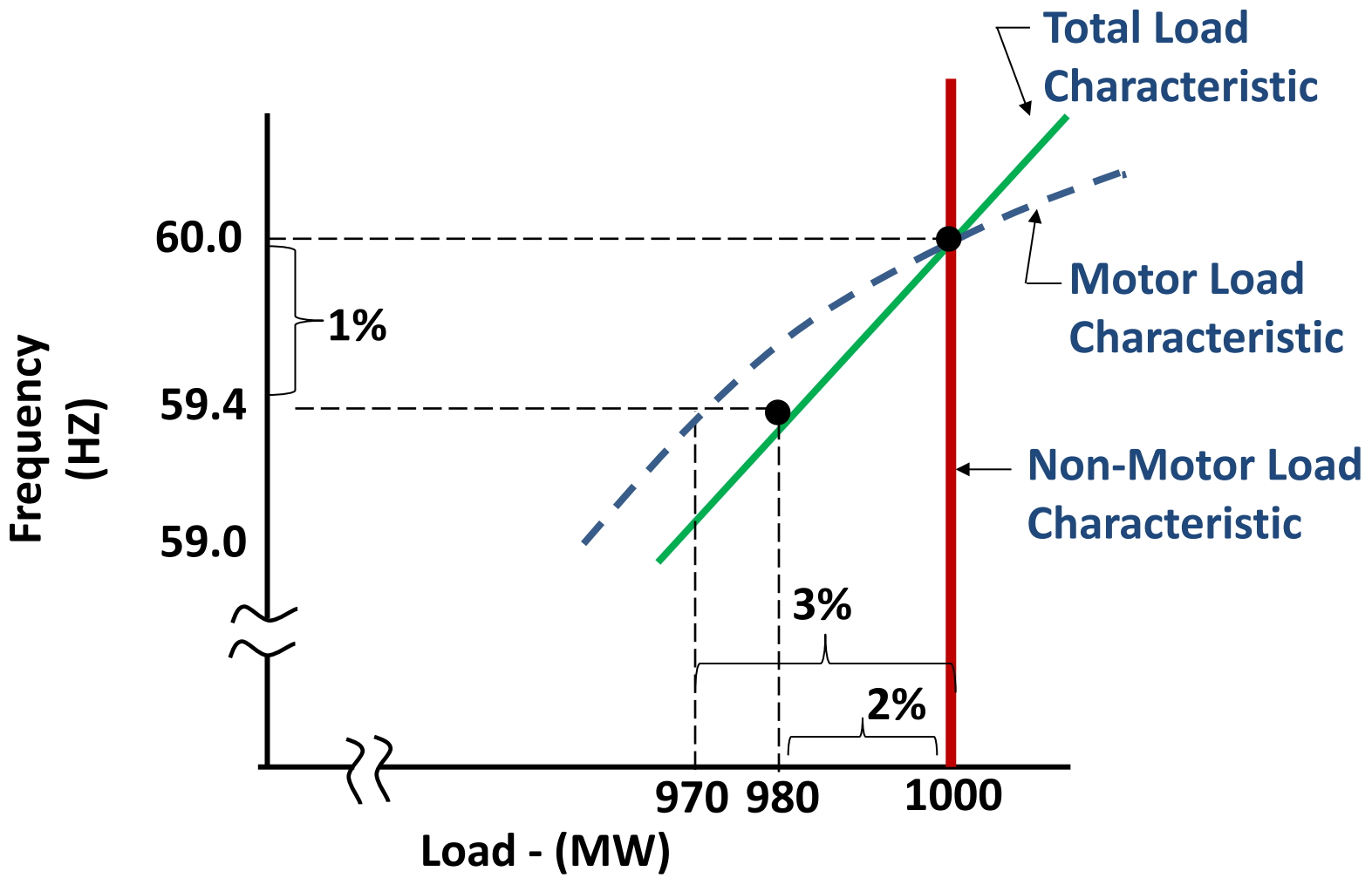
# Constant Power, Current and Impedance Example

## PowerWorld System Loads

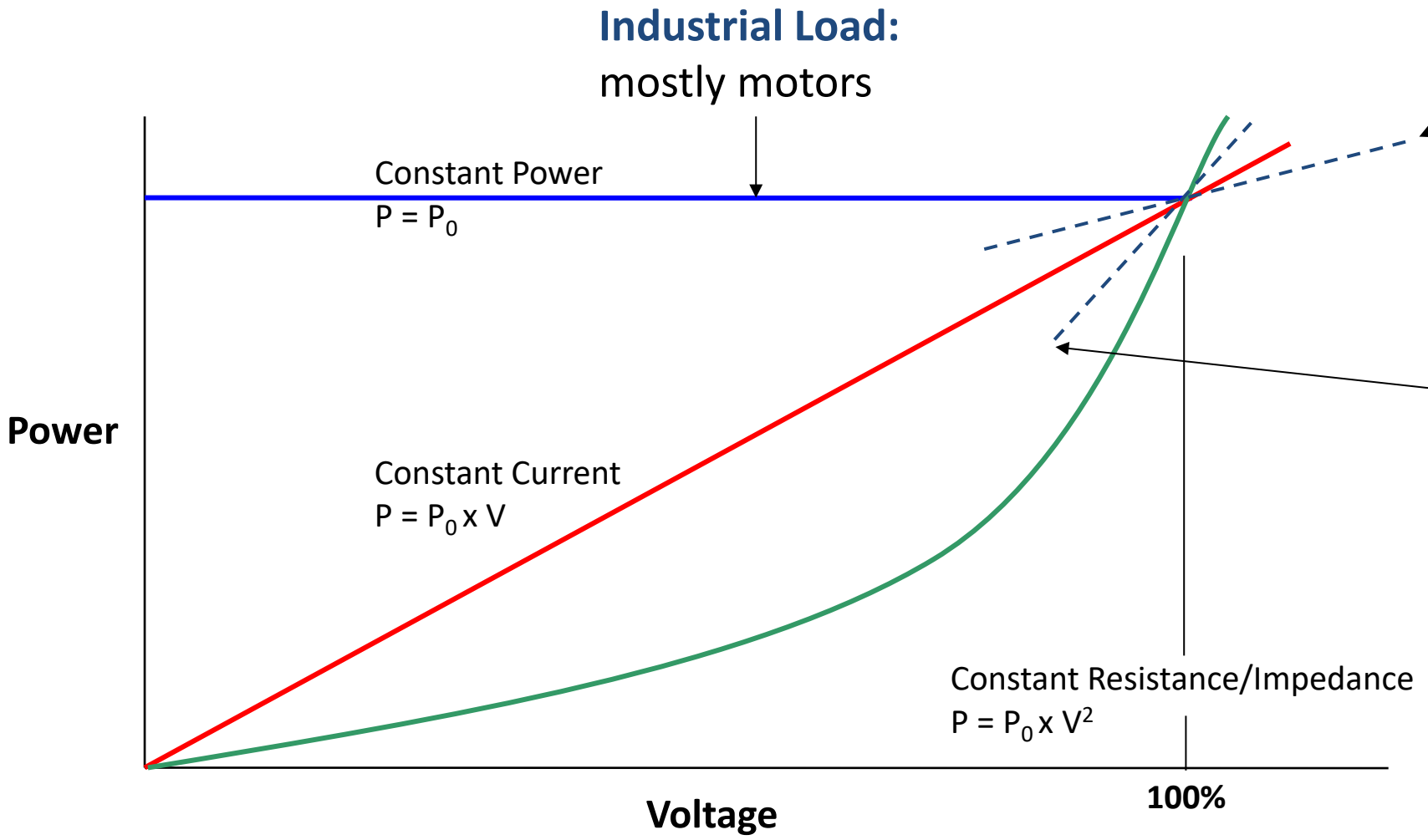
# Effect of Frequency on Load

- **Non-Motor Load**
  - More dependent on voltage than frequency
  - For all intensive purposes we could say that non-motor load does not vary with frequency
- **Motor Load**
  - More dependent on frequency than voltage
  - Rule of thumb is for a 1% drop in frequency, motor load will decrease by 3%

# Effect of Frequency on Load



# Effect of Voltage on Loads



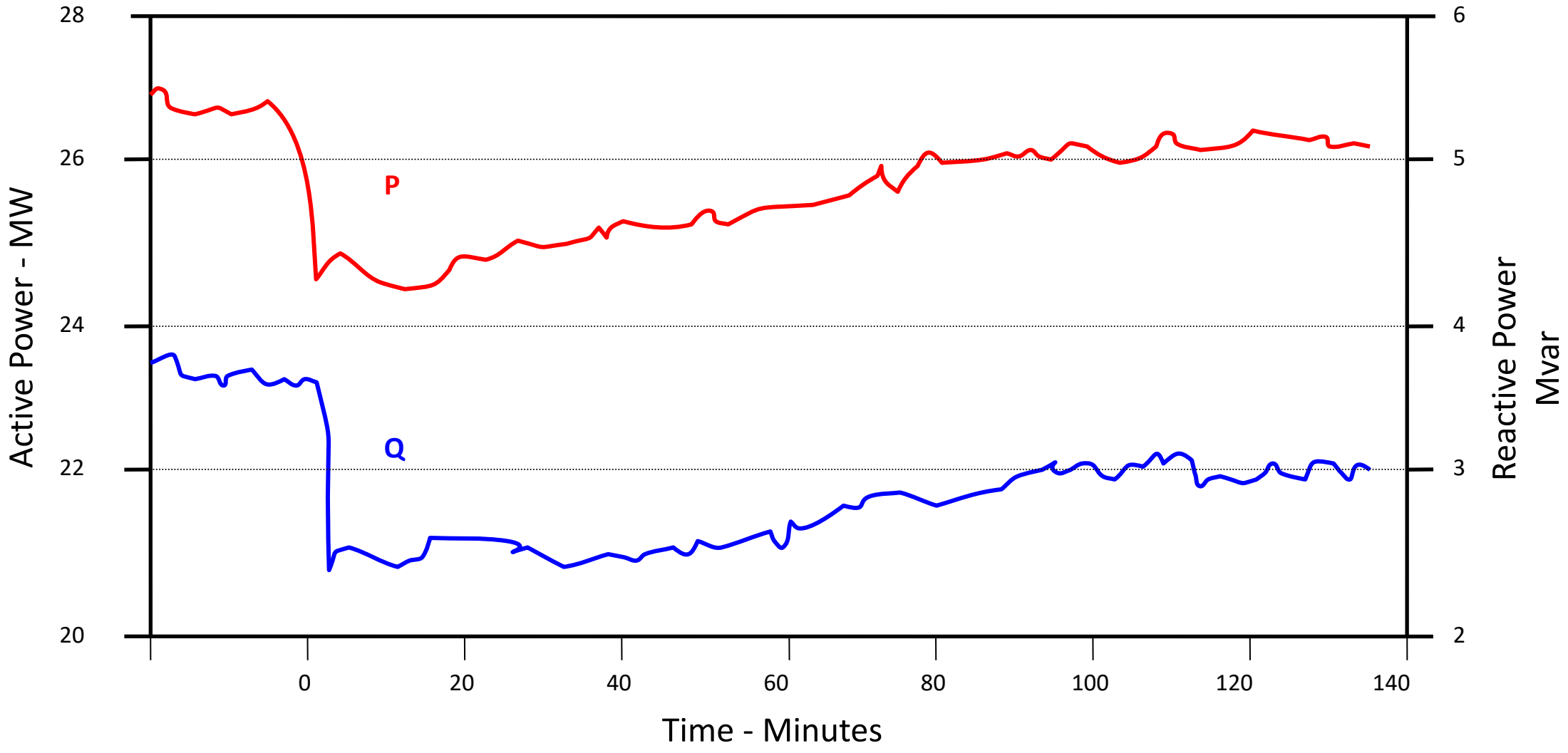

**Commercial Load:**
some motors, lots of fluorescent lighting, computers, cooking & miscellaneous

**Residential Load:**
smaller motors, some fluorescent lighting, incandescent lighting, some heating, miscellaneous

# Effect of Voltage on Loads

- Total System Load reduction due to a decrease in voltage
  - A rule of thumb is that for a **5% percent reduction in voltage** you will see approximately a **3% reduction in system load**

# Effect of Time on Load Magnitude



# Load Diversity

- Prolonged periods of low voltage will lead to loss of load diversity
  - During low voltage the output of a heater/air conditioner will reduce
  - This causes more units to be on at the same time or stay on longer to maintain the same temperature
  - More units operating and for longer periods will eventually cause an increase in total system load

# Questions?

**PJM Client Management & Services**

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**Toll Free Telephone: (866) 400-8980**

**Website: www.pjm.com**

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