# Electricity Generation from Lignite

Coyote Station Brad Zimmerman Plant Manager



## The many forms of energy

• Generating electricity requires *energy conversion* 











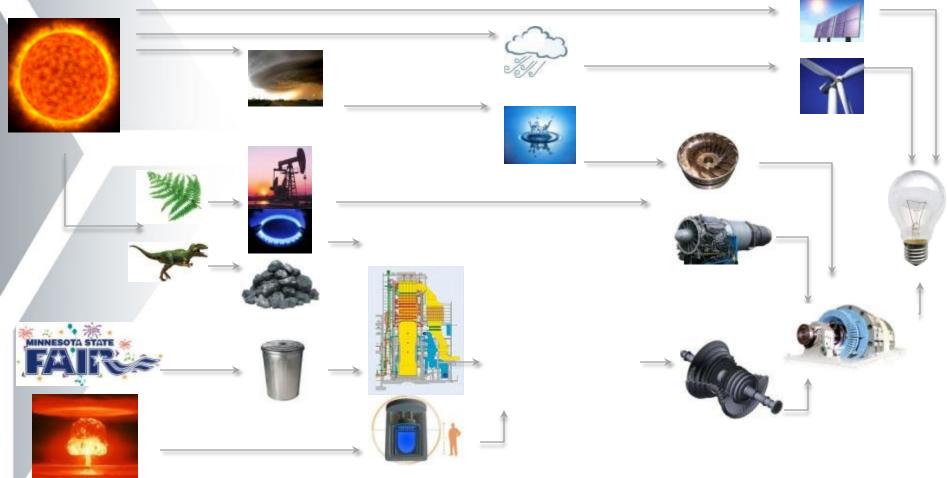






# Electrical power generation

• Energy conversion requires energy transfer



# What Influences Generation Choice

- Permitting, political factors
- Land availability
- Water availability
- Capital costs
- Ongoing Operations & maintenance costs
- How soon the resource is needed
- Capacity factors
- Load shape
- Existing generation mix

# Utility driving factors

- Environmental stewardship.
- Affordable rates/Customer satisfaction.
- Shareholder value.
- Regulatory compliance.
- Reliable service.
- Employee opportunity to succeed.

# **Types of Generation**

- Baseload power is available for 24-7 demand
  - High-capacity generating plants
  - Plants cost less to operate when at full efficiency
- <u>Intermediate</u> power plants cycle with demand
  - Operate between 12-16 hours a day when demand for electricity is highest, shut down evenings/weekends
- <u>Peaking</u> power is available when demand is highest
  - Higher cost to operate, but quick start-up to react to demand changes
- <u>Intermittent</u> power is available when supply allows
  - Cannot be relied upon to react to level of demand

# Hydro

### Advantages

- No fuel cost
- Low-cost energy to consumer
- No air emissions
- Can respond rapidly to dispatch

### Disadvantages

- Permitting considered impossible
- Affects fish and wildlife habitat
- Alters the natural flow of rivers
- Virtually no resources left to develop (some dams being removed)
- Montana's Yellowtail Dam finished in 1967



## Natural Gas

- Advantages
  - Less emissions than coal
  - Currently, natural gas is low-priced
  - Can be either designed for intermediate or peaking service
  - Moderate capital costs
  - Can be designed for dispatch

- Disadvantages
  - Costs have been historically volatile
  - Pipeline distribution not adequate for projected demand
  - Limited to no storage capability on a generation site

# Wind

### Advantages

Renewable

- No air emissions
- Financial incentives

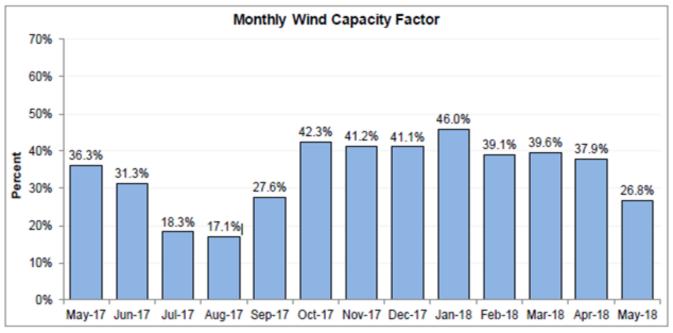
### Disadvantages

- Has intermittent production
- Turbines take a lot of space
- Equipment aesthetically unpleasing to some and kills birds
- Because of intermittent nature, requires back-up generation sources
- Poor match for load demand



# MISO monthly wind capacity factor

The capacity factors of other generating plants are based mostly on respective fuel cost. The capacity factor of wind energy is determined primarily by meteorological conditions.



\* Wind Capacity factor is calculated by taking the average of hourly actual wind generation divided by registered capacity.

The total registered wind capacity in May 2018 was 18,204 MW. The wind capacity factor decreased from last month to 26.8% this month.

Source: MISO Market Analysis

## Solar

### Advantages

- Renewable
- No air emissions
- Financial incentives

### Disadvantages

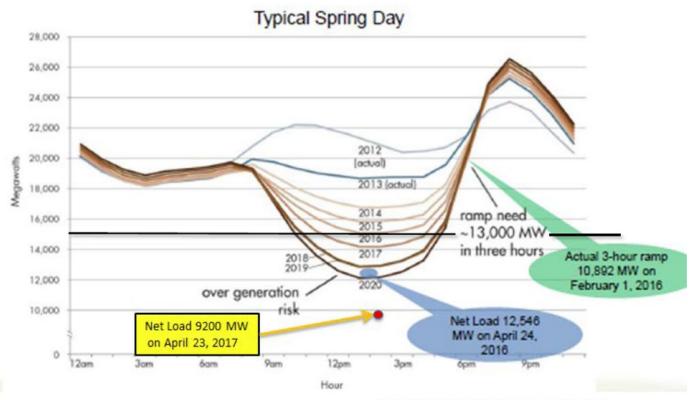
Expensive



- 15% capacity factor in Upper Midwest
- Affected by clouds, snow and season
- Steep decline in generation during peak demand time of day
- Large footprint needed

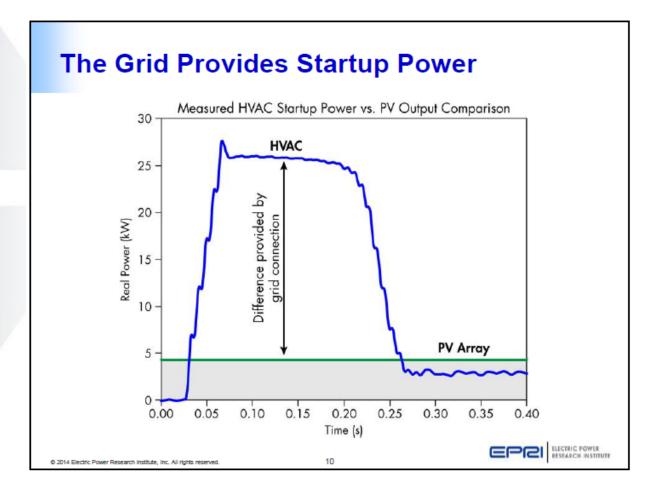
### CAISO Net Load 2012-2020 California Over-Generation Impacts

CAISO – Over-generation



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# Grid provides startup power



### Nuclear

### Advantages

- No CO<sub>2</sub> emissions
- Base load reliability
- Disadvantages
  - Large capital cost
  - Radioactive waste
  - Increasingly expensive fuel
  - Almost impossible to solve waste disposal problems through Congress
  - Lacks public support
  - Cannot respond effectively to changing dispatch



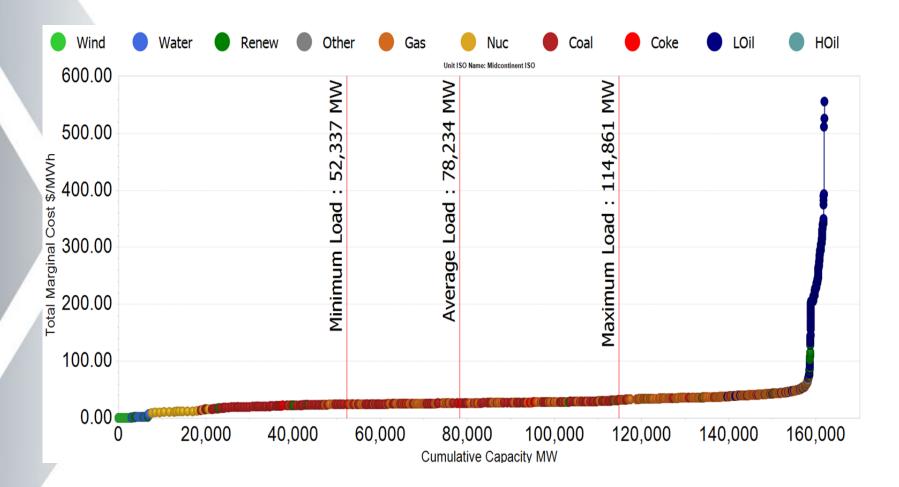
# Lignite

### Advantages

- Abundant fuel source
- Relatively inexpensive fuel source for base load
- Reliable and dispatchable
- Increasingly clean
- Disadvantages
  - Permitting due to federal regulations
  - Low Btu content
  - High moisture content
  - Cannot economically rail
  - Ramp rate is limited for increase or decrease in demand

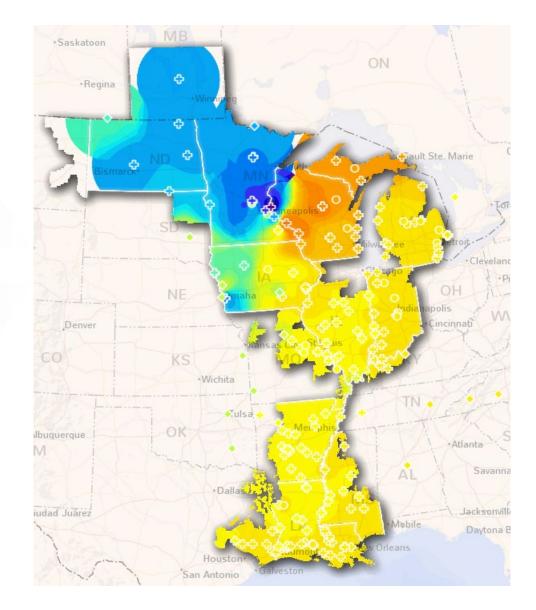


### **MISO Supply Curve**

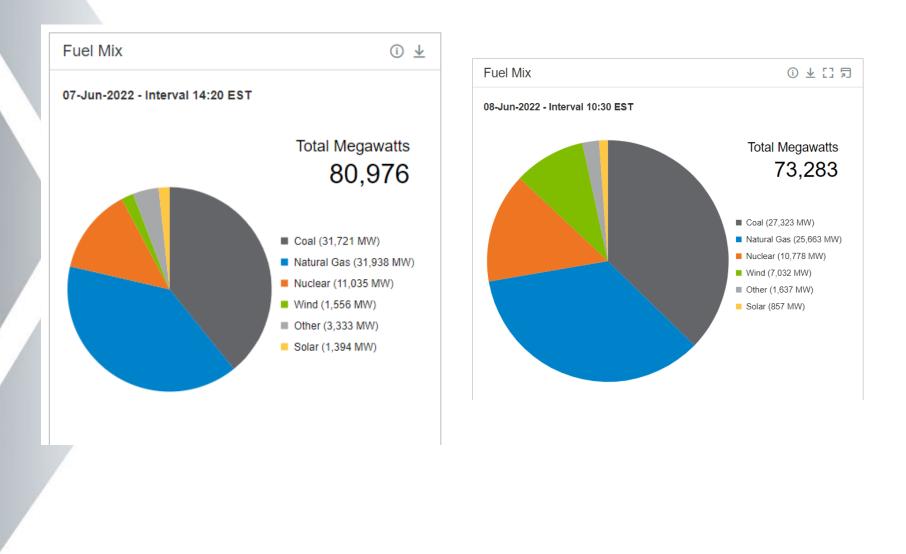


Source: Ventyx Velocity Suite

### MISO portfolio mix



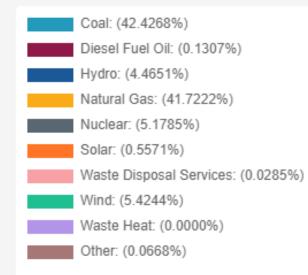
### MISO portfolio mix

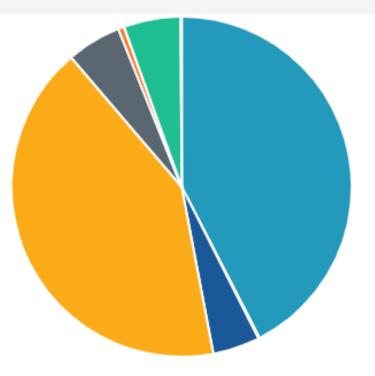


### SPP portfolio mix

#### Generation Mix for 2022-06-07 15:10:00 (Central Time)

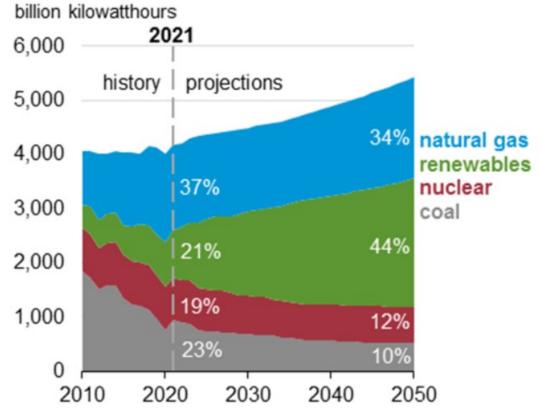
Pie chart view of current generation mix percentage by fuel type.





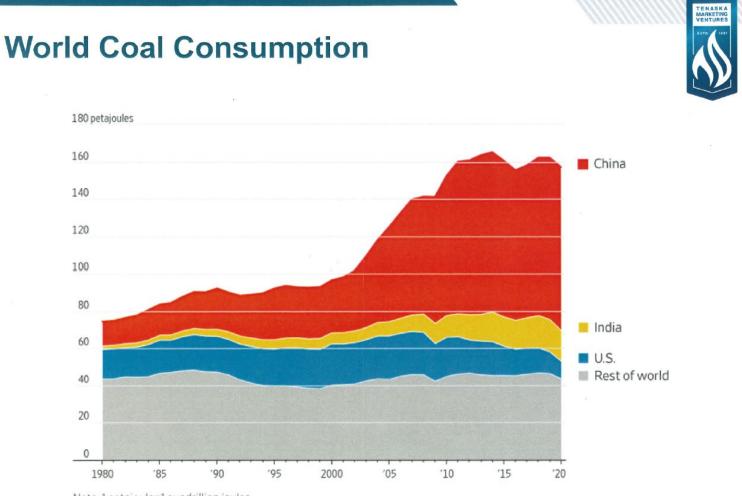
# US supply

#### U.S. electricity generation from selected fuels AEO2022 Reference case



Source: US Energy Information Administration, Annual Energy Outlook 2022 (AEO2022)

### Worldwide Coal Consumption



Note: 1 petajoule=1 quadrillion joules Source: International Energy Agency



### This Region Depends On Coal-Based Electricity

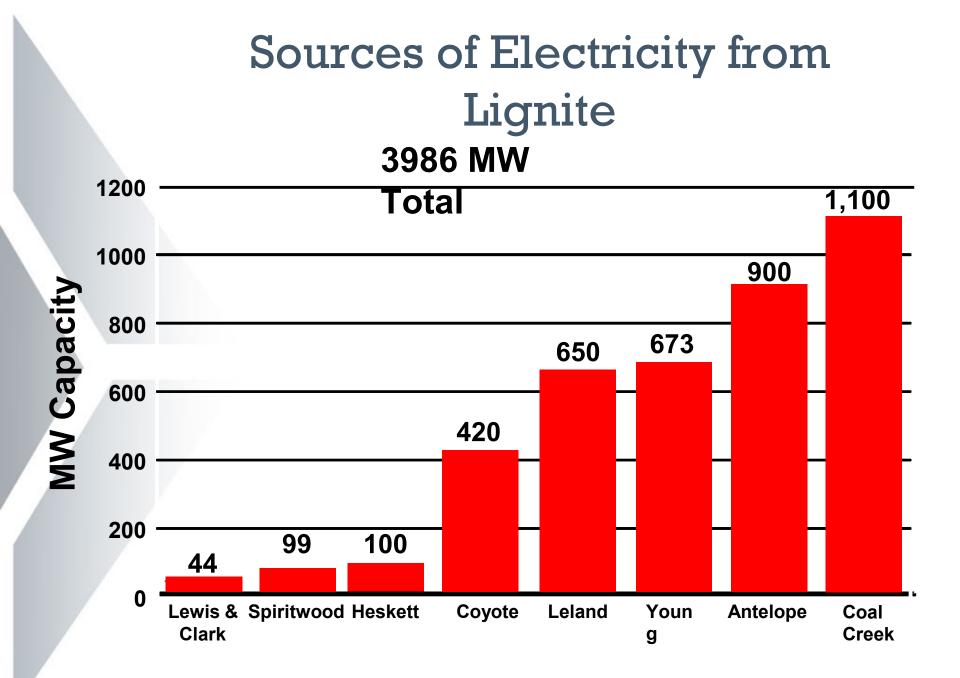
- Baseload power must
  remain a part of America's
  future
  - Coal most affordable baseload power source



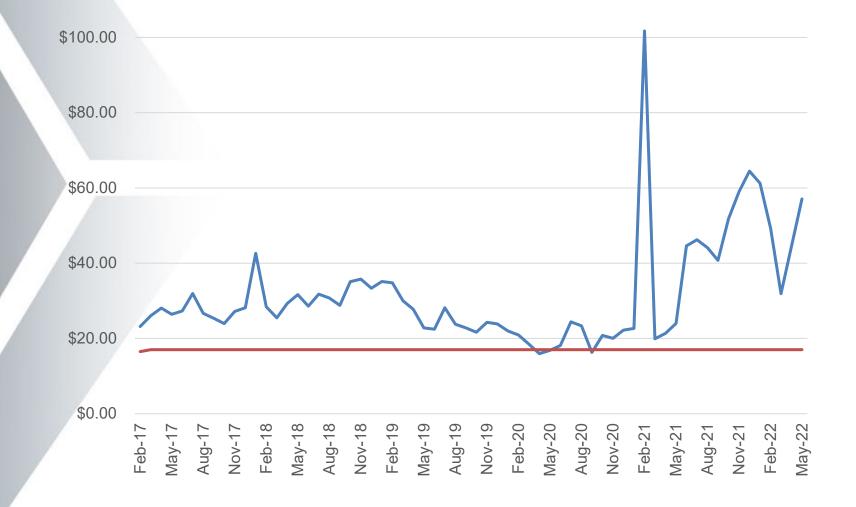
- New technology is required
- Time, investments, risk

Importance of Coal-Based Electricity

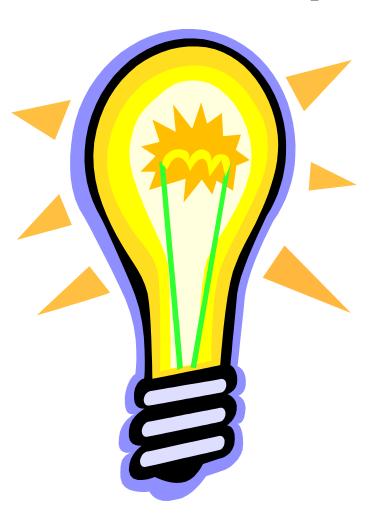
- Affordable, reliable electricity is important to families and businesses
  - Important for low-income families
  - Important competitive factor for region's farms & businesses
  - Important economic development incentive



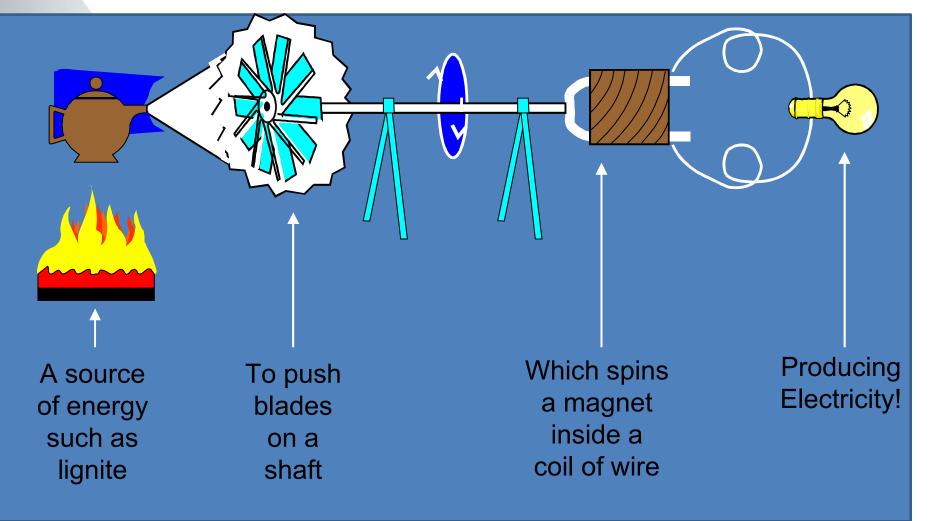
### ND Coal Generation Cost vs. Prices



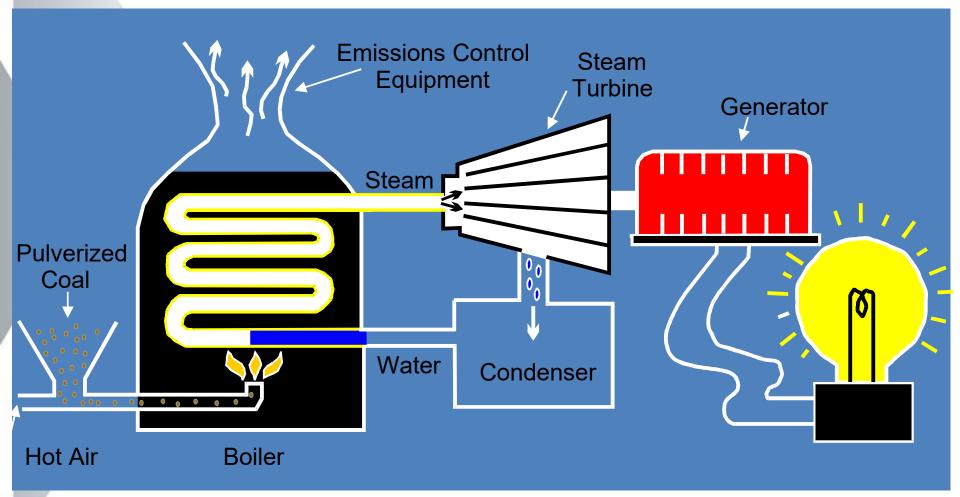
# How is Lignite Converted into Electricity?



### Basics of How Electricity is Made



### How Electricity is Made Using a Steam Turbine



### **Lignite-Fired Boiler**

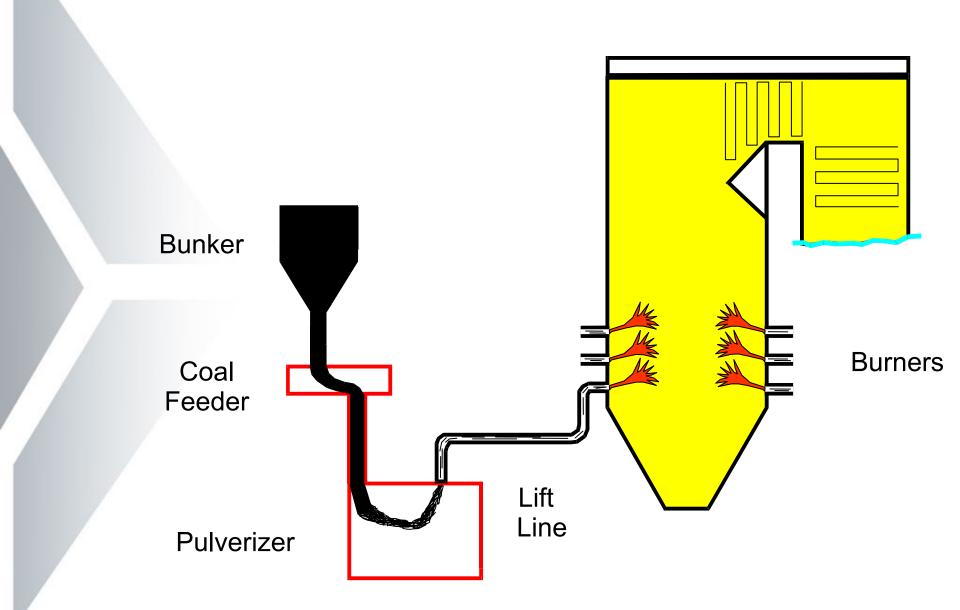


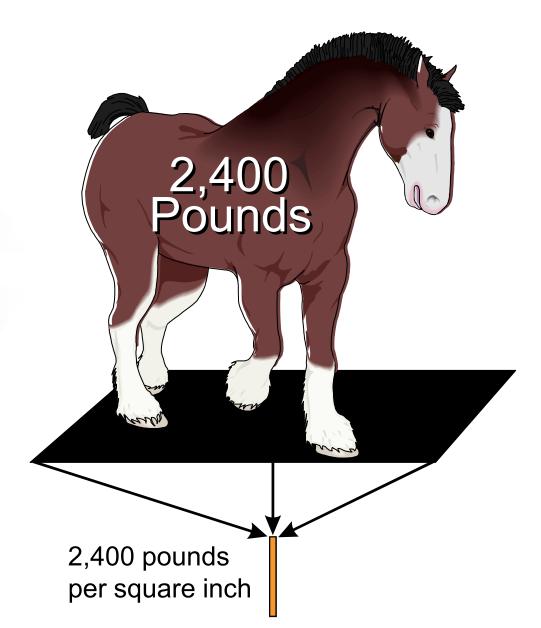




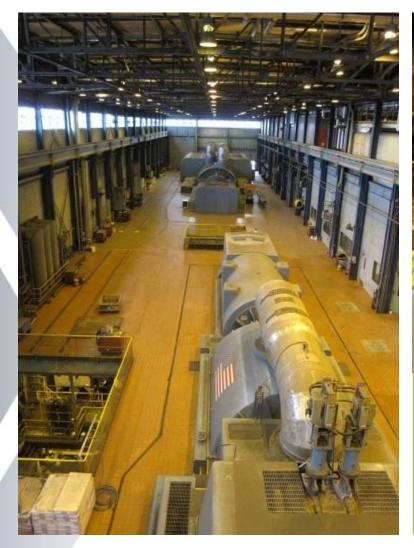
Photo of pulverized coal

Photo of oil during startup

### 2,400 PSI Steam Pressure





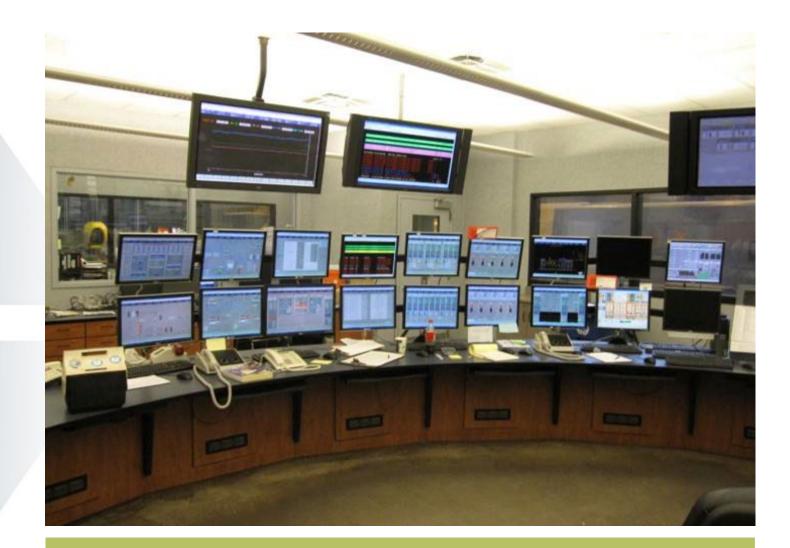




# Steam turbine generator

### **Generator during assembly**

### Generator stator work



### Modern control room with computer equipment

Plant Transformers

~7,200 volts

- A. Auxiliary transformers for plant power
- S. Step-Up transformers for sending power out



### **Power Plant Substation**



# Heat & Power

#### **Efficiency Improvements**

- Coal Creek Station sends a mix of primary & waste steam to Blue Flint Ethanol
  - Plant is low-cost producer of ethanol in the United States (no need to build or maintain a boiler)
- Spiritwood Station is a combined heat & power plant located near Jamestown, ND
  - Generates electricity & steam for Dakota Spirit AgEnergy Biorefinery
  - When fully utilized, plant will be 66 percent efficient
    - Compared to 30 to 35 percent efficient for most coal-based power plants





# Rule of thumb

How many plants does it take to meet the energy needs for a city of 1 Million people?





= 30



= 2

= 3

= 20



= 2,000 (40 x 75 acre wind farms)





= 24,000,000 (550 x 2 acre PV sites)

### **Estimated Demand**

- 350 MW

- Bismarck / Mandan 190 MW
- Fargo / Moorhead
- St. Cloud 335 MW
- Minneapolis/St. Paul 3,500 MW

About one-fifth of MN's electricity comes from ND -- the percentage is much higher in rural MN

### Summary

- Lignite is a low-cost, abundant resource for the generation of electricity that is beneficial for the region
- Lignite is a secure and reliable source of energy
- Lignite-based power plants are in compliance with all federal ambient air quality standards
- Maintaining current fleet important for grid stability

# **Additional information**

- www.misoenergy.org
- www.spp.org
- Energy Information Administration www.eia.gov

# Questions?