Electricity Generation from Lignite

Great River Energy
John Bauer
Director, ND Generation
Question

What is the largest coal-fired power plant in North Dakota?

1. Antelope Valley Station 1 25.0%
2. Coal Creek Station 2 25.0%
3. Coyote Station 3 25.0%
4. Heskett Station 4 25.0%
The many forms of energy

• Generating electricity requires *energy conversion*
Electrical power generation

- Energy conversion requires energy transfer
What Influences Generation Choice

- Permitting
- Capital costs
- Operations, maintenance costs
- How soon the resource is needed
  - How quickly it can be built
- Capacity factors
- Load shape
- Existing generation mix
Our triple bottom line...

- Affordable rates
- Reliable electric service
- Environmental stewardship
Types of Generation

• **Baseload** power is available for 24-7 demand
  – High-capacity generating plants
  – Plants cost less to operate when at full efficiency

• **Intermediate** power plants cycle with demand
  – Operate between 12-16 hours a day when demand for electricity is highest, shut down evenings/weekends

• **Peaking** power is available when demand is highest
  – Higher cost to operate, but quick start-up to react to demand changes

• **Intermittent** power is available when supply allows
  – Cannot be relied upon to react to level of demand
Advantages
- No fuel cost
- Low-cost energy to consumer
- No air emissions
- Can respond rapidly to dispatch

Disadvantages
- Permitting – nearly 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
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
Wind

- **Advantages**
  - Renewable
  - No air emissions

- **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.

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

- **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

Typical Spring Day

Net Load 9200 MW on April 23, 2017

Net Load 12,546 MW on April 24, 2016

Actual 3-hour ramp 10,892 MW on February 1, 2016

ramp need ~13,000 MW in three hours

over generation risk
Grid provides startup power

The Grid Provides Startup Power

Measured HVAC Startup Power vs. PV Output Comparison

Difference provided by grid connection

PV Array

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Nuclear

- Advantages
  - No CO₂ 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
GRE Generation Sources
MISO Supply Curve

Source: Ventyx Velocity Suite
MISO portfolio mix

Fuel Mix

23-May-2019 - Interval 07:10 EST

Total Megawatts: 64,331

- Coal (26,190 MW)
- Natural Gas (17,671 MW)
- Nuclear (11,277 MW)
- Other (1,672 MW)
- Wind (7,517 MW)
SPP portfolio mix

Generation Mix for 2019-05-23 07:10:00 (Central Time)

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

- Coal: (31.6766%)
- Diesel Fuel Oil: (0.0000%)
- Hydro: (6.9217%)
- Natural Gas: (24.1980%)
- Nuclear: (7.3674%)
- Solar: (0.0150%)
- Waste Disposal Services: (0.0403%)
- Wind: (29.7038%)
- Waste Heat: (0.0000%)
- Other: (0.0763%)
Electricity generation from selected fuels
(Reference case)
billion kilowatthours

2018

history | projections

natural gas renewables nuclear coal

2010 2020 2030 2040 2050

39%
31%
12%
17%
19%
34%
18%
19%
28%
17%
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
Sources of Electricity from Lignite

3986 MW Total

MW Capacity

Lewis & Clark: 44
Spiritwood: 99
Heskett: 100
Coyote: 420
Leland: 650
Young: 673
Antelope: 900
Coal Creek: 1,100
ND Coal Generation

Cost vs. Prices

Average DA Prices

Variable $ - Both Boilers

ND Generation

General range of variable cost $15-$20 MW/hr
How is Lignite Converted into Electricity?
To push blades on a shaft which spins a magnet inside a coil of wire, producing electricity. A source of energy such as lignite.
How Electricity is Made
Using a Steam Turbine

- Pulverized Coal
- Hot Air
- Boiler
- Emissions Control Equipment
- Water
- Condenser
- Steam Turbine
- Generator
- Pulverized Coal
- Hot Air
- Boiler
- Emissions Control Equipment
- Water
- Condenser
- Steam Turbine
- Generator
Lignite-Fired Boiler

- Bunker
- Coal Feeder
- Pulverizer
- Lift Line
- Burners
Photo of oil during startup

Photo of pulverized coal
2,400 PSI Steam Pressure

2,400 Pounds

2,400 pounds per square inch
Steam turbine generator
Generator during assembly
Generator stator work
Modern control room with computer equipment
• Plant Transformers
  A. Auxiliary transformers for plant power
  S. Step-Up transformers for sending power out
Power Plant Substation
Why is the Spiritwood Station unique among the state’s eight power plants?

1. It is the newest power plant
2. It provides steam to ag processing facilities along with making electricity
3. It is more efficient than the other ND plants
4. All of the above

25.0% 25.0% 25.0% 25.0%
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
Spiritwood Video
GRE’s Coal Plants – Lowest ND CO2
How Many?

How many solar panels does it take to replace two large ND lignite plants?

Multiple choice answers:
1. 10,000  
2. 24,000  
3. 2,400,000  
4. 10,000,000
Rule of thumb

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

= 1
= 30
= 2
(40 x 75 acre wind farms)
= 3
= 2,000
= 20
(550 x 2 acre PV sites)
<table>
<thead>
<tr>
<th>Location</th>
<th>Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bismarck / Mandan</td>
<td>190</td>
</tr>
<tr>
<td>Fargo / Moorhead</td>
<td>350</td>
</tr>
<tr>
<td>St. Cloud</td>
<td>335</td>
</tr>
<tr>
<td>Minneapolis / St. Paul Area</td>
<td>3,500</td>
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</tbody>
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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
- www.sailflow.com
- Energy Information Administration
  www.eia.gov
Questions