NEBRASKA WIND AND SOLAR CONFERENCE

CASEY CATHEY, TRANSMISSION PLANNING AND SEAMS MANAGER

OCTOBER 29-30, 2019

SPP Southwest Power Pool

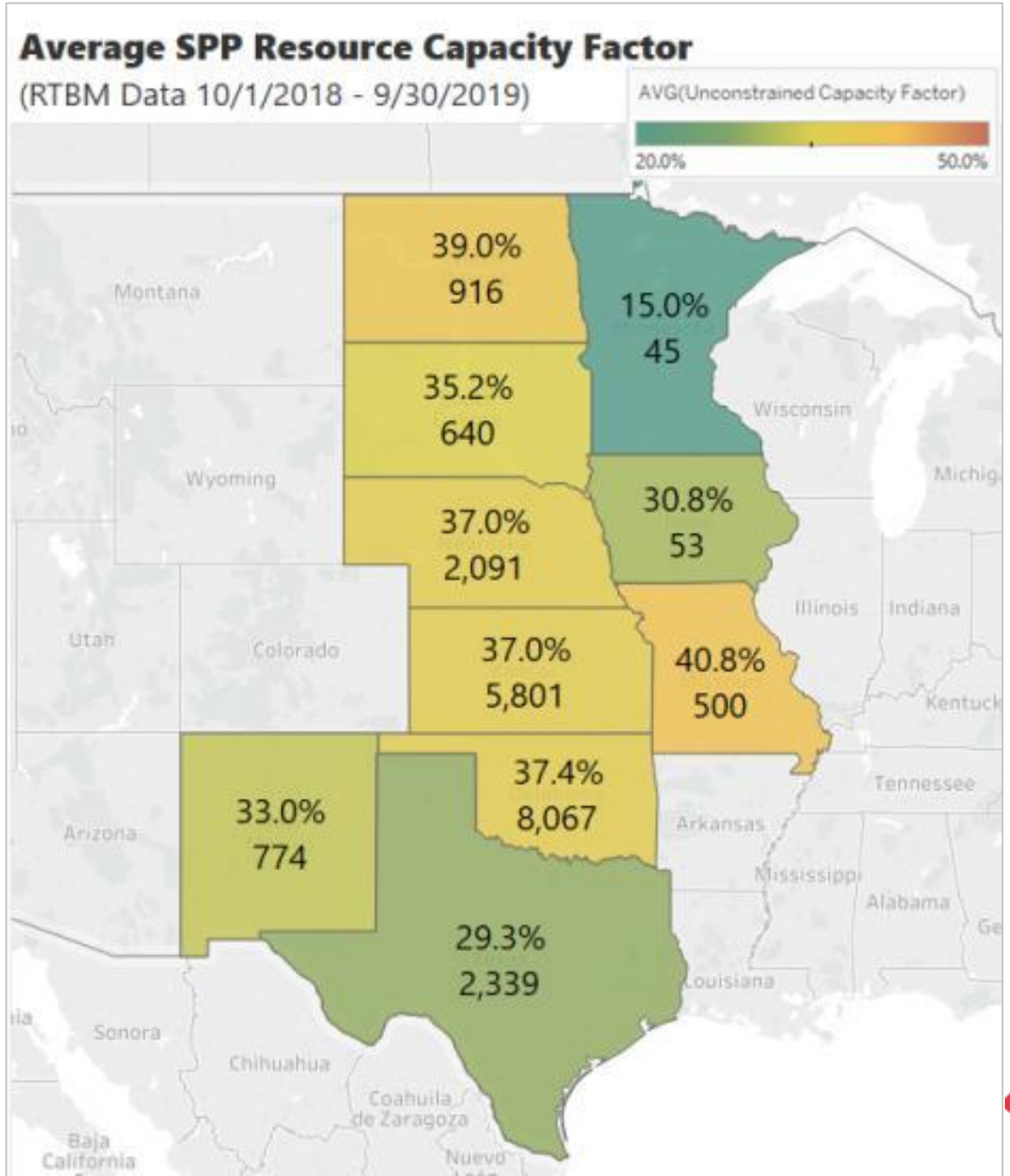
Helping our members work together to keep the lights on... today and in the future.

SouthwestPowerPool SPPorg southwest-power-pool

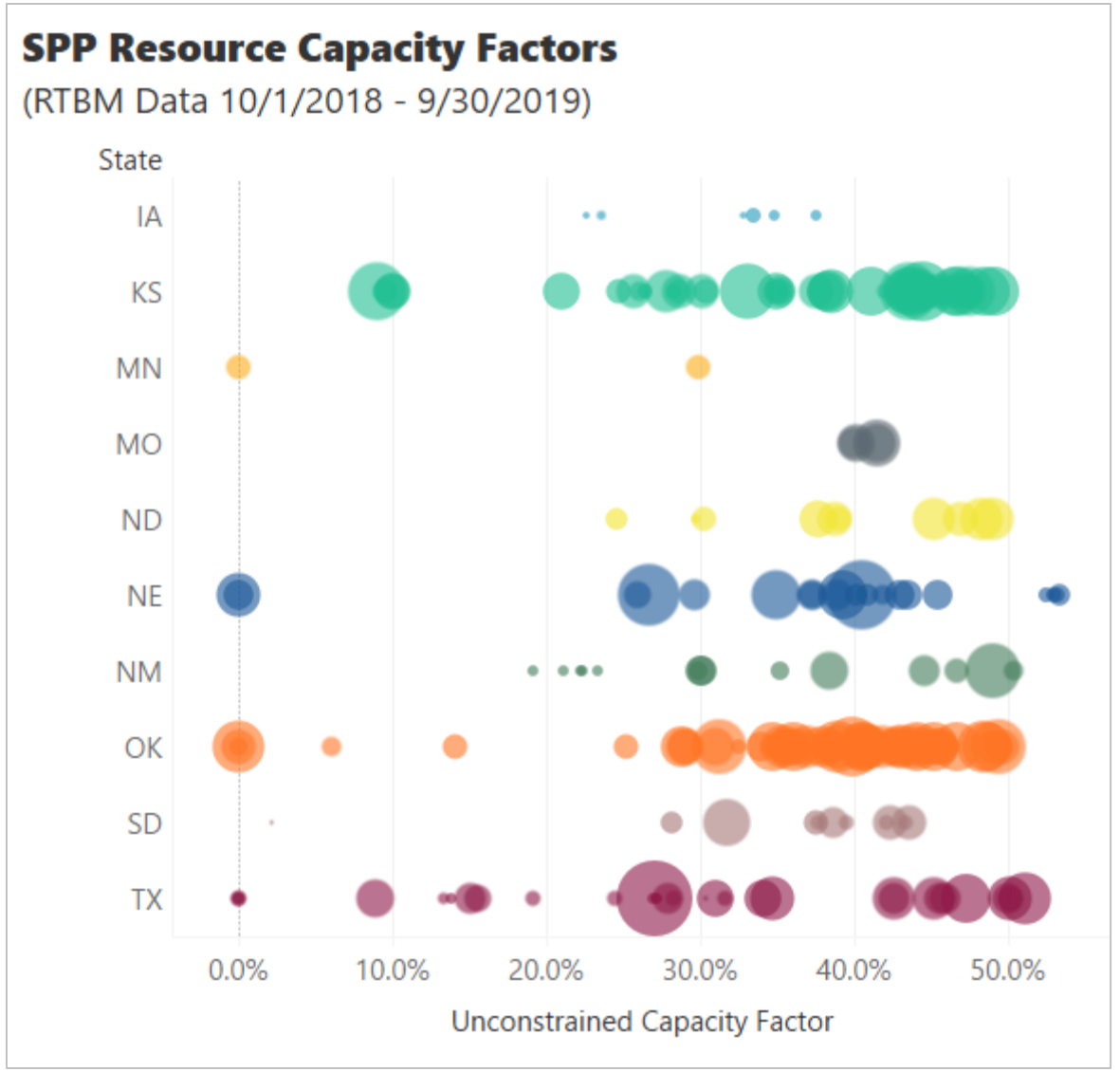
STATE-LEVEL DATA

NEBRASKA

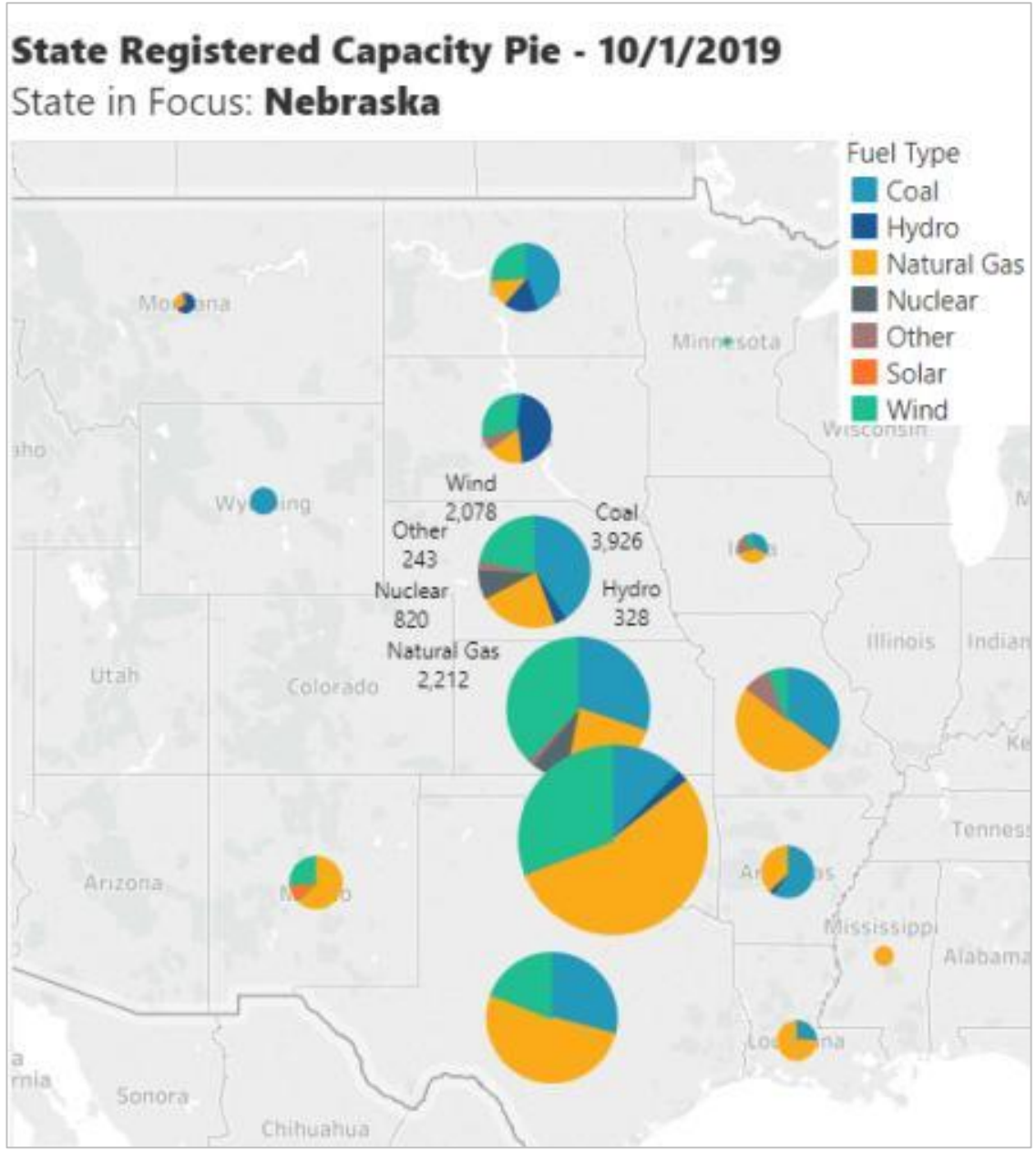
- Top number is average per-resource (unconstrained) capacity factor
- Bottom number is MW of wind for the year



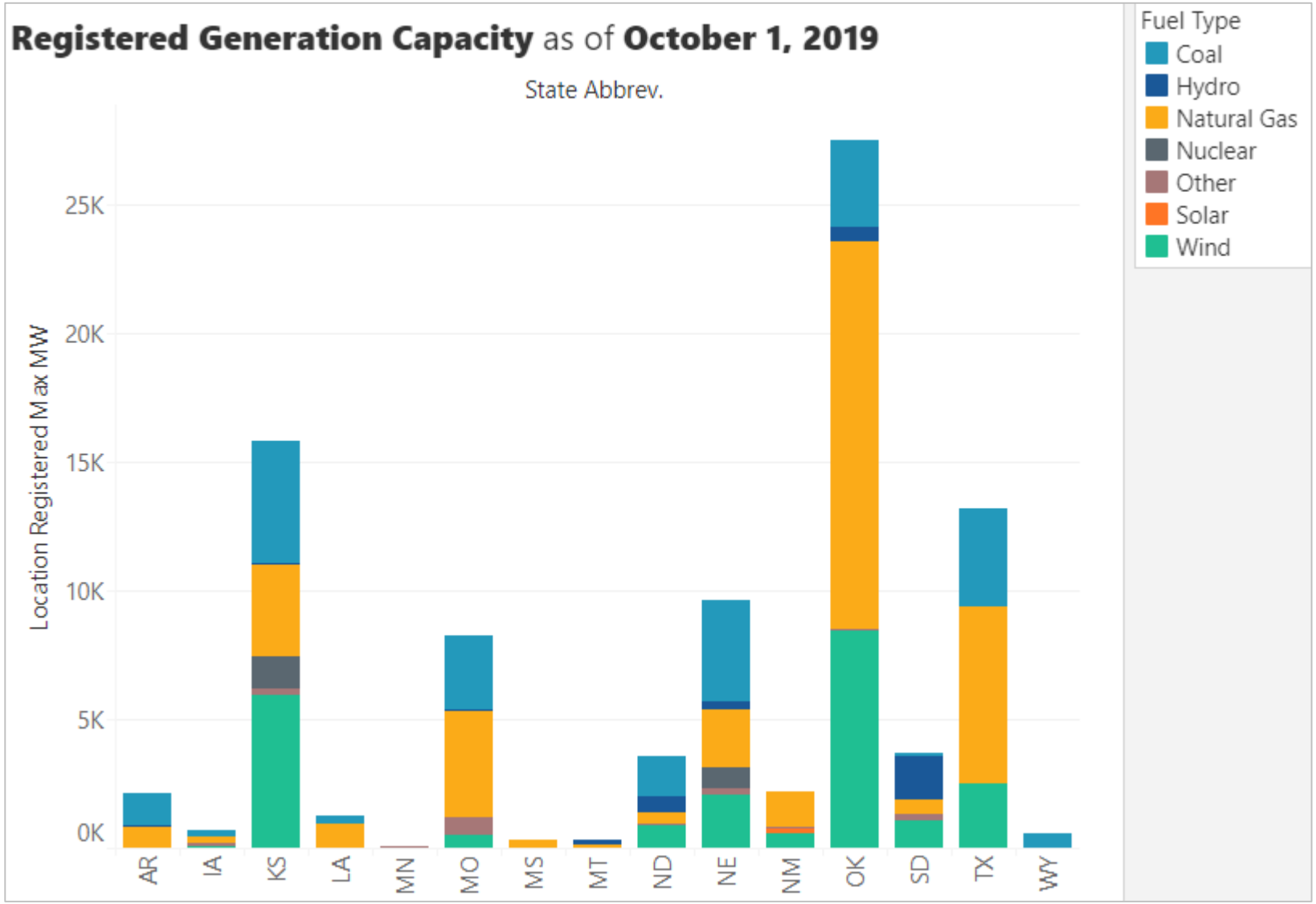
- Showing for each state, all wind resources and their (unconstrained) capacity factor
- Bubble size is proportional to resource capacity MW
  - Largest is 478 MW, smallest is 2 MW



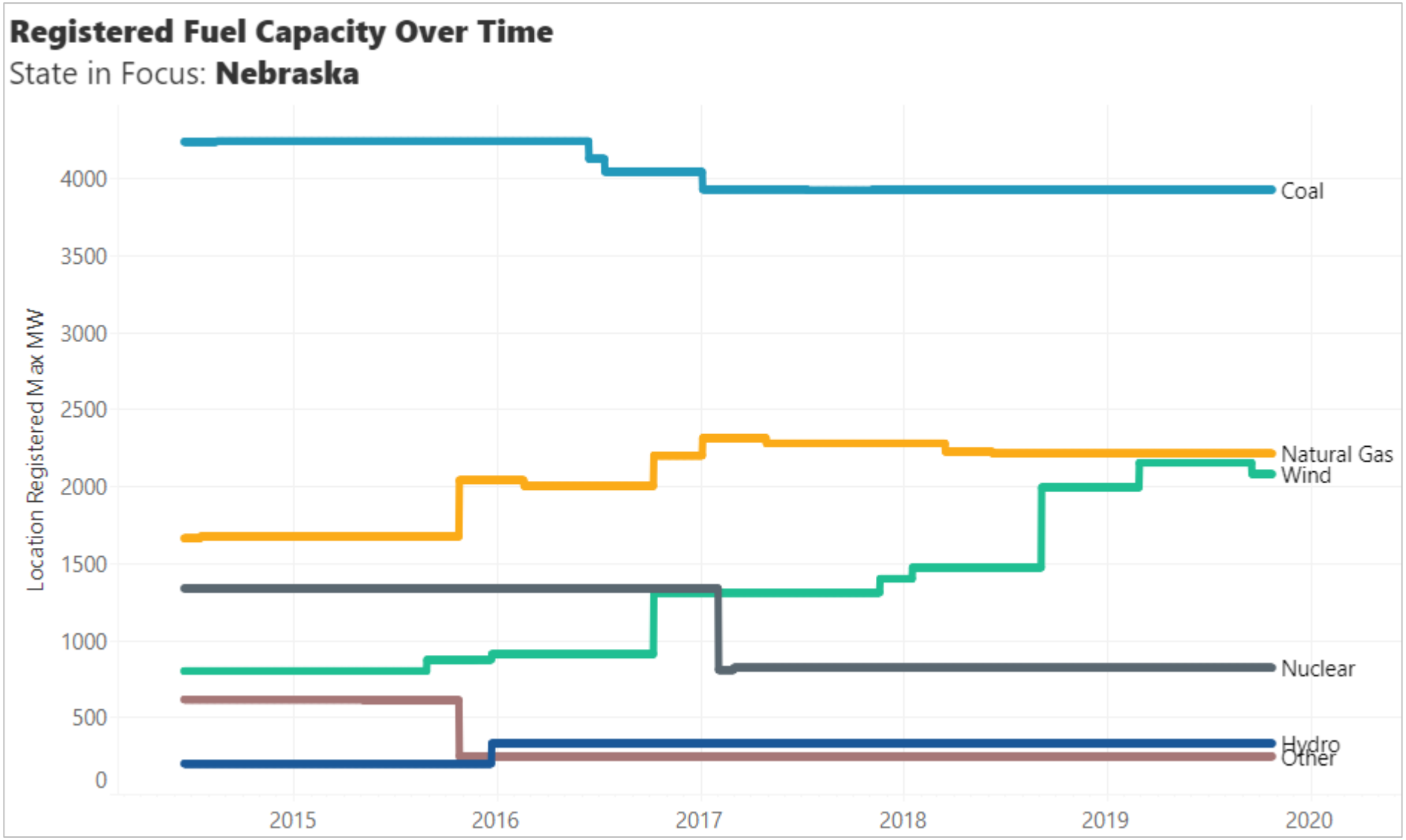
REGISTERED CAPACITY



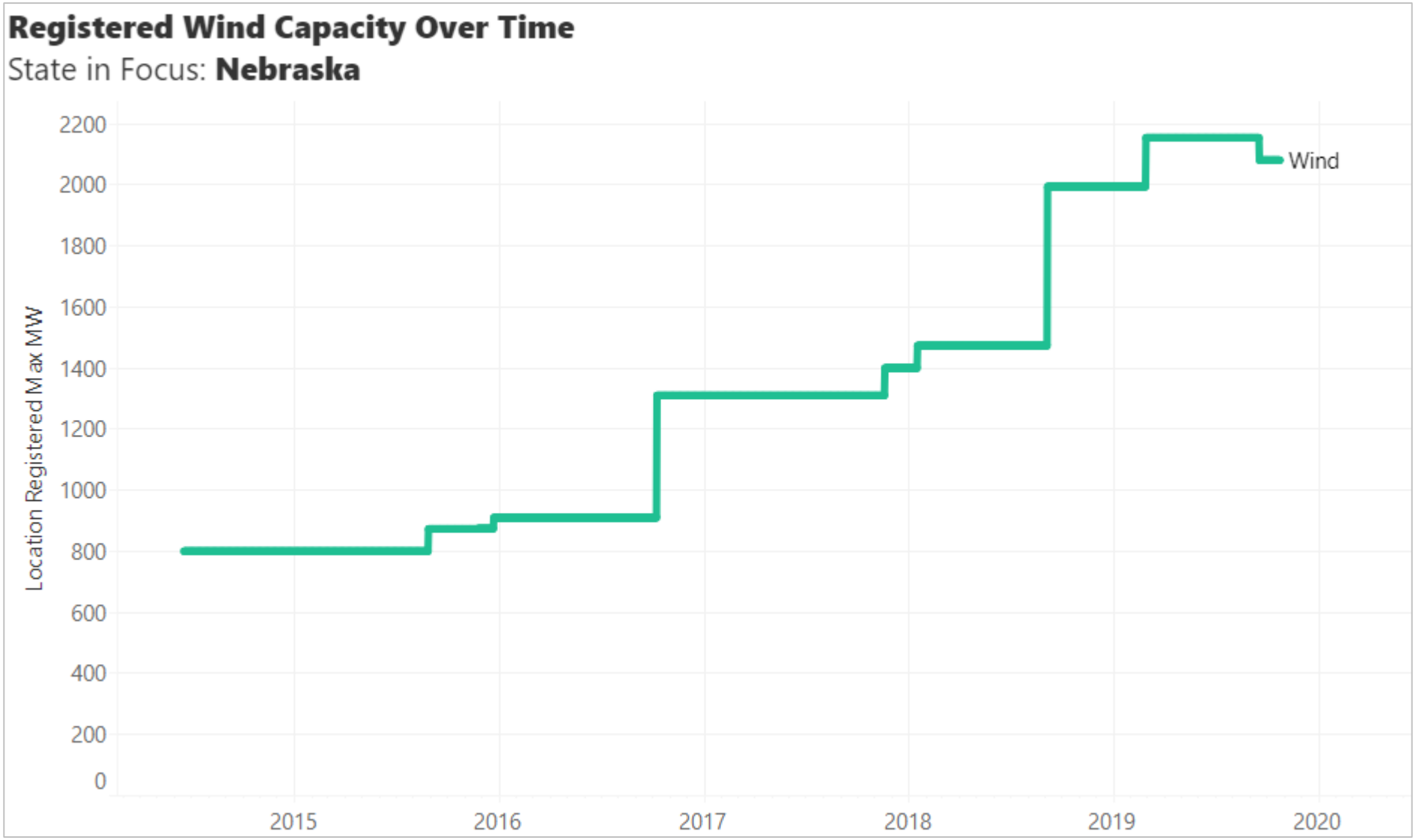
REGISTERED CAPACITY

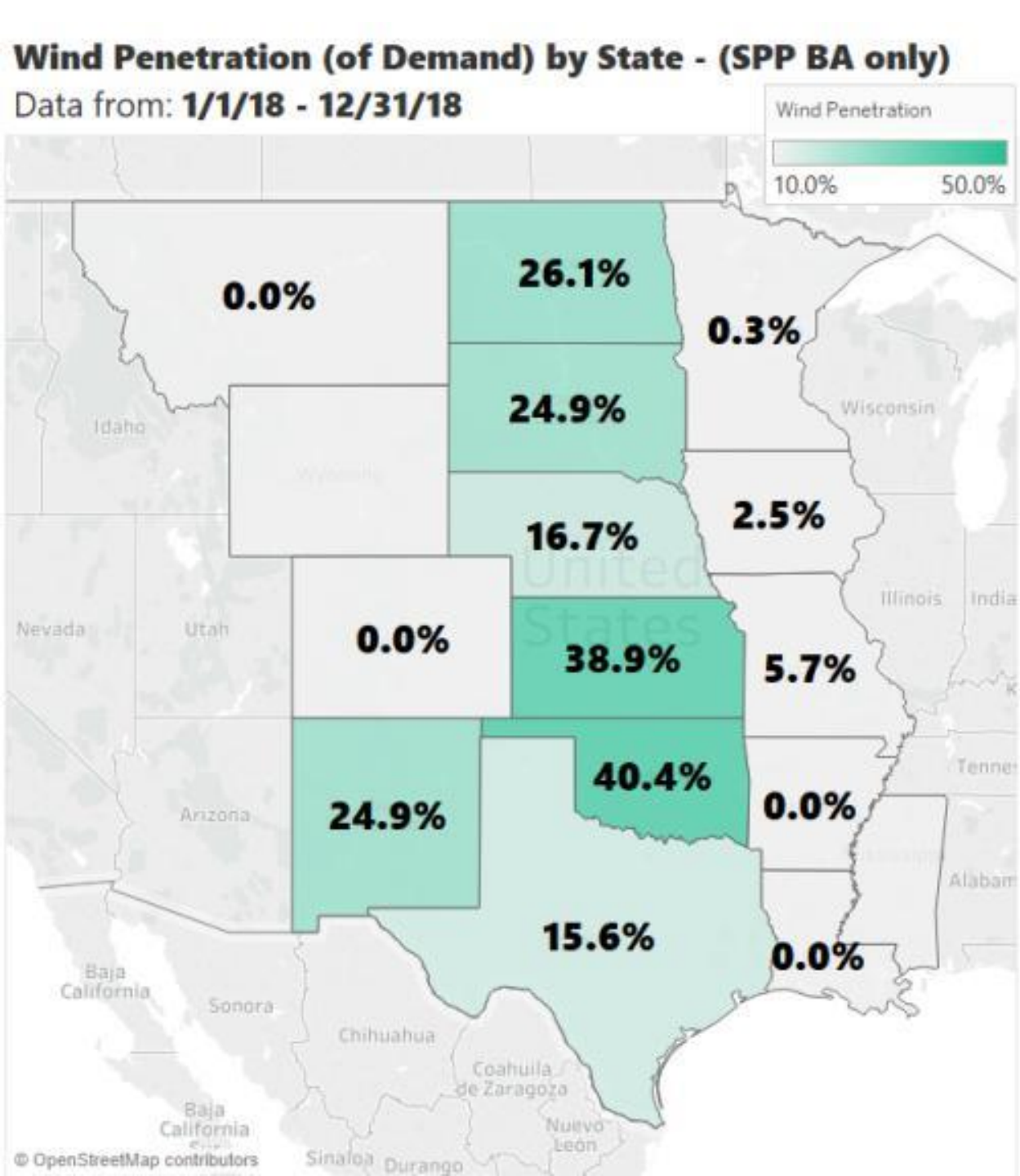


REGISTERED CAPACITY



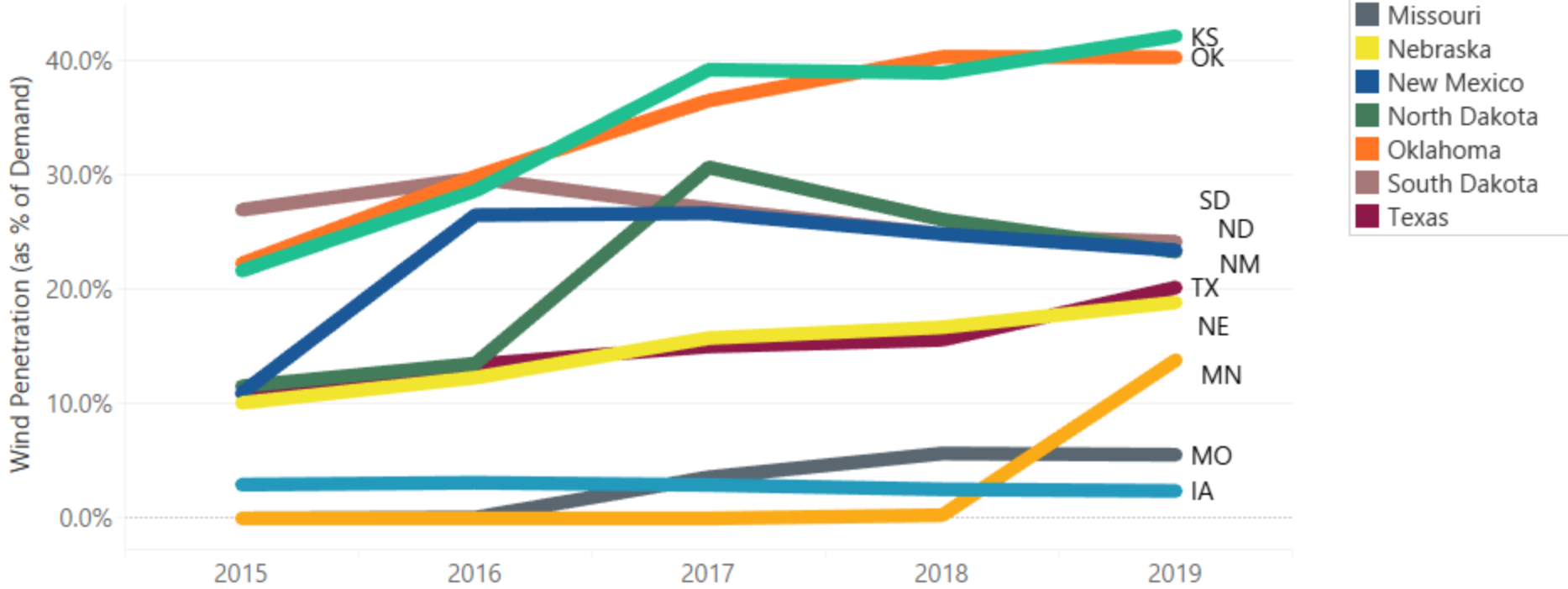
REGISTERED CAPACITY



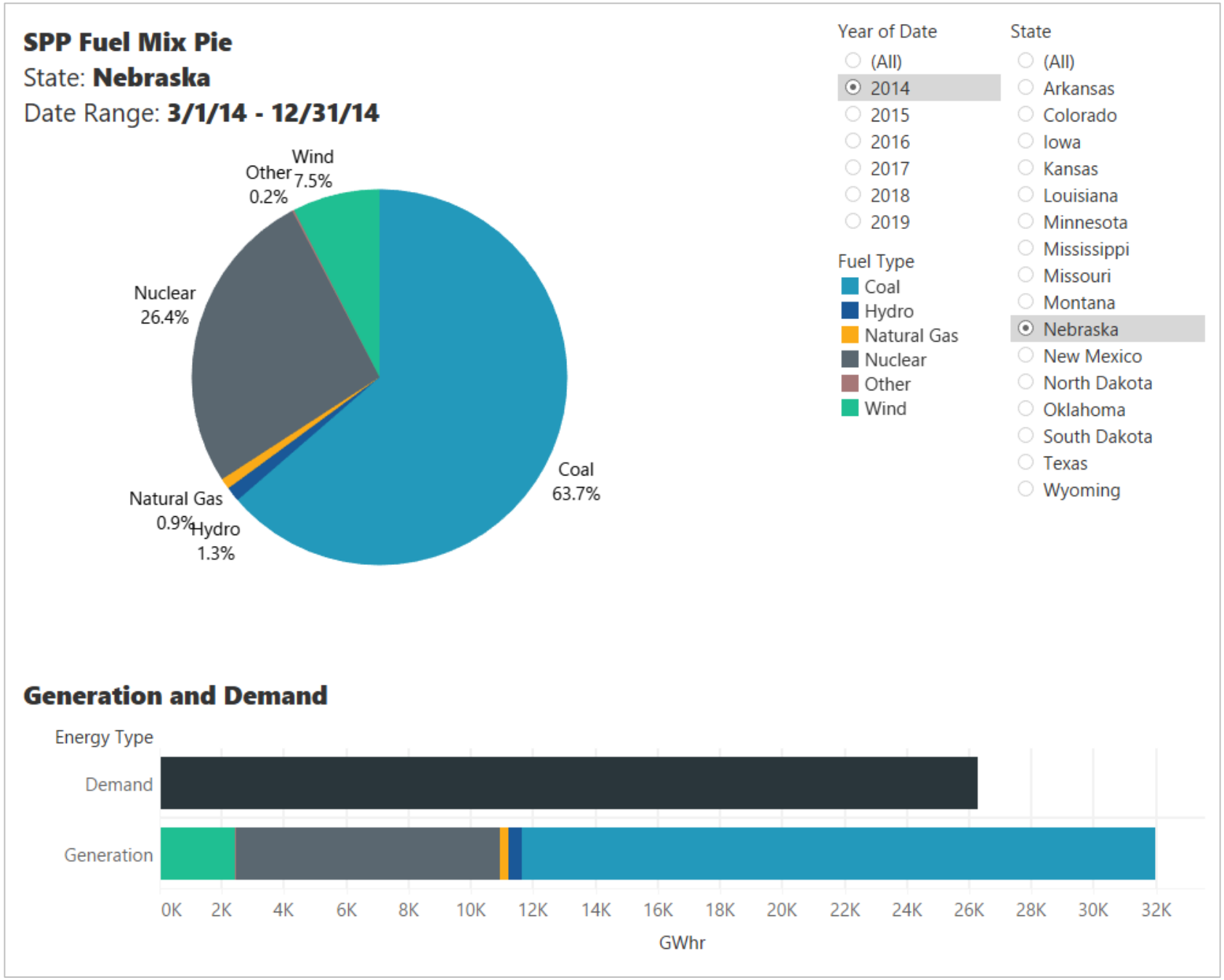

Wind Penetration (of Demand) by State - (SPP BA only)
Data from: 1/1/18 - 12/31/18
Wind Penetration
10.0%
50.0%
0.0%
26.1%
0.3%
24.9%
2.5%
16.7%
0.0%
38.9%
5.7%
24.9%
40.4%
0.0%
15.6%
0.0%
Idaho
Wisconsin
Illinois
Nevada
Utah
Arizona
Baja California
Sonora
Chihuahua
Coahuila de Zaragoza
Nuevo Leon
Baja California
Sinaloa
Durango
© OpenStreetMap contributors

Wind Penetration (of Demand) by State
SPP Market/BA Only

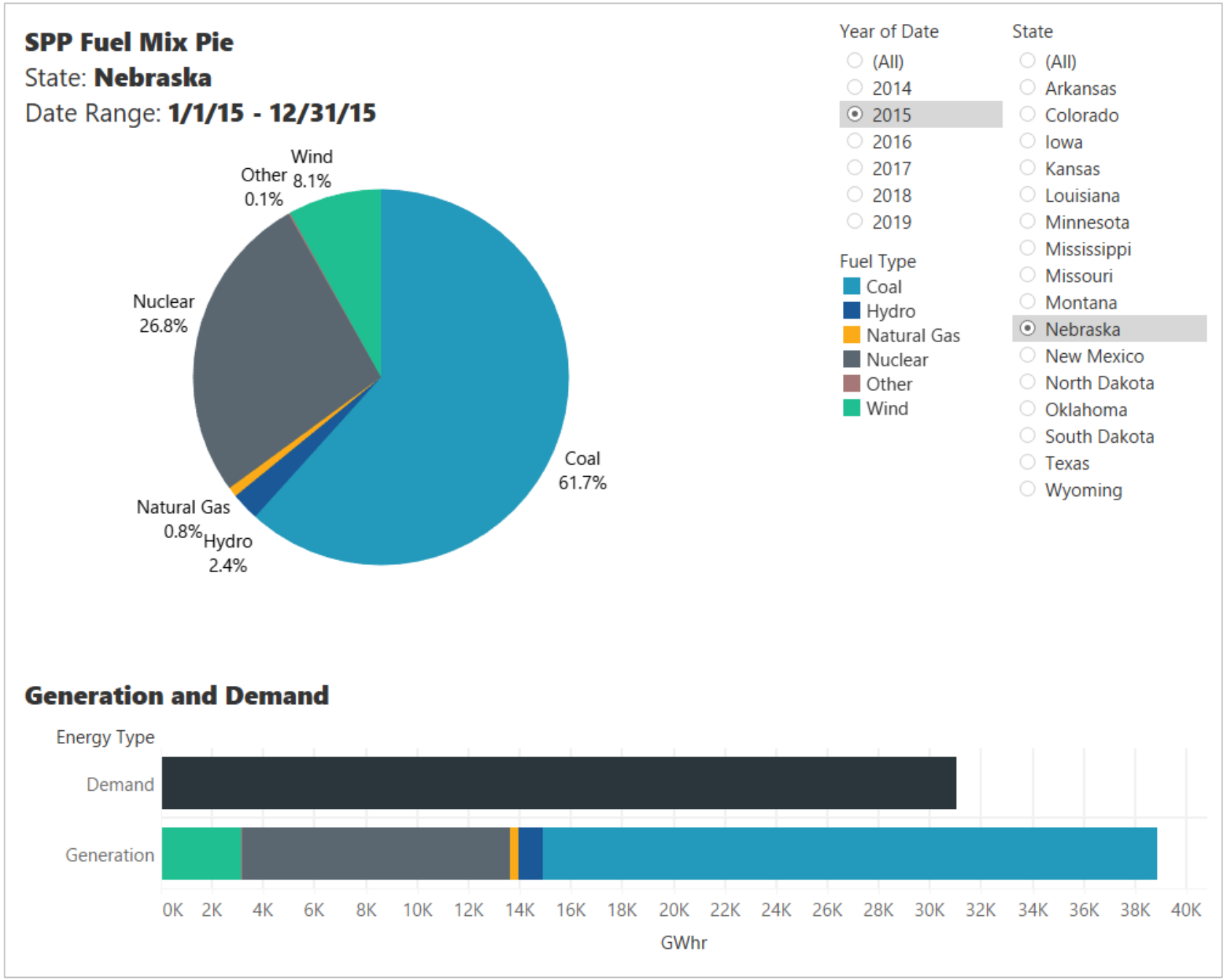
Data from 3/1/2014 - 8/31/2019



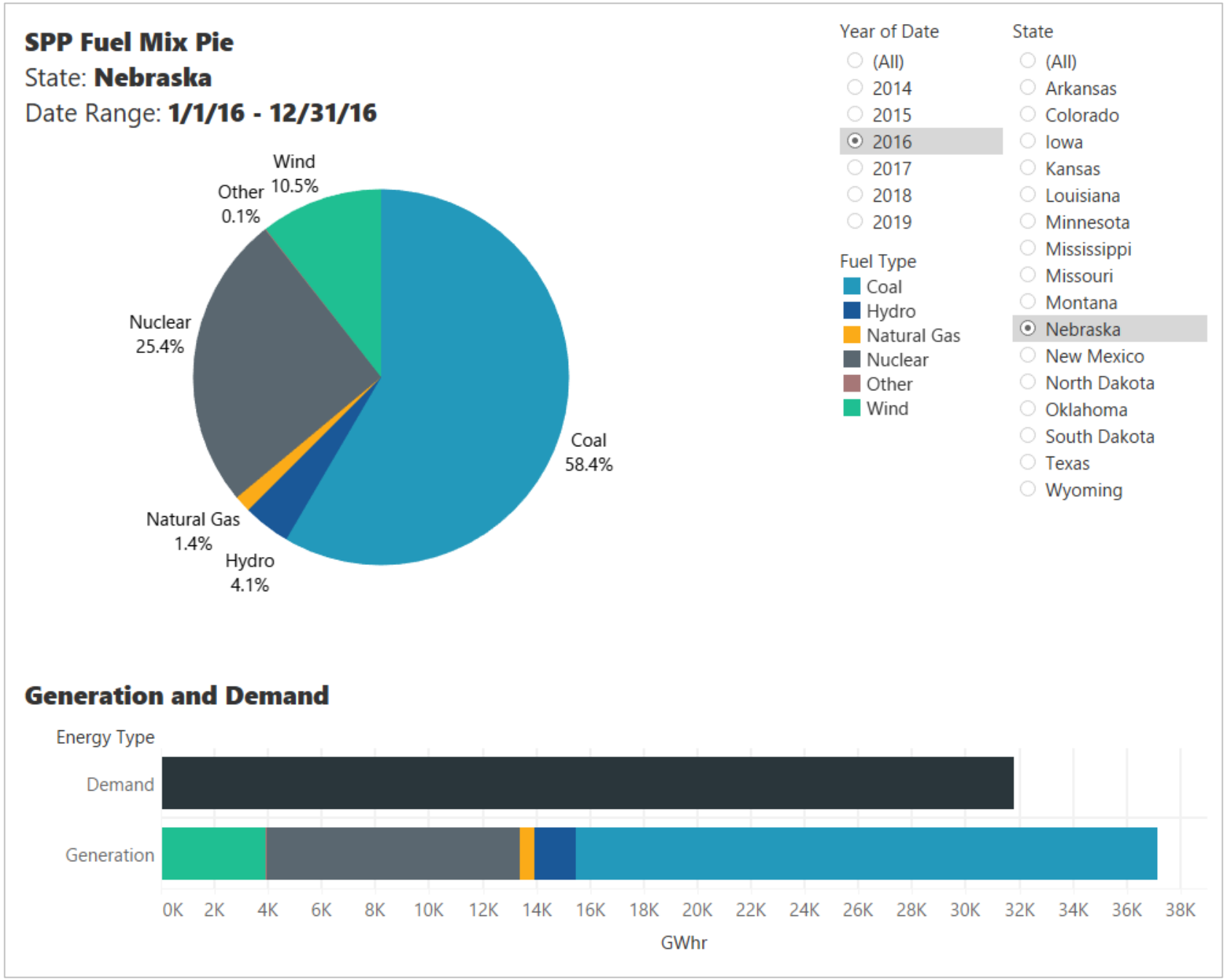
2014 PARTIAL



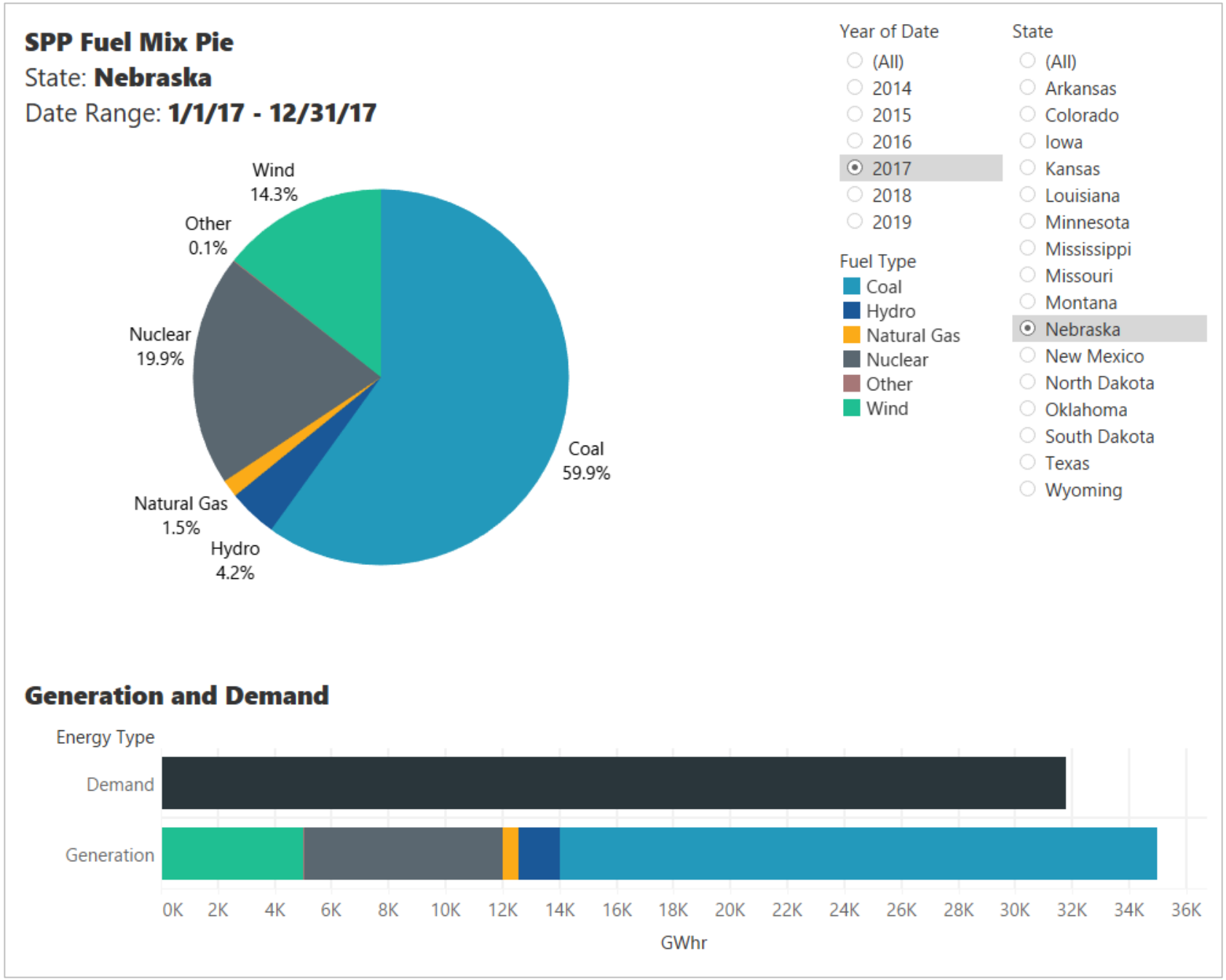
2015


SPP Fuel Mix Pie
State: Nebraska
Date Range: 1/1/15 - 12/31/15
Wind 8.1%
Other 0.1%
Nuclear 26.8%
Coal 61.7%
Natural Gas 0.8%
Hydro 2.4%
Year of Date
(All)
2014
2015
2016
2017
2018
2019
Fuel Type
Coal
Hydro
Natural Gas
Nuclear
Other
Wind
State
(All)
Arkansas
Colorado
Iowa
Kansas
Louisiana
Minnesota
Mississippi
Missouri
Montana
Nebraska
New Mexico
North Dakota
Oklahoma
South Dakota
Texas
Wyoming
Generation and Demand
Energy Type
Demand
Generation
0K 2K 4K 6K 8K 10K 12K 14K 16K 18K 20K 22K 24K 26K 28K 30K 32K 34K 36K 38K 40K
GWhr

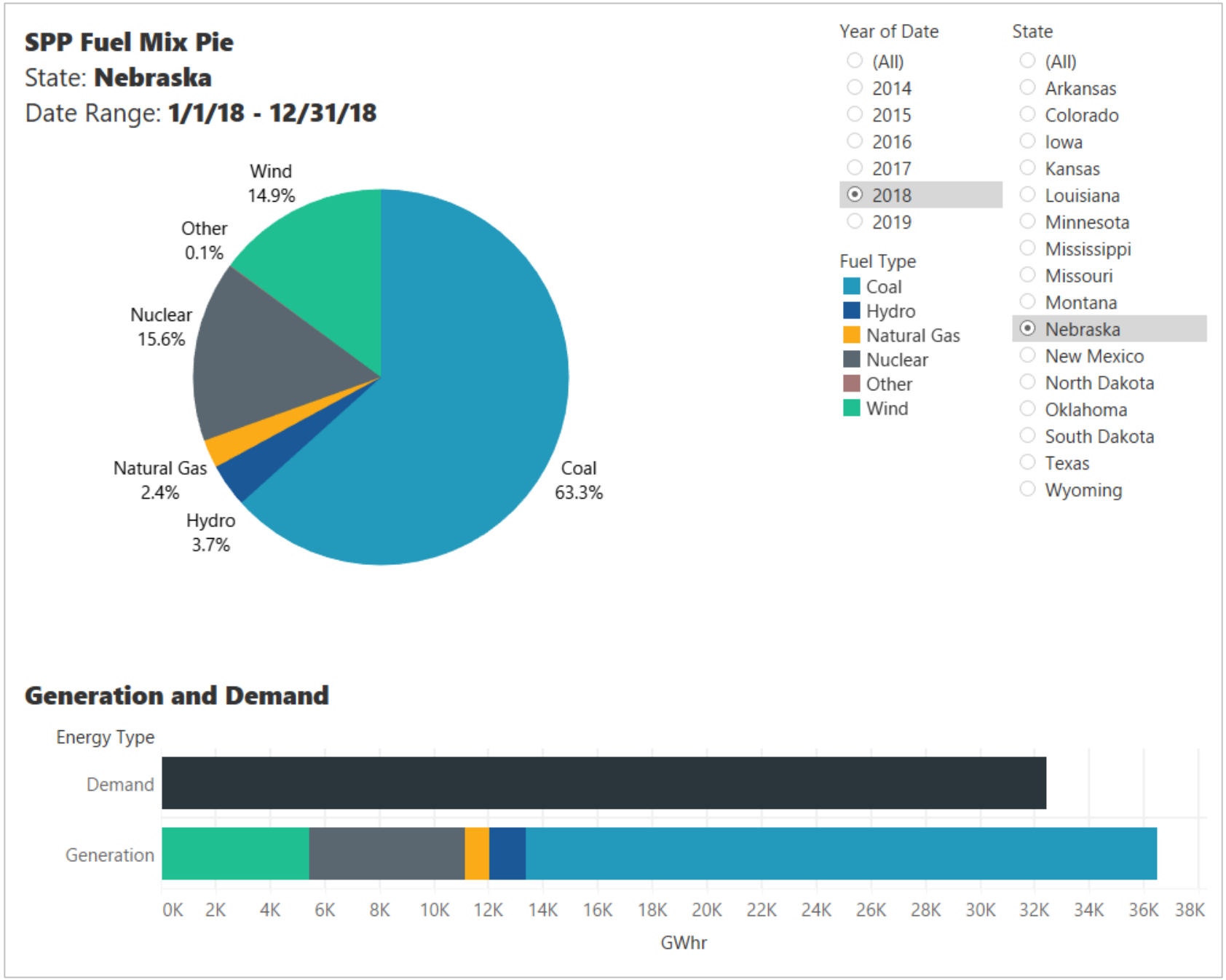
2016


SPP Fuel Mix Pie
State: Nebraska
Date Range: 1/1/16 - 12/31/16
Wind 10.5%
Other 0.1%
Nuclear 25.4%
Coal 58.4%
Natural Gas 1.4%
Hydro 4.1%
Year of Date
(All)
2014
2015
2016
2017
2018
2019
Fuel Type
Coal
Hydro
Natural Gas
Nuclear
Other
Wind
State
(All)
Arkansas
Colorado
Iowa
Kansas
Louisiana
Minnesota
Mississippi
Missouri
Montana
Nebraska
New Mexico
North Dakota
Oklahoma
South Dakota
Texas
Wyoming
Generation and Demand
Energy Type
Demand
Generation
0K 2K 4K 6K 8K 10K 12K 14K 16K 18K 20K 22K 24K 26K 28K 30K 32K 34K 36K 38K
GWhr

2017


SPP Fuel Mix Pie
State: Nebraska
Date Range: 1/1/17 - 12/31/17
Wind 14.3%
Other 0.1%
Nuclear 19.9%
Natural Gas 1.5%
Hydro 4.2%
Coal 59.9%
Year of Date
(All)
2014
2015
2016
2017
2018
2019
Fuel Type
Coal
Hydro
Natural Gas
Nuclear
Other
Wind
State
(All)
Arkansas
Colorado
Iowa
Kansas
Louisiana
Minnesota
Mississippi
Missouri
Montana
Nebraska
New Mexico
North Dakota
Oklahoma
South Dakota
Texas
Wyoming
Generation and Demand
Energy Type
Demand
Generation
0K 2K 4K 6K 8K 10K 12K 14K 16K 18K 20K 22K 24K 26K 28K 30K 32K 34K 36K
GWhr

2018

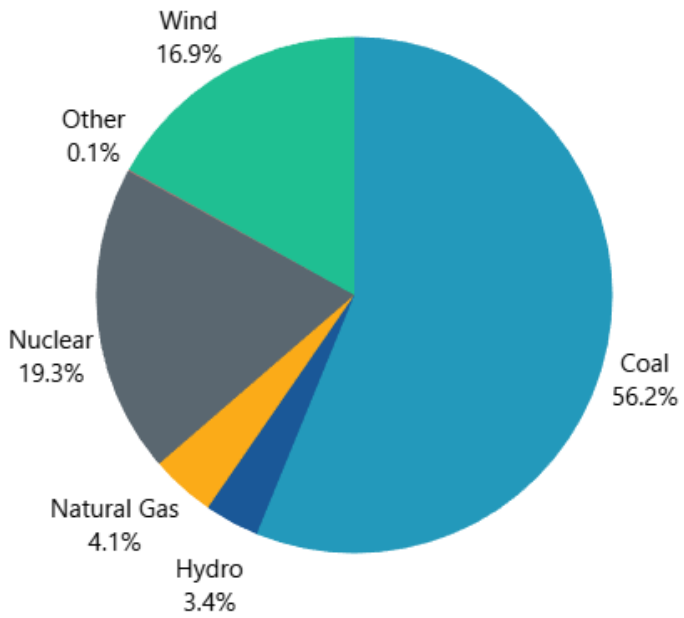

SPP Fuel Mix Pie
State: Nebraska
Date Range: 1/1/18 - 12/31/18
Wind 14.9%
Other 0.1%
Nuclear 15.6%
Natural Gas 2.4%
Hydro 3.7%
Coal 63.3%
Year of Date
(All)
2014
2015
2016
2017
2018
2019
State
(All)
Arkansas
Colorado
Iowa
Kansas
Louisiana
Minnesota
Mississippi
Missouri
Montana
Nebraska
New Mexico
North Dakota
Oklahoma
South Dakota
Texas
Wyoming
Fuel Type
Coal
Hydro
Natural Gas
Nuclear
Other
Wind
Generation and Demand
Energy Type
Demand
Generation
0K 2K 4K 6K 8K 10K 12K 14K 16K 18K 20K 22K 24K 26K 28K 30K 32K 34K 36K 38K
GWhr

2019 SO FAR

SPP Fuel Mix Pie

State: **Nebraska**

Date Range: **1/1/19 - 8/31/19**

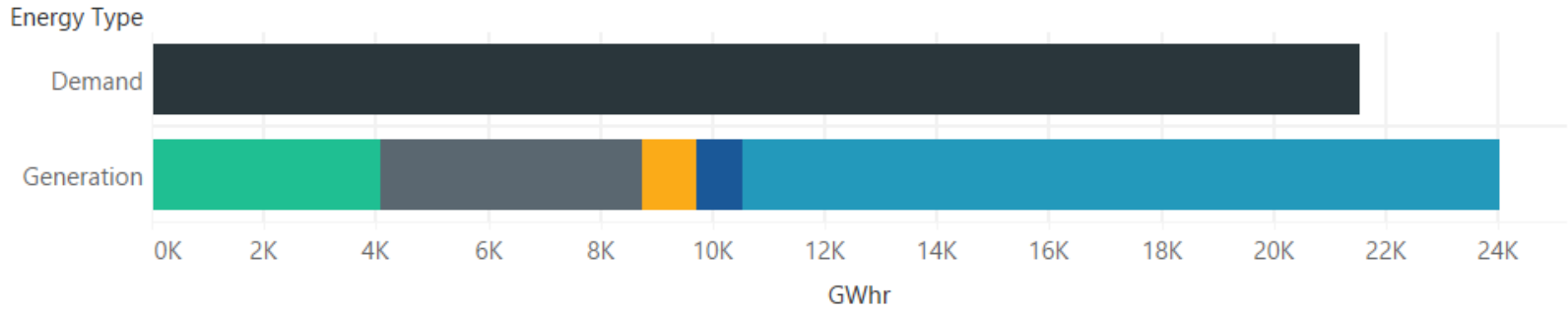


Year of Date
- (All)
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019

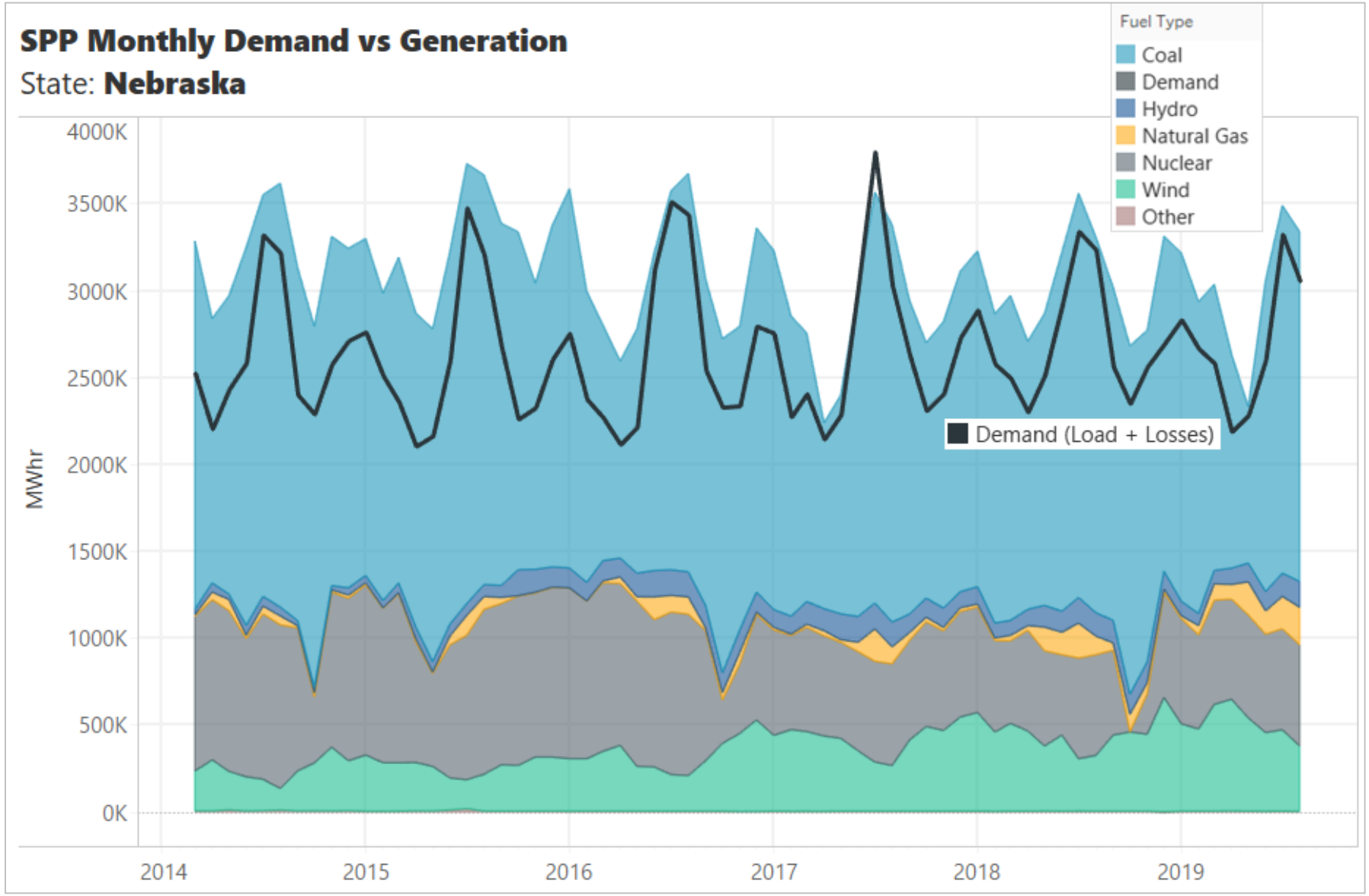
Fuel Type
- Coal
- Hydro
- Natural Gas
- Nuclear
- Other
- Wind

State
- (All)
- Arkansas
- Colorado
- Iowa
- Kansas
- Louisiana
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- New Mexico
- North Dakota
- Oklahoma
- South Dakota
- Texas
- Wyoming

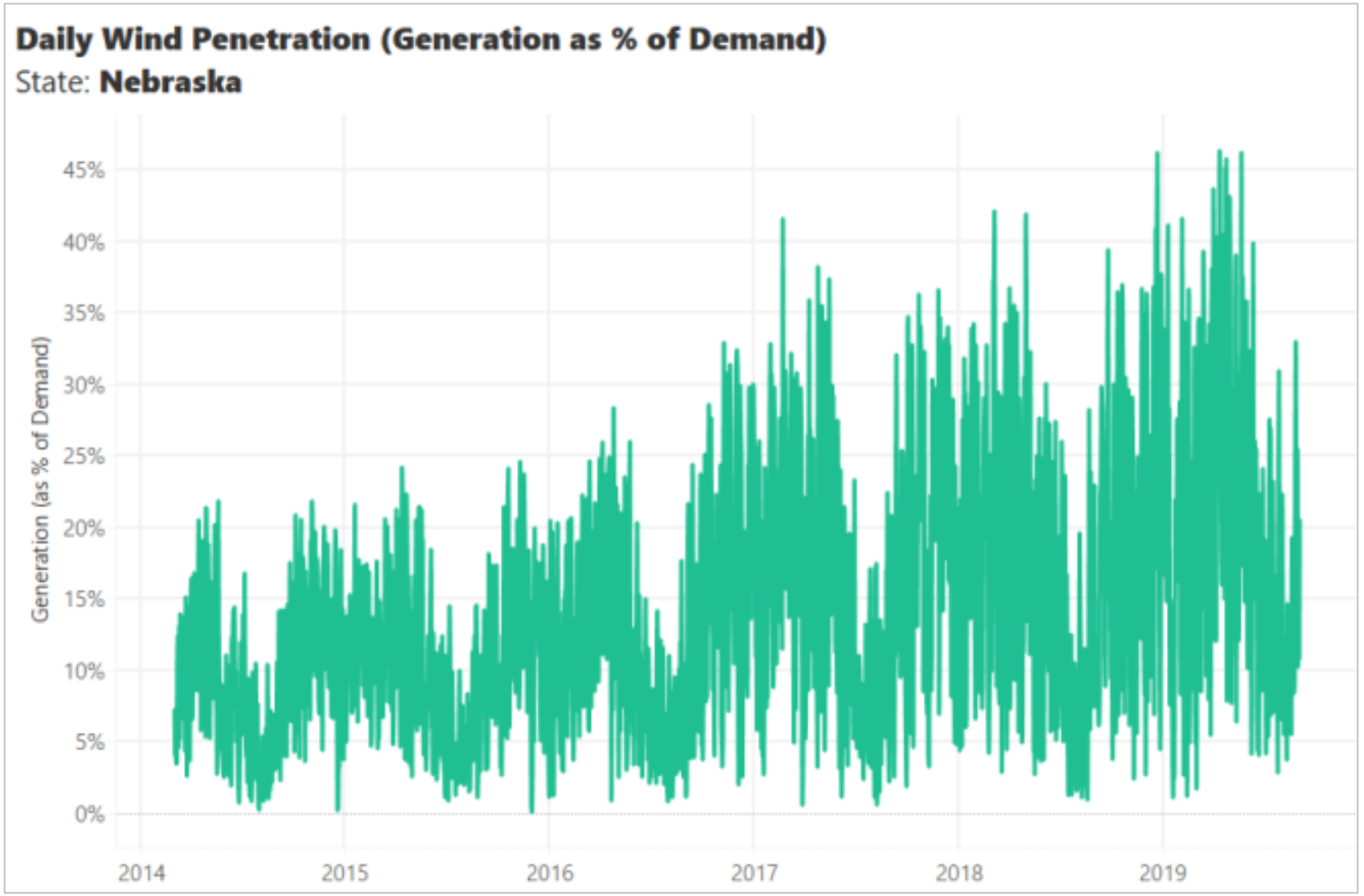
Generation and Demand



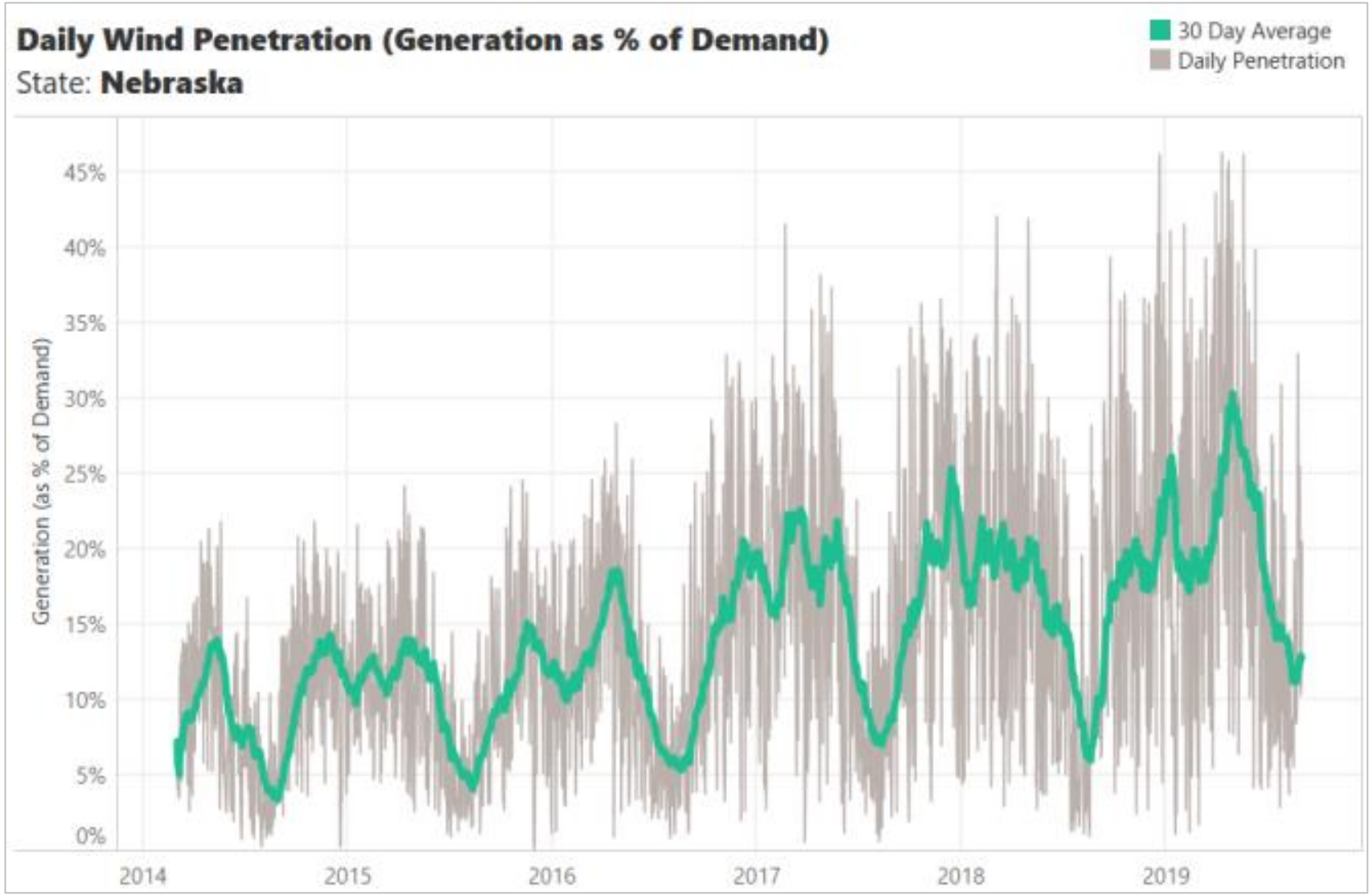
ALL GENERATION (BY FUEL) VS DEMAND ENERGY



DAILY WIND PENETRATION LEVELS



DAILY WIND PENETRATION LEVELS



An Energy Marketing View
2019 Nebraska Wind & Solar Conference

Ron Thompson

Energy Manager

October 29, 2019

Discussion items

- Generation Impacts
  - Negative prices
  - Cycling concerns
    - Many Units are not designed to cycle
  - Longer Generation Outages
    - How can generation costs be reduced for marginal units
- Behind the Meter Generation (BTM) impacts
  - Offsets Market Load
  - Load Forecast Error increases
  - The need for Real Time and after the Fact Generation metering
- Reliability
  - Enough Generation available – Timing is important
    - Do we have enough resources available for changes
      - The potential of large swings in Renewable generation
      - Potential of Scarcity prices when Forecasts are off
    - Solar impacts reliability as well
    - Need to look at paying Resources for Reliability
- Transmission impacts
  - Day Ahead (DA) and Real Time (RT) impacts when not converging
  - Transmission Flowgates concerns changing resulting in flows being different than projected resulting in more congestion on the system

Omaha Public Power District

A Transmission Operations View

2019 Nebraska Wind & Solar Conference

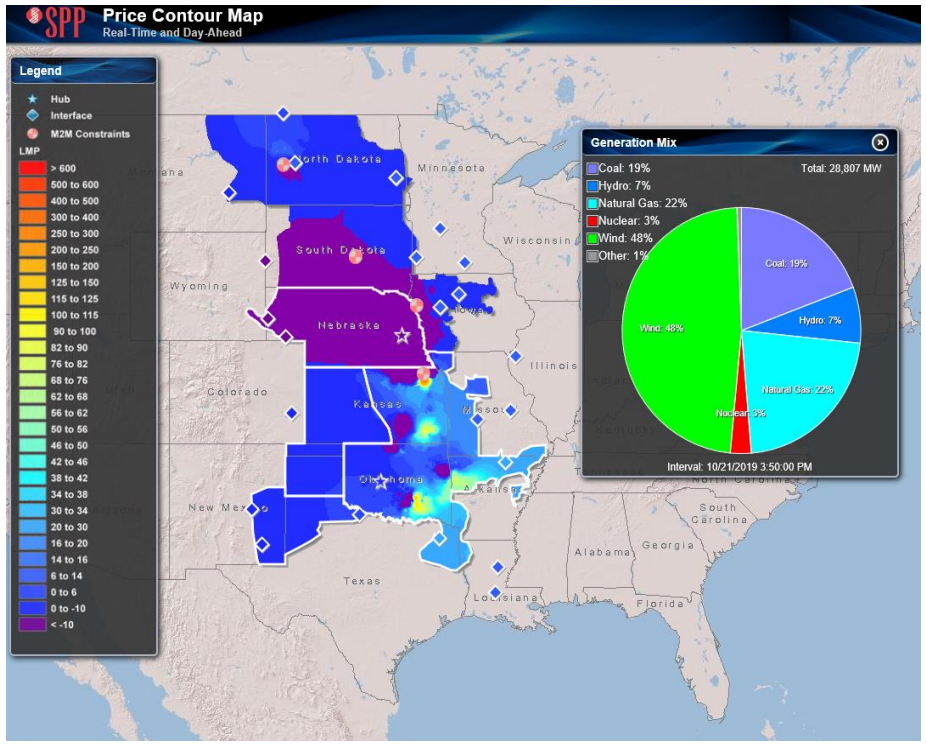
Aaron Smith

Director – Operations

October 29, 2019

Transmission Operations Evolution

- SPP Consolidated Balancing Area (CBA), 2014
- Changing Resource Mix in SPP
- Day Ahead Analysis vs Real-time
  - Forecasting errors
  - Flows changing hourly
- Real Time Assessment (RTA) & Modeling
  - OPPD conducts RTA every 2 minutes
  - 3600+ MW of wind in OPPD's EMS (Energy Management System) model
- Energy Emergency Alert (EEA) Level 1
  - August 6, 2019
    - Forecast error combined with forced generation outages
    - 98% of SPP record peak load with only 7% online wind capacity



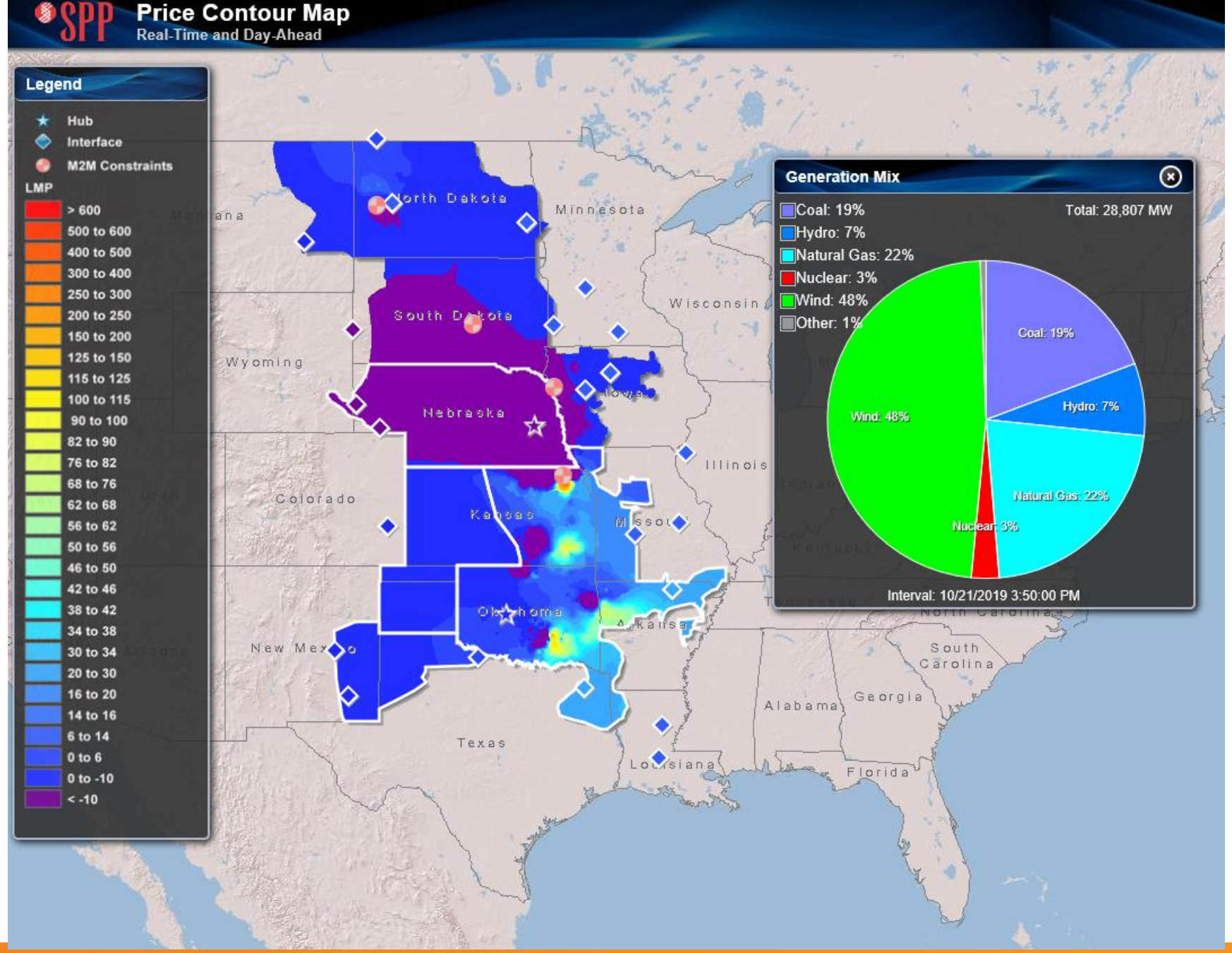
Question & Answer

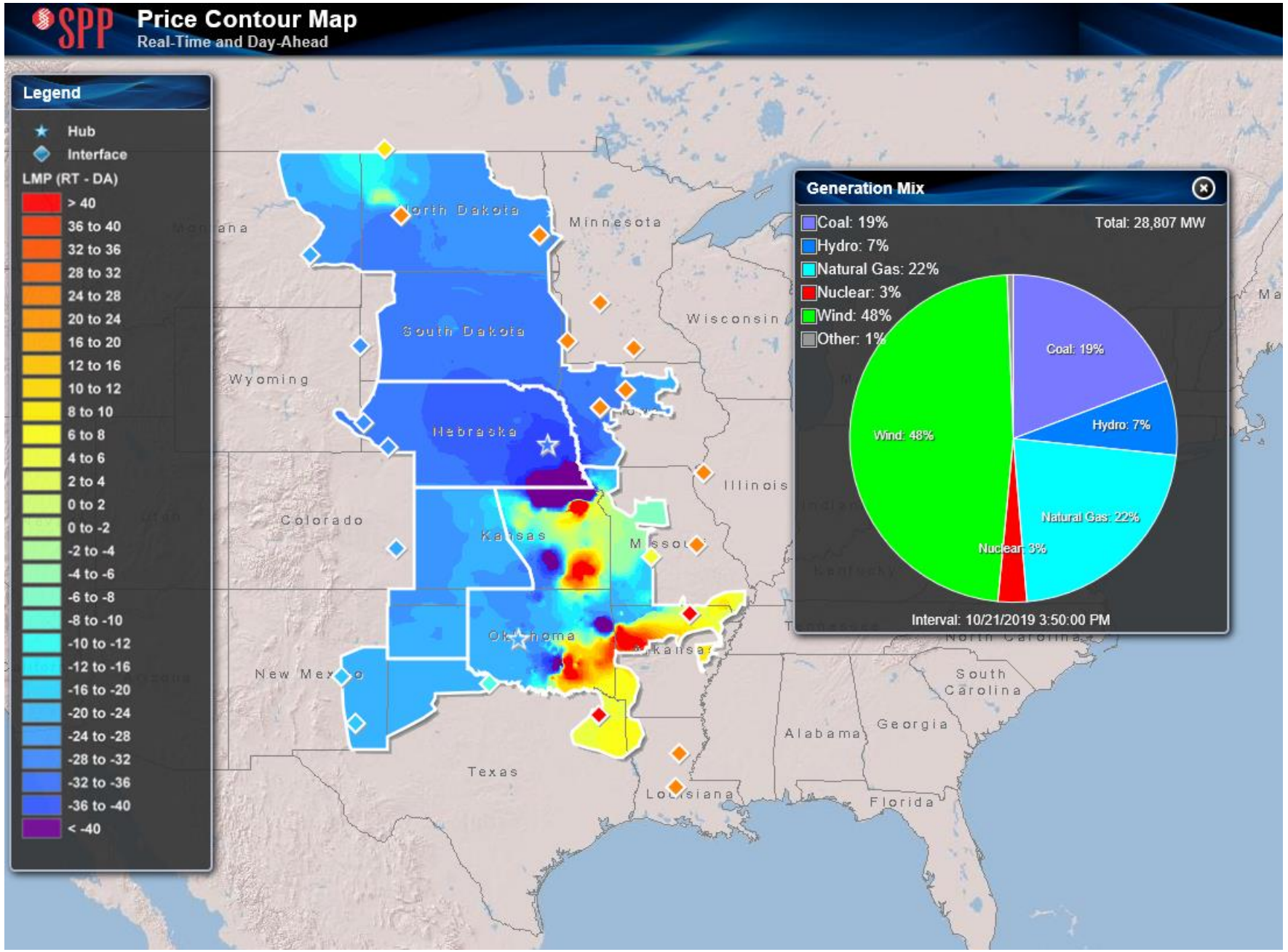
Omaha Public Power District

OPPD Appendix Slides

(1) Negative Real-time LMP

(2) Deviation from Day Ahead LMP


SPP
Price Contour Map
Real-Time and Day-Ahead
Legend
Hub
Interface
M2M Constraints
LMP
> 600
500 to 600
400 to 500
300 to 400
250 to 300
200 to 250
150 to 200
125 to 150
115 to 125
100 to 115
90 to 100
82 to 90
76 to 82
68 to 76
62 to 68
56 to 62
50 to 56
46 to 50
42 to 46
38 to 42
34 to 38
30 to 34
20 to 30
16 to 20
14 to 16
6 to 14
0 to 6
0 to -10
< -10
Generation Mix
Total: 28,807 MW
Coal: 19%
Hydro: 7%
Natural Gas: 22%
Nuclear: 3%
Wind: 48%
Other: 1%
Interval: 10/21/2019 3:50:00 PM
North Dakota
Minnesota
South Dakota
Wisconsin
Wyoming
Nebraska
Illinois
Colorado
Kansas
Oklahoma
New Mexico
Texas
Louisiana
Alabama
Georgia
South Carolina
Florida


SPP
Price Contour Map
Real-Time and Day-Ahead
Legend
Hub
Interface
LMP (RT - DA)
> 40
36 to 40
32 to 36
28 to 32
24 to 28
20 to 24
16 to 20
12 to 16
10 to 12
8 to 10
6 to 8
4 to 6
2 to 4
0 to 2
0 to -2
-2 to -4
-4 to -6
-6 to -8
-8 to -10
-10 to -12
-12 to -16
-16 to -20
-20 to -24
-24 to -28
-28 to -32
-32 to -36
-36 to -40
< -40
Generation Mix
Coal: 19%
Hydro: 7%
Natural Gas: 22%
Nuclear: 3%
Wind: 48%
Other: 1%
Total: 28,807 MW
Coal: 19%
Hydro: 7%
Natural Gas: 22%
Nuclear: 3%
Wind: 48%
Interval: 10/21/2019 3:50:00 PM
North Dakota
Minnesota
South Dakota
Wisconsin
Wyoming
Nebraska
Illinois
Colorado
Kansas
Oklahoma
New Mexico
Texas
Louisiana
Arkansas
Alabama
Georgia
South Carolina
Florida