The Role of Coal in the West

Western Interstate Energy Board

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Western Interstate Energy Board

EIA Baseload Definitions

- **Base load:** The minimum amount of electric power delivered or required over a given period of time at a steady rate.
- **Base load capacity:** The generating equipment normally operated to serve loads on an around-the-clock basis.
- **Base load plant:** A plant […] which is normally operated to take all or part of the minimum load of a system, and which consequently produces electricity at an essentially constant rate and runs continuously.

For the Purposes of the Presentation

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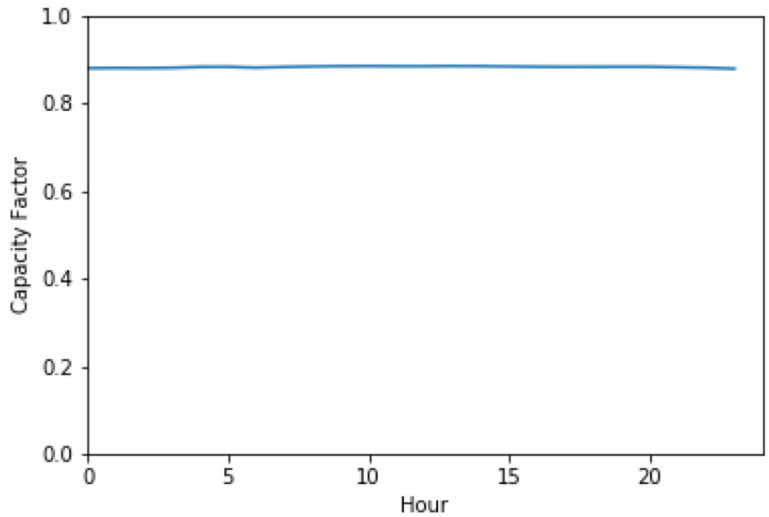


Baseload Generation is not a requirement

- A portion of a resource fleet that provides reliability services is necessary
- Having more baseload generation makes system planning easier, but does not necessarily result in a more reliable or lower-cost portfolio

- Coal and nuclear resources are designed for low cost O&M and continuous operation
- Baseload resources have low forced and maintenance outage hours
- Low exposure to fuel supply chain issues

What is the CEM Database?

- **C**ontinuous **E**missions **M**onitoring **D**ata
- EPA collects data from generators
- Includes hourly data for Heat Input, Generated Load, Emissions, etc.
- 96 Coal Units, 544 NG Units
- 13,315,200 rows of data for Coal

  96 units x 365 days x 24 hours a day x 16 years
- Compiled using Python and parsed with SQL

Out[1]: u'Connected: None@2016.db'

In [50]:
```
%%sql select * from data limit 10
```

Done.

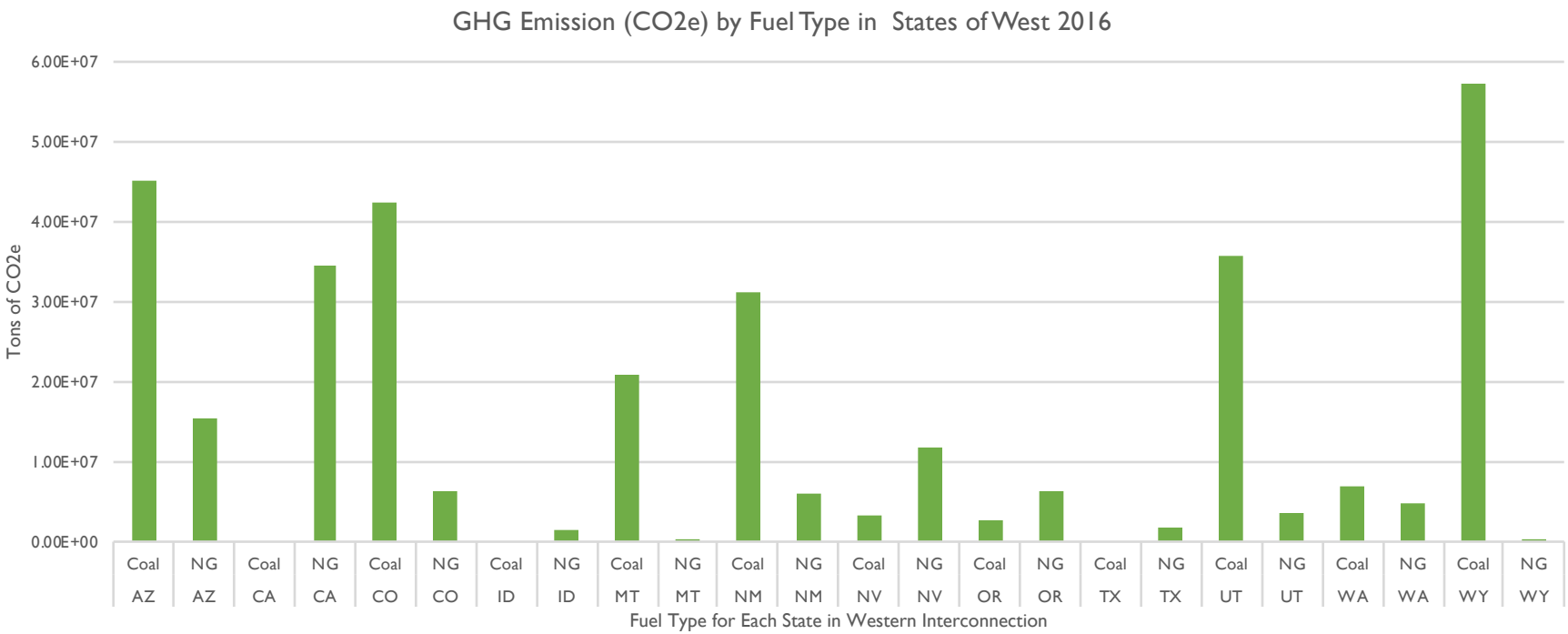
Out[50]:

state	name	orispl_code	unitid	op_date	op_hour	op_time	gload	SO2_MASS	NOX_MASS	CO2_MASS	heat_input	county	latitude	longitude	fuel_ty
WA	Fredonia Generating Station	607	CT3	01-01-2016	0	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	1	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	2	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	3	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	4	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	5	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	6	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	7	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	8	0.0						Skagit	48.4553	-122.435	Natu G
WA	Fredonia Generating Station	607	CT3	01-01-2016	9	0.0						Skagit	48.4553	-122.435	Natu G

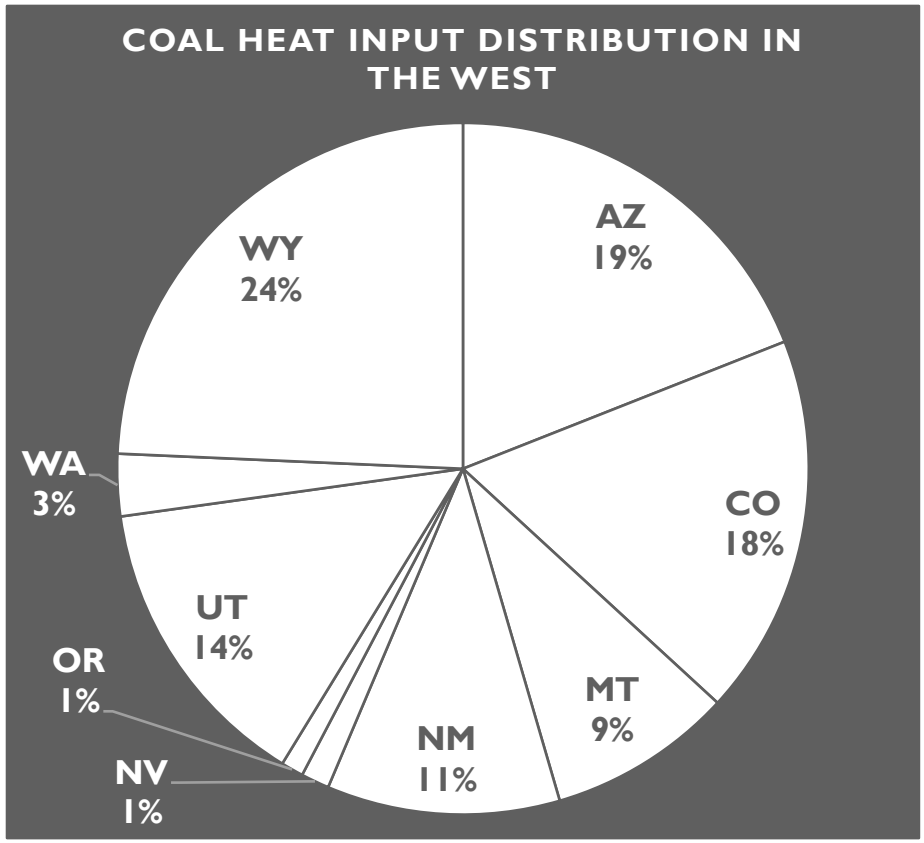
In [2]:
```
%%sql
select state, fuel_actual, count(distinct orispl_code) as num_plants,  SUM(heat_input), SUM(CO2_MASS)
FROM (
    select *,
    CASE WHEN (fuel_type is 'Natural Gas' or fuel_type is 'Pipeline Natural Gas' or fuel_type is 'Natural Gas, Pipeline Natural G
    THEN ('NG') ELSE (fuel_type) END as fuel_actual
    FROM data
)
group by state, fuel_actual
```

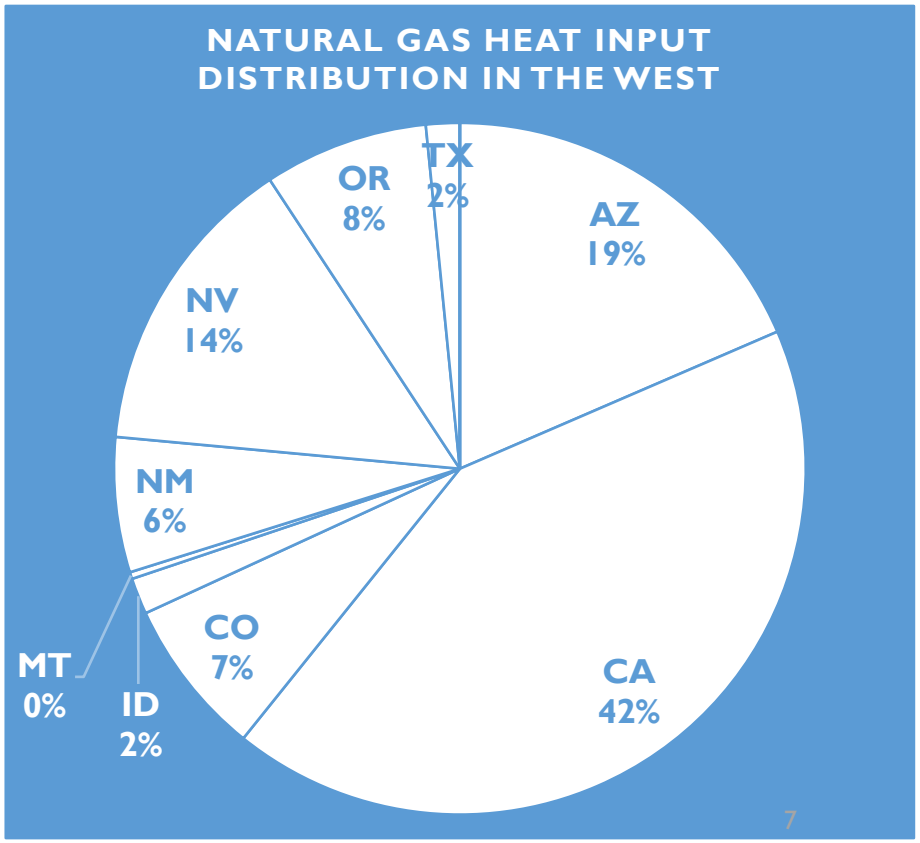
Sample query for the database

Emissions in CO_2 equivalents

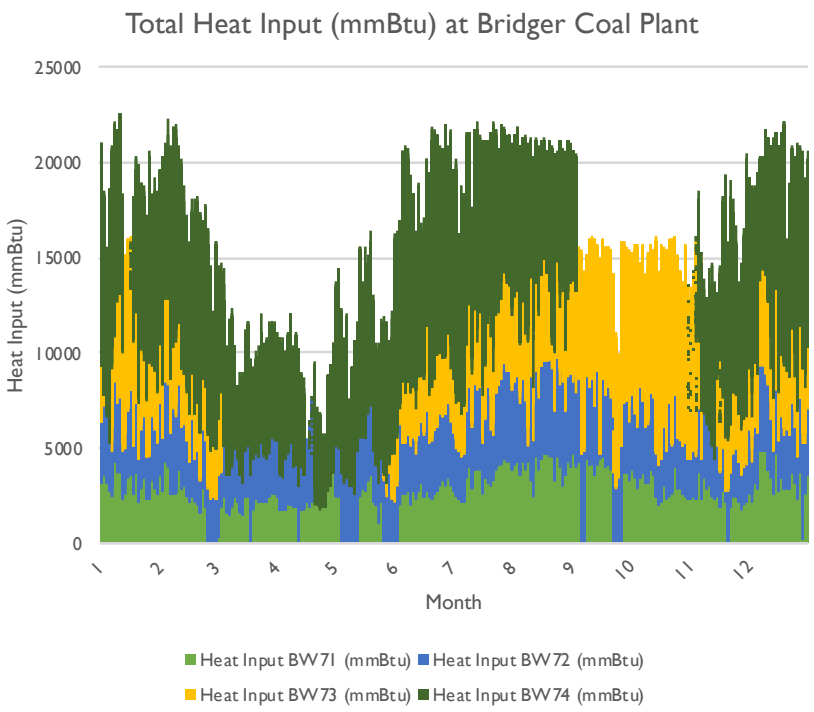


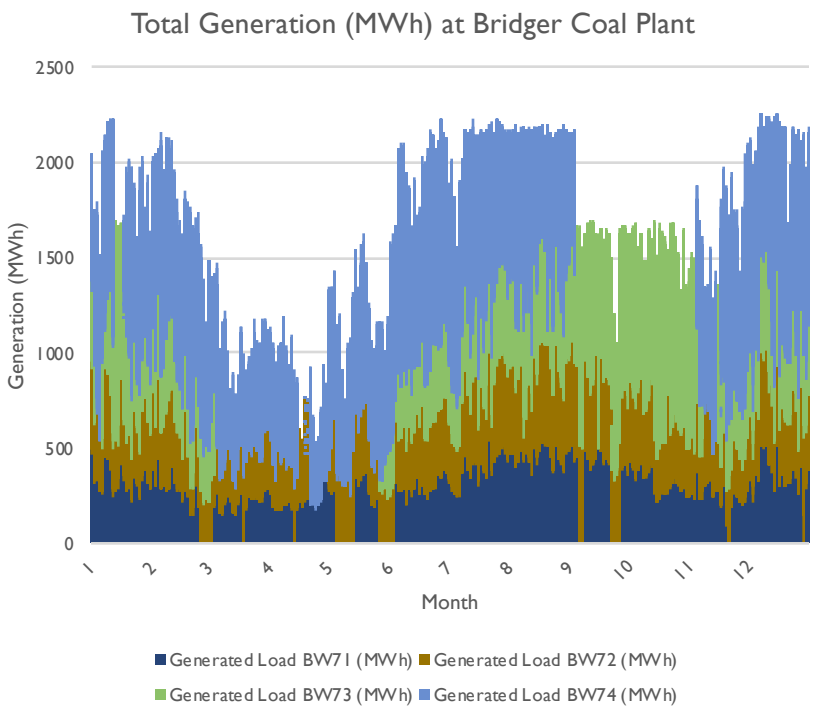
How It Breaks Up in the West



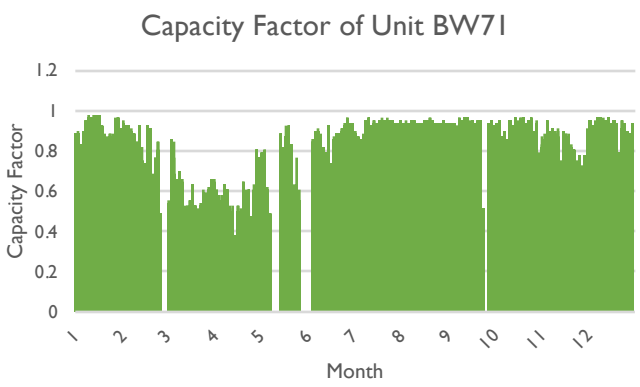


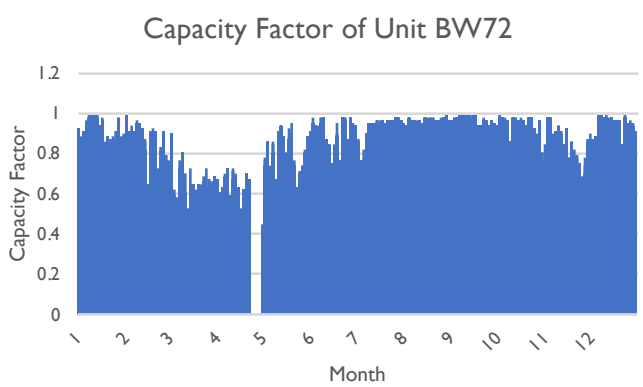
Heat Input and Generation at Bridger Coal Plant in 2016

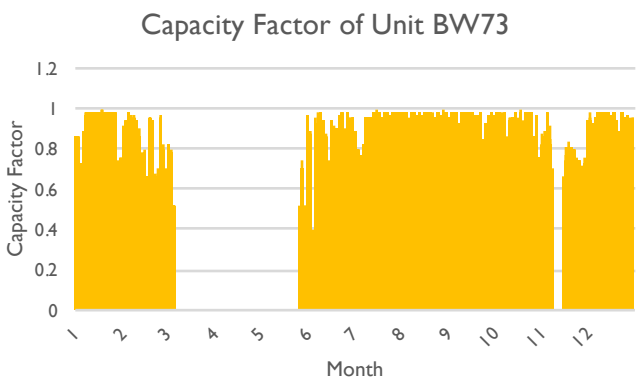


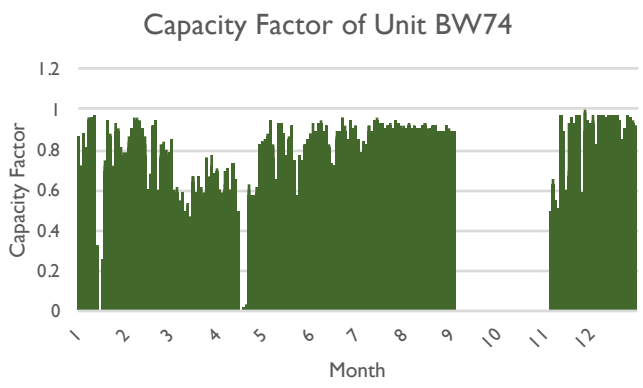


Estimated Capacity Factors for EGU's at Bridger in 2016 Based on Generation





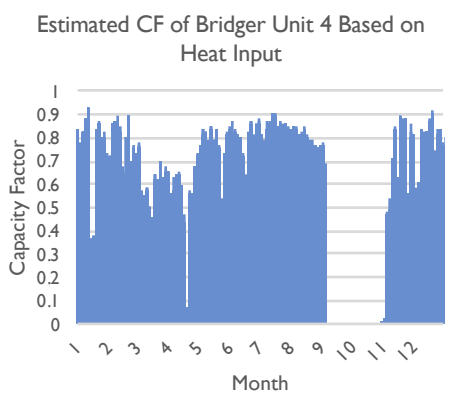


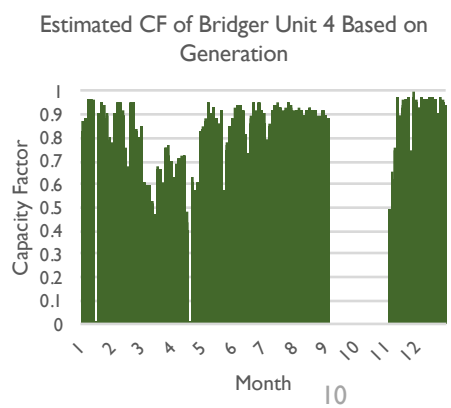


Estimation of Data Driven Capacity Factor

- Underlying Assumptions:
  - $CF \approx \frac{Hourly\ Heat\ Input}{Maximum\ Heat\ Input\ from\ 2001-2016}$
  - Likewise for generated load
  - Maximum heat input or generated load over the 16 year period can exceed the nameplate capacity
  - Capacity factor values and trends derived from heat input or generated load are relatable

Plant Name	ORISPL CODE	Unit #	Max Generation (MW)	Max Heat Input (mmBtu)	Fuel Type	Nameplate Capacity (MW)
Jim Bridger	8066	BW71	581	7096.6	Coal	535
Jim Bridger	8066	BW72	585	7276.1	Coal	527
Jim Bridger	8066	BW73	570	7402.2	Coal	527
Jim Bridger	8066	BW74	580	6776.3	Coal	530

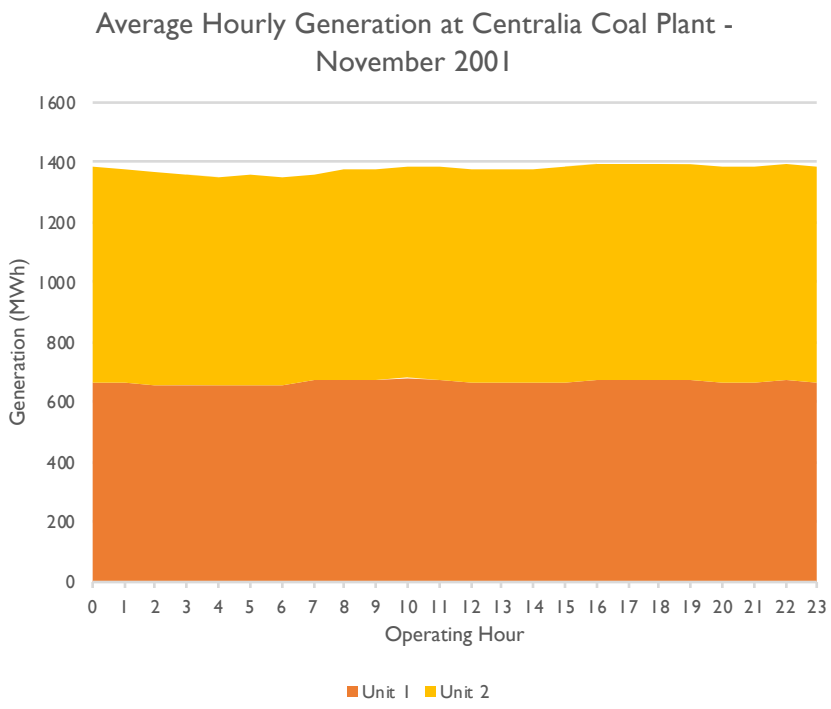


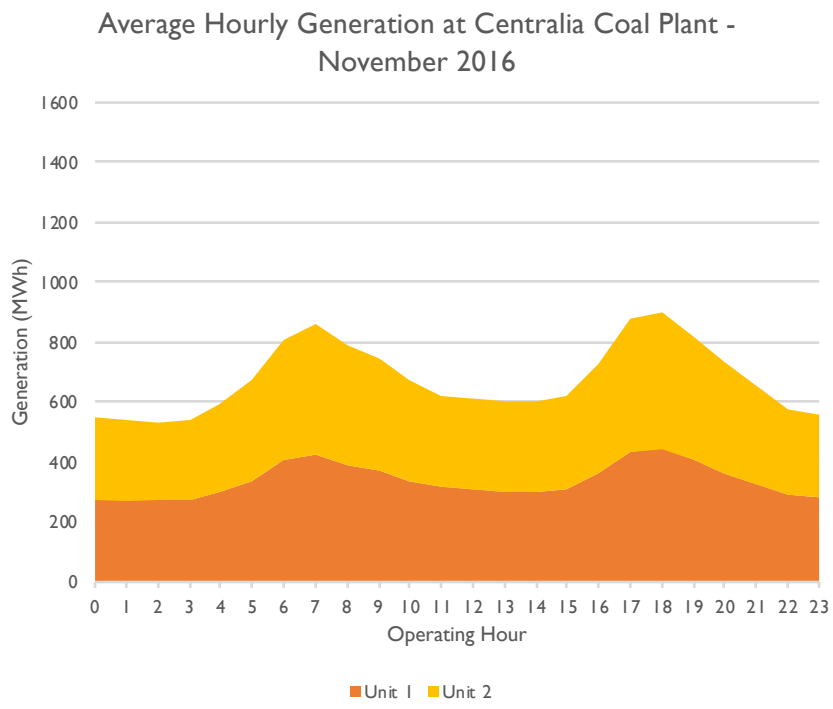


All coal fired power is solely used for baseload power and is consistently running at max capacity.

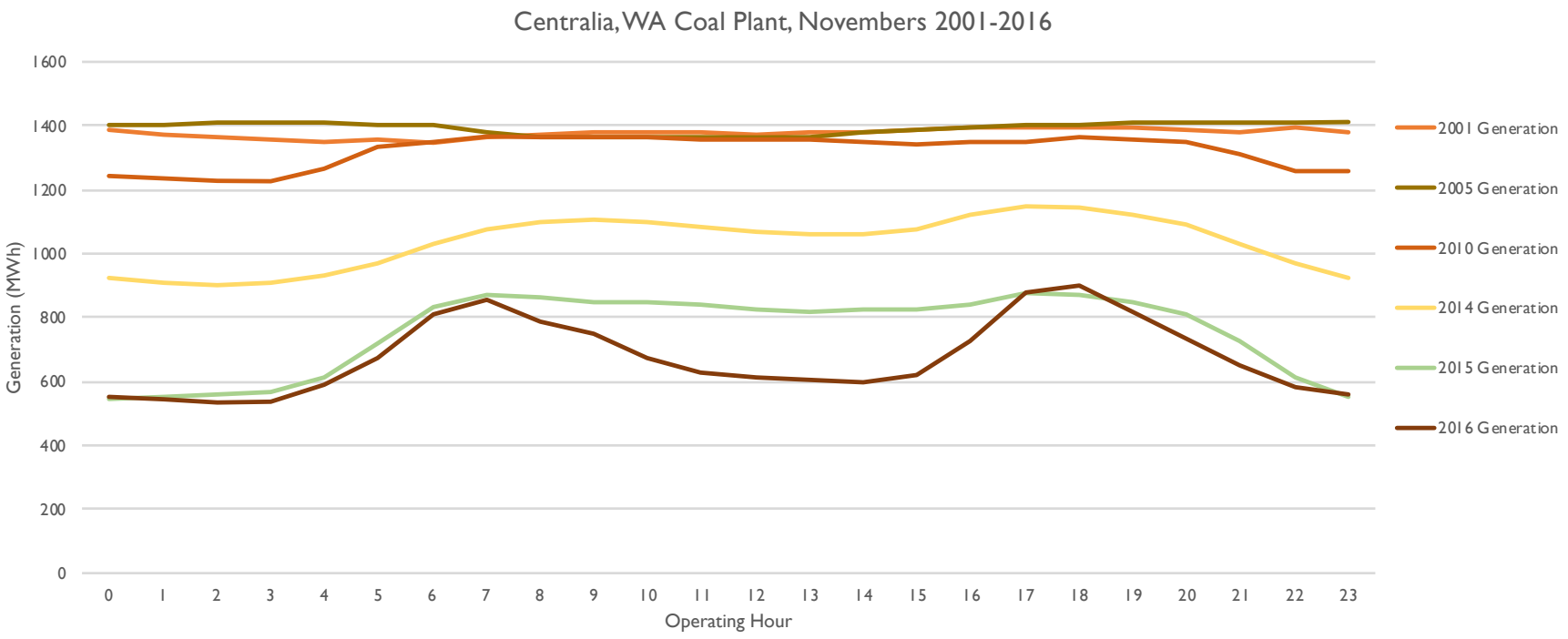
~~All~~ coal fired power is ~~solely~~ **sometimes** used for baseload power and is ~~consistently~~ running at ~~max~~ a **variable** capacity factor.

The Changing Grid – 2001 vs 2016

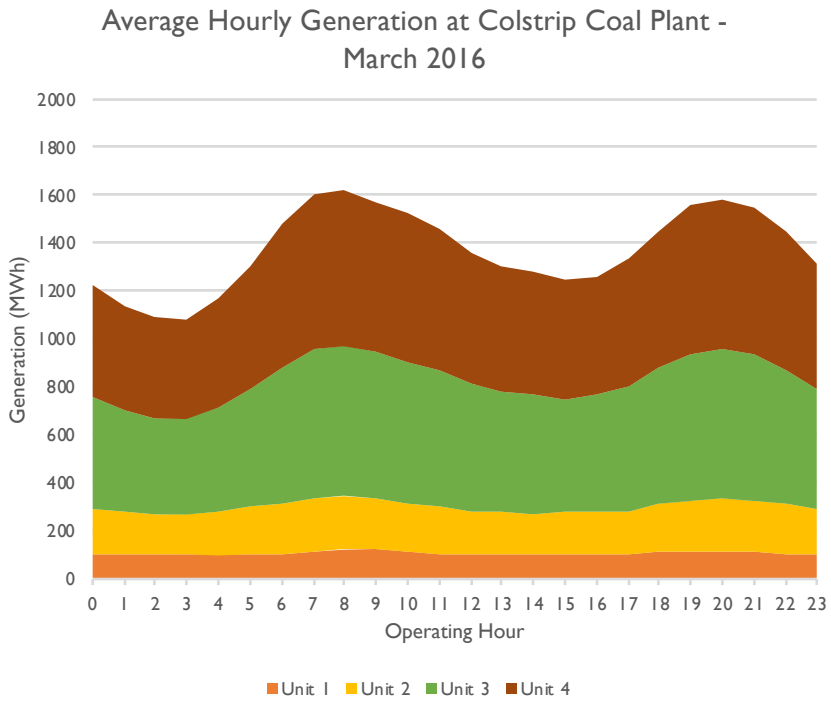


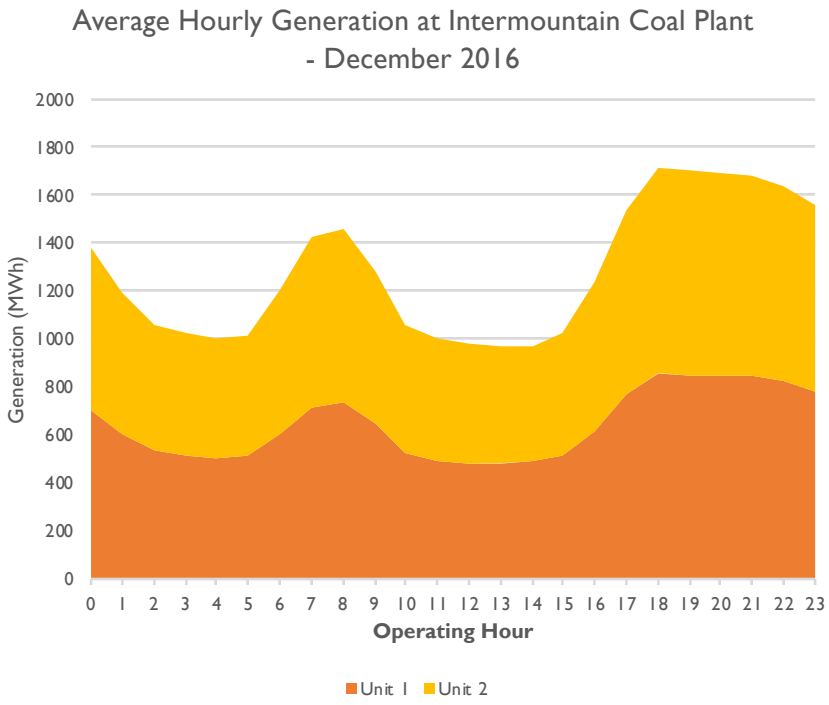


Duck Curve Development



Other Major Coal Plants



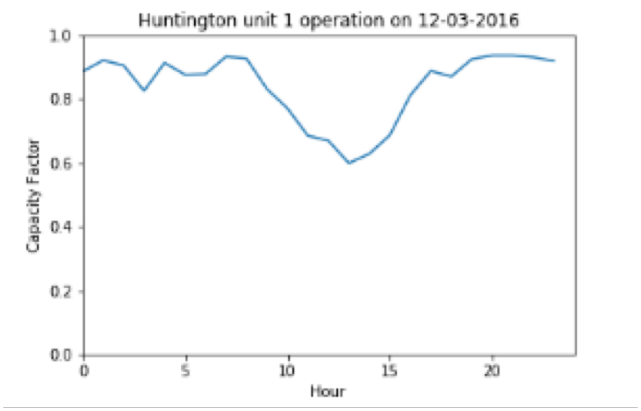


Systematic Analysis

- Clustering – Unsupervised Learning Algorithm
- Over 500,000 unit-days in the database

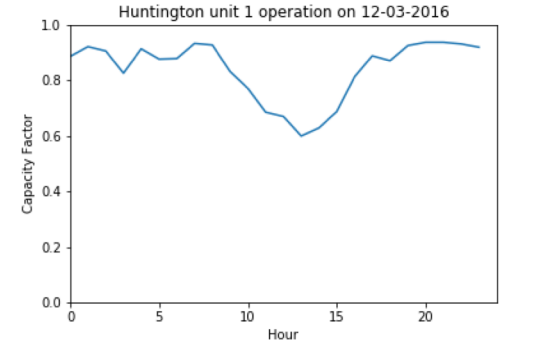
  95 units x 365 days x 16 years

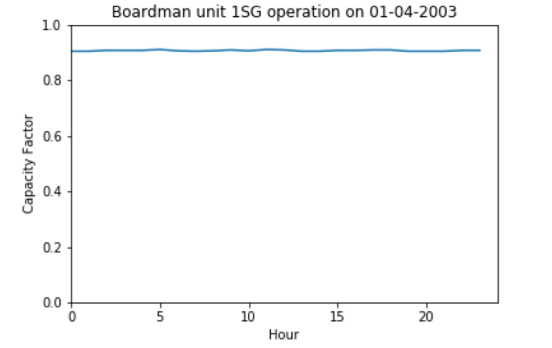
- Logic/algorithm is a filter for bias and is the basis of fairness



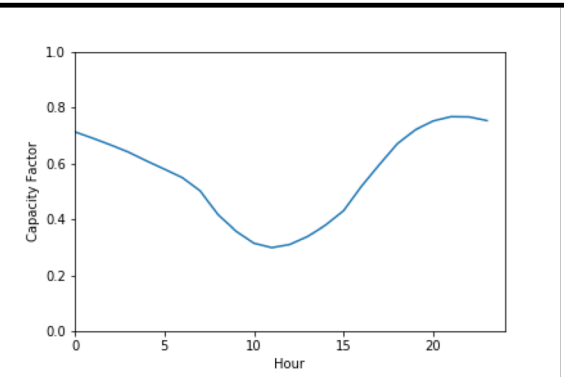
Sorting Unit-Days Into Generation Profiles

Actual Generation

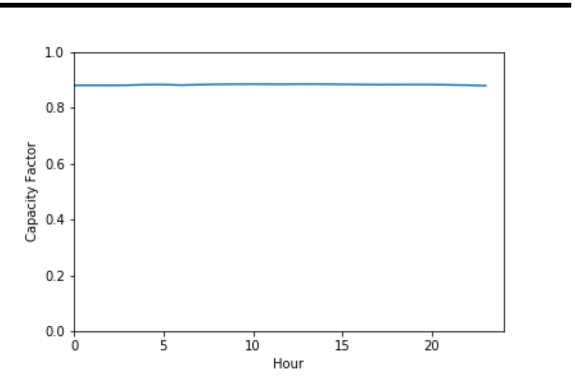




Profile of Generation

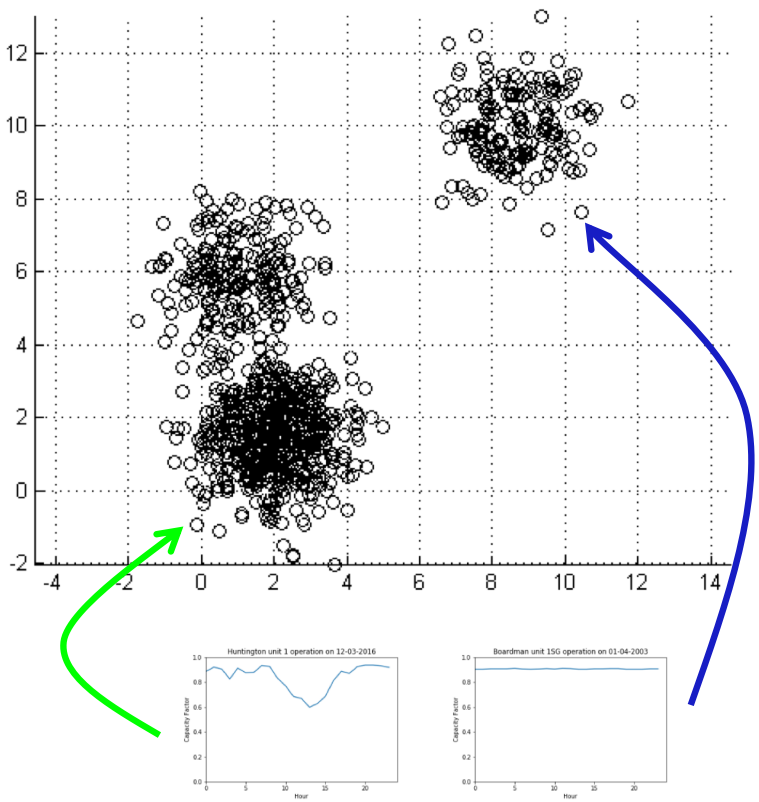


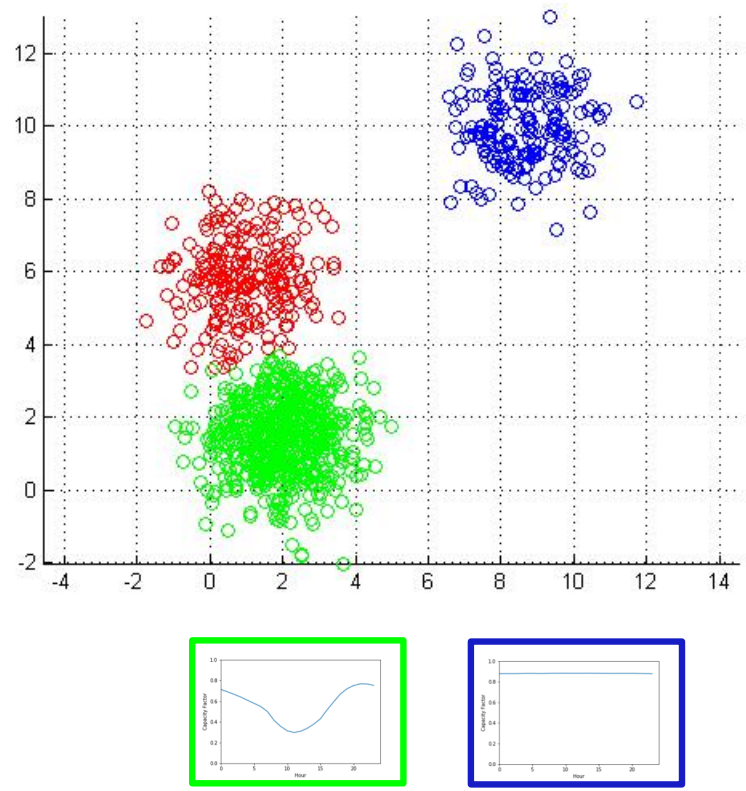
How many flexible generation days?



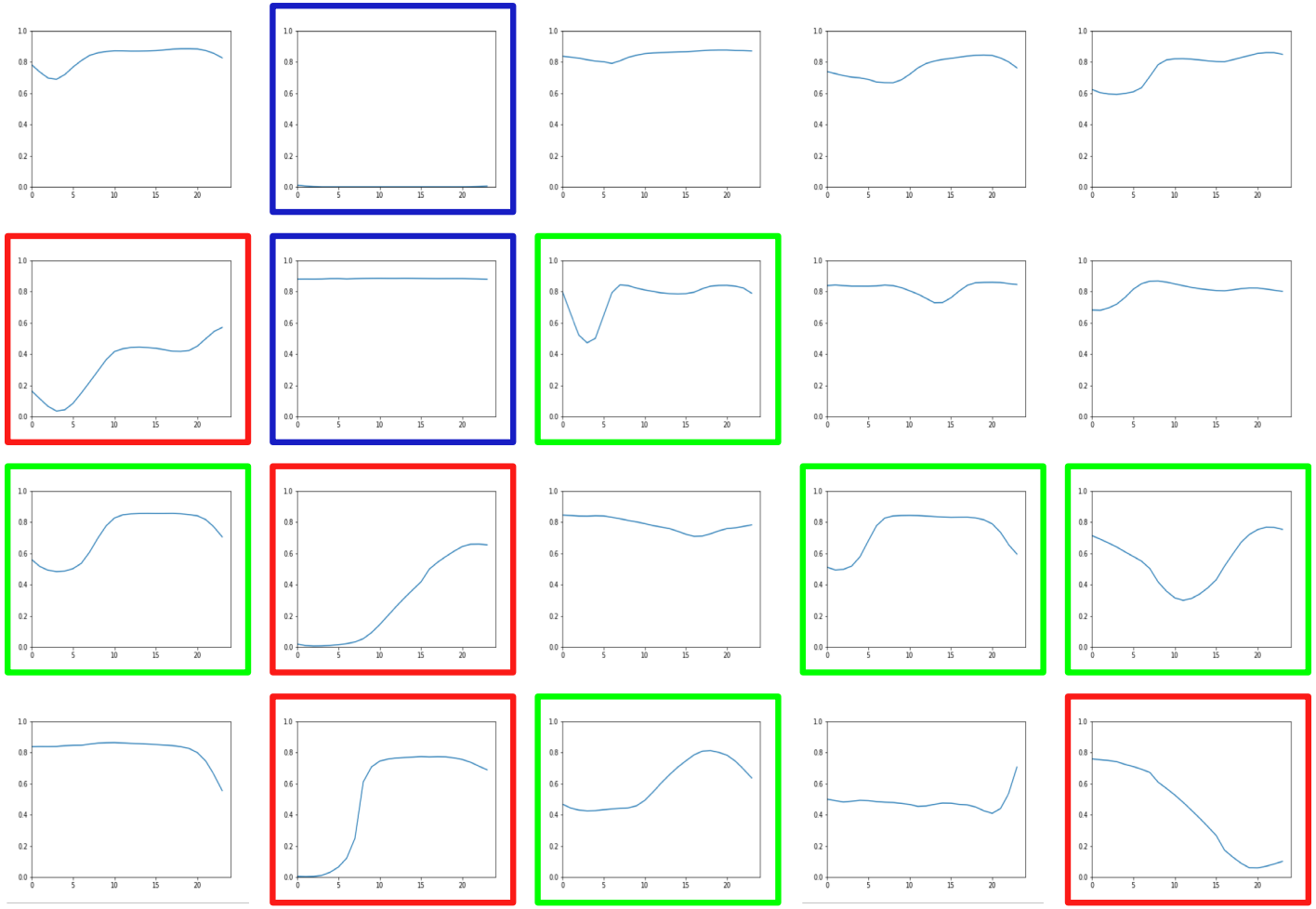
How many baseload days?

How It Works: Clustering



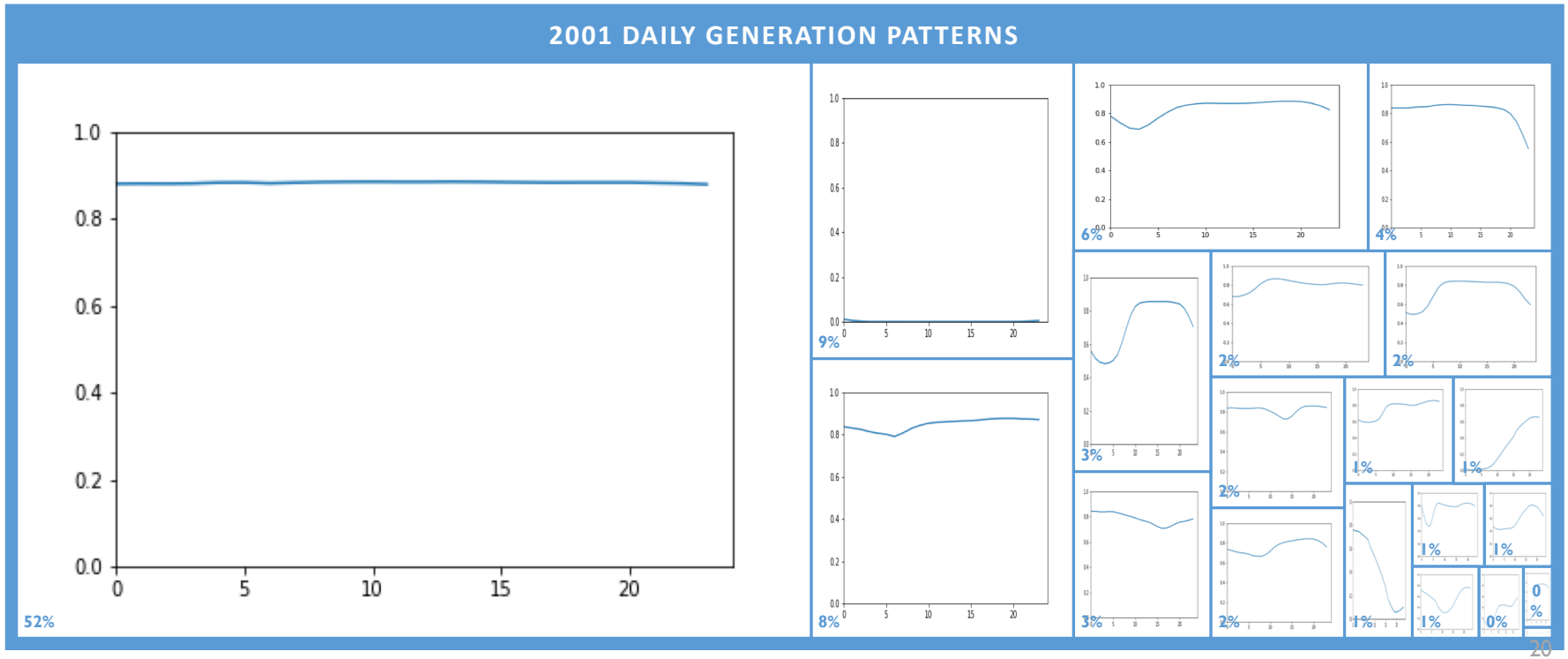


20 Distinct Generation Profiles



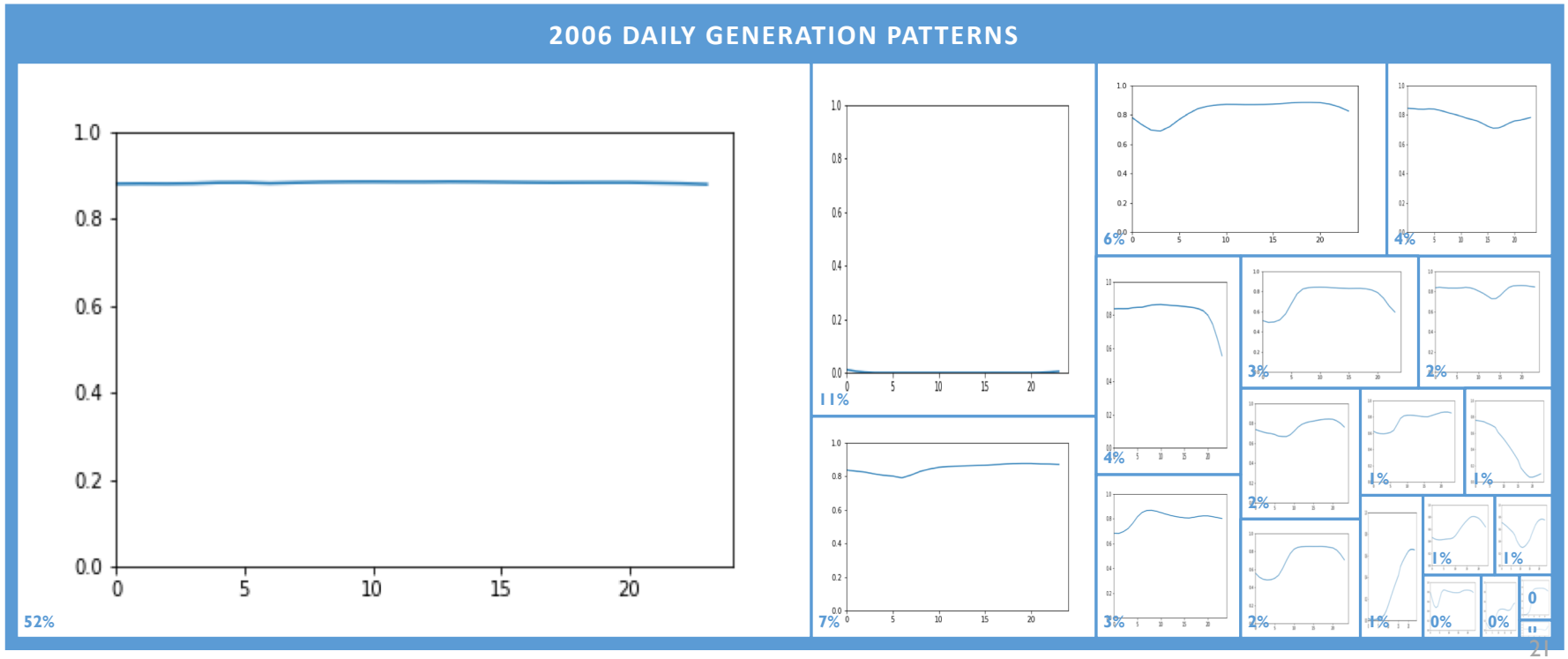
Generation Patterns of Western Coal Plants - 2001

52% of the Unit-Days were baseload generation



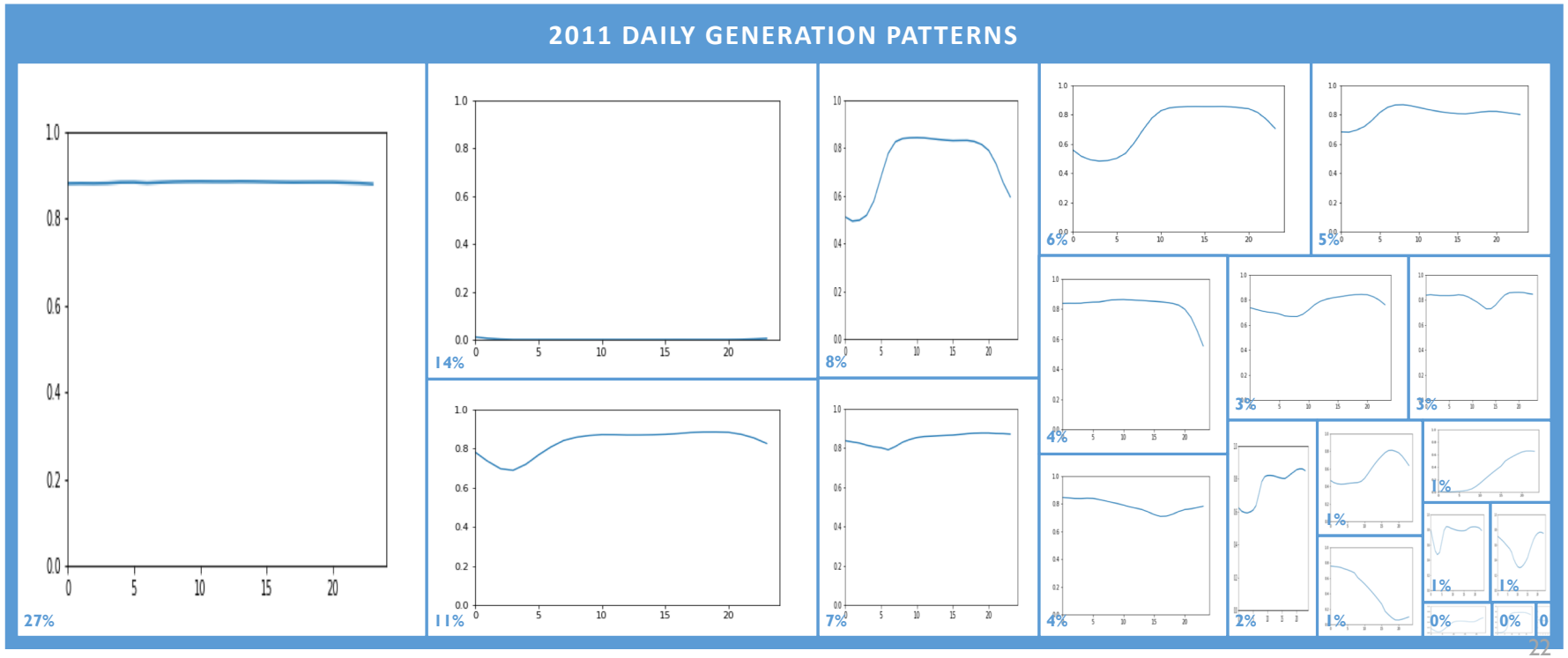
Generation Patterns of Western Coal Plants - 2006

Over 5 years, coal continued to operated largely as baseload



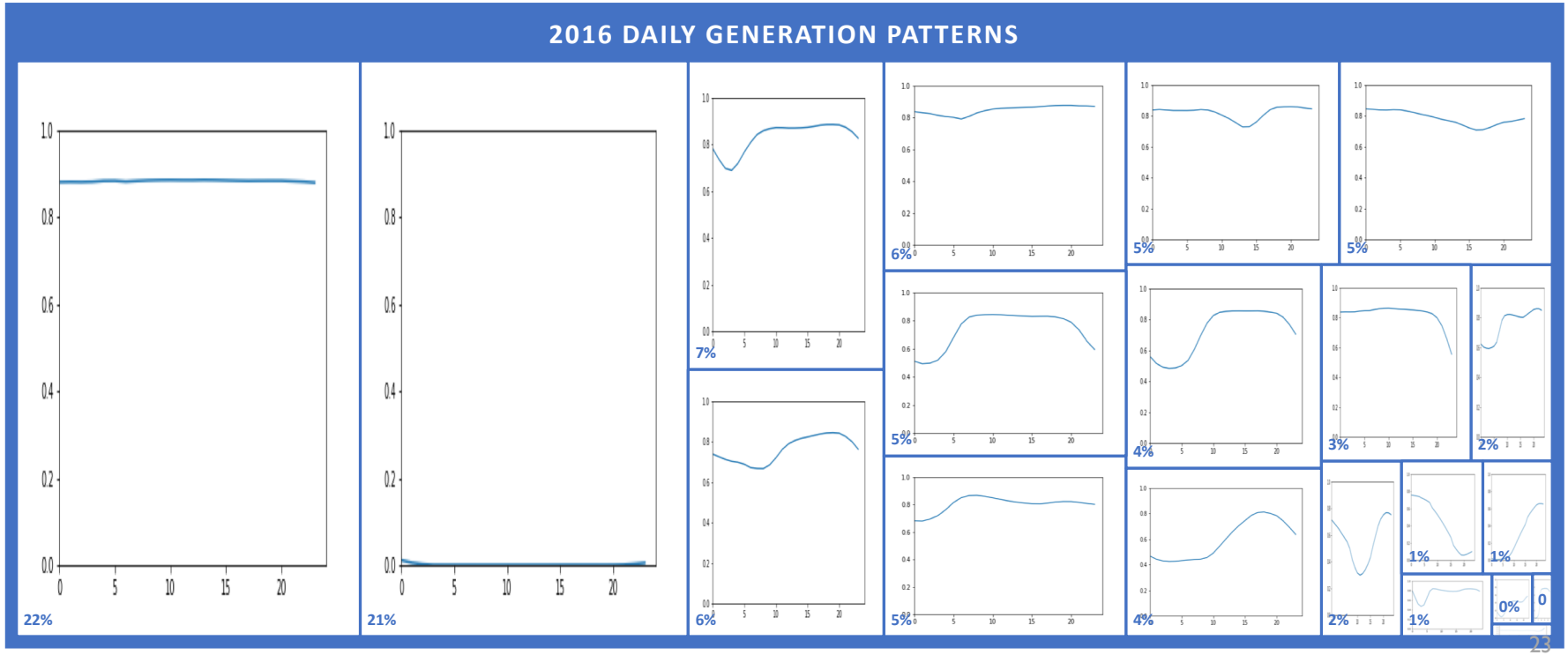
Generation Patterns of Western Coal Plants - 2011

In the next 5 years, baseload generation nearly halved for coal



Generation Patterns of Western Coal Plants - 2016

In the last 15 years, coal unit operation has shifted dramatically



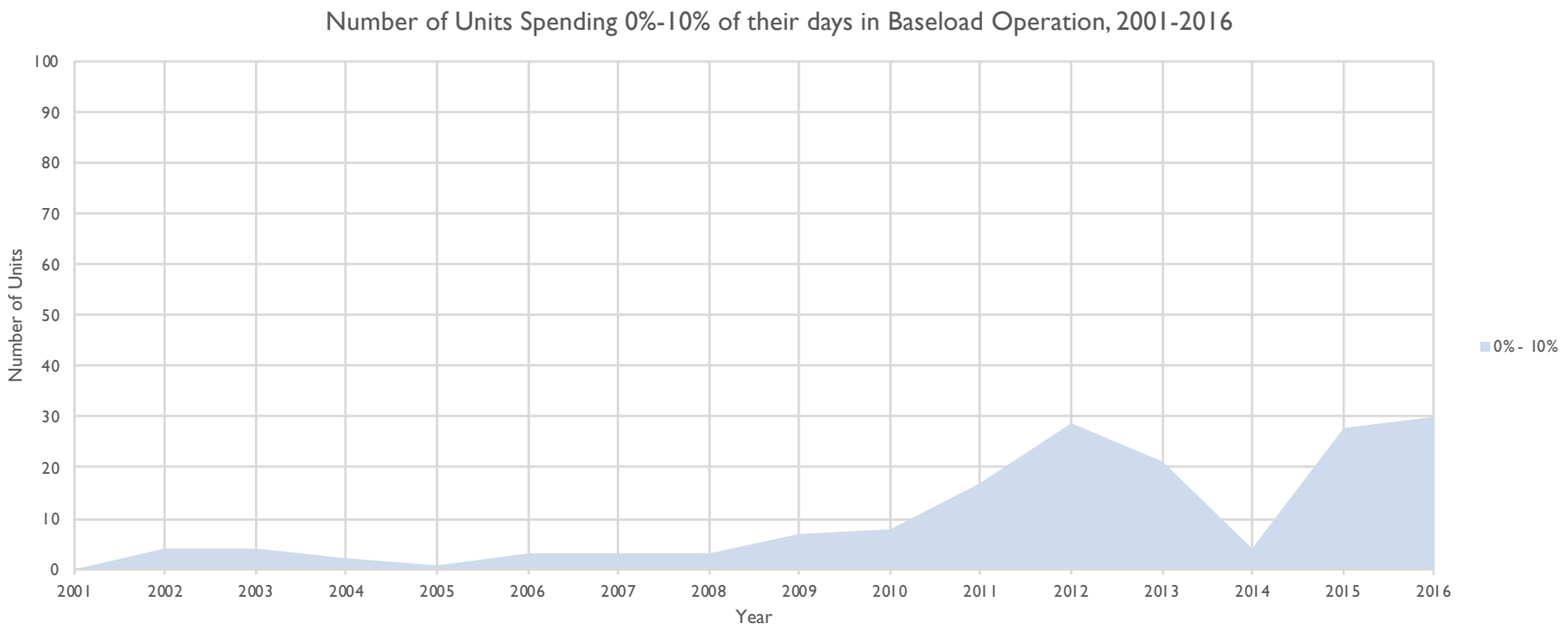
Recap of Aggregate Results

- Baseload operation days for coal decreased from 52% in 2001 to **22% in 2016**
- Offline days for units increased from 9% in 2001 to **21% in 2016**

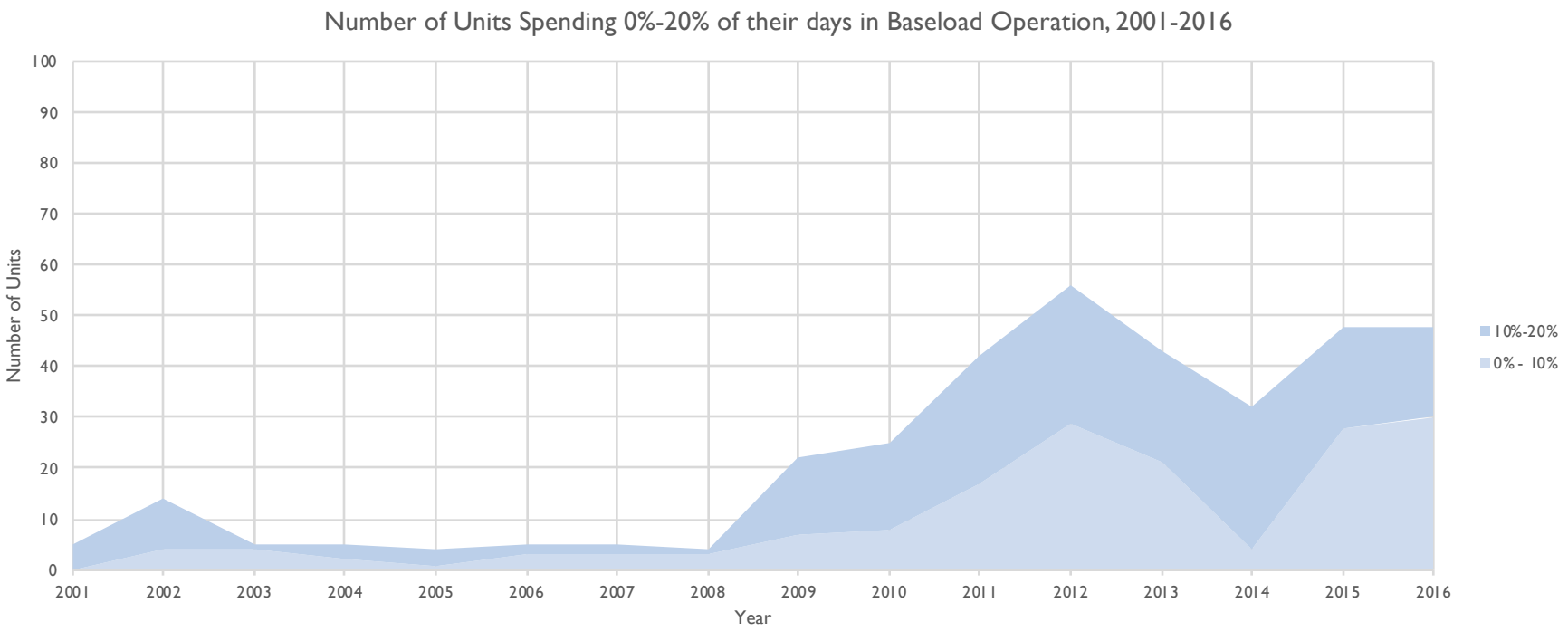
How Have Individual Units Changed?

- We have a measure of aggregate changes in the fleet
- We want to examine information about individual units
  - Are all units changing, or just a few?
  - When did most units shift from baseload operation?
  - What factors could have influenced this shift?

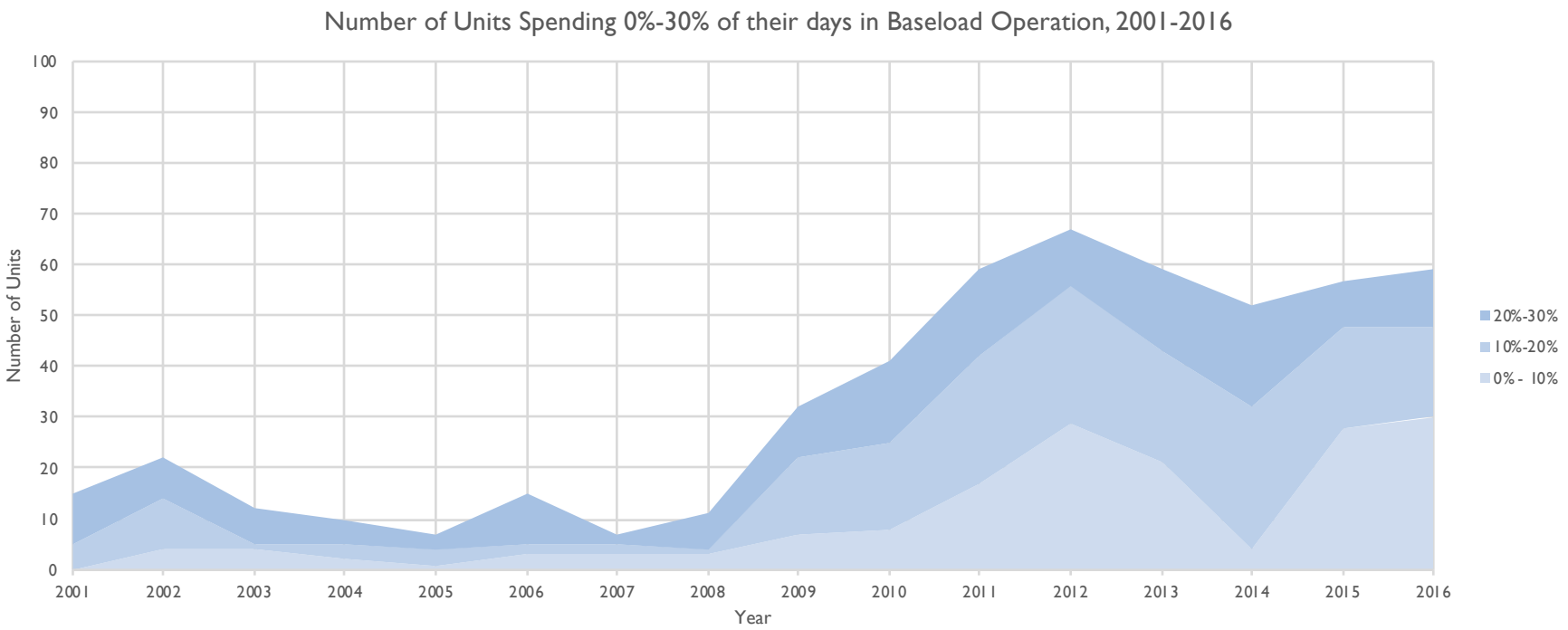
How many units spend less than 10% of their days in baseload operation?



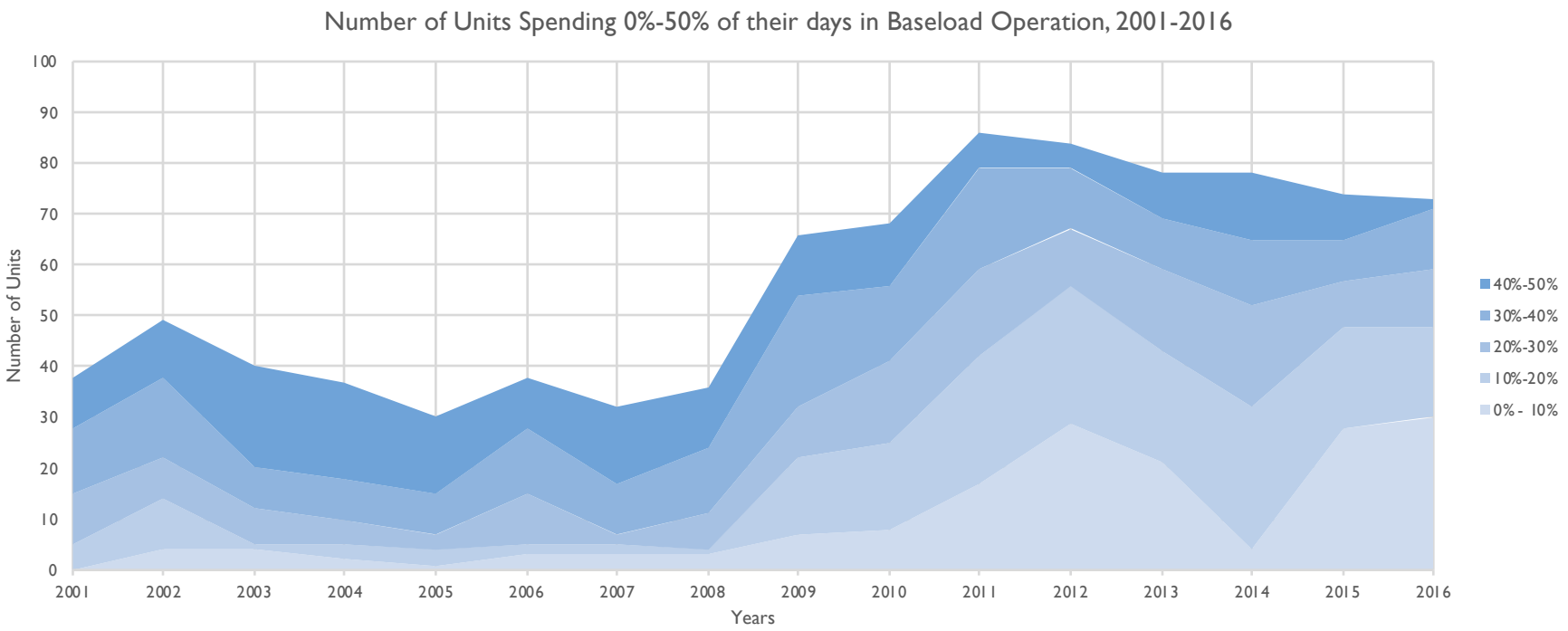
How many units spend less than 20% of their days in baseload operation?



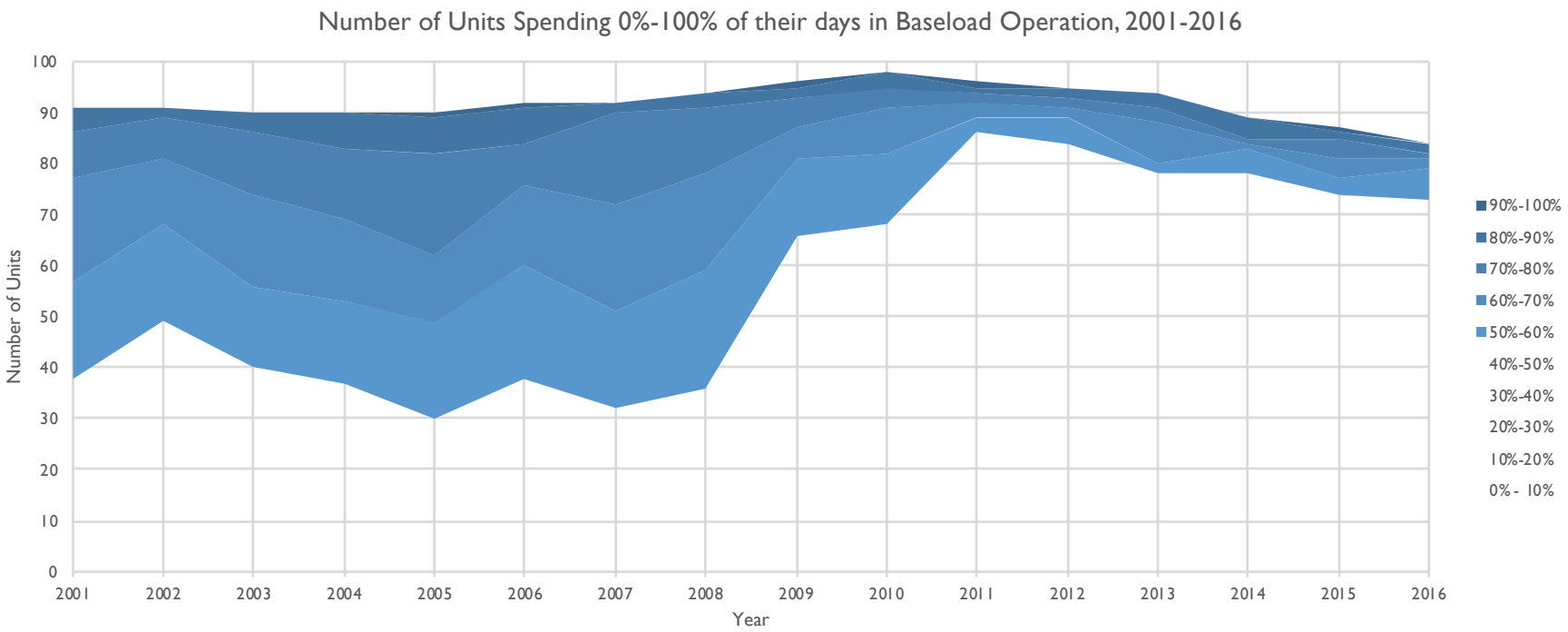
Since 2011, the majority of coal units spent less than 30% of their days in baseload operation.



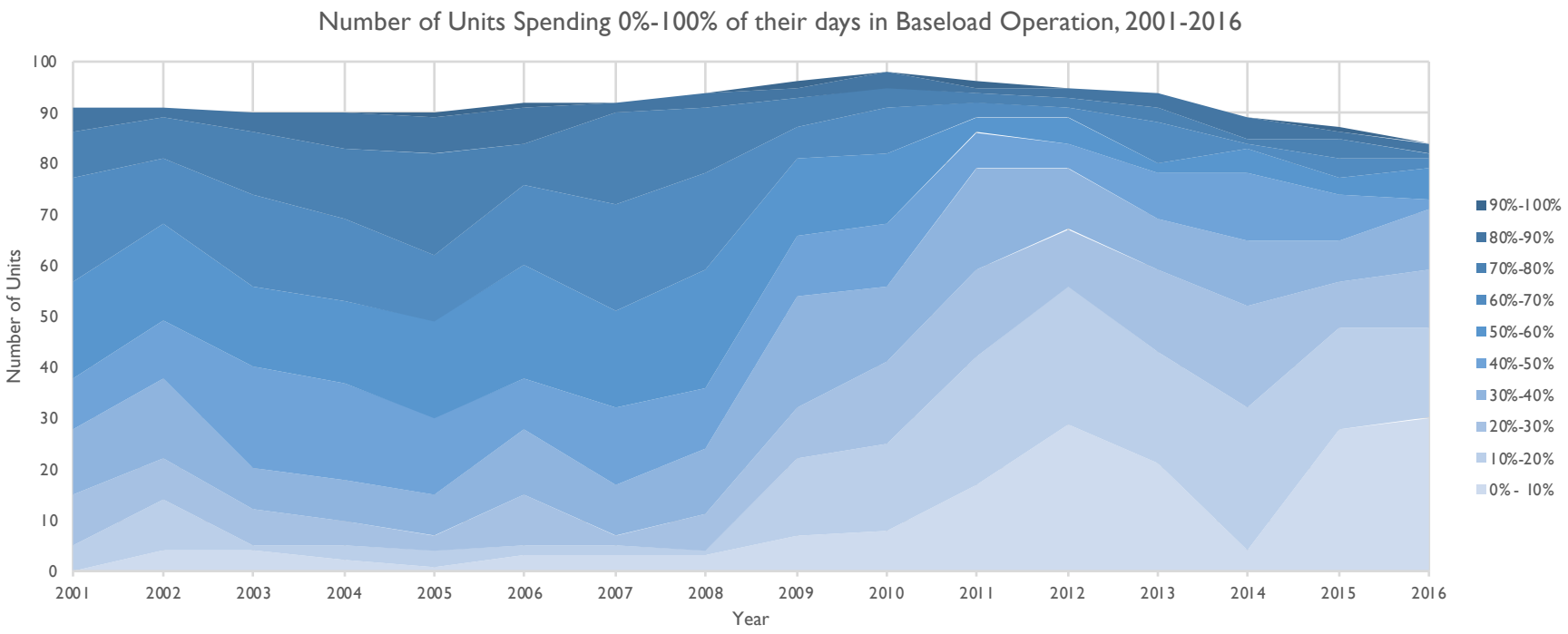
In 2016, 73 out of 84 coal units spent less than 50% of days in baseload operation



In 2001, 53 units spent more than 50% of the time in baseload operation. In 2016, 11 units did.

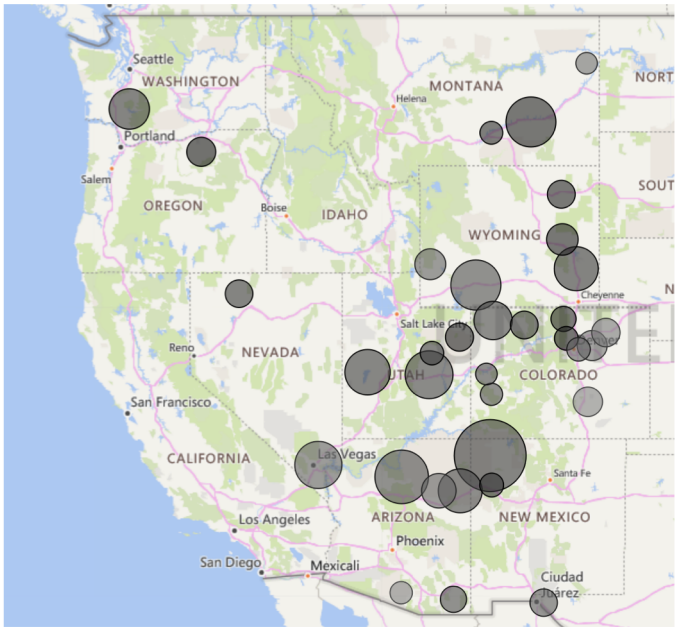


Jumping to the whole picture:

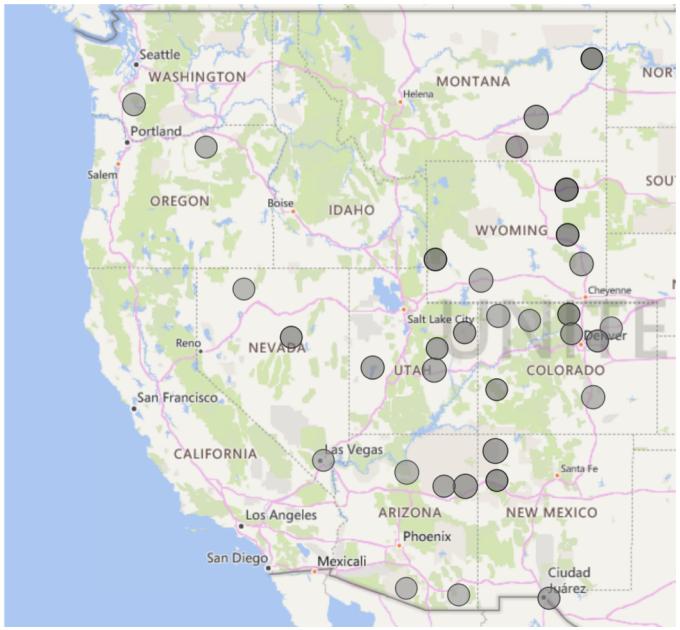


Generation and Percent Baseload Days

2001



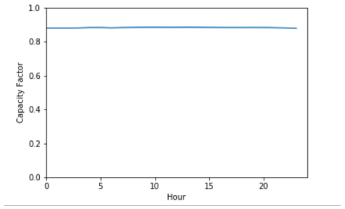
2016



= 300 million MWh

= 0% of the time like this:

= 100% of the time like this:

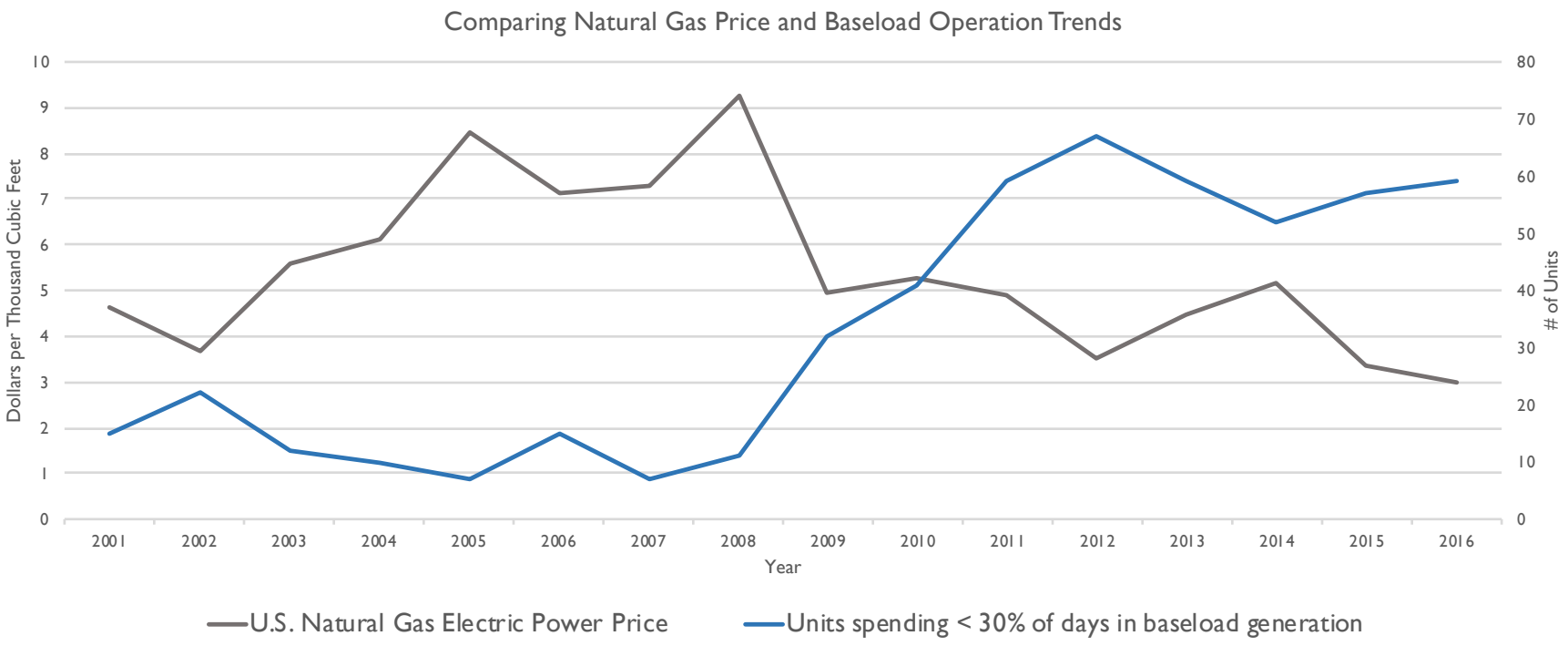


Size is Total Generation (MWh)

Saturation is Percent Baseload Days

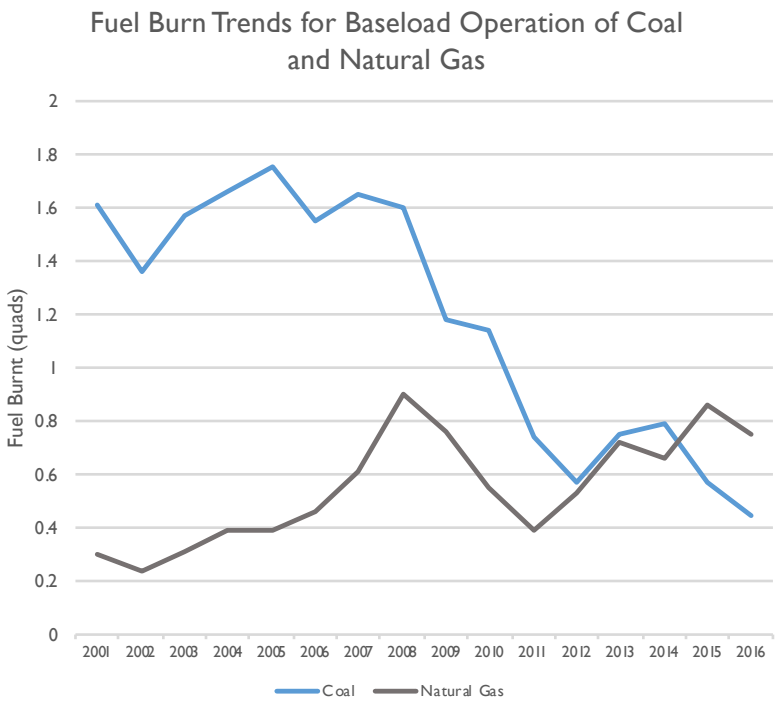
A possible explanation: Natural Gas Prices

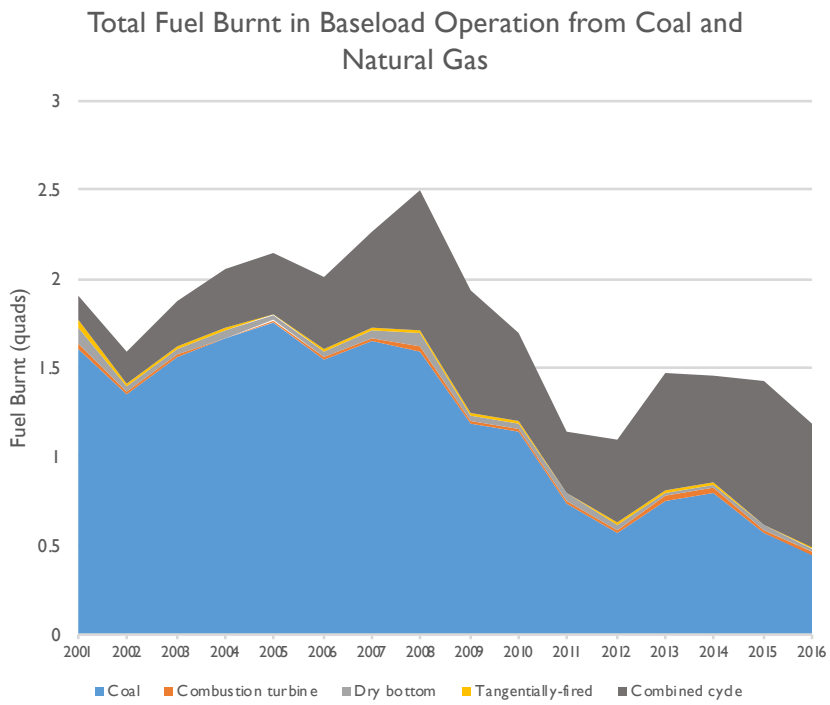
Source: eia.gov



Changing Resources: NG Over Coal

Consumption of Coal decreased by 72% and NG increased by 145%





Other Drivers for Operational Shift

- Increase in variable generation (wind and solar)
- Aging, less efficient power plants
- Flat electrical demand
- Regional economic dispatch
- Wear and tear cycling costs

In Summary

- **Baseload operation** has decreased from **52%** of coal unit operating days in **2001** to **22% in 2016** in the Western U.S.
- Individual coal units in the Western U.S. with baseload operation greater than or equal to 50% of days in the year decreased from **53 units in 2001 to 11 in 2016**.
- **Since 2011**, the majority of coal units have spent **less than 30%** of their days in **baseload** operation.
- **Offline operation** increased from **9%** of coal unit operating days in **2001** to **21% in 2016**
- Baseload operation resource **consumption of Coal decreased by 72%** and **NG increased by 145%** from 2001 to 2016

~~All~~ coal fired power is ~~solely~~ **sometimes** used for baseload power and is ~~consistently~~ running at ~~max~~ a **variable** capacity factor.

Next Steps

- Highlight trends in coal alongside hourly wind and solar generation
- Compare spot prices for electricity to coal unit output
- Focus on plants slated for retirement
  - Look at trends leading up to retirement for decommissioned plants/units