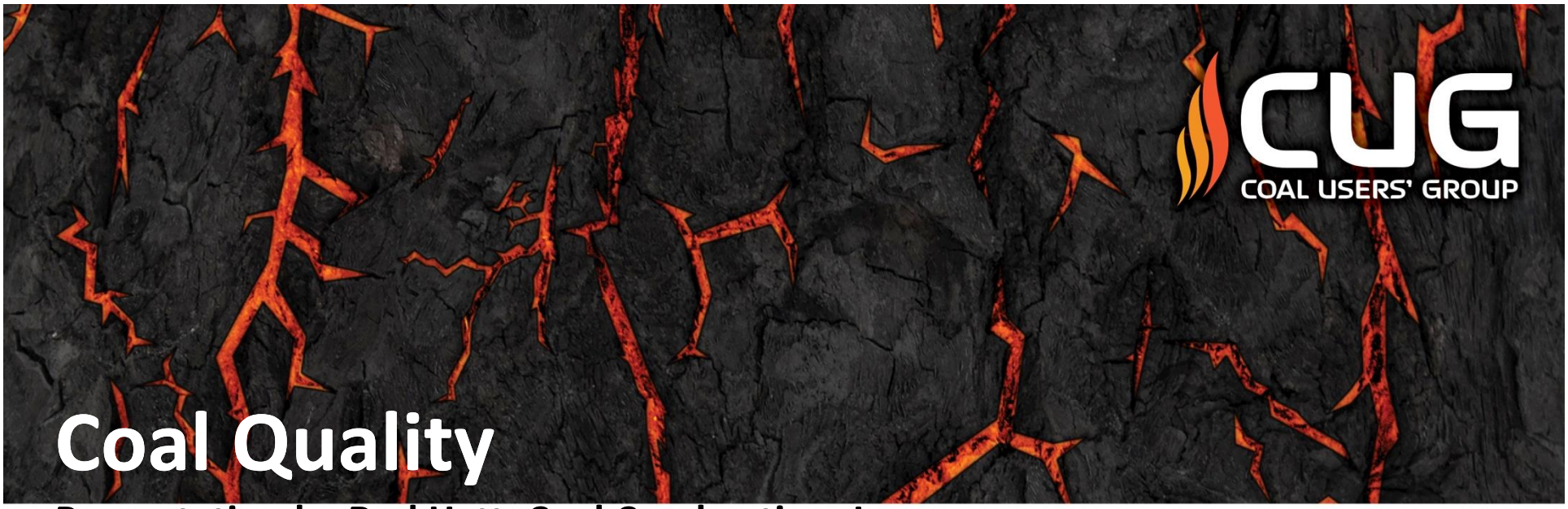
Coal Quality and Combustion

A look at a vast resource



Coal Quality

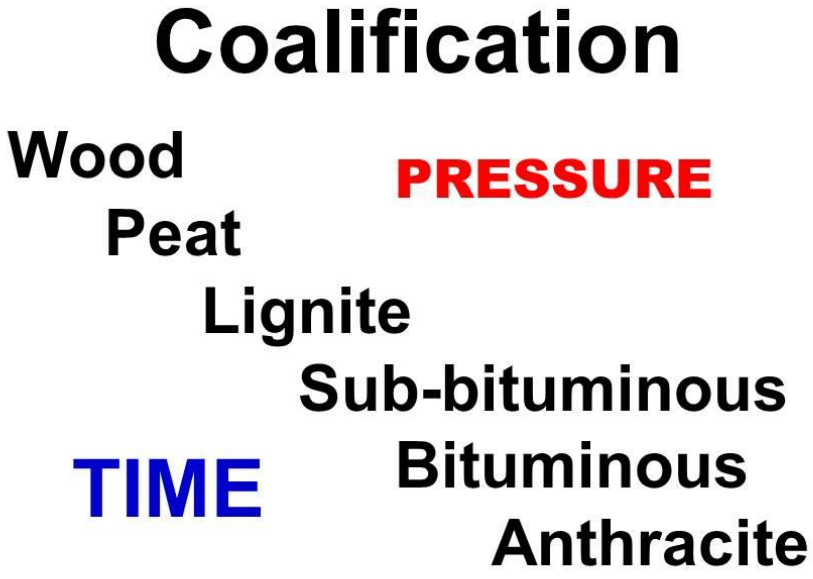
Presentation by Rod Hatt, Coal Combustion, Inc.

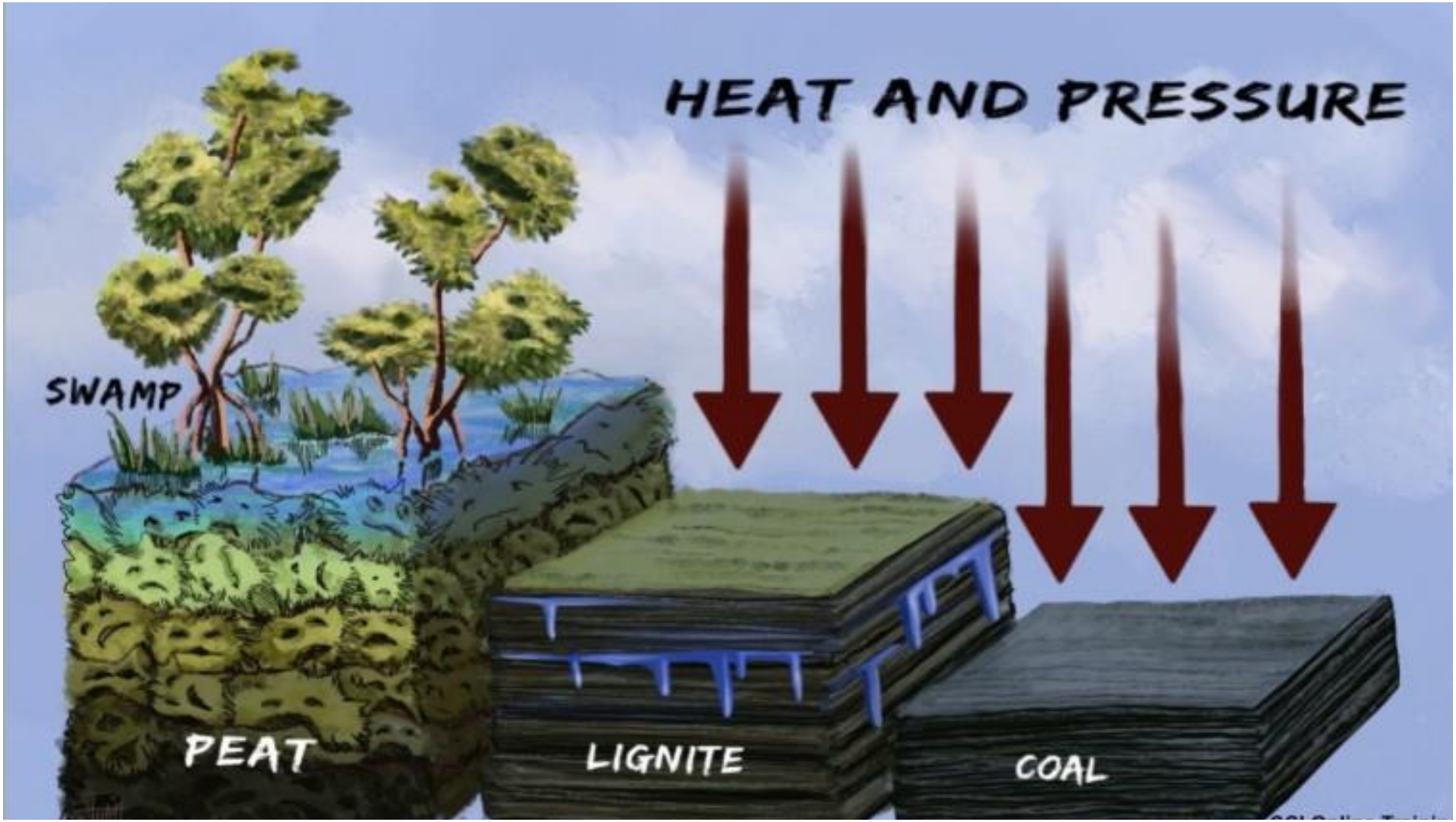
www.coalcombustion.com

rod_hatt@coalcombustion.com

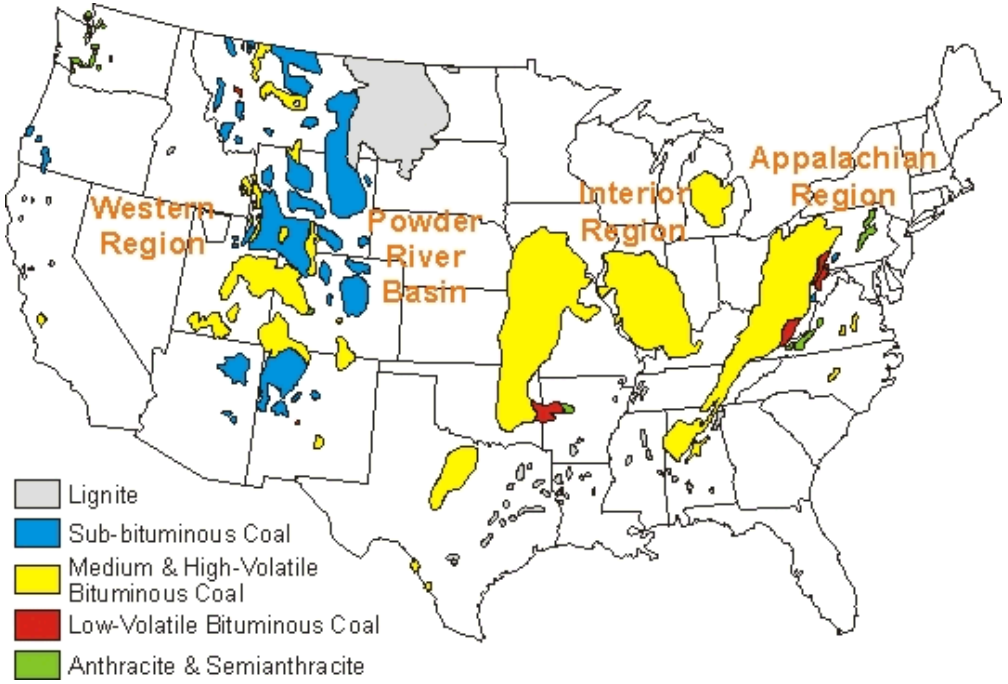
Member of CUG Board of Directors

Coal Rank

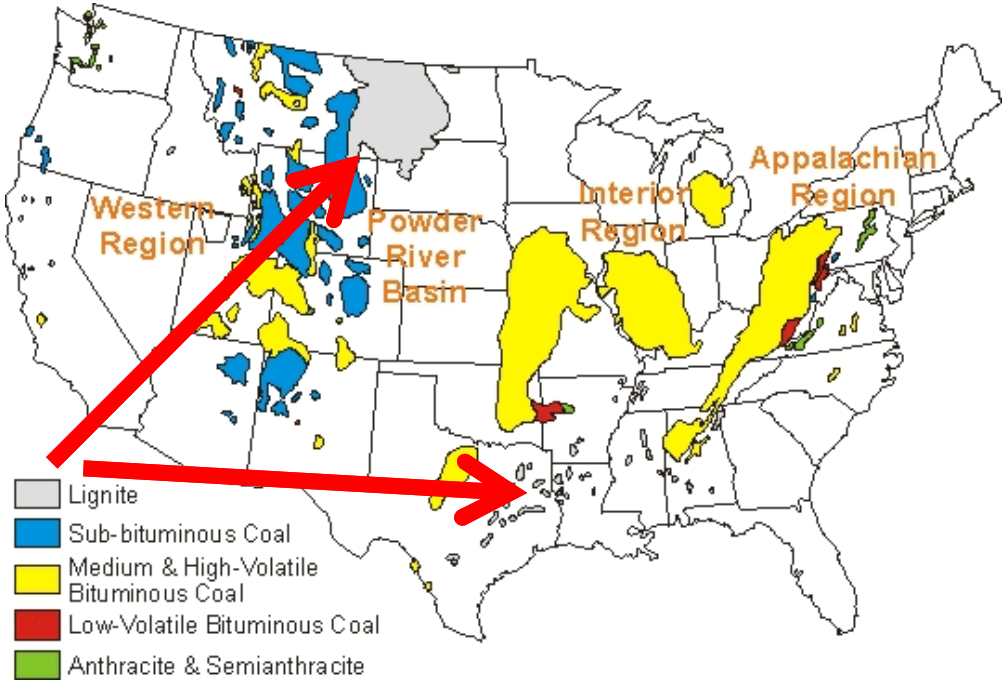

Coalification
Wood
Peat
Lignite
Sub-bituminous
Bituminous
Anthracite
PRESSURE
TIME


HEAT AND PRESSURE
SWAMP
PEAT
LIGNITE
COAL

Coal Rank


Western Region
Powder River Basin
Interior Region
Appalachian Region
Lignite
Sub-bituminous Coal
Medium & High-Volatile Bituminous Coal
Low-Volatile Bituminous Coal
Anthracite & Semianthracite

Coal Rank


Western Region
Powder River Basin
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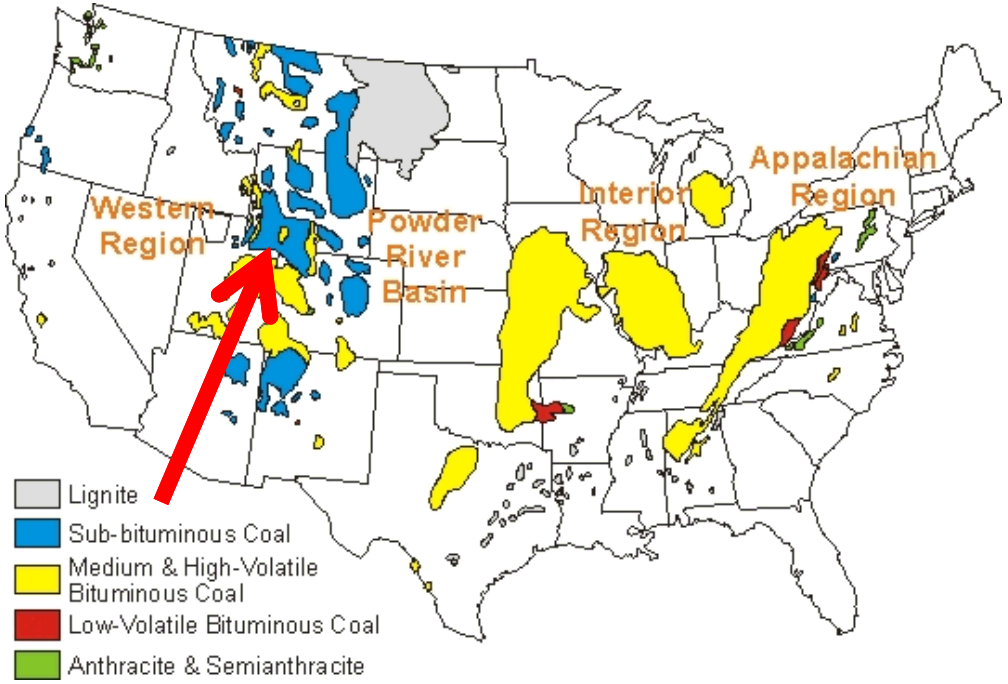
Coal Rank


Western Region
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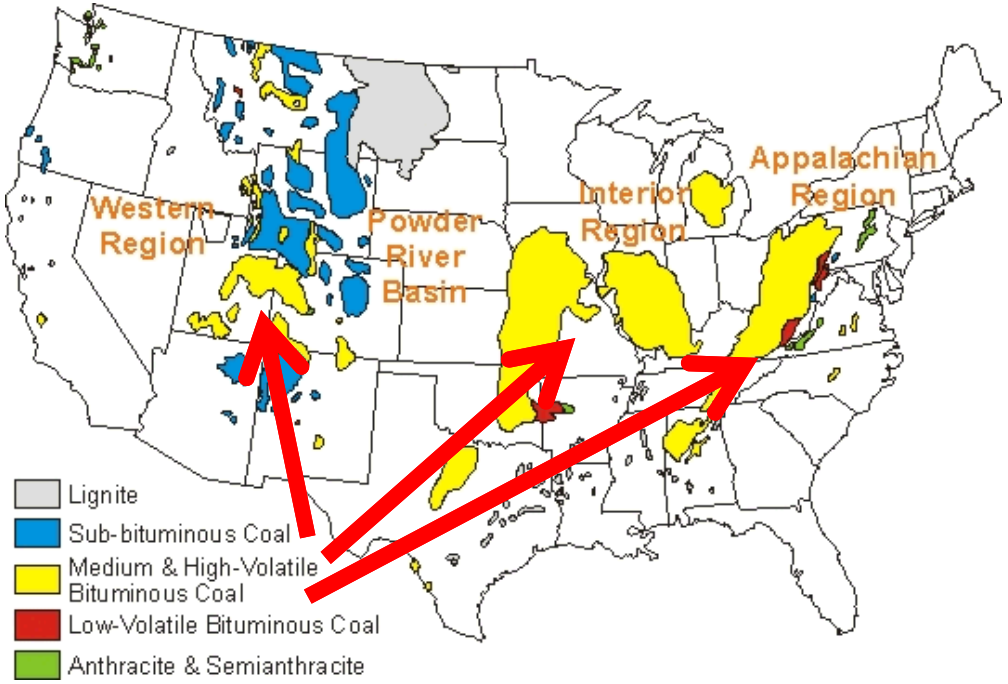
Coal Rank


Western Region
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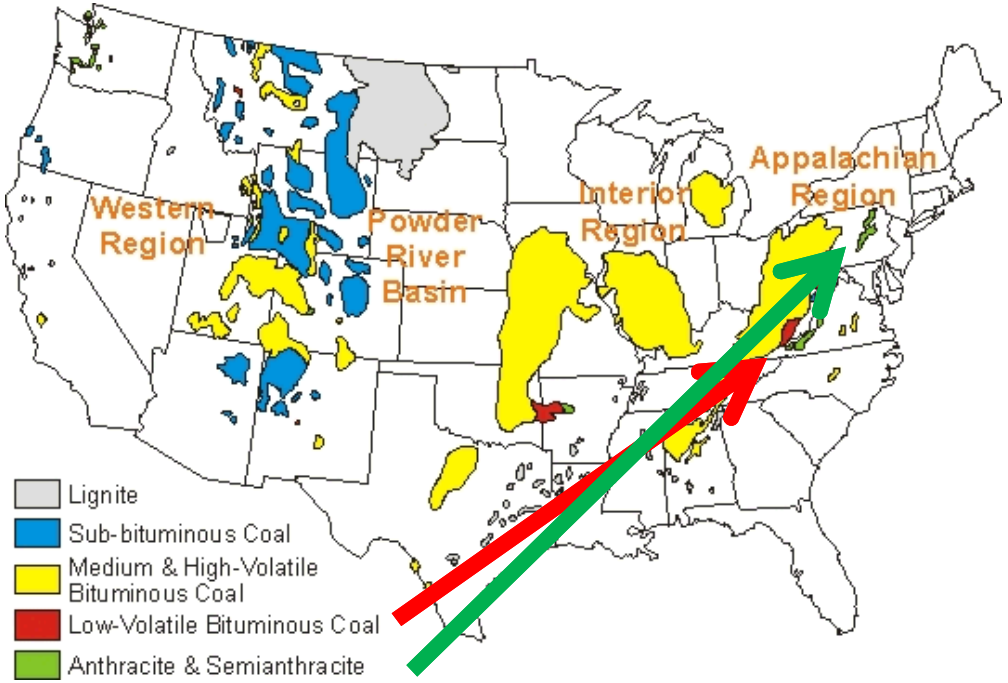
Coal Rank


Western Region
Powder River Basin
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Sub-bituminous Coal
Medium & High-Volatile Bituminous Coal
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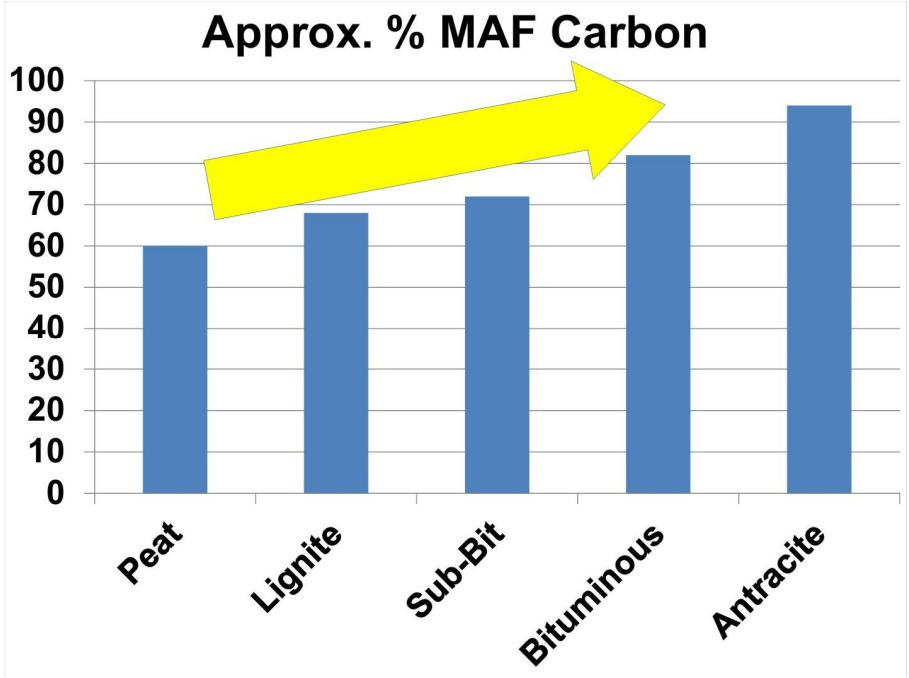
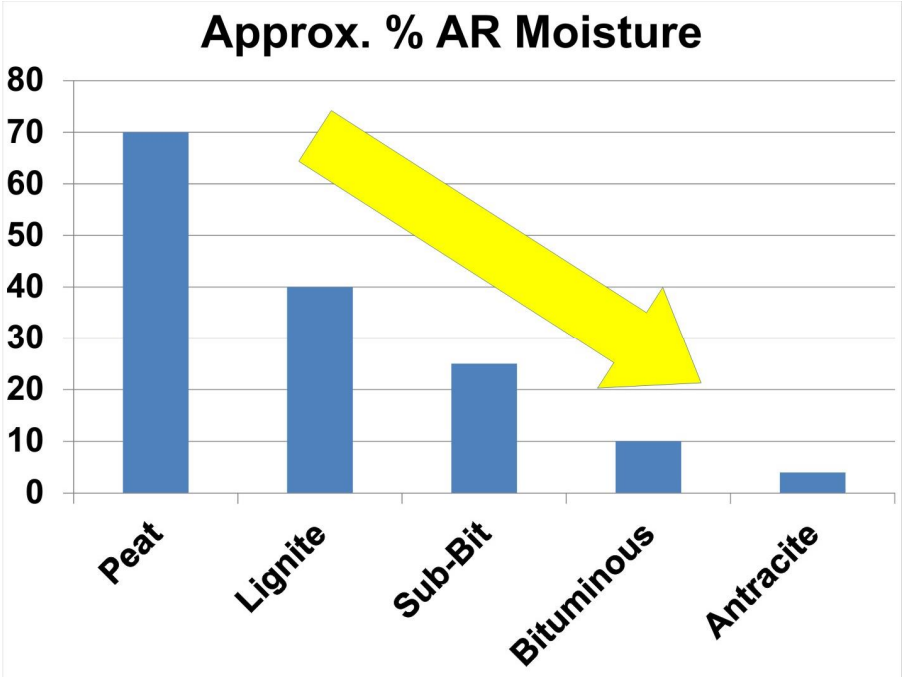
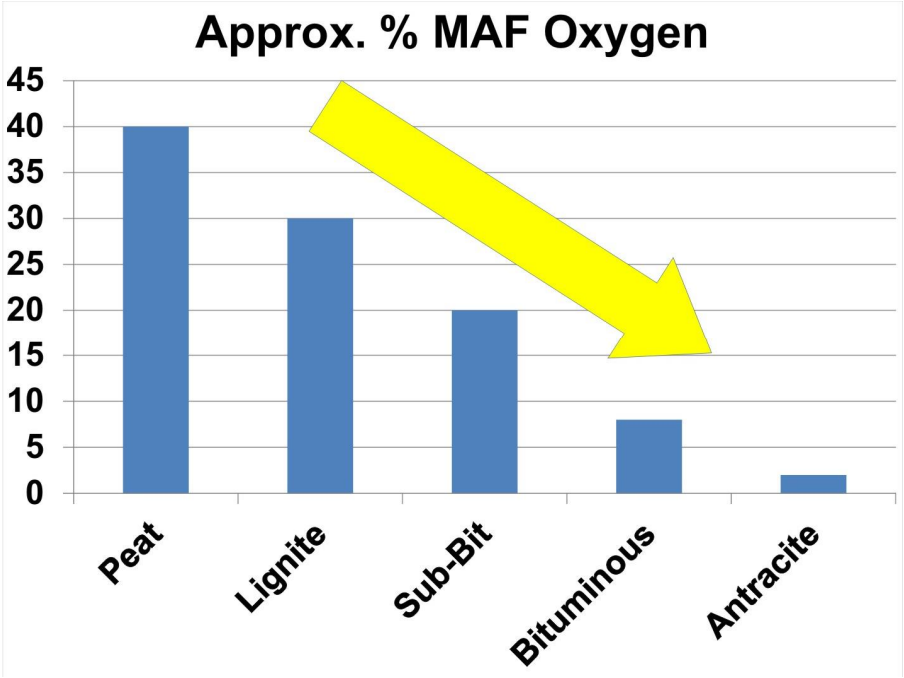
Coal Rank


Approx. % MAF Carbon
100
90
80
70
60
50
40
30
20
10
0
Peat
Lignite
Sub-Bit
Bituminous
Antracite

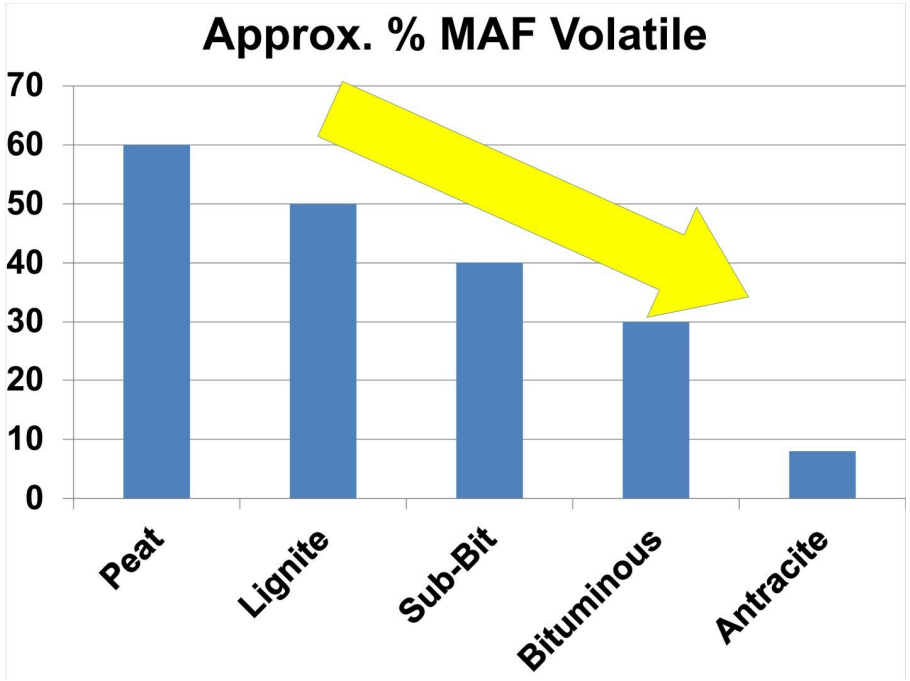
Coal Rank


Approx. % AR Moisture
80
70
60
50
40
30
20
10
0
Peat
Lignite
Sub-Bit
Bituminous
Antracite

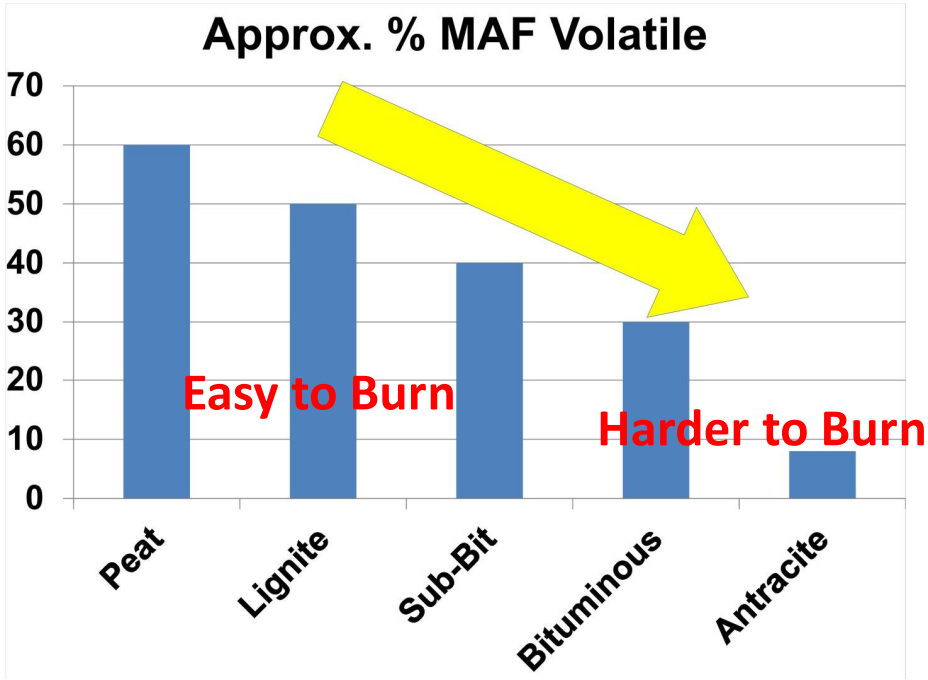
Coal Rank


Approx. % MAF Oxygen
45
40
35
30
25
20
15
10
5
0
Peat
Lignite
Sub-Bit
Bituminous
Antracite

Coal Rank


Approx. % MAF Volatile
70
60
50
40
30
20
10
0
Peat
Lignite
Sub-Bit
Bituminous
Antracite

Coal Rank


Approx. % MAF Volatile
70
60
50
40
30
20
10
0
Easy to Burn
Harder to Burn
Peat
Lignite
Sub-Bit
Bituminous
Antracite

Coal Rank

- High Rank Lower Volatile and Anthracite coals tend to make more NOx due to nitrogen levels and increase excess air.
- Low Rank Lignites and Sub-Bituminous coals can make less NOX due to lower nitrogen and lower excess air requirements.

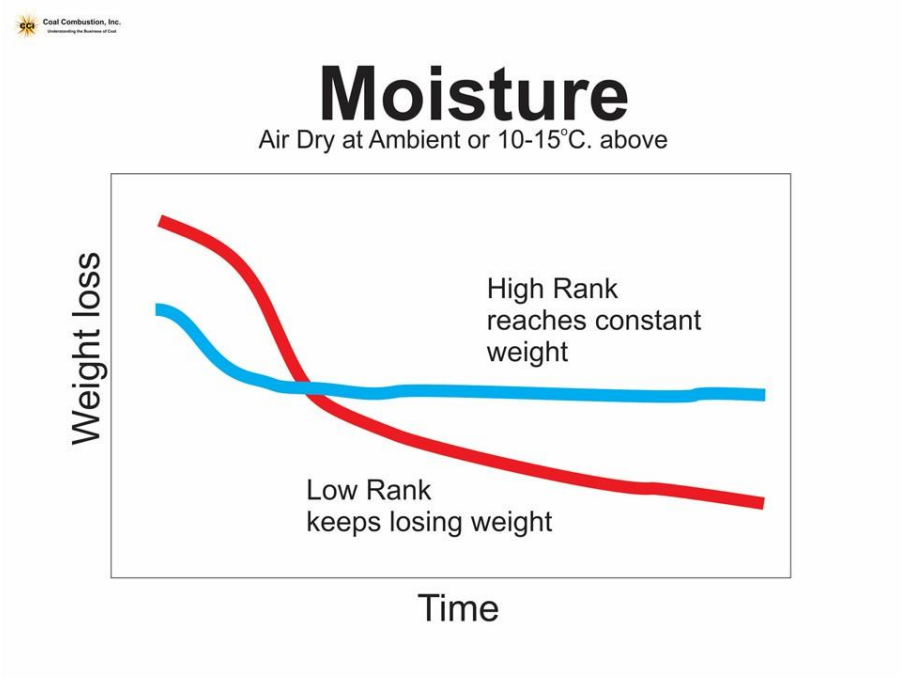
Coal Rank

- High Rank Low Volatile and Anthracite coals require fine grinding and plenty of AIR.
- Low Rank Lignites and Sub-Bituminous coals can burn with less grinding and less AIR.

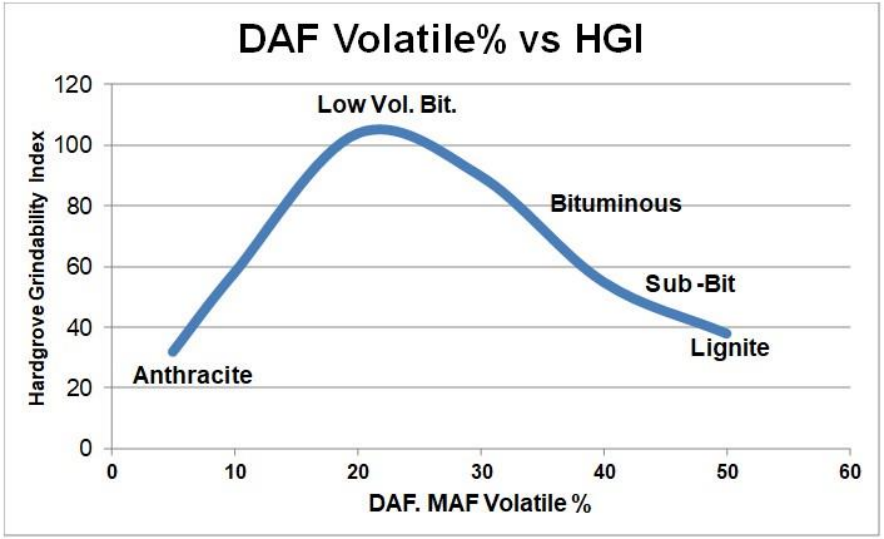
Coal Rank

Low rank fuels are reactive and are subject to ***spontaneous combustion***

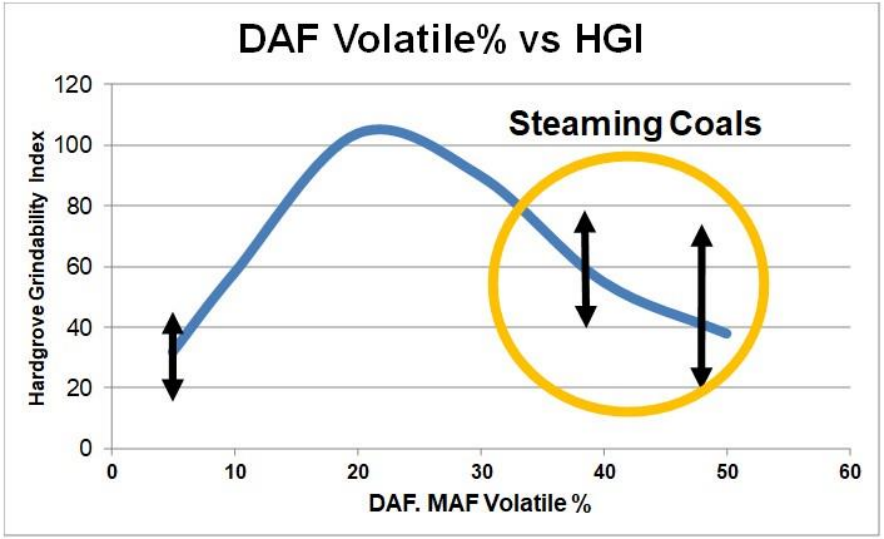
Coal Rank


Coal Combustion, Inc.
Moisture
Air Dry at Ambient or 10-15°C. above
Weight loss
High Rank
reaches constant
weight
Low Rank
keeps losing weight
Time

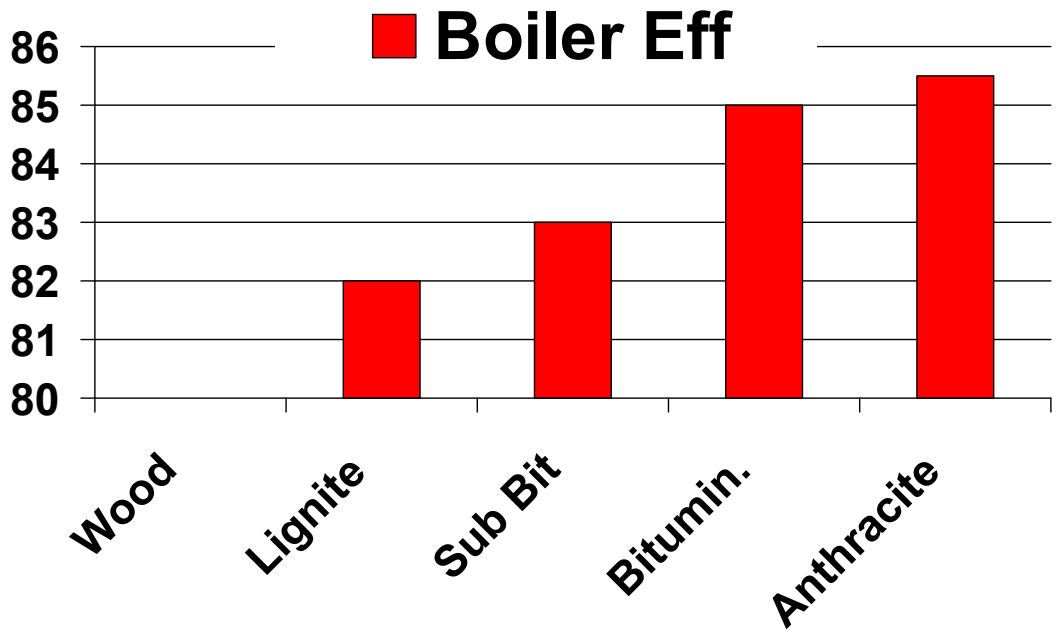
Coal Rank


DAF Volatile% vs HGI
Hardgrove Grindability Index
120
100
80
60
40
20
0
0
10
20
30
40
50
60
DAF. MAF Volatile %
Low Vol. Bit.
Bituminous
Sub -Bit
Lignite
Anthracite

Coal Rank


DAF Volatile% vs HGI
Steaming Coals
Hardgrove Grindability Index
120
100
80
60
40
20
0
0
10
20
30
40
50
60
DAF. MAF Volatile %

Coal Rank


Boiler Eff
86
85
84
83
82
81
80
Wood
Lignite
Sub Bit
Bitumin.
Anthracite

Coal Rank

Coal Reactivity

- Volatile
- Fuel Ratio, FC/Vol
- MAF Oxygen
- C/H
- HGI and others

Coal Rank

Coal Reactivity

- Volatile
- Oxygen
- per million Btus

Coal Rank

Coal Rank

Coal Rank

Coal Ash

- Typically Surface mined coal is RAW
  - Lignite
  - PRB and other Sub-Bit and Bituminous coals
- Typically Underground mined coal is WASHED
  - Illinois Basin
  - Pitt #8
  - Metalugical

Coal Ash

Coal Ash


High Fusion Temp Ash
RAW COAL ASH
CLEAN COAL ASH
Low Fusion Temp Ash


BTU
It would not show up on an ASTM average type sample!

Coal Ash

- Low ash coals, particularly Lignite and Sub-Bit, and high sulfur Bituminous coals can have low fusion ash associated with the coal

Coal Ash

Ash Chemistry - Major & Minor Elements

SiO_2	Fe_2O_3
Al_2O_3	CaO
TiO_2	MgO
others	K_2O
SO_3	Na_2O
P_2O_5	

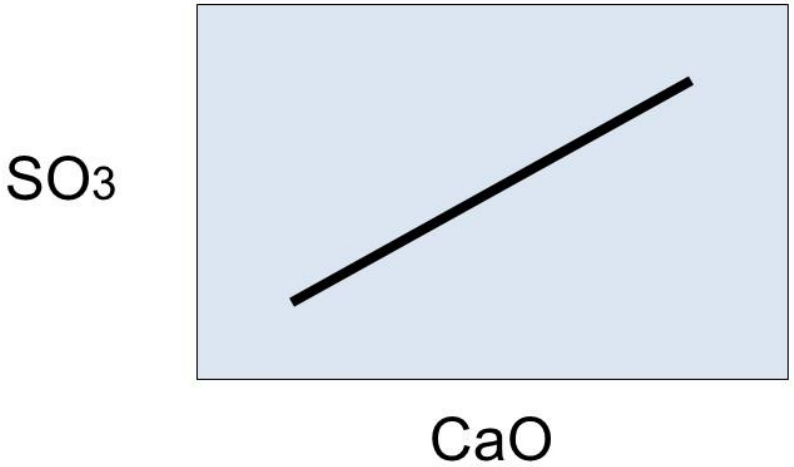
Coal Ash

Minerals include:

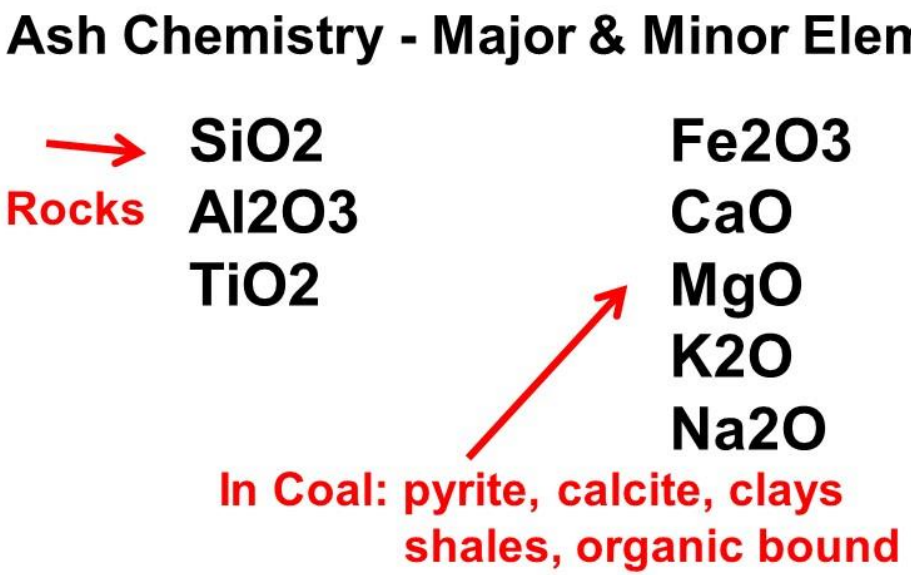
Quartz
Pyrite
Clays and shales
Carbonates

Coal Ash

What does the SO3 represent?

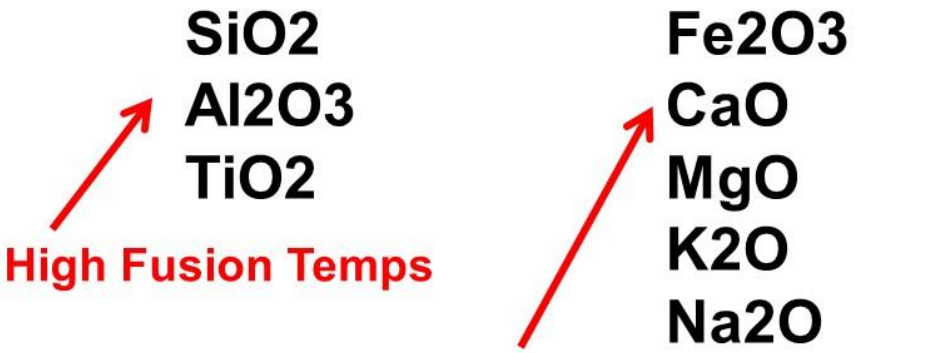


Coal Ash

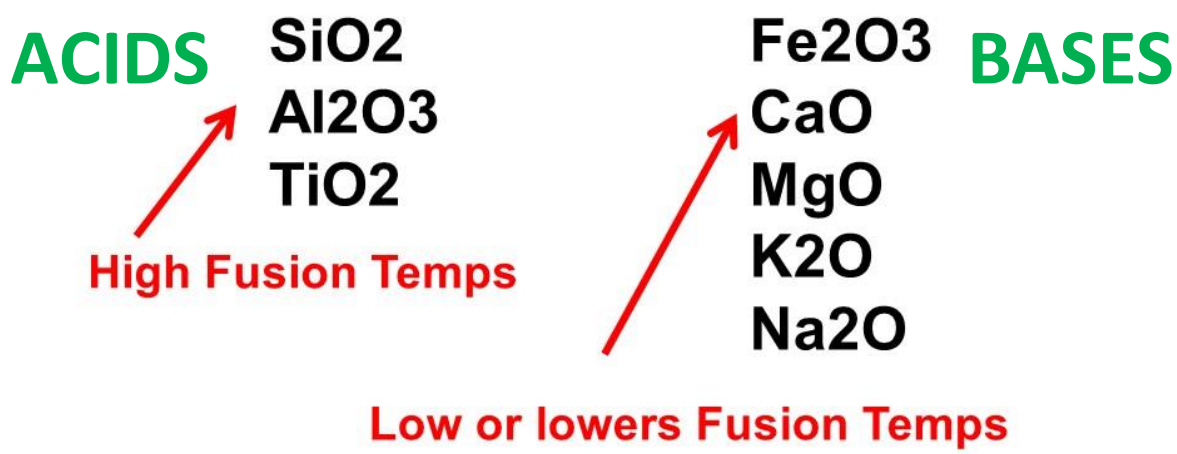

Ash Chemistry - Major & Minor Elements
Rocks
SiO2
Al2O3
TiO2
Fe2O3
CaO
MgO
K2O
Na2O
In Coal: pyrite, calcite, clays
shales, organic bound

Coal Ash

Ash Chemistry - Major & Minor Elements



Coal Ash


Ash Chemistry - Major & Minor Elements
ACIDS
SiO2
Al2O3
TiO2
High Fusion Temps
Fe2O3
CaO
MgO
K2O
Na2O
BASES
Low or lowers Fusion Temps

Coal Ash

Role of Iron

Acid	Base
Fe_2O_3	FeO
	Fe_3O_4
Oxidized O_2	Reduced CO
Good Comb	Poor Comb

Coal Ash

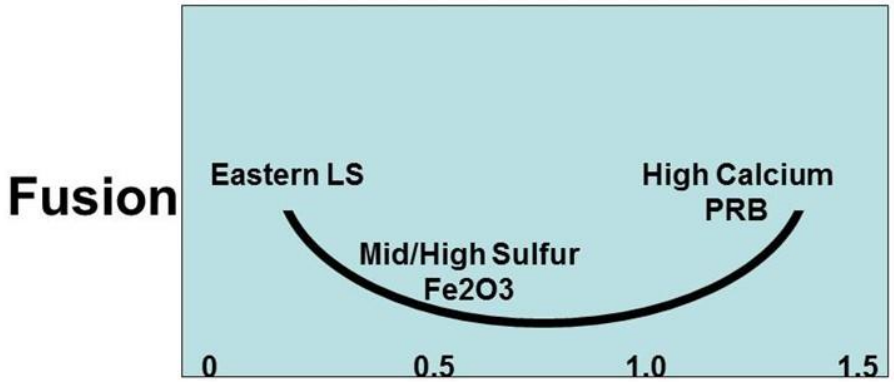
Ash Chemistry - Major & Minor Elements

Base to Acid Ratio,
B/A

$$= \frac{Fe_2O_3+CaO+MgO+K_2O+Na_2O}{SiO_2+Al_2O_3+TiO_2}$$

Coal Ash

Fusion verse Base to Acid Ratio



Slag and Fouling Index

Bituminous

SI = %dry sulfur x B/A

FI = % sodium X B/A

Western

You are on your own

Coal Ash

Slag Index = dry S x B/A

= dry S (~1/3 to 2/3 pyrite) x B/A

= dry S (FeS_2)xFe2O3+CaO+…/SiO2+…

Traditional Slagging Index

SI ~ $(Fe)^2$ (iron squared)

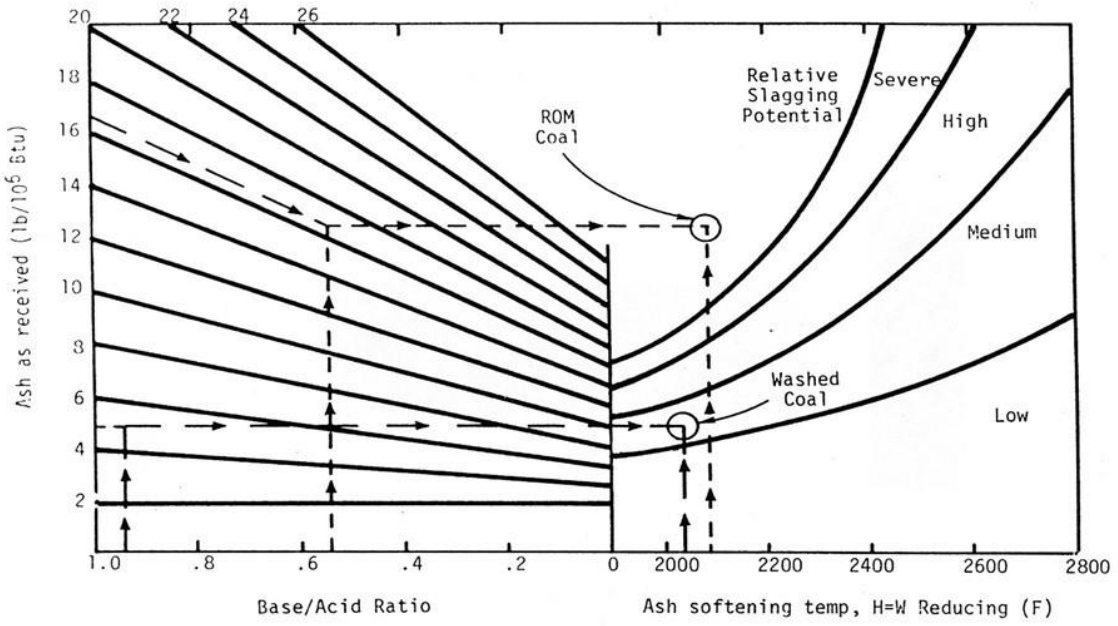
This means that as sulfur increases the slagging increases exponentially.

Coal Combustion Inc.
Understanding the business of coal

Coal Ash

Slag is a build up
of rate process
so,
the amount of
ash should matter.

Coal Ash


Ash as received (lb/10⁶ Btu)
20
22
24
26
18
16
14
12
10
8
6
4
2
ROM Coal
Relative Slagging Potential
Severe
High
Medium
Low
Washed Coal
1.0
.8
.6
.4
.2
0
2000
2200
2400
2600
2800
Base/Acid Ratio
Ash softening temp, H=W Reducing (F)

Coal Ash

Kg of ash/MKcal
= %ash / (Kcal/10,000)

Lbs of ash/MBtu
= %ash / (Btu/10,000)

Questions