Coal in Kentucky

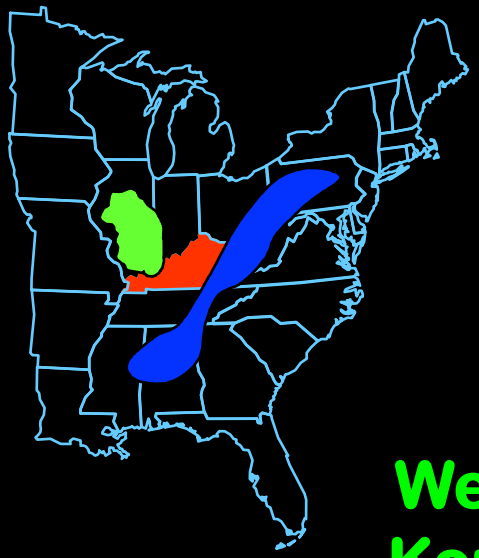
Cortland Eble

Kentucky Geological Survey
University of Kentucky
Lexington, Kentucky

National Academy of Sciences Potential Human Health Effects of Surface Coal Mining Operations in Central Appalachia
Lexington, Kentucky
22 August, 2017

Kentucky Geological Survey

Coal in Kentucky



The eastern Kentucky Coal Field is part of the Central Appalachian Basin.

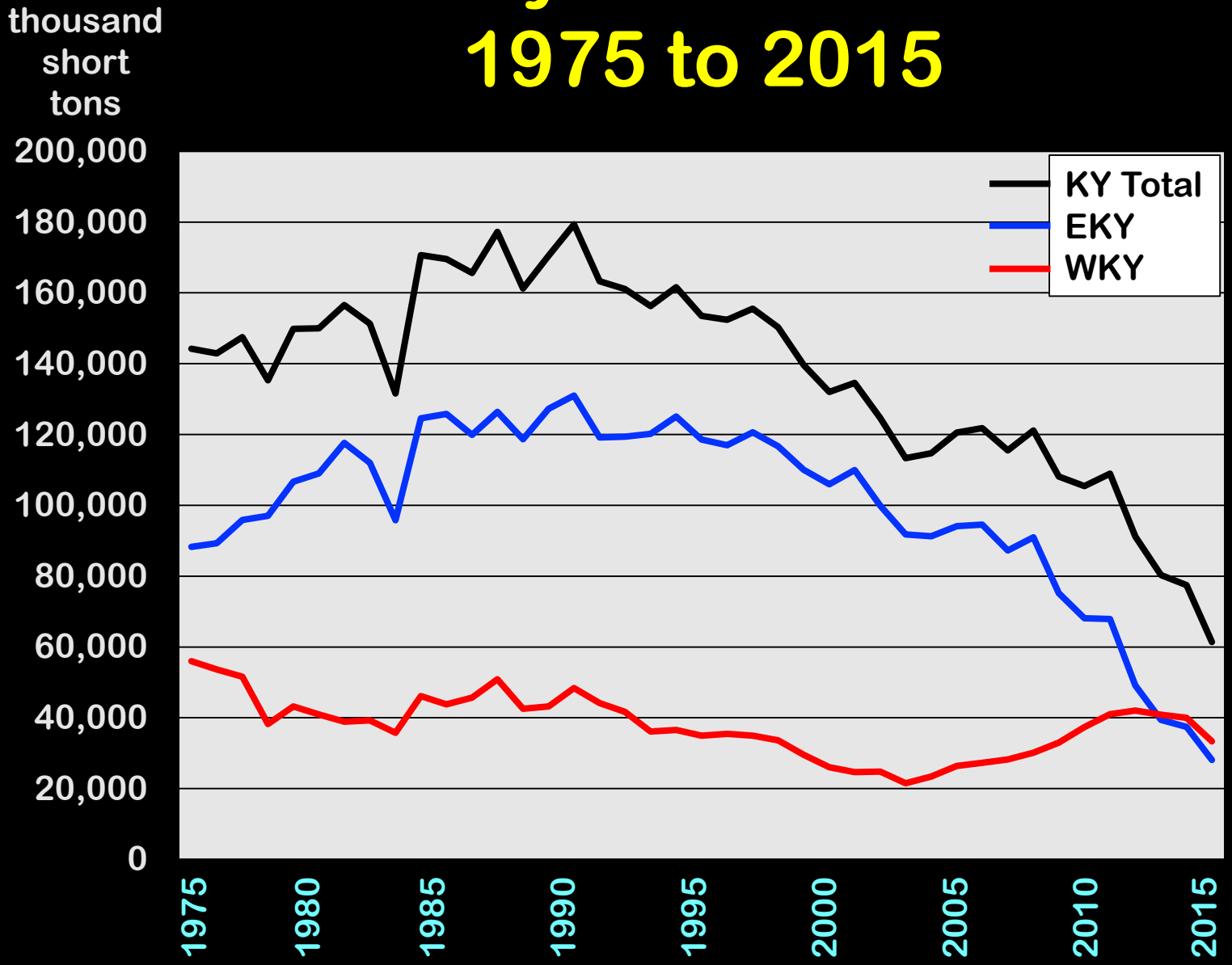
The Western Kentucky Coal Field is part of the Illinois Basin.

Western Kentucky Coal Field

Eastern Kentucky Coal Field

Kentucky Geological Survey

Kentucky Coal Production 1975 to 2015

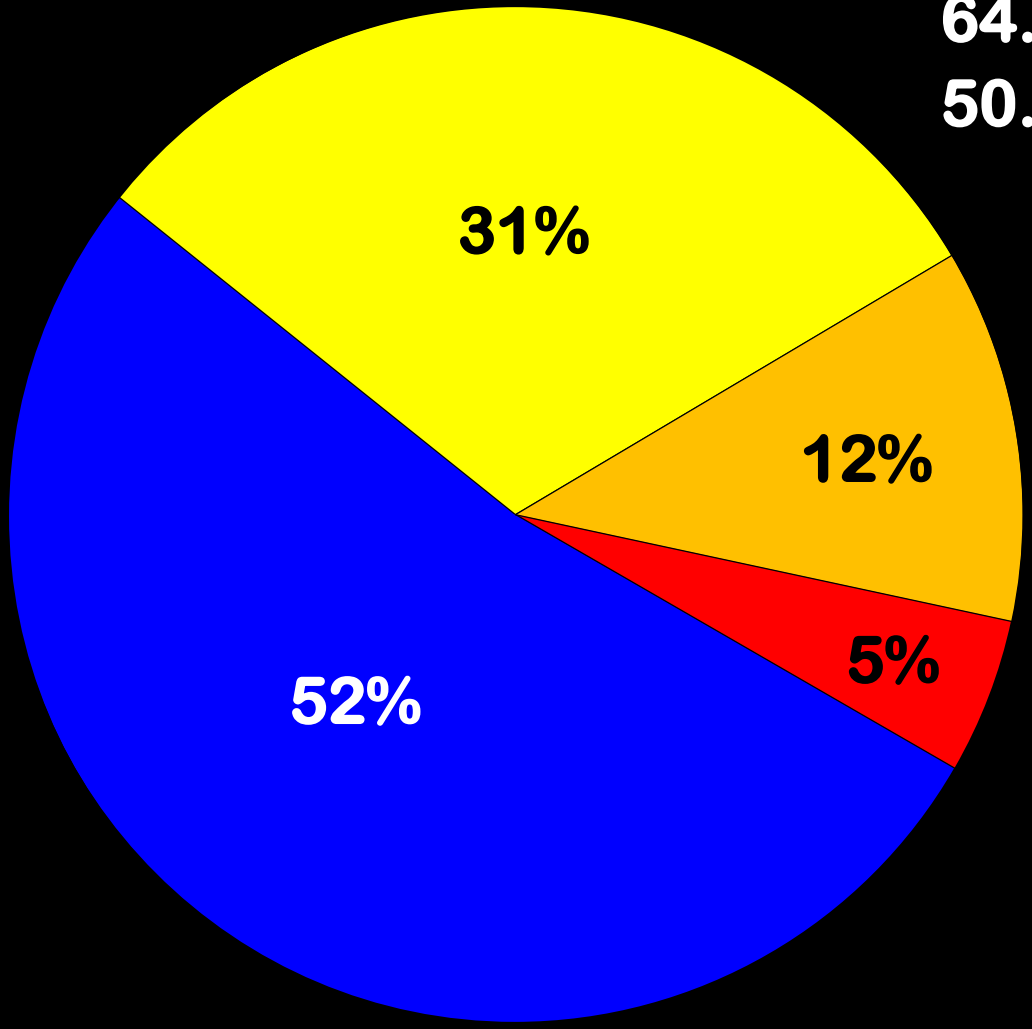


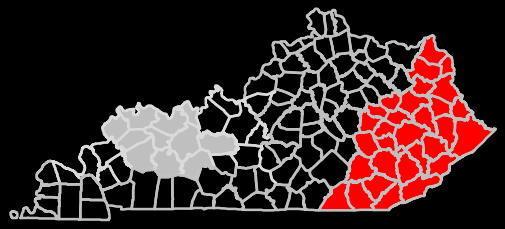
Source: USDOE/EIA

Kentucky Geological Survey

Original Eastern Kentucky Coal Resources

64.1 BT Original resource
50.0 BT Remaining





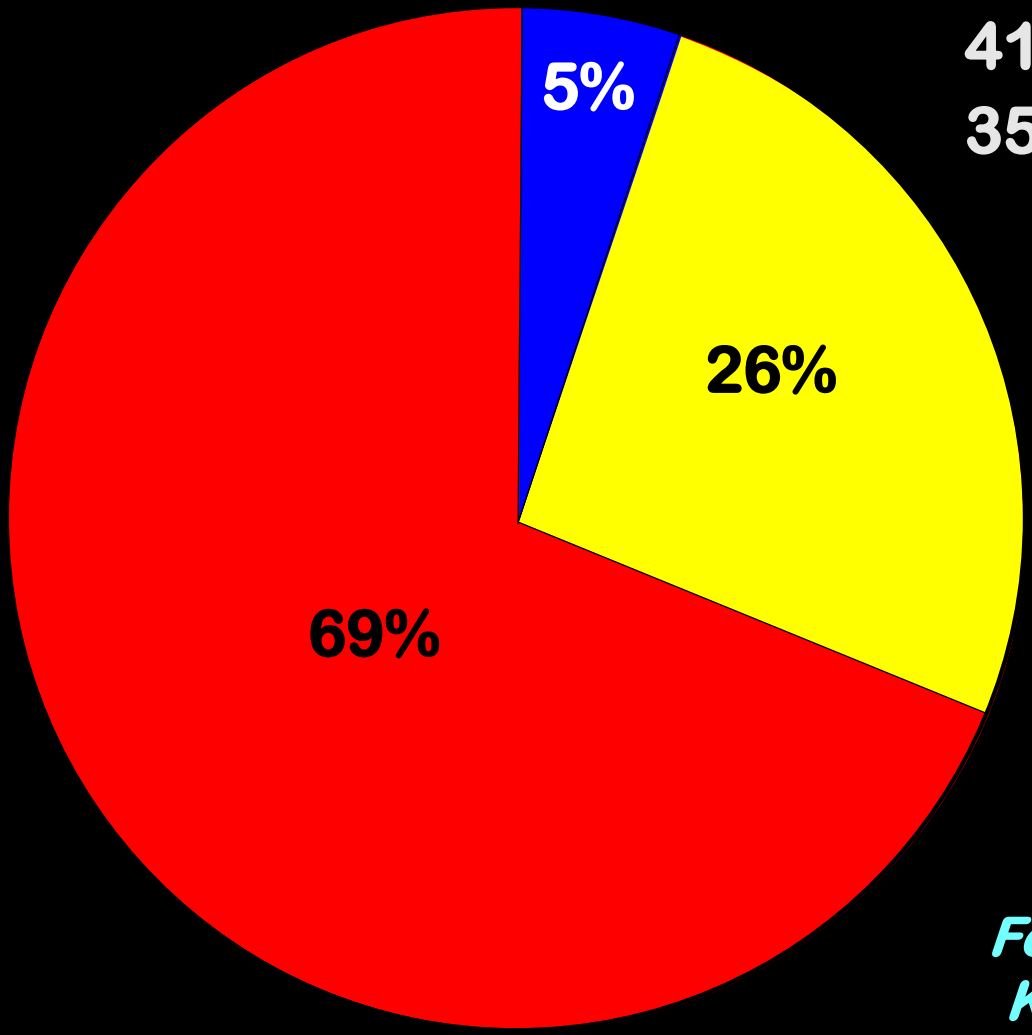
Coal thickness

- 14 to 28 in
- 28 to 42 in
- 42 to 56 in
- > 56 in

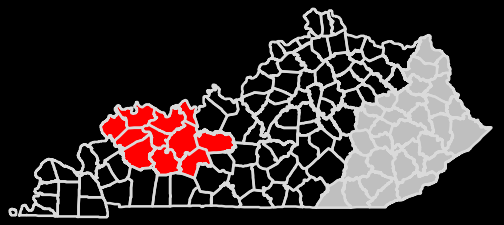
Substantial resource base, but more than 50 % is ≤ 28 inches thick

Source: Brant and others, 1980-1983, Kentucky Geological Survey

Original Western Kentucky Coal Resources



41 BT Original resource
35.4 BT Remaining



Coal thickness

- 14 to 28 in
- 28 to 42 in
- >42 in

Fewer resources than eastern Kentucky, but mineable beds are typically thicker

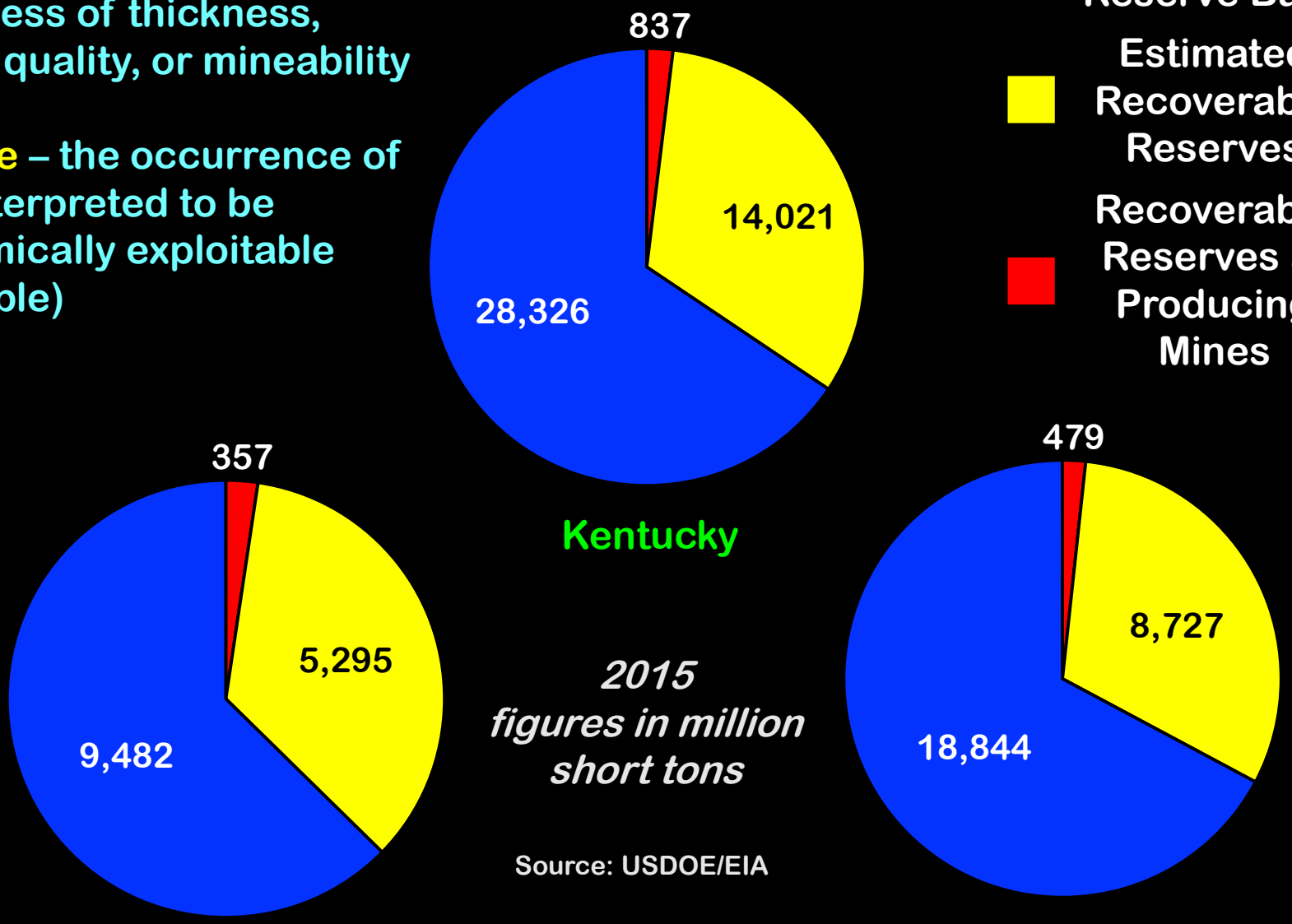
Source: Brant and others, 1980-1983, Kentucky Geological Survey

Kentucky Geological Survey

Resources vs. Reserves

Resource – the occurrence of coal, regardless of thickness, extent, quality, or mineability

Reserve – the occurrence of coal interpreted to be economically exploitable (mineable)

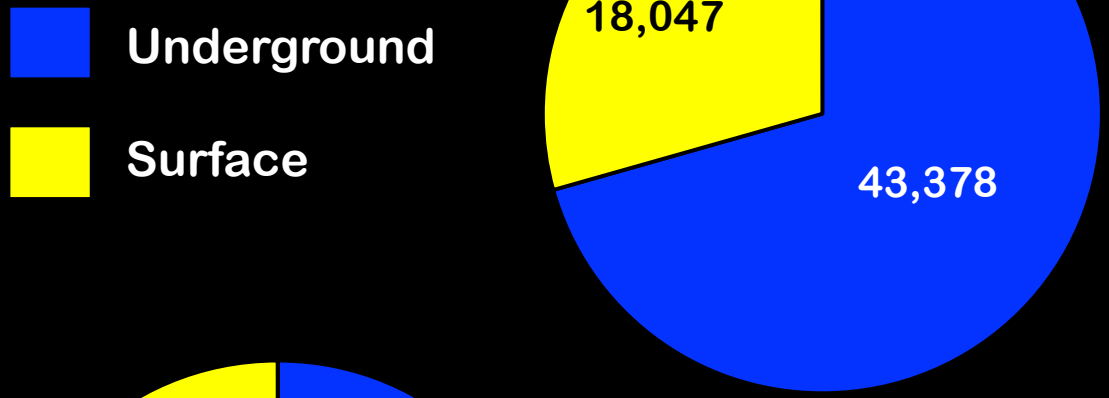


2015
figures in million short tons

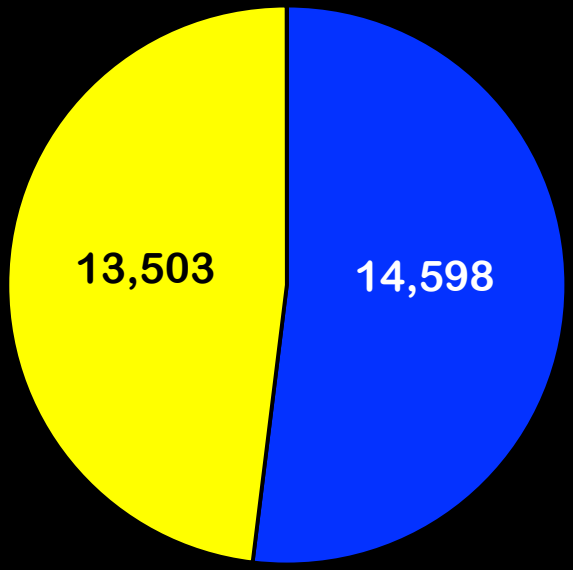
Source: USDOE/EIA

Kentucky Geological Survey

Underground vs. Surface Mining



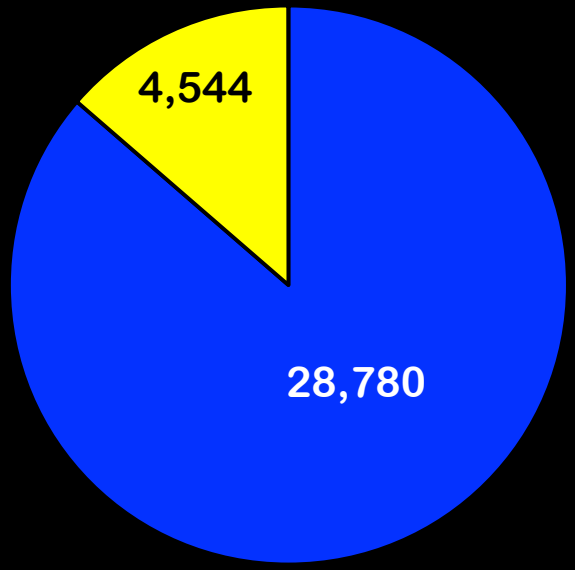
Kentucky
61.4 MM
short tons



Eastern Kentucky
28.1 MM short tons

2015 figures in thousand short tons

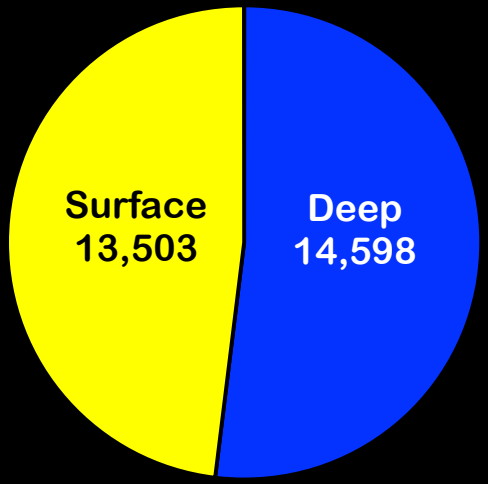
Source: USDOE/EIA



Western Kentucky
33.3 MM short tons

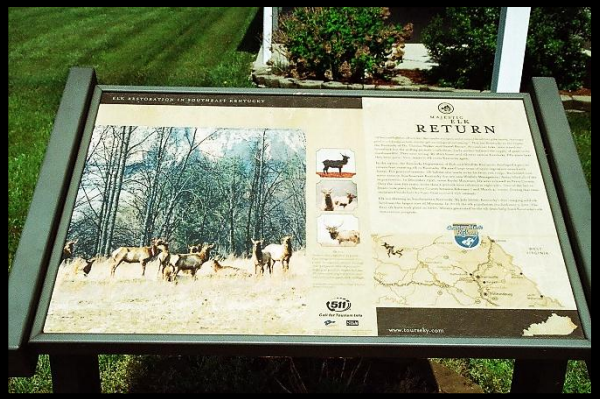
Surface Mining Issues in Eastern KY

48 % of EKY's production in 2015 was from surface mining



Martin County, KY - Google Earth image

- More stringent surface mining regulations
- Continued opposition from NGO's is likely



Elk repopulation program

Big Sandy Industrial Park

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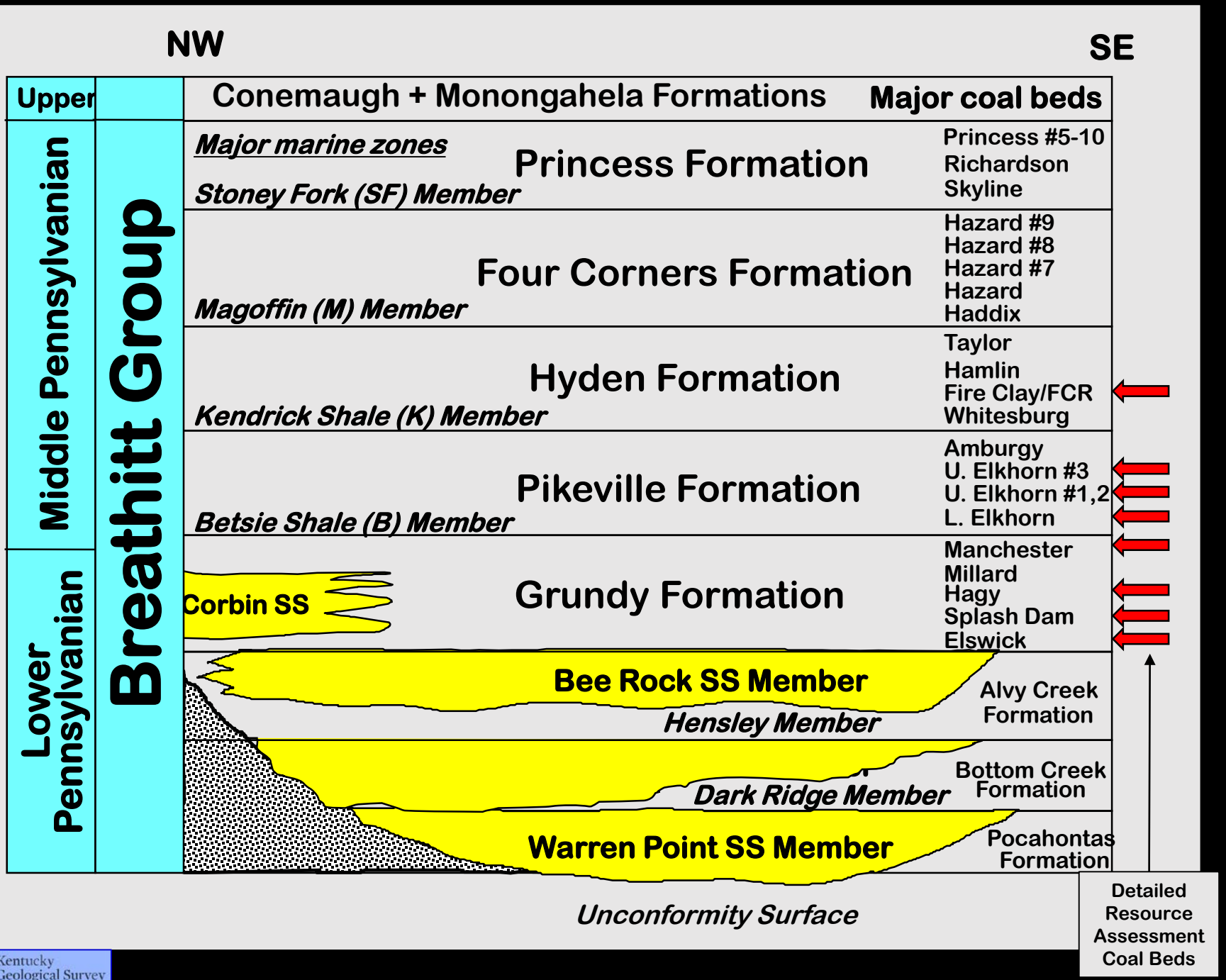
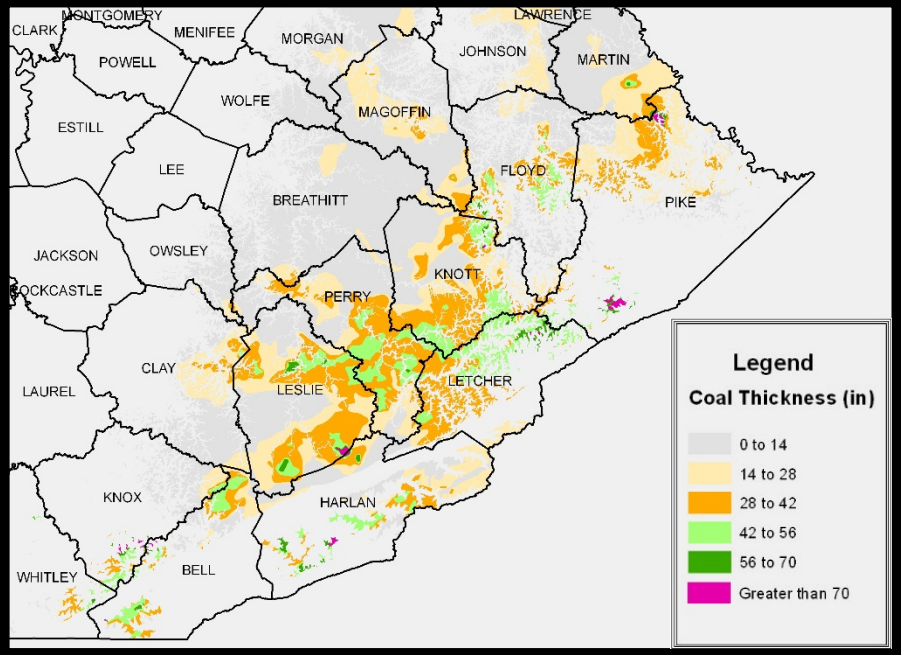
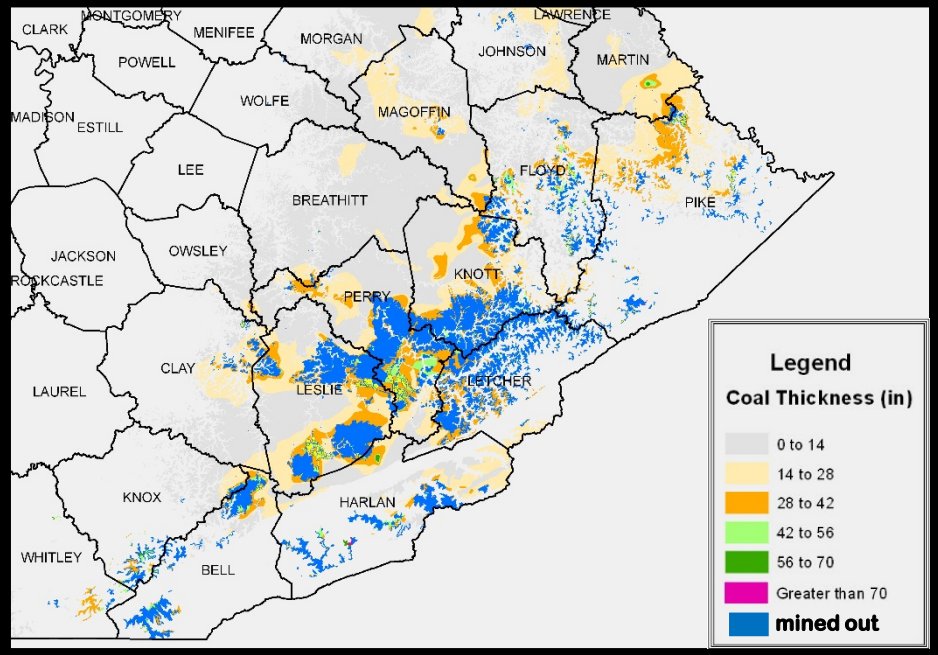

NW
SE
Upper
Middle Pennsylvanian
Lower Pennsylvanian
Breathitt Group
Conemaugh + Monongahela Formations
Major coal beds
Major marine zones
Stoney Fork (SF) Member
Princess Formation
Princess #5-10
Richardson
Skyline
Four Corners Formation
Magoffin (M) Member
Hazard #9
Hazard #8
Hazard #7
Hazard
Haddix
Hyden Formation
Kendrick Shale (K) Member
Taylor
Hamlin
Fire Clay/FCR
Whitesburg
Pikeville Formation
Betsie Shale (B) Member
Amburgy
U. Elkhorn #3
U. Elkhorn #1,2
L. Elkhorn
Grundy Formation
Corbin SS
Manchester
Millard
Hagy
Splash Dam
Elswick
Bee Rock SS Member
Hensley Member
Alvy Creek Formation
Dark Ridge Member
Bottom Creek Formation
Warren Point SS Member
Pocahontas Formation
Unconformity Surface
Detailed Resource Assessment Coal Beds
Kentucky Geological Survey

Fire Clay Coal Bed

Original Resources



Remaining Resources



Category	>28 in (71 cm)	<28 in (71 cm)	Total
Original Resources	2,745.2	1,418.3	4,163.5
Mined Resources	1,658.6	46.2	1,704.8
Remaining Resources	1,086.6	1,372.1	2,458.7
Remaining %	40 %	92 %	59 %

Figures are expressed as million short tons

Eble and Weisenfluh, 2012

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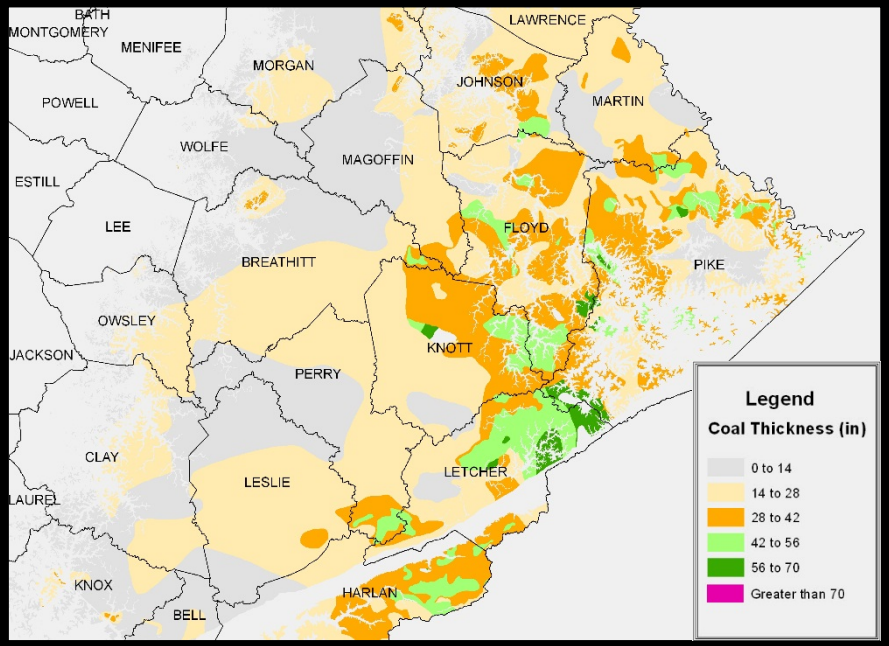
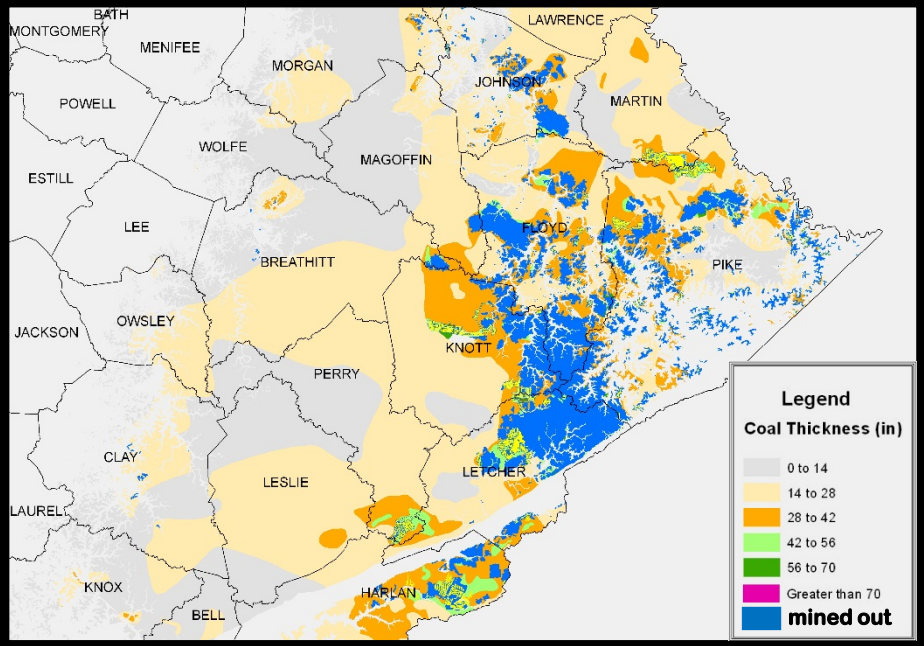
Upper Elkhorn #3 Coal Bed

Original Resources



Remaining Resources



Category	>28 in (71 cm)	<28 in (71 cm)	Total
Original Resources	3,571.5	4,430.2	8,001.7
Mined Resources	1,725.1	57.2	1,782.3
Remaining Resources	1,846.4	4373.0	6,219.4
Remaining %	52 %	99 %	78 %

Figures are expressed as million short tons

Eble and Weisenfluh, 2012

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EKY Coal Resource Summary

The Eastern Kentucky Coalfield is a mature mining region. For the eight coal beds assessed:

Most of the resources of optimal thickness (>42 in) have been mined out, and current development is in thinner coals that require mining of additional rock, resulting in higher mining and processing costs.

For coal >28 in thick:
Original resources = 11.4 BT
Remaining resources = 5.5 BT (48 %)

More than 90 % of the coal <28 in thick remains.

For (optimal) coal >42 in thick:
Remaining resources = 1.9 BT (17 %)

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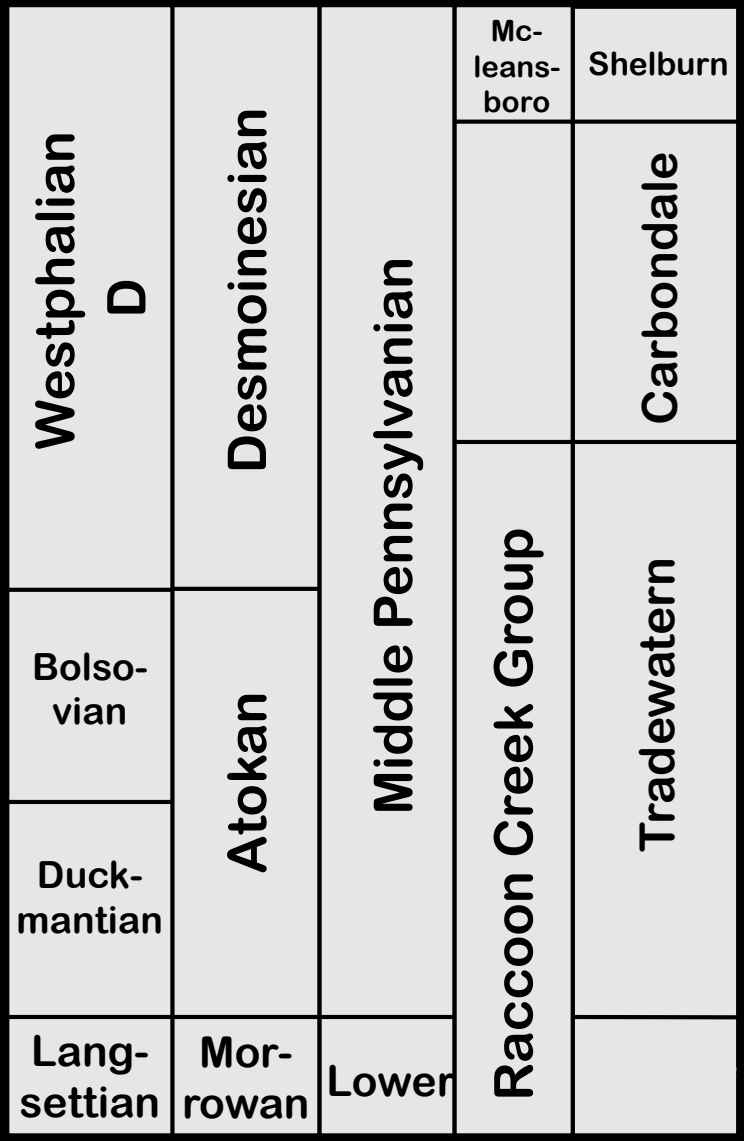
Western Kentucky Coal Beds



Western Kentucky #14 (Coiltown)

Western Kentucky #13 (Baker)

Western Kentucky #12 (Paradise)

Western Kentucky #11 (Herrin)

Western Kentucky #10 (Briar Hill)

Western Kentucky #9 (Springfield)

Western Kentucky #8 (Colchester)

Western Kentucky #7 (Dekovan)

Western Kentucky #6) (Davis)

Western Kentucky #5 (Wheatcroft)

Western Kentucky #4 (Mining City)

Elm Lick zone

Dunbar zone

Western Kentucky #3 (Ice House)

Amos/Foster zone

Deanefield

Bell

Battery Rock

Main Nolin

Principle Mining Targets

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WKY Coal Resource Summary

Although extensive coal mining has occurred in western Kentucky, significant resources remain in the Springfield, Herrin and Baker coal beds.

Although production initially declined after the CAAA90, the increase in scrubber capacity at U.S. power plants has increased the demand for these high sulfur, but lower cost coals.

Baker

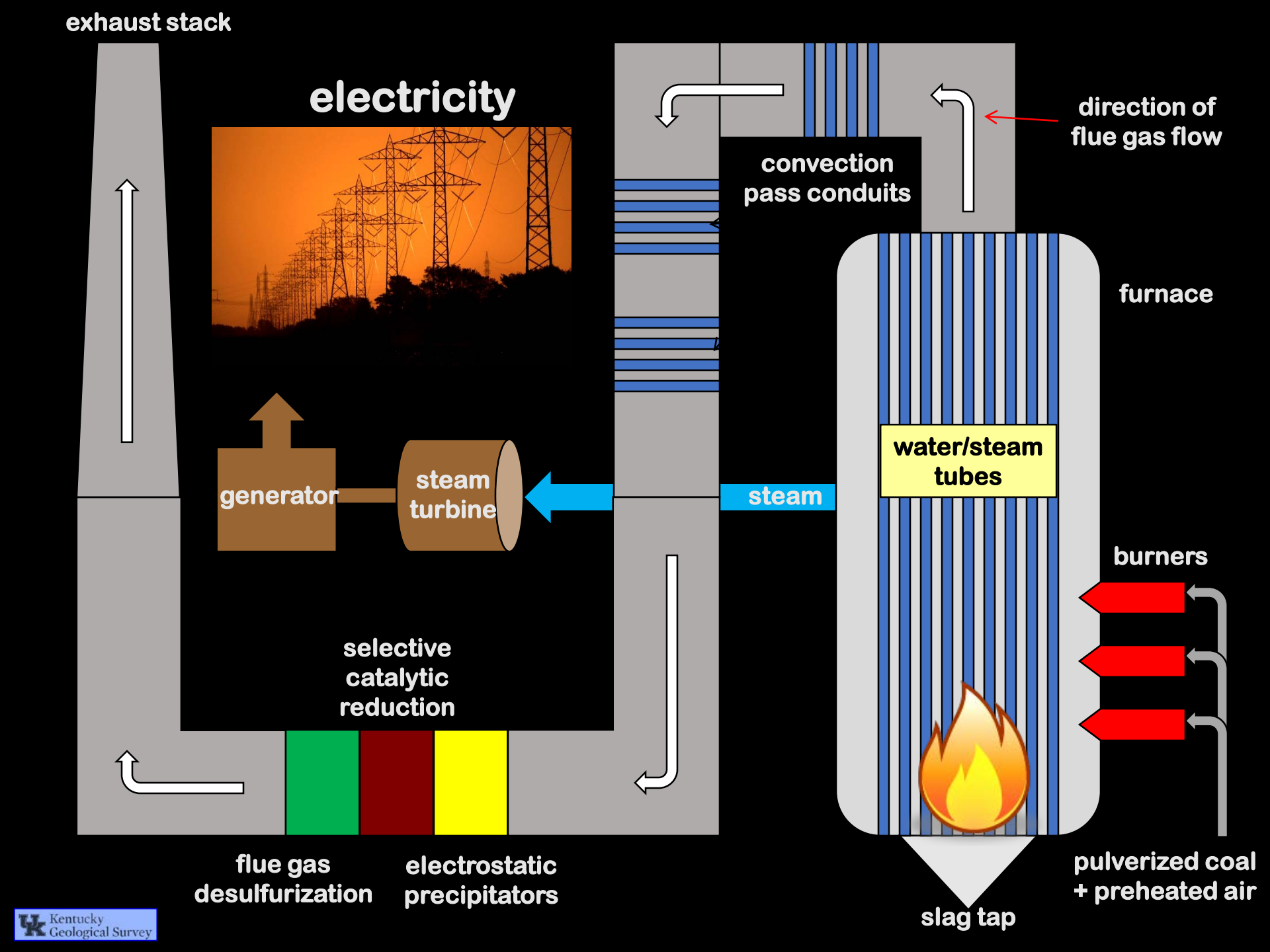
Thickness Categories	Original	Mined-Out Total	Remaining	Percent Mined Out
14-28	1,036.6	33.2	1.003.5	3
28-42	1,021.1	28.6	992.5	3
> 42	1,762.6	122.9	1,639.6	7
Total	3,820.3	1,031.784	3,635.6	5

Herrin

Thickness Categories	Original	Mined-Out Total	Remaining	Percent Mined Out
14-28	207.2	2.9	204.2	1
28-42	569.7	16.9	552.8	3
> 42	3,162.0	1,011.9	2,150.1	32
Total	3,938.9	1,031.8	2,907.1	26

Springfield

Thickness Categories	Original	Mined-Out Total	Remaining	Percent Mined Out
14-28	1.0	1.2	9.8	11
28-42	217.5	12.7	204.8	6
> 42	9,688.8	2,389.1	7,299.7	25
Total	9,917.3	2,403.0	7,514.3	24


exhaust stack
electricity
direction of
flue gas flow
convection
pass conduits
furnace
water/steam
tubes
generator
steam
turbine
steam
burners
selective
catalytic
reduction
flue gas
desulfurization
electrostatic
precipitators
slag tap
pulverized coal
+ preheated air
Kentucky
Geological Survey

Flue Gas Desulfurization (FGD)

FGD - Flue gas desulfurization (FGD, scrubbers) effectively controls the emission of SO_2, and several other effluents, including:

- Acid gases (HCl, HF)
- Mercury (Hg)
- Particulate matter (PM)

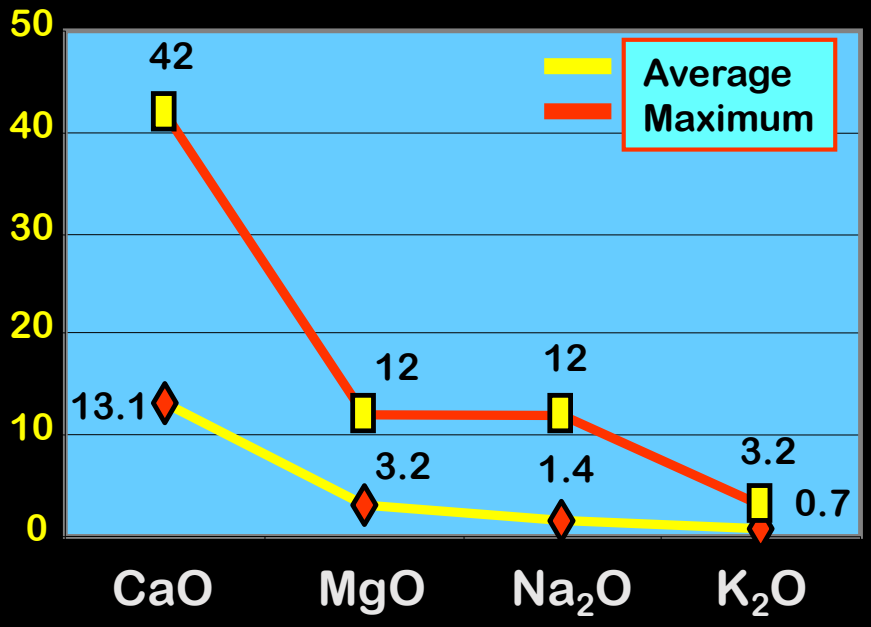
FGD decreases fuel costs: low-sulfur EKY coal is more expensive than high-sulfur WKY coal.

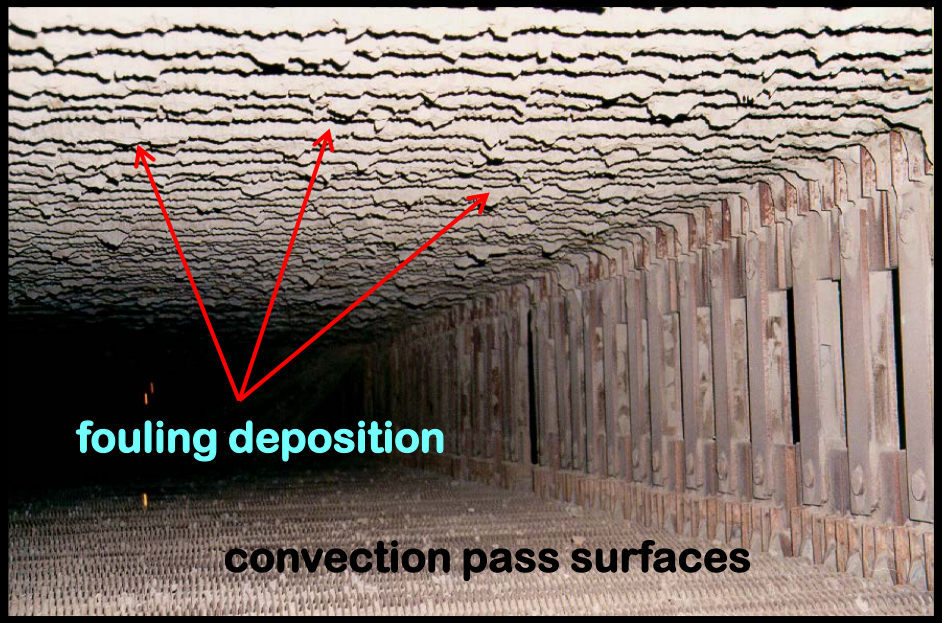
- As electric utilities increase the amount of FGD on coal-fired capacity, the demand for low-sulfur, compliance coal for electricity production is projected to decrease (USDOE/EIA).

Ghent Generating Station, Carroll Co., KY

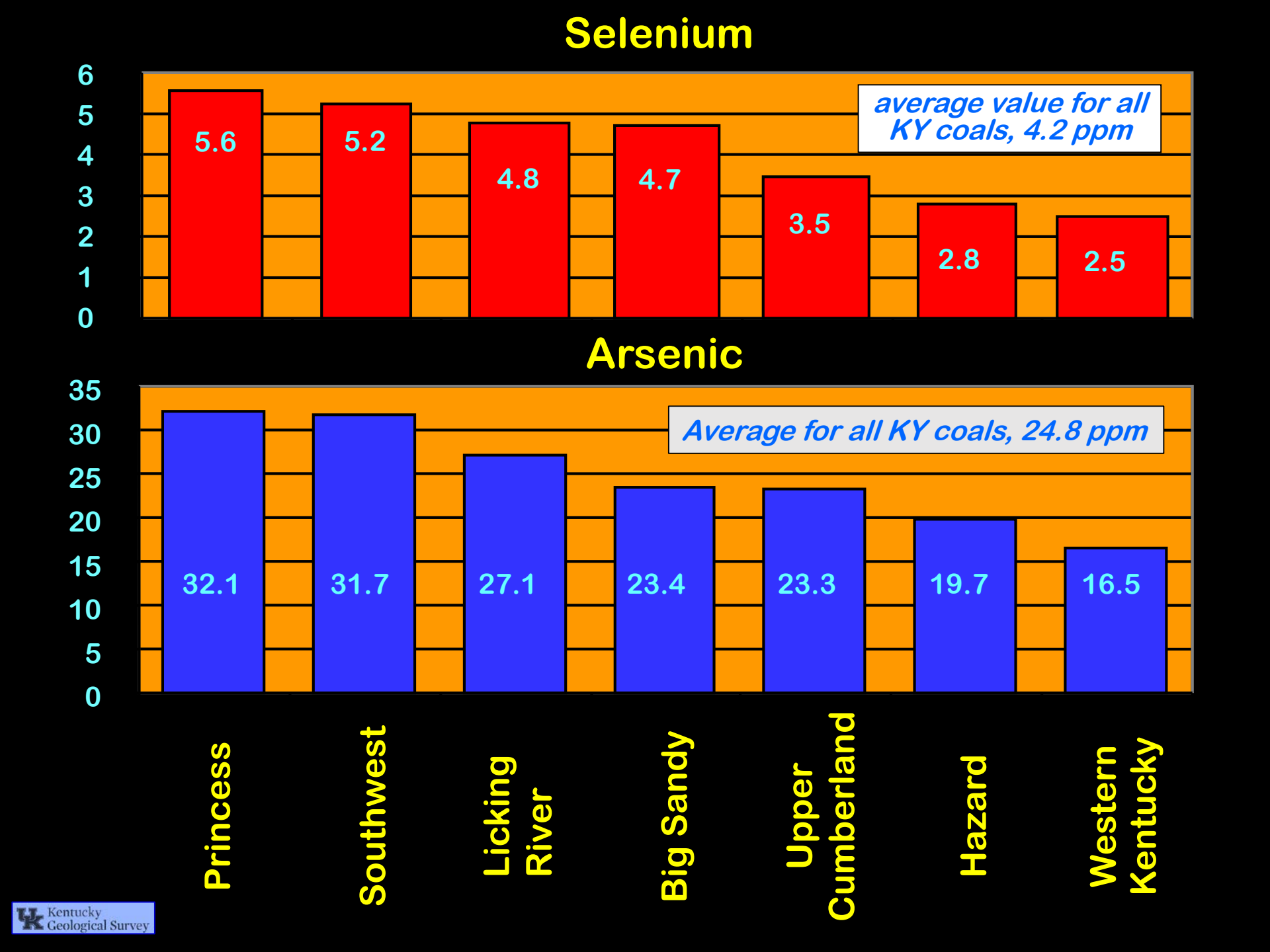
Paradise Fossil Plant, MuhlenburgCo., KY

Trace Element Data

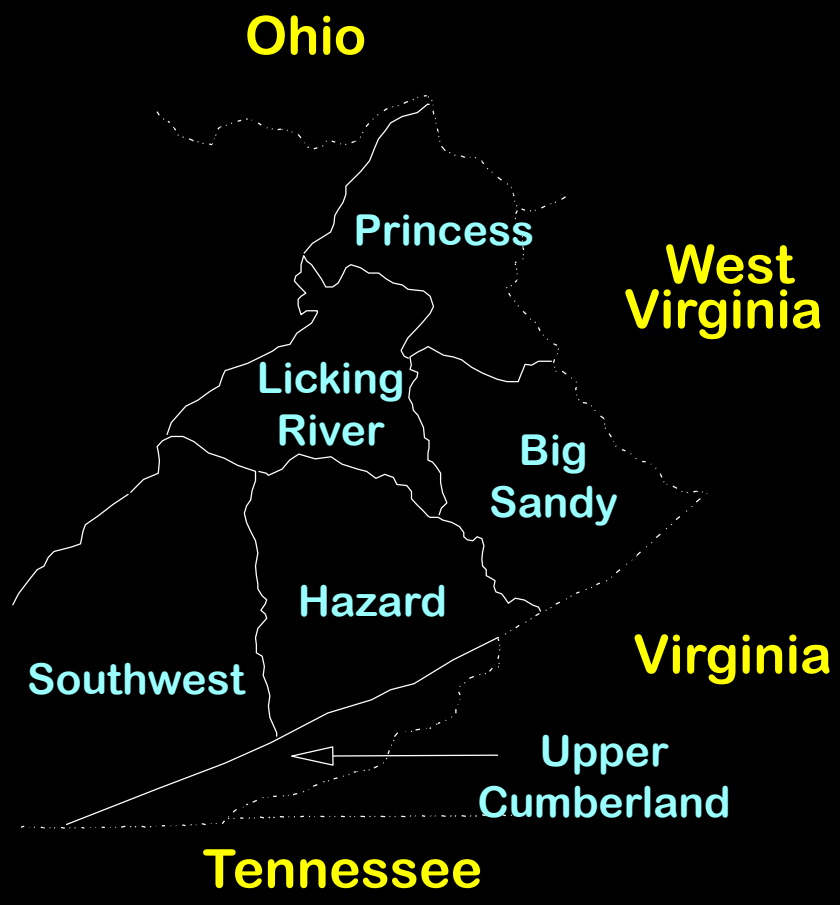




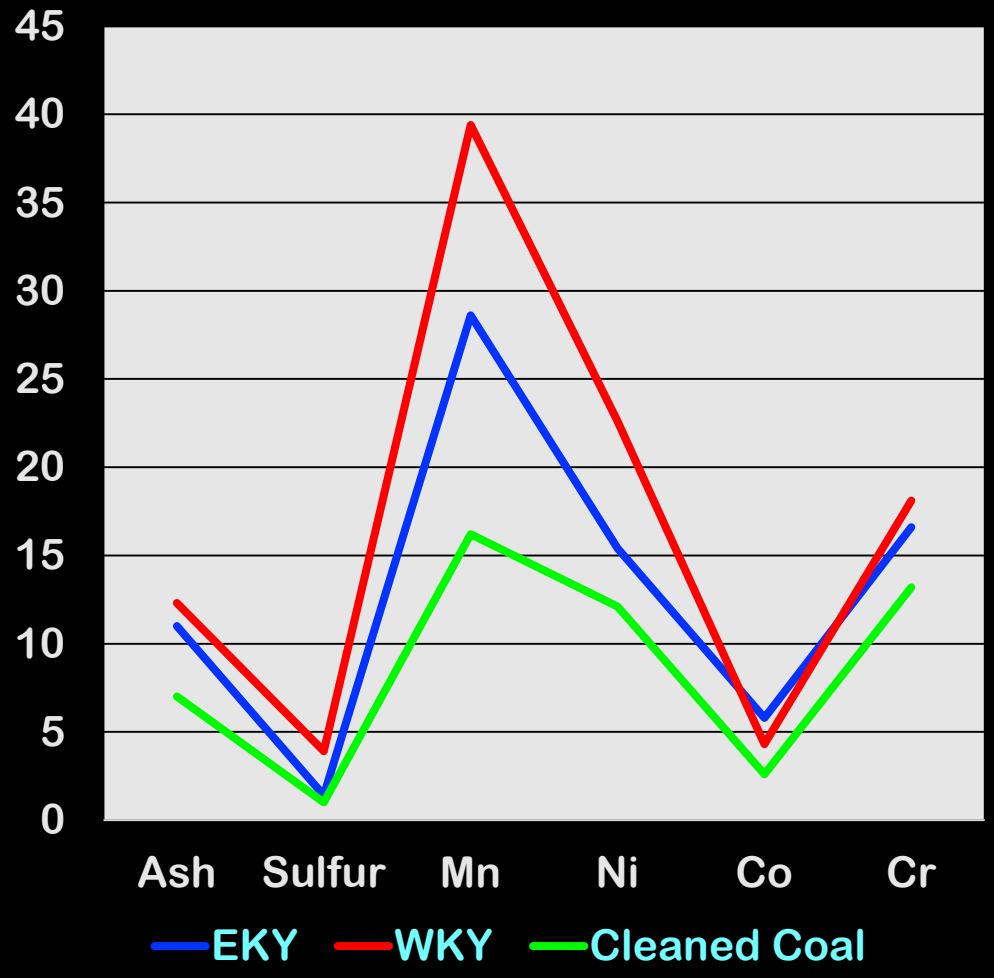
	CaO	MgO	Na_2O	K_2O
PRB	13.1	3.2	1.4	0.7
WKY	3.7	0.8	0.4	1.8
EKY	1.6	0.8	0.3	2


Selenium
6
5
4
3
2
1
0
5.6
5.2
4.8
4.7
3.5
2.8
2.5
average value for all KY coals, 4.2 ppm
Arsenic
35
30
25
20
15
10
5
0
32.1
31.7
27.1
23.4
23.3
19.7
16.5
Average for all KY coals, 24.8 ppm
Princess
Southwest
Licking River
Big Sandy
Upper Cumberland
Hazard
Western Kentucky
Kentucky Geological Survey

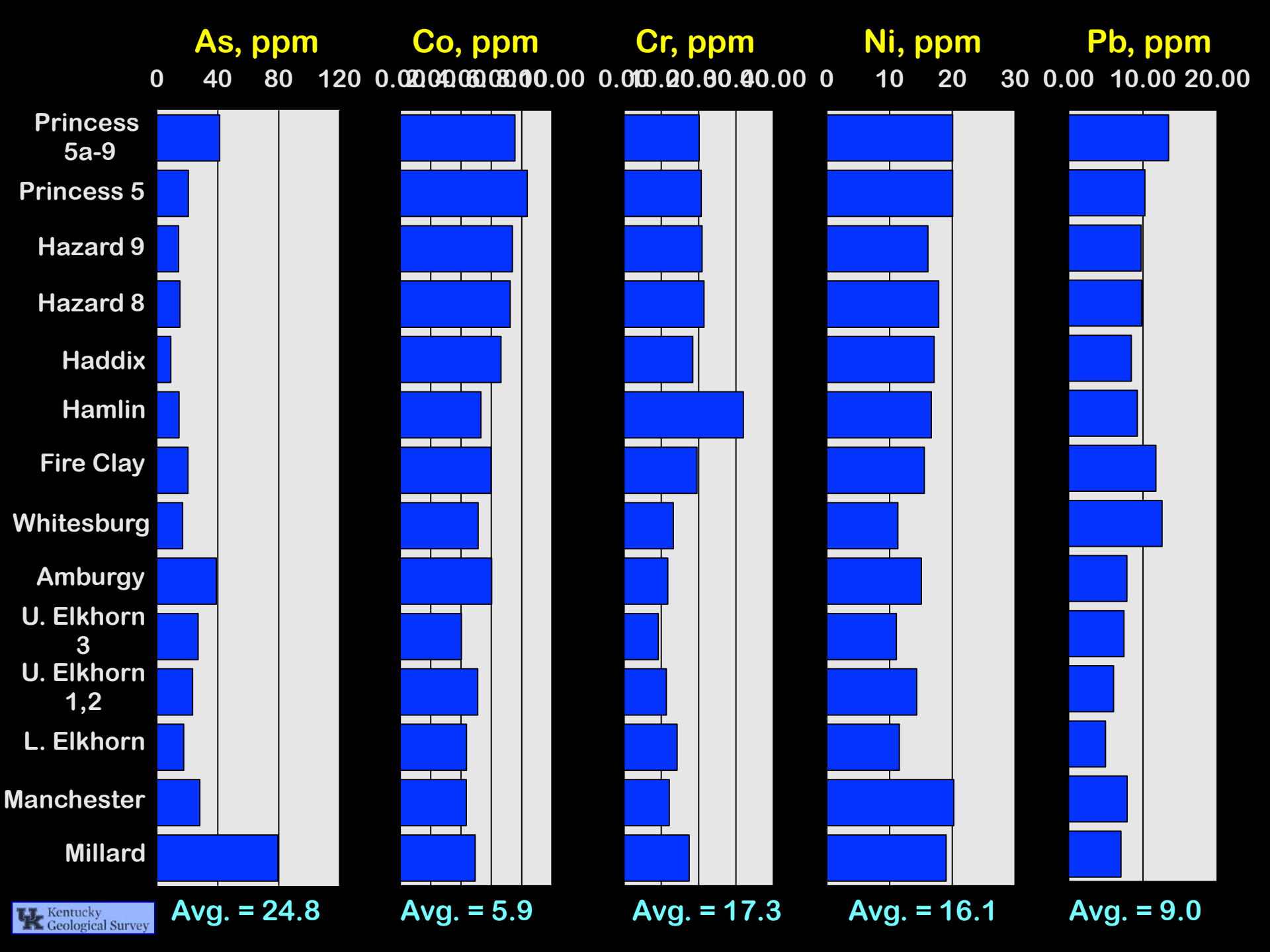
Eastern Kentucky Reserve Districts



Coal Beneficiation



	Ash	Sulfur	Mn	Ni	Co	Cr
EKY	11	1.4	28.6	15.4	5.8	16.6
WKY	12.3	3.9	39.4	22.6	4.3	18.1
Cleaned Coal (64)	7.0	1.0	16.2	12.1	2.6	13.2


As, ppm
Co, ppm
Cr, ppm
Ni, ppm
Pb, ppm
0
40
80
120
0.00
10.00
20.00
30
Princess 5a-9
Princess 5
Hazard 9
Hazard 8
Haddix
Hamlin
Fire Clay
Whitesburg
Amburgy
U. Elkhorn 3
U. Elkhorn 1,2
L. Elkhorn
Manchester
Millard
Avg. = 24.8
Avg. = 5.9
Avg. = 17.3
Avg. = 16.1
Avg. = 9.0
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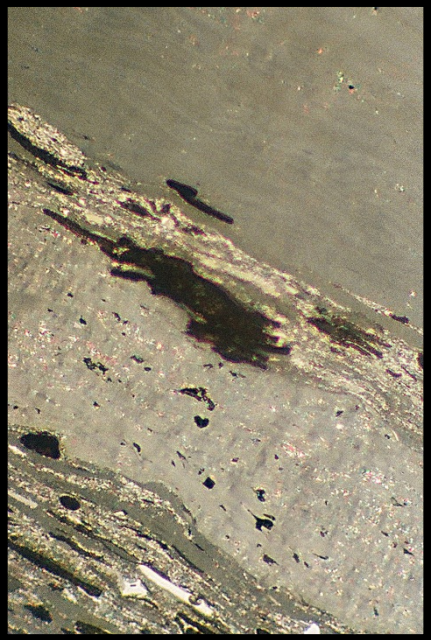
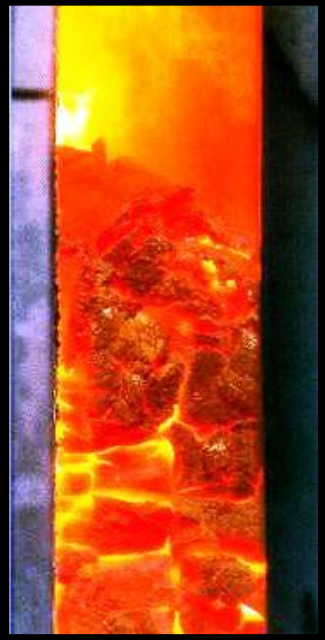
Metallurgical Coal Resources

Met Coal – Used to make coke, a principle component in the production of steel. Coke serves as a reducing-agent for iron ore; it is also a source of process heat. Results indicate that many eastern Kentucky coals have favorable metallurgical properties.

- Less than 10 % of Kentucky coal production was used for met coal in 2015

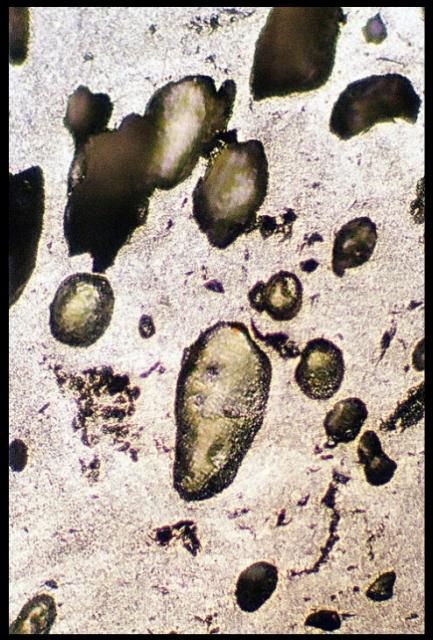


Pond Creek Coal
Polished Section
Reflected Light (900X)



Coke Oven

Coke Charge Being "Pushed"



Metallurgical Coke
Polished Section
Reflected Light (900X)

Kentucky Geological Survey

KGS REE Research

Sample Collection
(mines, prep and power plants)

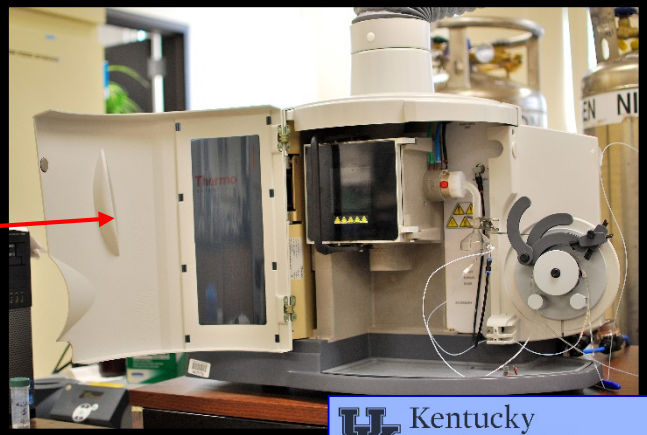
Sample Preparation
(reduce material to -325 mesh)

Sample Ashing
(500^0 C for 5 to 6 hours)

Sample Digestion
(HF/HCL/HNO_3 for 10 to 12 hours)

Sample Analysis
(5 to 10 minutes, via ICAP)

ICAP = ***Inductively-coupled argon plasma optical emission spectroscopy***



Kentucky Geological Survey

Fire Clay Coal Bed

James River Coal Co., mine #90
Perry County, Kentucky
Hazard South Quadrangle
Latitude: 37.175121
Longitude: 83.157591

	Total REE + Y (ppm)
Gray, silty shale roof rock, 3" sampled	295.9
Top Bench, 32"	976.6
	1100.4
Flint Clay Parting, 3"	292.0
Bottom Bench, 16"	1018.3
Seat Rock (covered) 3" sampled	263.7

Coal average = 1031.8 ppm
Rock average = 283.9 ppm

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Thank You