Power Plant Cooling
Geo Thermal
A Possible Alternative to Surface Water

WV Water Conference 2010

Morgantown, WV

October 6, 2010

Jeffrey J. Brown

PANGEA

GLOBAL

Current Situation, Possible Trends

Power Generation is a significant consumer of water and thermal impairment of surface water.

- 39% of Fresh Water Withdrawals in 2000
- 3% or Water Consumed in 1995
- Water Vapor is a GHG
- Cooling is a major factor in fuel efficiency which is in turn a key factor in CO_2 emission reduction

GTCC technology is gaining share relative to coal

Air cooling predominates in new GTCC

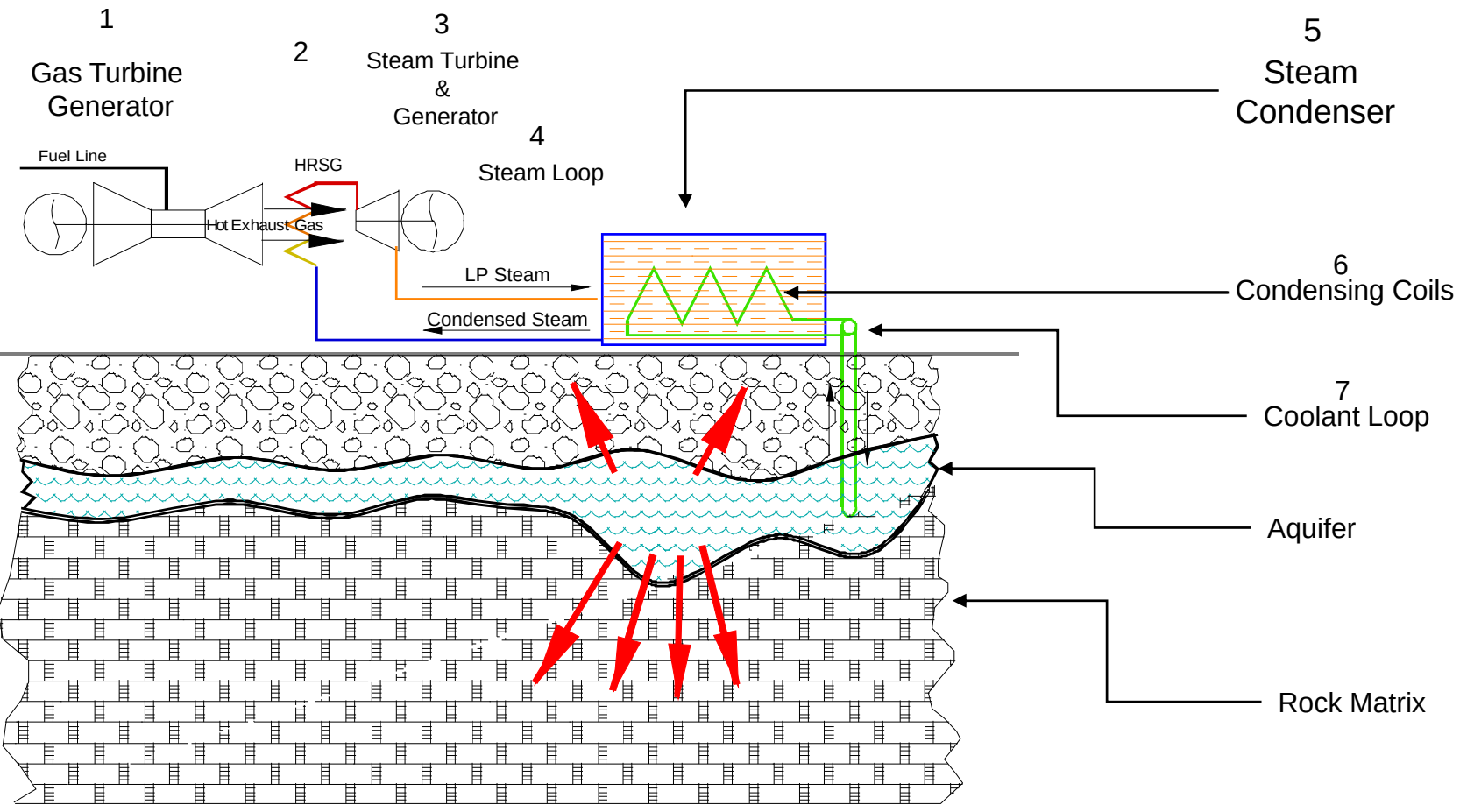
Advantages of small GTCC/Cogen/CHP/DG:

- heat rate
- Closer to load, reduced line losses

an Geo Thermal Cooling ease demand for surface water?
oncept-substitute rock for water bodies/atmosphere as a
eat sink.

Widely used with commercial heat pumps
nlikely to work for large coal or GTCC.
lay be feasible for smaller plants.
- CHP plants
ritically dependent on thermal transfer
- Thermal absorption of contacted rock
- Conductivity and dispersal
- Non-potable-HDS/Saline Aquifers
nly an idea at this time.

A Simple Schematic



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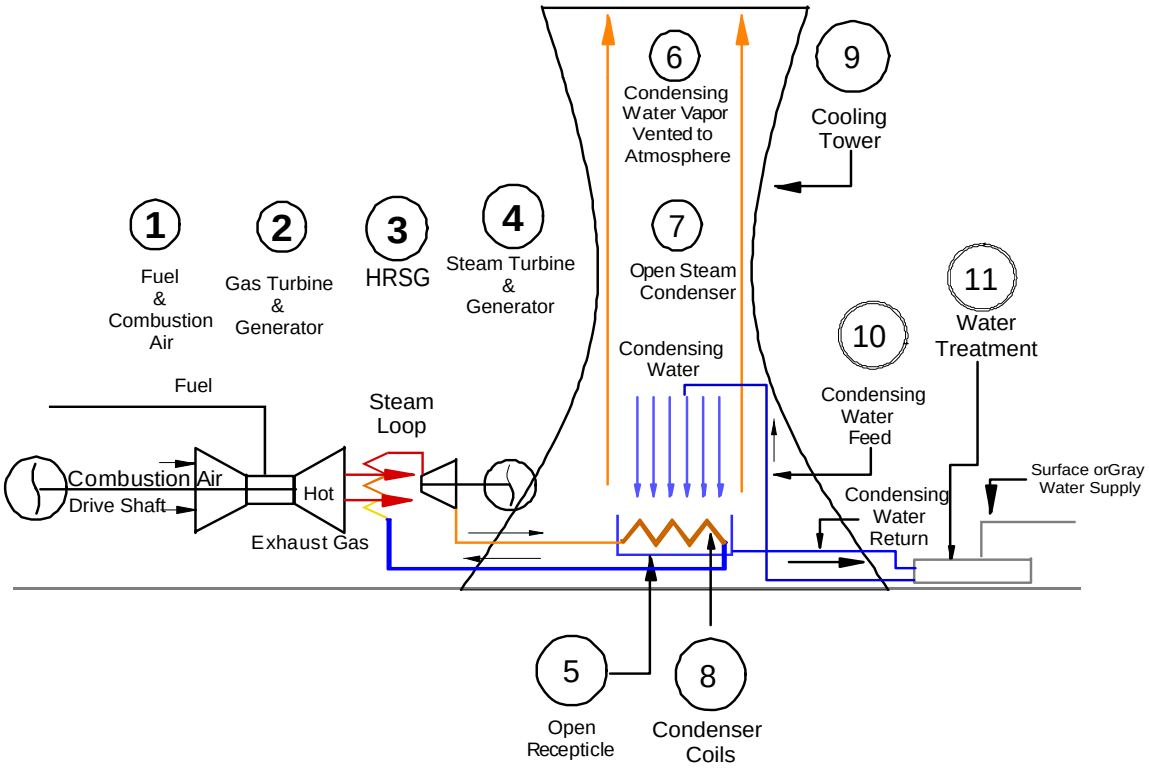
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Combustion
Air
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Gas Turbine
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Generator
3
HRSG
4
Steam Turbine
&
Generator
6
Condensing
Water Vapor
Vented to
Atmosphere
7
Open Steam
Condenser
9
Cooling
Tower
10
Condensing
Water
Feed
11
Water
Treatment
Fuel
Steam
Loop
Condensing
Water
Combustion Air
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Surface orGray
Water Supply
Condensing
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5
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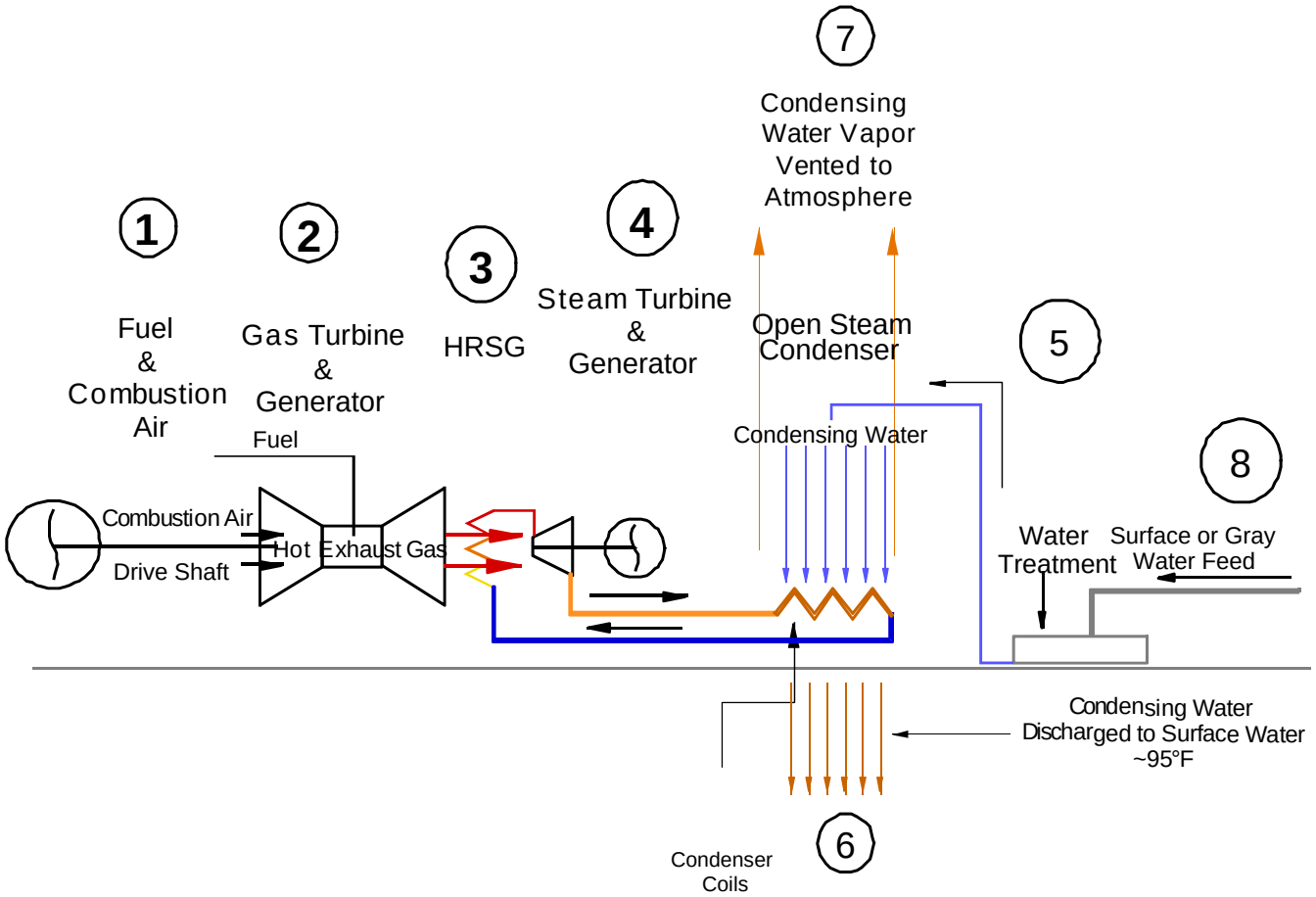
8
Condenser
Coils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Drive Shaft
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Water
Treatment
Surface or Gray
Water Feed
Condensing Water
Discharged to Surface Water
~95°F
6
Condenser
Coils

Air Impacting Water

How Carbon Emissions Standards Could Impact West Virginia Water

Emily Grubert, UT Austin

West Virginia Water Conference

7 October 2010

Outline

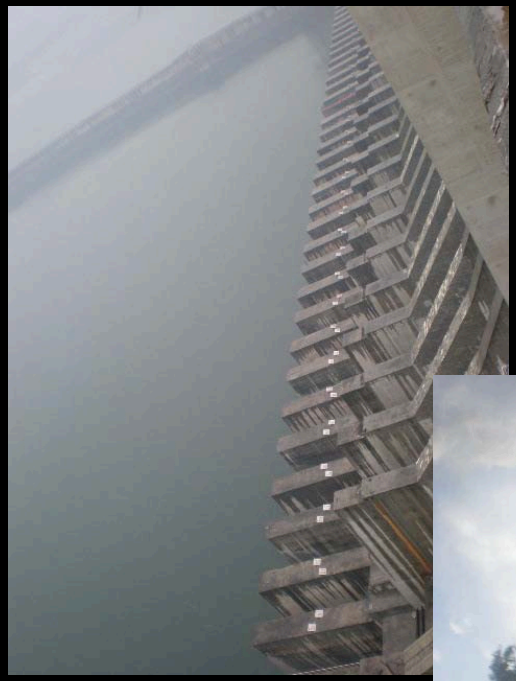
- Energy and water are interdependent
- Water is a major part of fuel extraction
- Both water quality and quantity are important
- Carbon capture uses a lot of extra fuel
  - ...and a lot of extra water
- Air-focused policy can affect water too
- Carbon and sulfur restrictions affect mining

Energy and Water are Interdependent

- **Energy for water**

- **Water for energy**
  - **Quantity and quality**
  - **Upstream and downstream**

Water is Used for Energy



- Hydroelectric power
- Thermoelectric cooling
- Water for extraction

West Virginia Has Both Water and Energy

We Can Reduce Atmospheric Carbon Loading

- **Prevent emitted carbon from entering the atmosphere**
  - **Carbon capture and sequestration from coal plants**

- **Do not emit carbon**
  - **Wind generation**

...But It Can Be Challenging

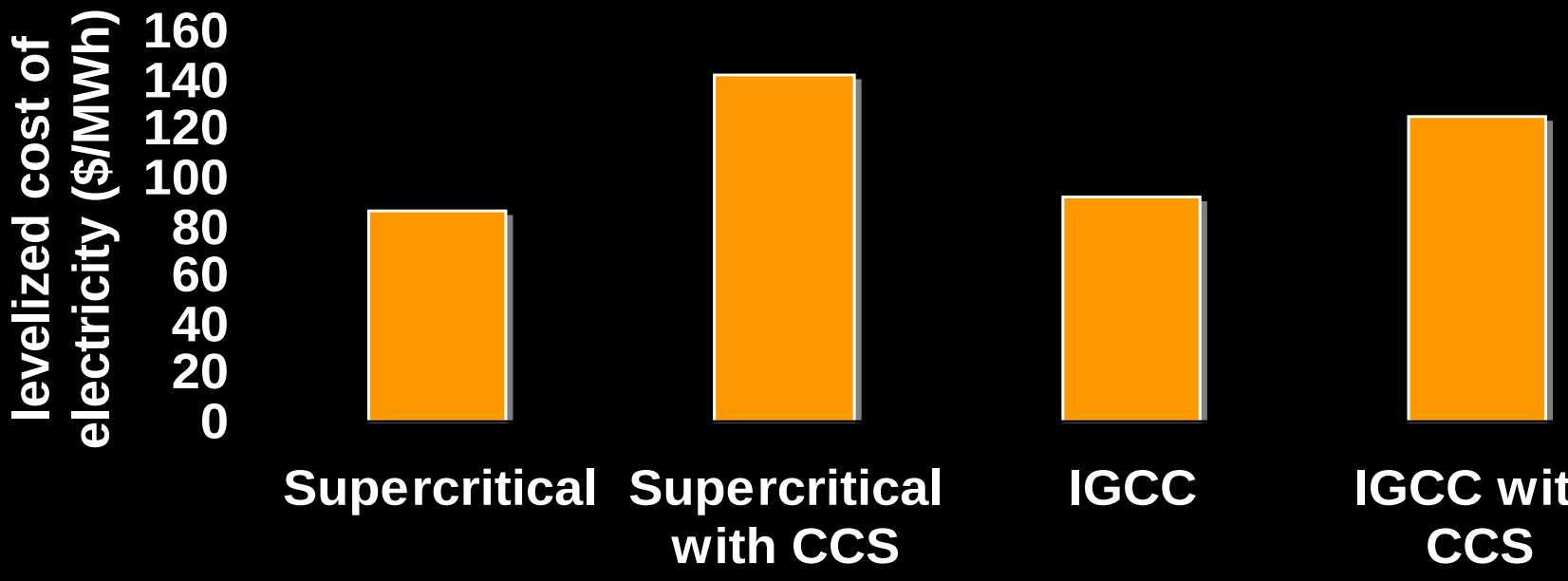
- **Renewables are often expensive**
- **Capture and storage technologies are expensive**
- **Much planning and information is required**

Carbon-focused Legislation Might Come

- **Carbon cap and trade and carbon taxes have been proposed**
- **International and domestic policy might address greenhouse pollution**
- **Different schemes emphasize CCS to differing degrees**

Carbon Capture is Expensive

- **Capital investment and operating costs are high**
  - **...especially for first-of-a-kind plants**



NEI 2010, The Cost of New Generating Capacity in Perspective

The Cost is Energy

- **“High energy use” means high coal use**
  - **...which means more coal mining**
- **There exist proposals to use natural gas to fire capture units**
- **The upstream impacts get little attention**

A Power Plant with Carbon Capture Needs More Fuel

- **Parasitic loads for carbon capture and sulfur capture**
  - **...and possibly for other controls**
- **Size of the parasitic load depends on technology**
  - **Early stage estimates are about 30%**
  - **Targets range from 10-15% with mature technologies (PC)**
- **Parasitic load is an ELECTRICITY demand, not a fuel demand**

CCS is Coal Intensive

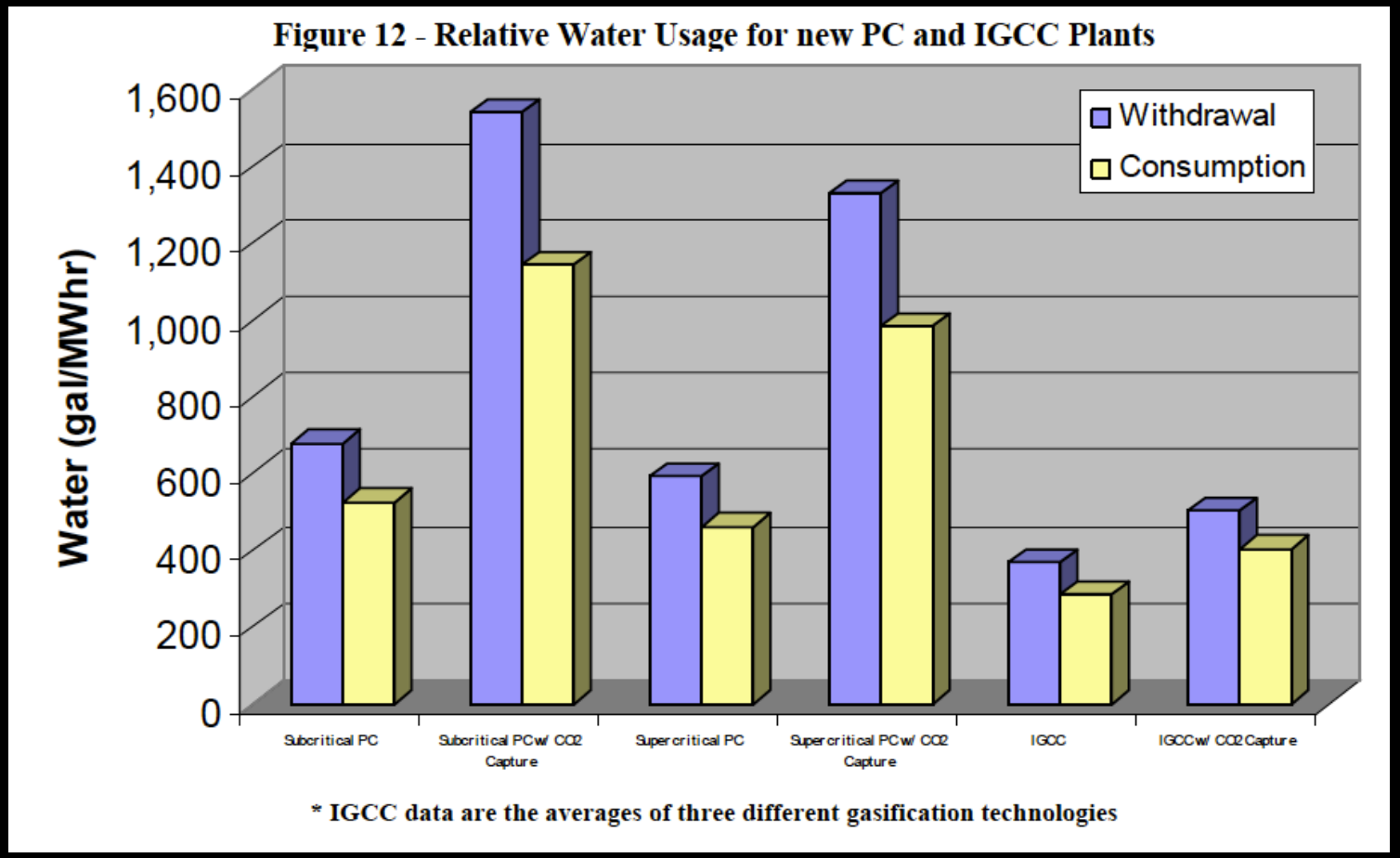
- **83%**
  - **the amount of extra coal a new coal-fired power plant deployed in 2030 with CCS could consume per unit of CO_2**
  - **Assumes PC plant, 90% capture efficiency, 46% plant efficiency, 27.8% net efficiency with CCS (LHV)**
- **Coal is used continuously for the 30-50 years of a plant's life**

Coal Can Be Environmentally Intensive

- **Mining has water, land, and community impacts**
  - **Many, not all, are negative**

- **Current CCS technologies are sulfur sensitive**
  - **Low sulfur U.S. coals are often low in energy density**
  - **West Virginia has relatively low sulfur, high energy coal**

CCS is Also Water Intensive

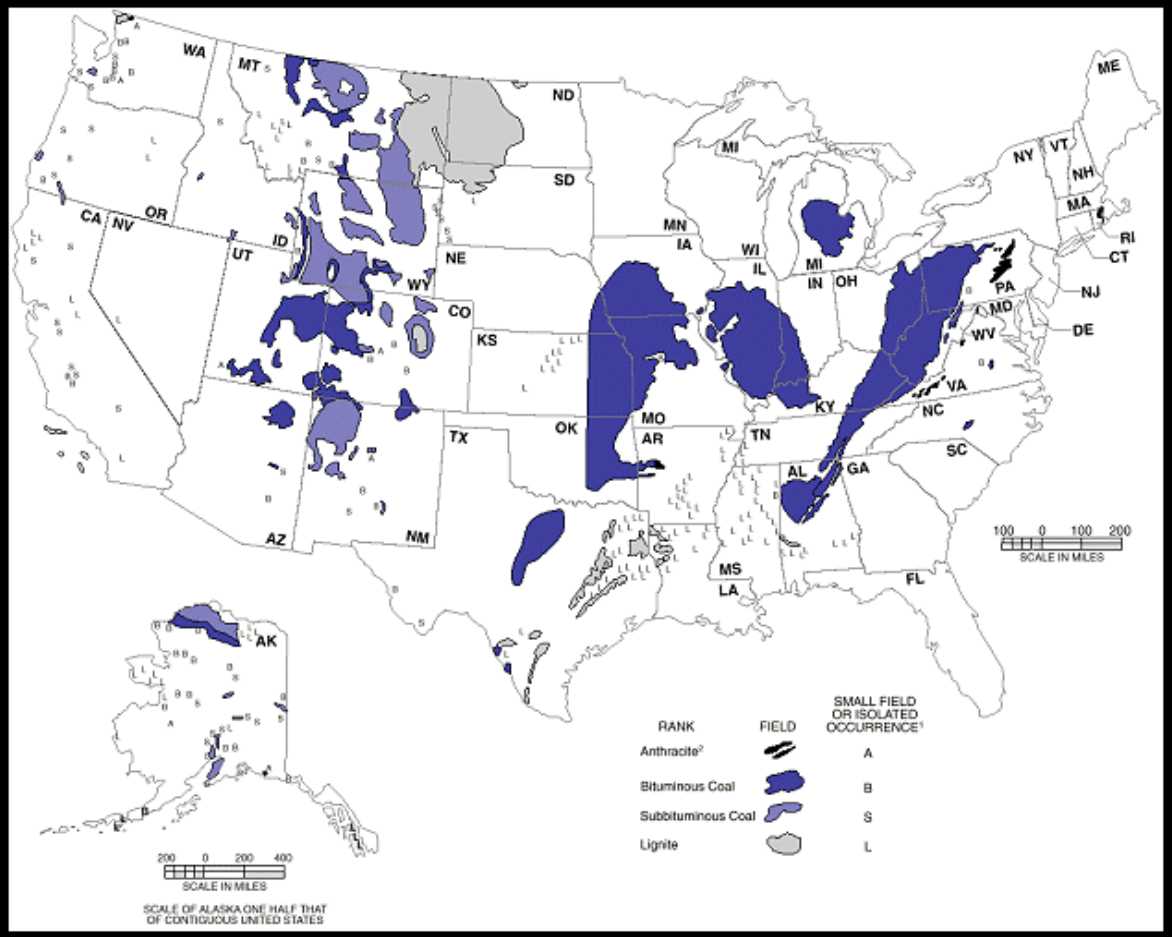


- Water use at the power plant for cooling also increases.
  - Upper boundary estimates, assuming closed-loop cooling

DOE/NETL-400/2008/1339

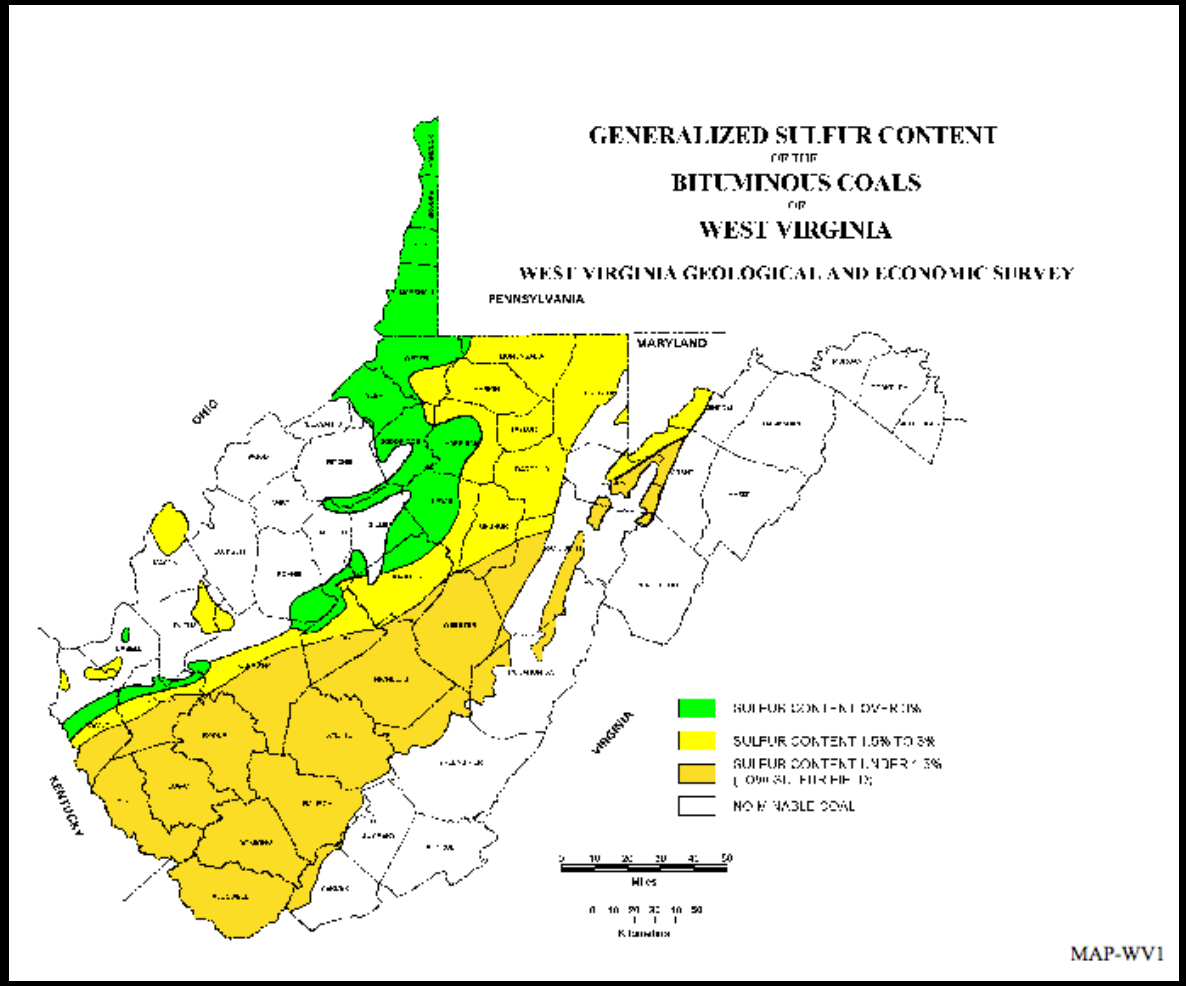
Where is the Coal Coming From?

- **Sulfur limitations**
- **Reserves issues**
- **Proximity of reserves to coal plants**



USGS

West Virginia Has Coal



http://www.wvgs.wvnet.edu/www/maps/maps.htm

- High energy density, low sulfur in places
- Suited to sulfur-sensitive IGCC that prefers high energy density
- Close to existing supply lines

More Mining, More Problems?

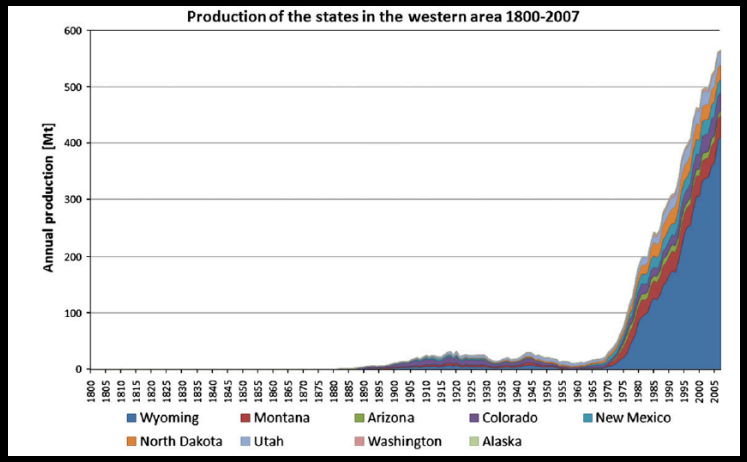
- More mine water
- More monitoring
- More nonpoint discharges
- More newly exposed reactive surfaces
- Faster depletion
- ...But, more revenue

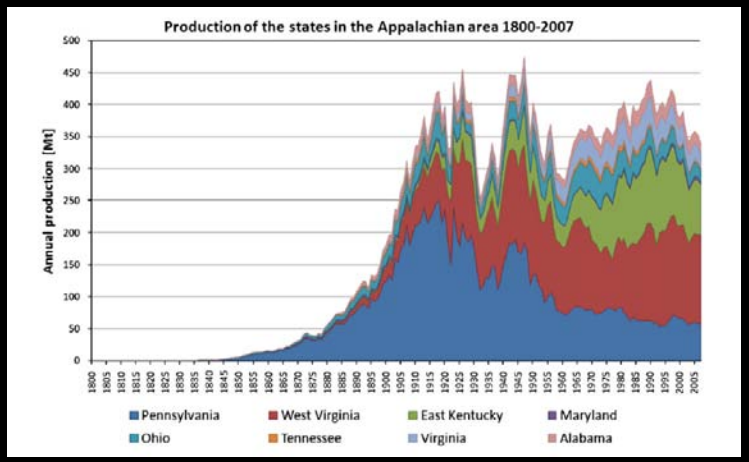
The West Also Has Coal

- **Less water there**
- **Less sulfur**
- **Lower energy density coal**
- **Larger transport requirements**
- **...But closer to high growth regions interested in climate change mitigation**

Air Standards Impact Production Patterns

- **Clean Air Act sulfur limitations largely shifted coal production to the West**
- **Sulfur limits likely altered impacts to US water from coal mining**
- **...But it came at a similar time as the Clean Water Act**





Hook, Aleklett 2009

Single Parameter Policies Can Be Harmful

- **Environmentally sound choices consider multiple systems**
- **Climate policy -- and energy policy -- often focuses on carbon emissions**
- **There are other problems to be aware of:**
  - **Conventional air emissions**
  - **Water use and contamination**
  - **Land use and contamination**
  - **Waste disposal**
  - **Community justice**

The University of Texas at Austin

http://www.webberenergygroup.com

Calculations and Assumptions

Coal plant efficiency drops from 46% to 27.8% overall

This assumes a 99% sulfur capture rate and a 90% carbon capture rate (vs usual 95% and 0)-- Pehnt, Henkel 2009

Efficiency numbers are based on LHV.

46/27.8 = 1.65 times as much coal per unit electricity

Removal efficiency is 90%

1.65/0.9 = 1.83 times as much coal per unit of electricity with removal

	operating mines *(2008)*	production per mine *(tonnes)*	energy content *(kJ/kg coal)*	emissions factor *(lb CO_2/mmbtu)*	combustion emissions factor *(kg CO_2/kg coal)*
Powder River Basin	17	26,500,000	20,500	212.7	1.87
Central Appalachia	841	252,000	29,200	207.1	2.59

Wastewater Quality and Treatment Challenges for Coal-Burning Power Plants: Can We Meet the Standards?

Rob J. Reash
American Electric Power
Columbus, OH

AEP®

Overview

- Coal in the US energy portfolio
- Key regulatory drivers for electric utilities
- Changes to effluent quality
- Compliance strategies

Coal in US Energy Portfolio

- US Electric Generation By Source (2000):

  coal (52%)
  nuclear (20%)
  natural gas (16%)
  hydropower (7%)
  oil (3%)
  renewables (2%)
  Total fossil fuel = 71%

Key Regulatory Drivers

- Wastewater: revision to steam electric ELGs (effluent guidelines) – 2012 proposal
- Coal combustion byproducts: regulate as hazardous waste or non-hazardous solid waste? Final rule in 2011
- CWA Section 316(b) – fish impingement & entrainment. Proposed rule early 2011.
- Clean Air Transport Rule and Utility MACT rules: more stringent emission requirements for SO_2, NO_x, acid gases, organics, metals. No trading.

Coal Combustion Product Production and Use – 2007 (ACAA)

Total CCP's produced = 126 metric t x 10^6

Total CCP's utilized = 51.2 metric t x 10^6

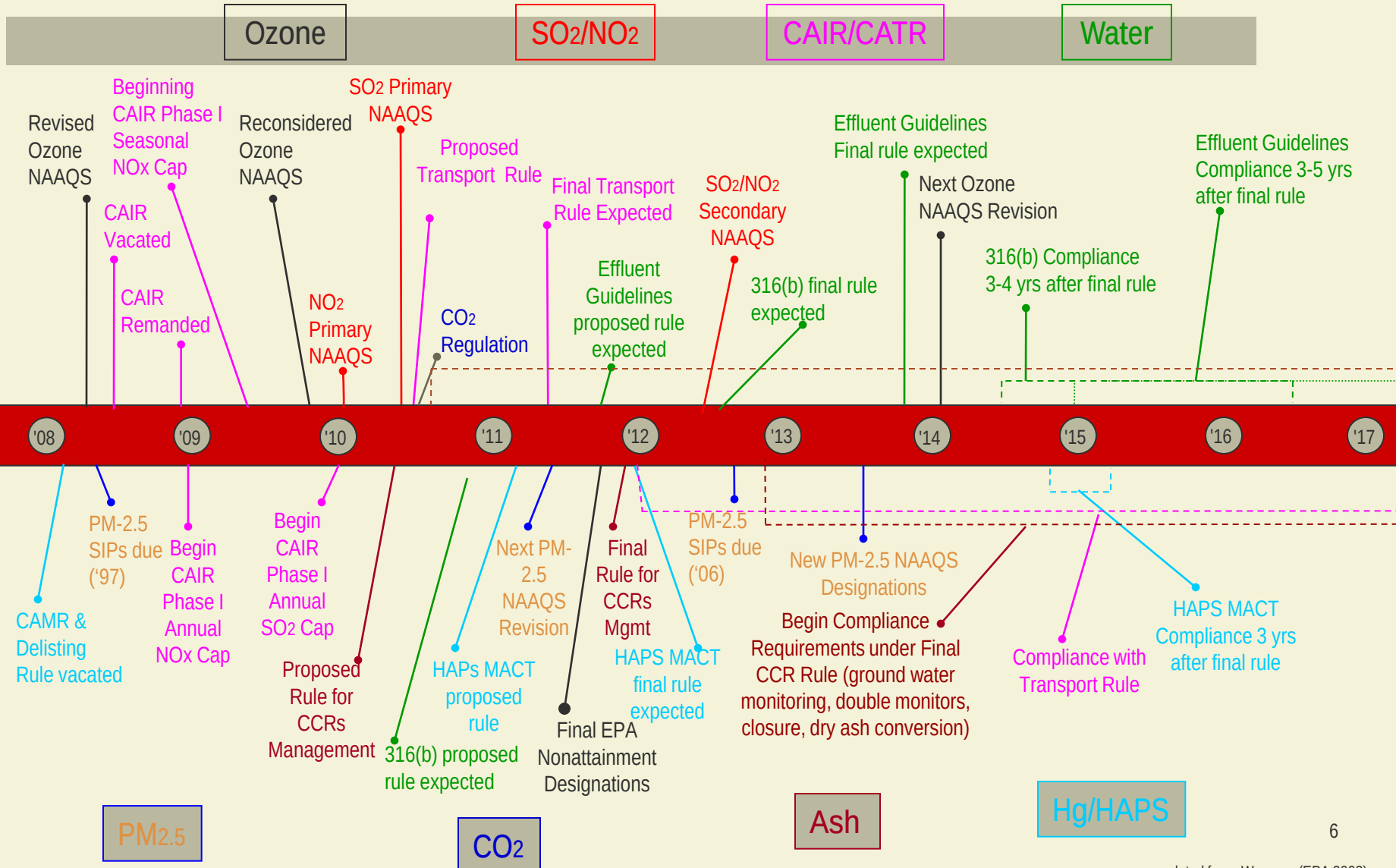
⇨ Distribution: Fly ash: 31.6 mt x 10^6

FGD gypsum: 9.2 mt x 10^6

Top utilization uses: 1) concrete products

2) gypsum panels

The Utility Federal Regulation Siege



-- updated from Wegman (EPA 2003)

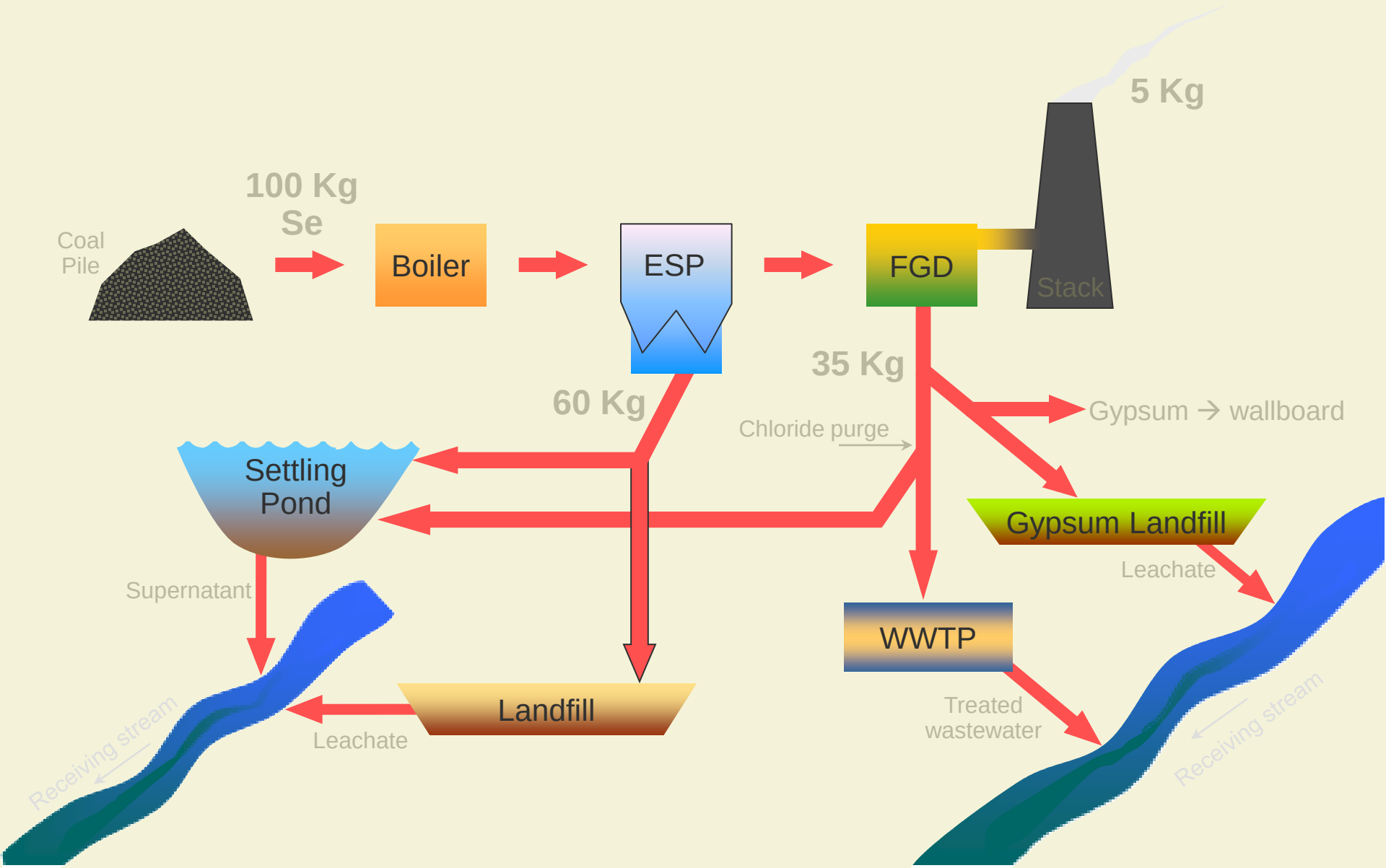
Changes to Effluent Quality

- Reductions in levels of SO_2, NO_x, and volatile trace metals (As, Hg, Se) from air emissions means that these pollutants are partitioned to solid waste and/or wastewater.
- CAA implementation benefits global, regional, and (most likely) local air quality.

Flue Gas Desulfurization (FGD) Systems

- Installed (or are being installed) at several coal plants. >98% removal of SO_2, co-benefit removal of volatile metals.
- Partitioning of trace metals and salts: to solid waste (e.g, gypsum) or blowdown wastestream?
- Most balance calculations done to date indicate that majority of As, B, Hg, Se, and SO_4 transfers to solids. FGD liquor chemistry and particle size distribution important determinants.

Sources of Se from Coal-Fired Power Plants



Power Plant Entrainment/Impingement

- Expect stringent, across-the-board compliance requirement in draft 2011 rule
- Make technology retrofits where there is documented impact or reasonable likelihood. Cost-benefit analysis makes sense
- “He who defends everything, defends nothing.” (Winston Churchill - 1940)

Compliance Strategies

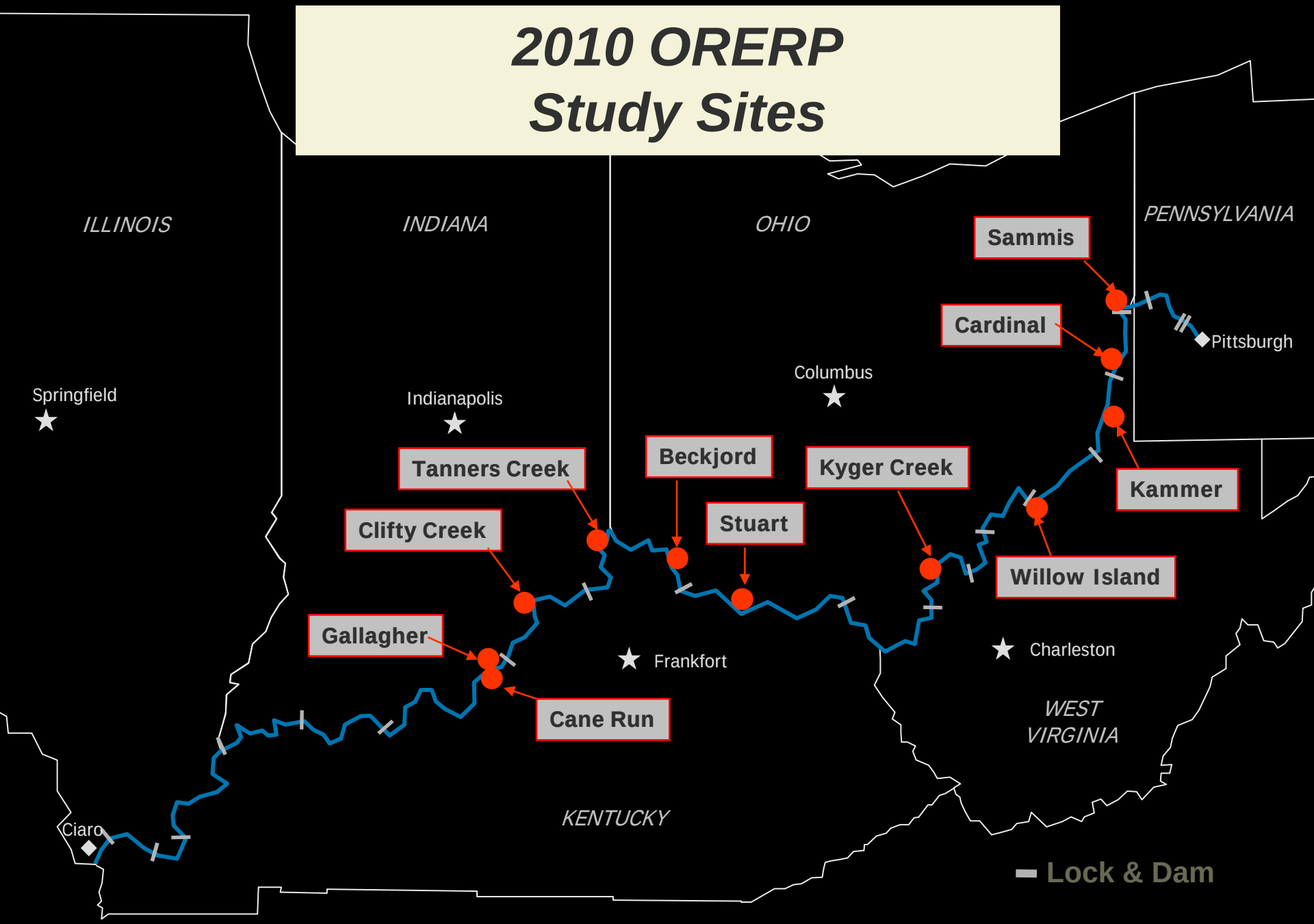
- To meet new wastewater limits
  - Install FGD WWTPs (already done)
  - Install advanced treatment if needed
  - Site-specific bioavailability demonstrations (DMT, WER)
  - Mixing zone studies

Mercury in the Ohio River

- Regulatory concern that Hg levels in fish/water are increasing due to power plant wastewater loads
- ORSANCO 2009 fish tissue date suggests possible exeedances of USEPA MeHg fish tissue criterion. These analyses, however, only measured ***total*** Hg
- In early 2010, WV DEP proposed that Ohio River be designated as mercury-impaired, relying on 2009 ORSANCO data

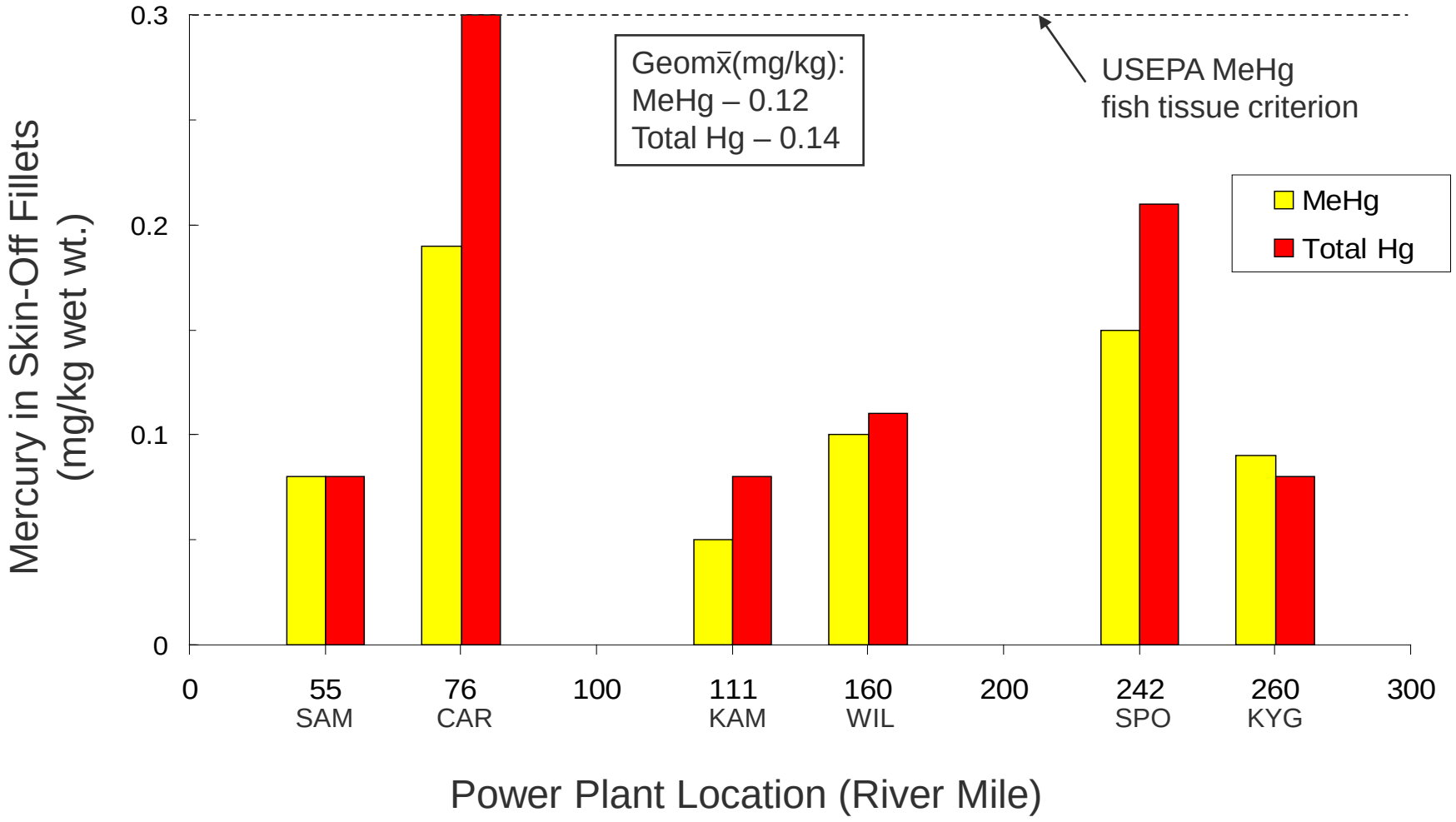
August 2010 Fish Tissue Study

- Fish collected near 6 coal-fired power plants. Two species selected: TL3 (channel catfish) and TL4 (sauger)
- Skin-off fillet samples collected per Ohio EPA/Ohio DOW procedures
- Samples analyzed for total Hg, MeHg, As, and Se. Analysis by Brooks Rand Labs.


2010 ORERP
Study Sites
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
Springfield
Indianapolis
Columbus
Pittsburgh
Charleston
Frankfort
Ciaro
KENTUCKY
WEST VIRGINIA
Sammis
Cardinal
Kammer
Willow Island
Kyger Creek
Beckjord
Stuart
Tanners Creek
Clifty Creek
Gallagher
Cane Run
Lock & Dam

Results of Fish Tissue Mercury Analysis Near Six Power Plant Sites (August 2010)

Species = Sauger



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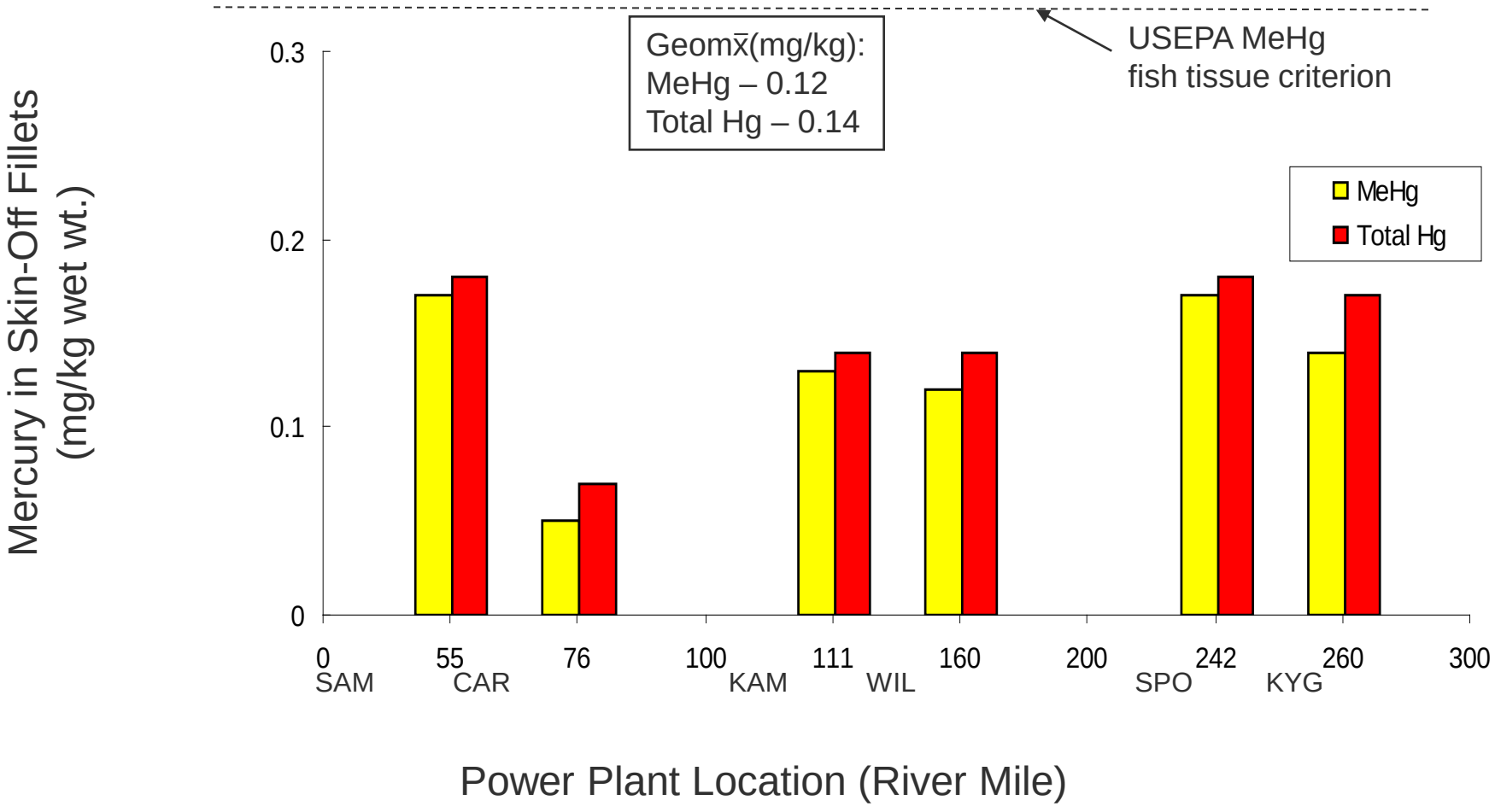

Environmental issues of concern

- Climate change: changing water availability in several watersheds
- Water constraints will force development of “dry” and low volume processes
- New organic compounds with global cycling
- Bedbug infestations

Conclusions

- Lots of challenges for the electric utility industry
- There is no free lunch. Be prepared for possible higher rates, no matter how your electricity is generated
- Let’s focus on fixing the problems

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