Welcome to Conesville Power Plant

Electricity from coal

Conesville Plant

177 employees

Retired Units:

Unit 2 (125 MW): 1957 – 2005

Unit 1 (125 MW): 1959 – 2005

Unit 3 (165 MW): 1962 – 2012

Active Units:

Unit 4 (780 MW): 1973 + 2009 scrubber retrofit

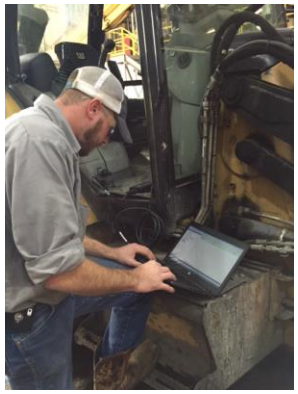
Unit 5 (410 MW + scrubber): 1976

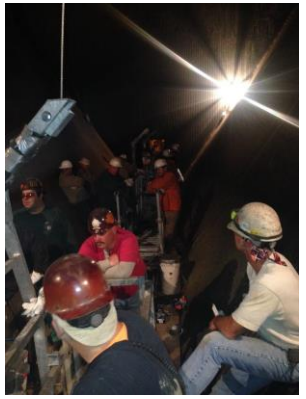
Unit 6 (410 MW + scrubber): 1978

Active Total Output = 1,600 MW

27 million 60 W light bulbs

People run the processes that make the power





Learning Objectives

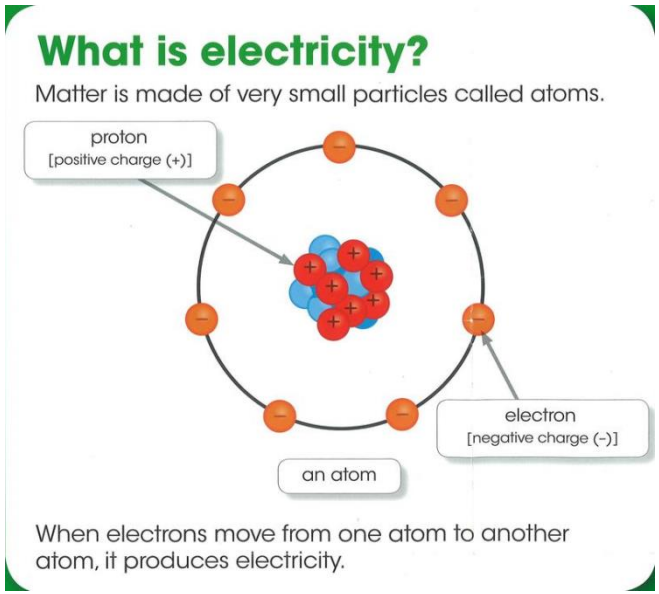
- Electric system - “the grid”
- Types of generation – pros vs. cons
- Coal fired generation
- Environmental protection

Conflicts & Constraints

Electricity

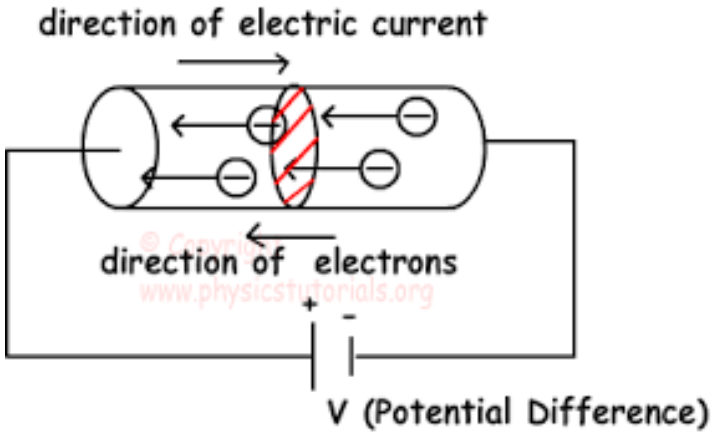
Electricity

Definition



Uncontrolled

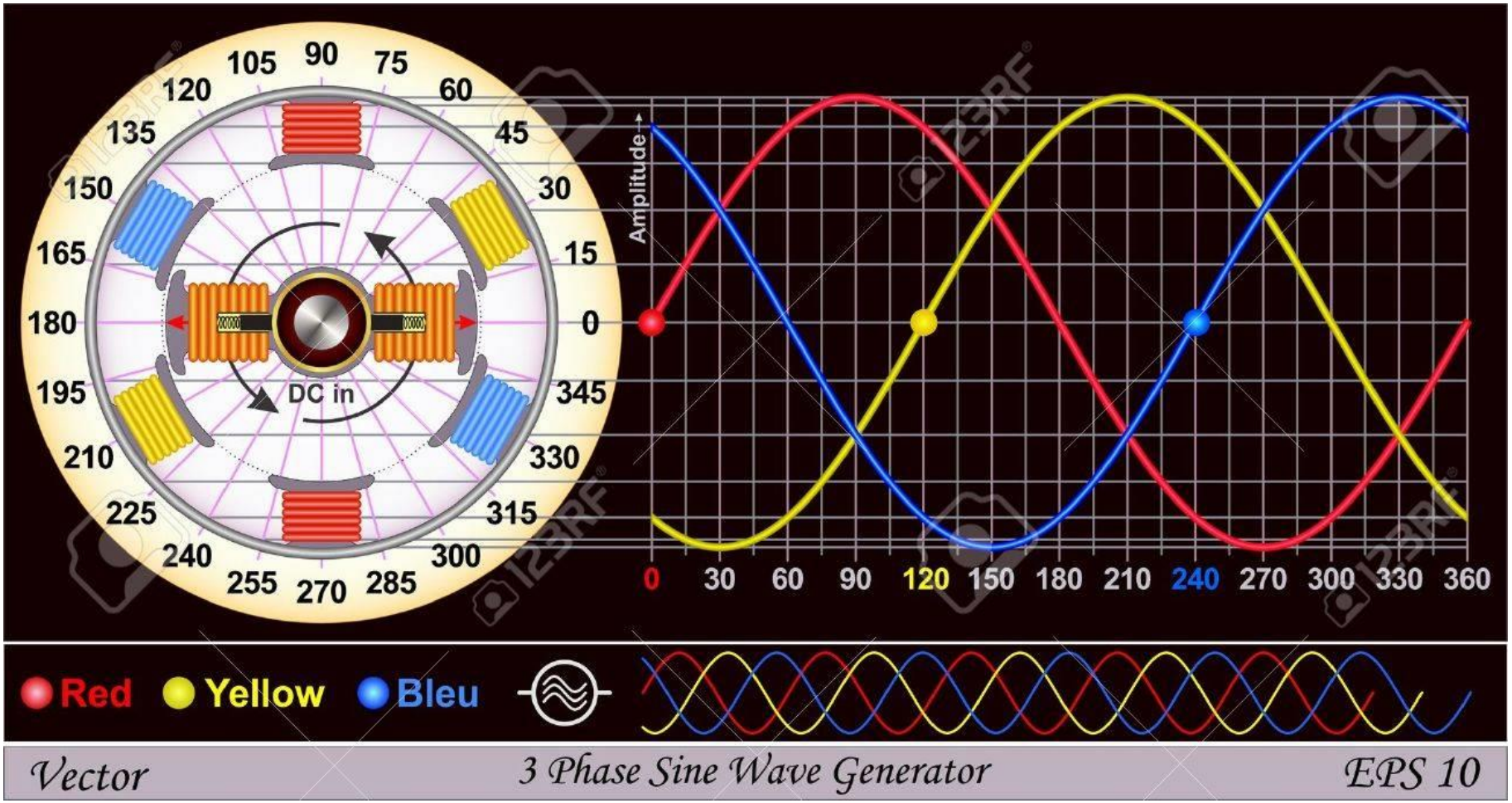
Controlled



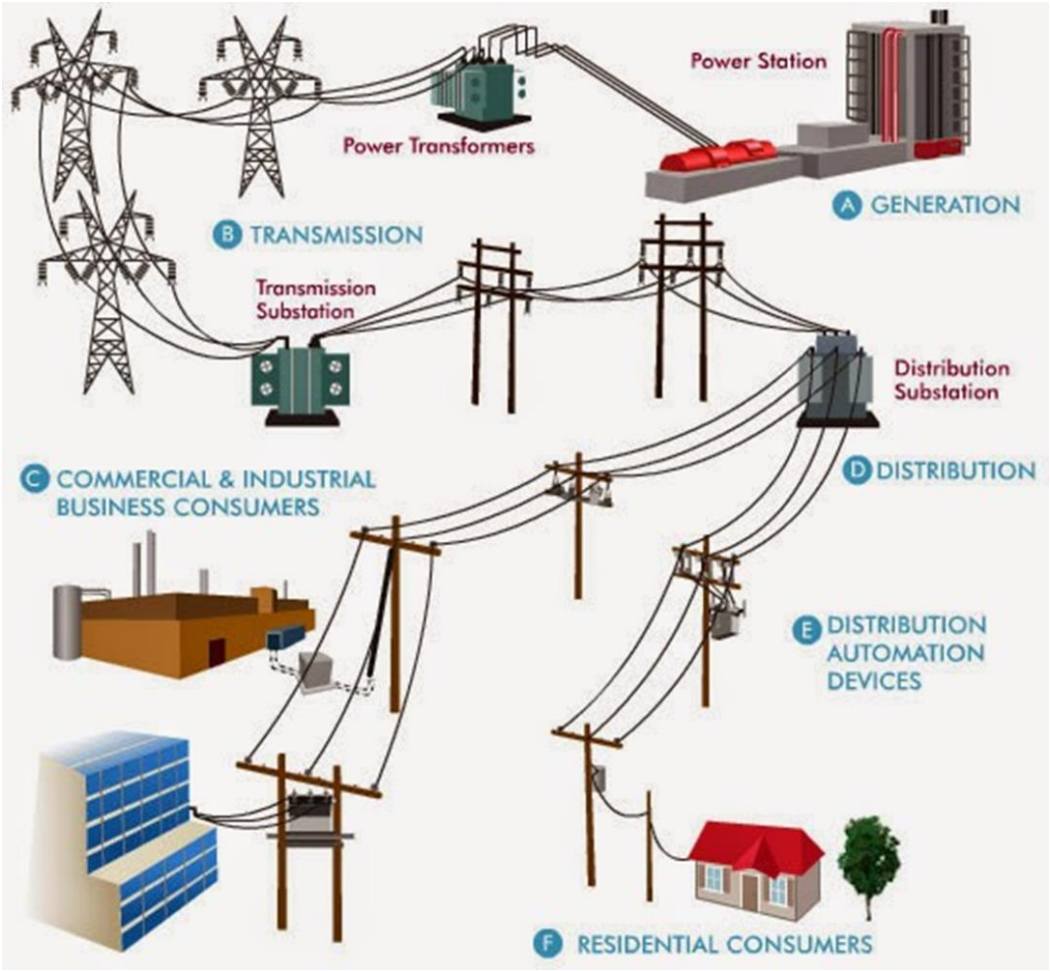
Useful

AC Power

U. S. generators spin at 60 revolutions / sec. (60 Hz) causing a sinusoidal wave form

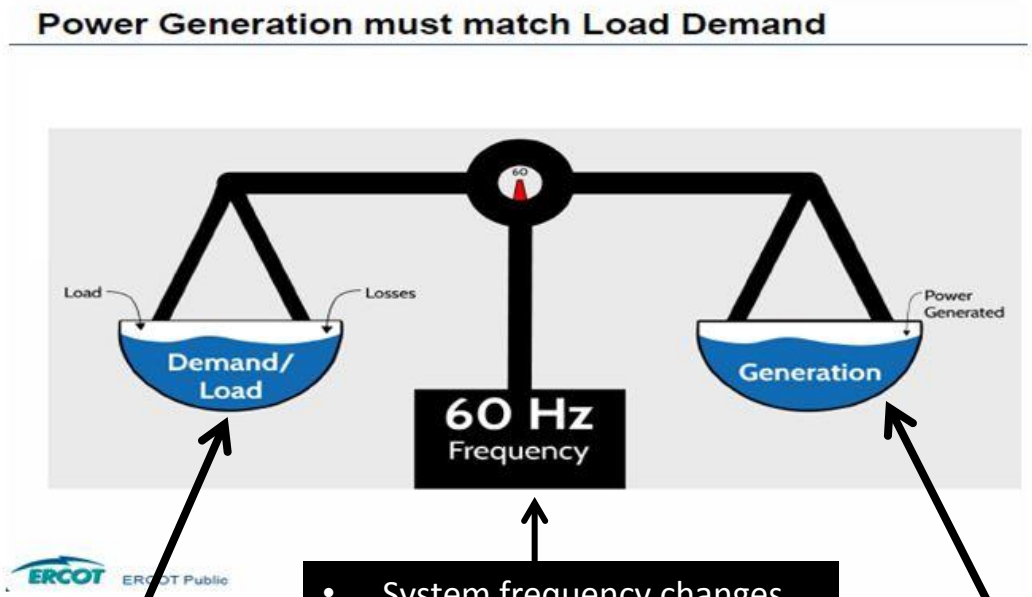


Power System

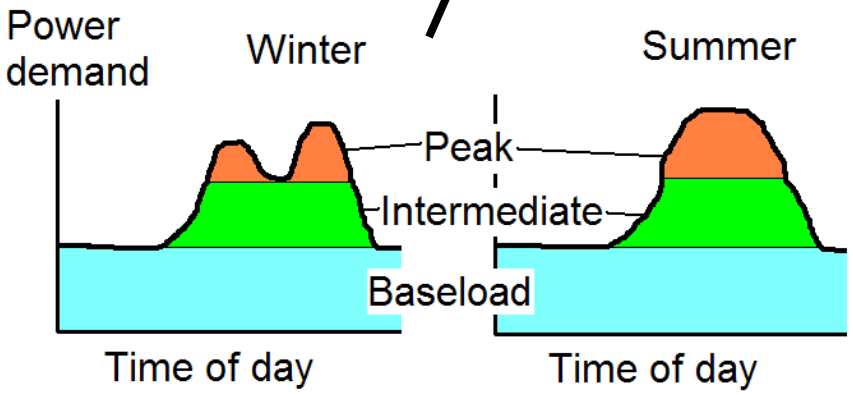


- A giant network
- More stable if large
- Economy of scale
- 24/7 operation
- Instantaneous
- On demand - no storage

Supply vs. Demand

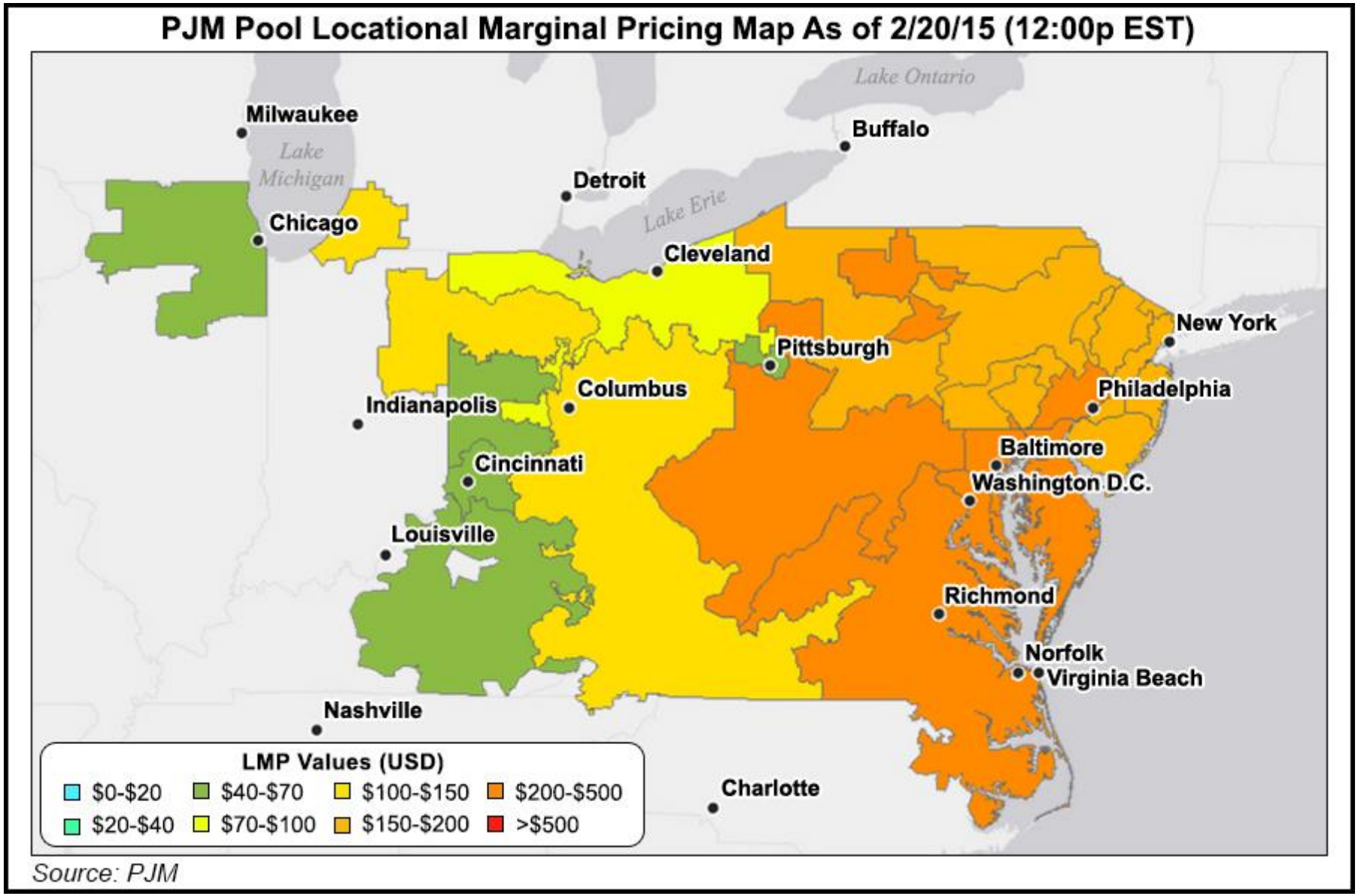


- System frequency changes
- Adjustment made to supply to match demand
- Frequency rebalances



Supply Changes:
Generation, Transmission, or Distribution disruption

PJM – Footprint

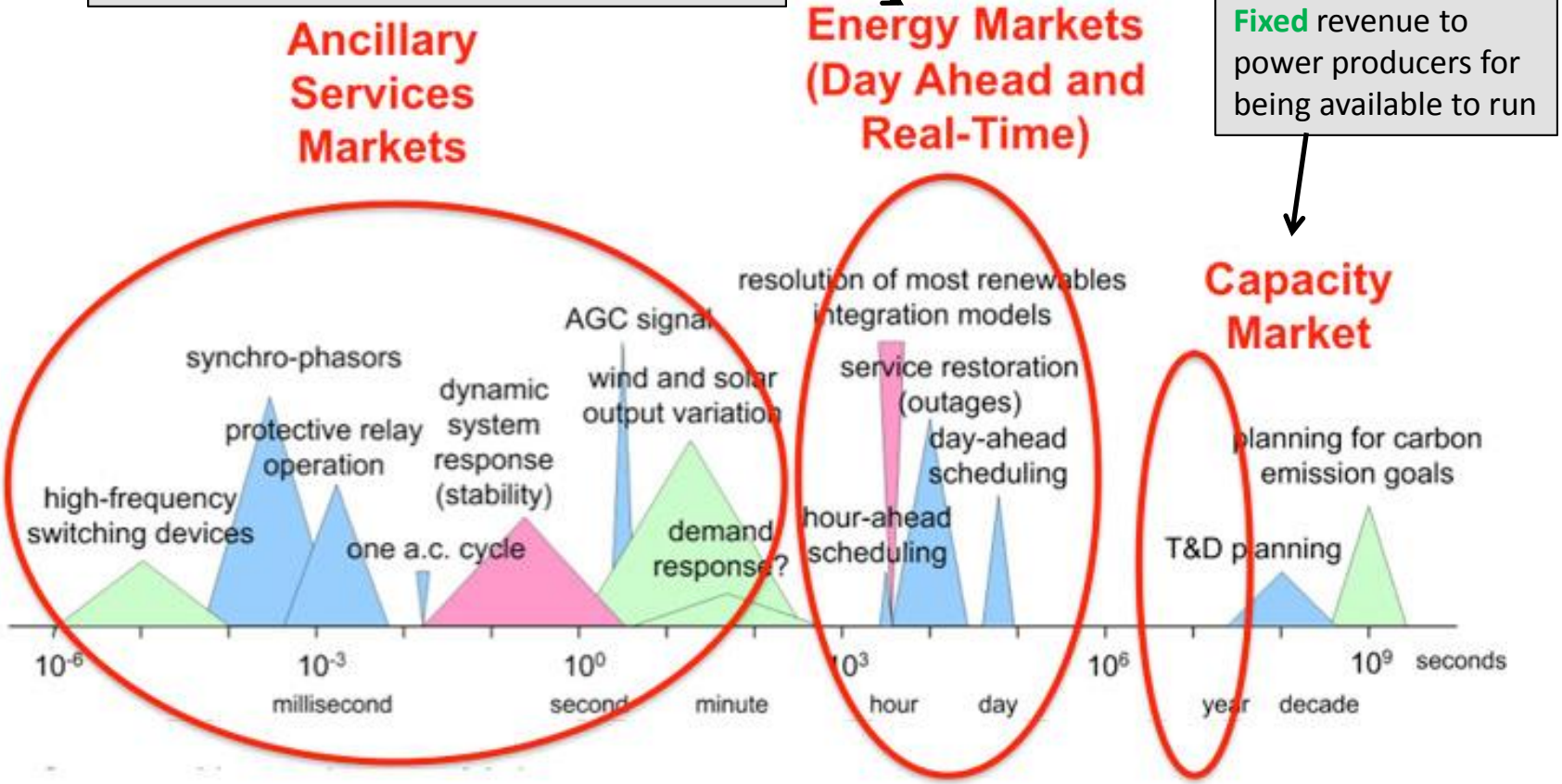


Regional Transmission Organization (RTO)

- Control the system (GRID)
- Conesville produces power that is fed into the GRID

Variable revenue to power producers – prices can be volatile based on supply and demand

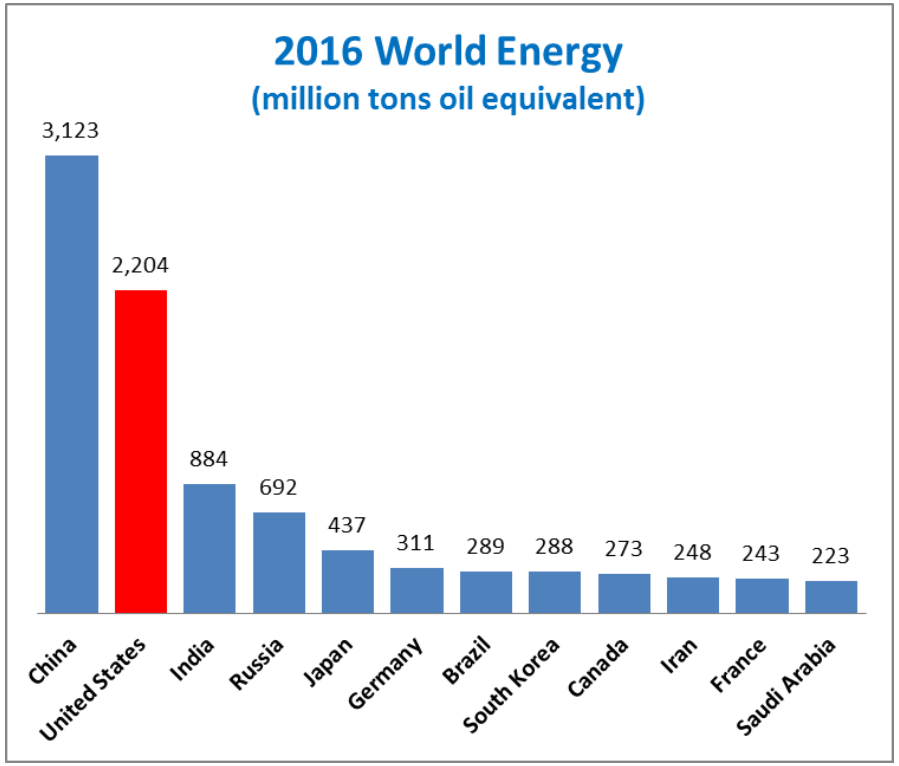
Fixed revenue to power producers for being available to run

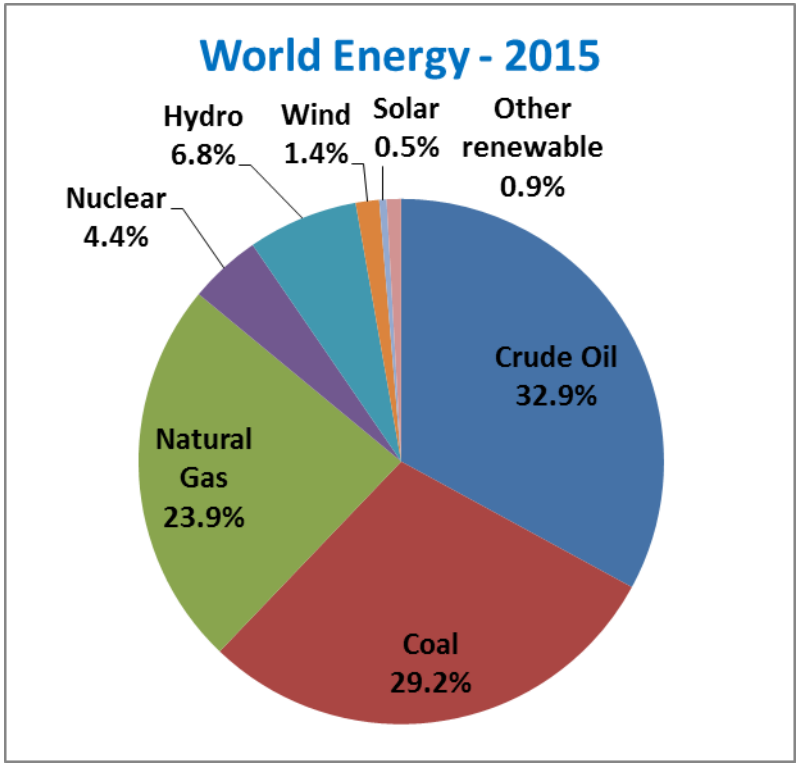


Energy Types

Pros **Cons**

World Energy – Fossil Fuels 86%





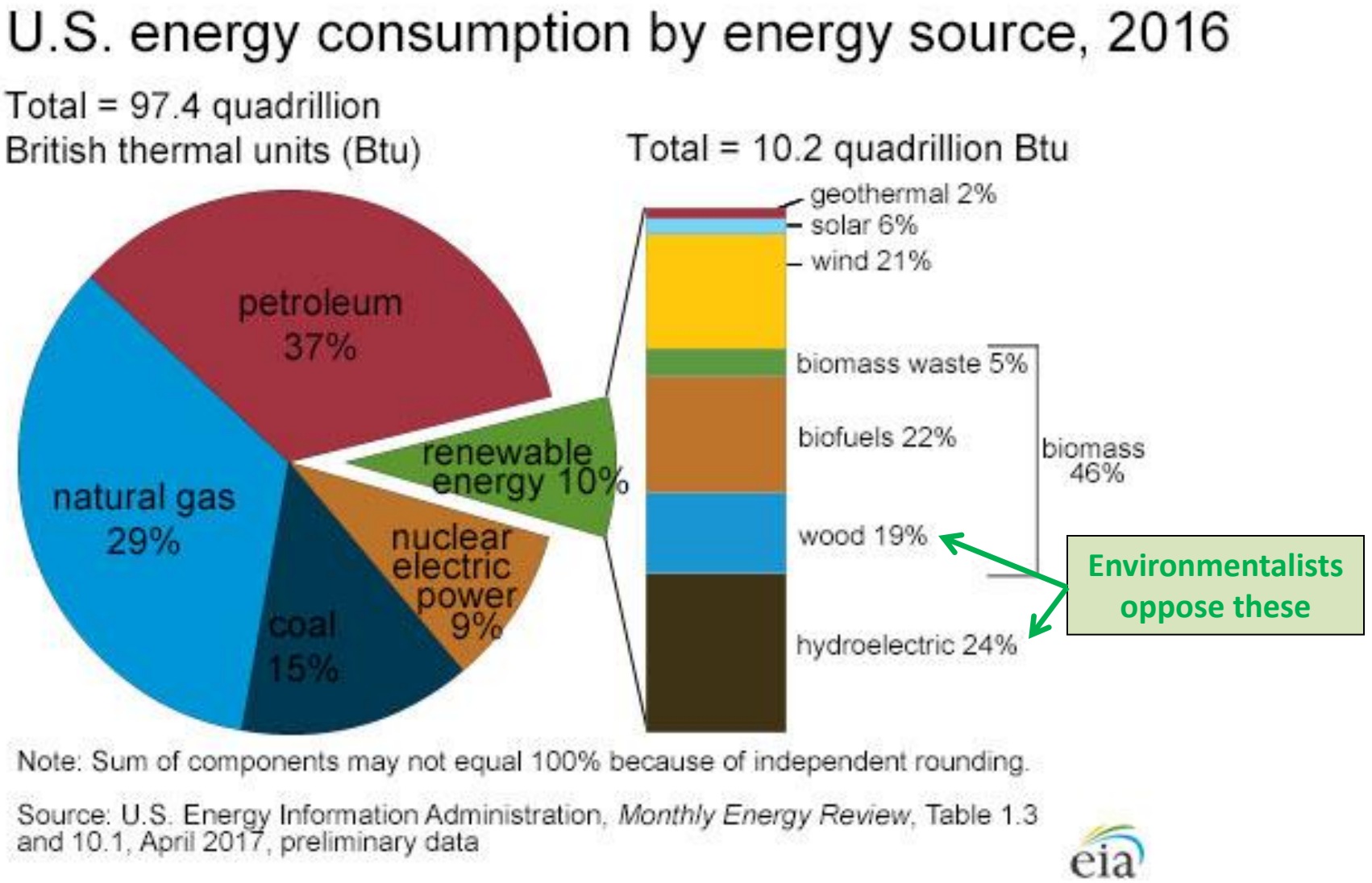
Fossil Fuels

- Protect people from the climate
- Lift people out of poverty
- Power the world

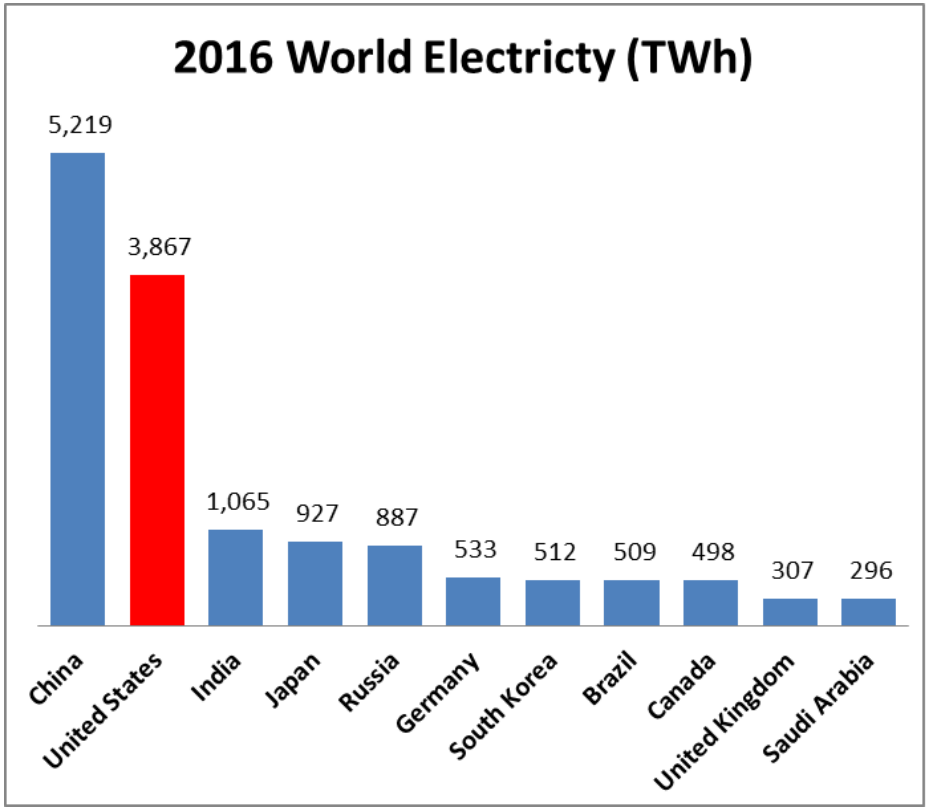
1.3 billion people (19%)
have no electricity

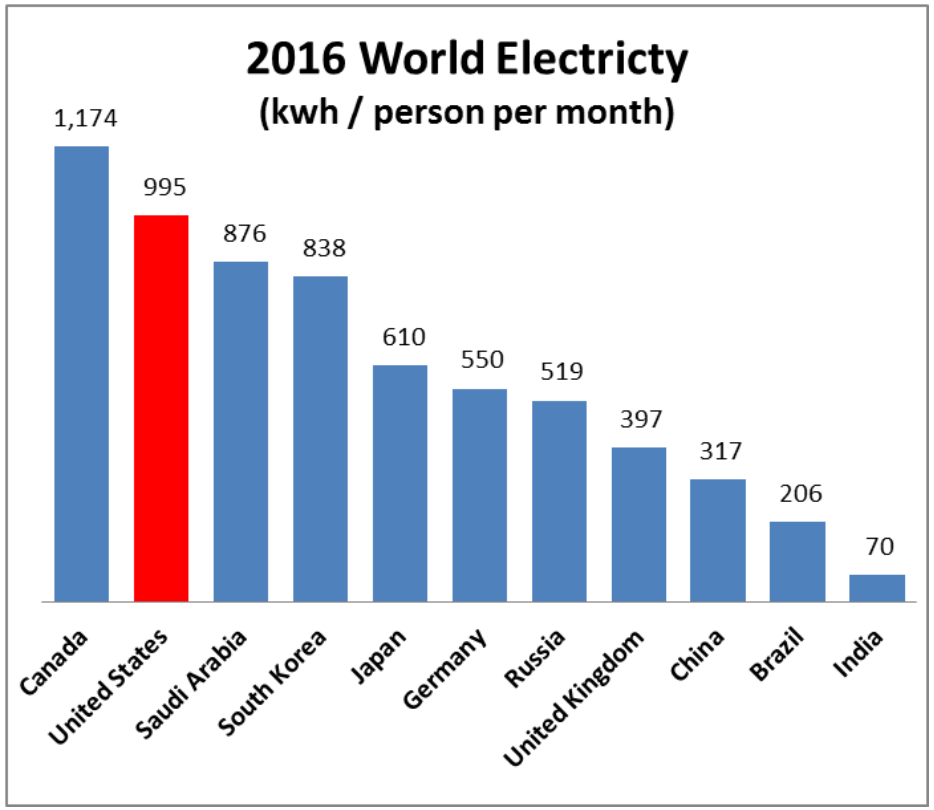
U.S.A. - 25% of the world's energy
- 5% of the world's population

US Energy – 81% Fossil Fuels

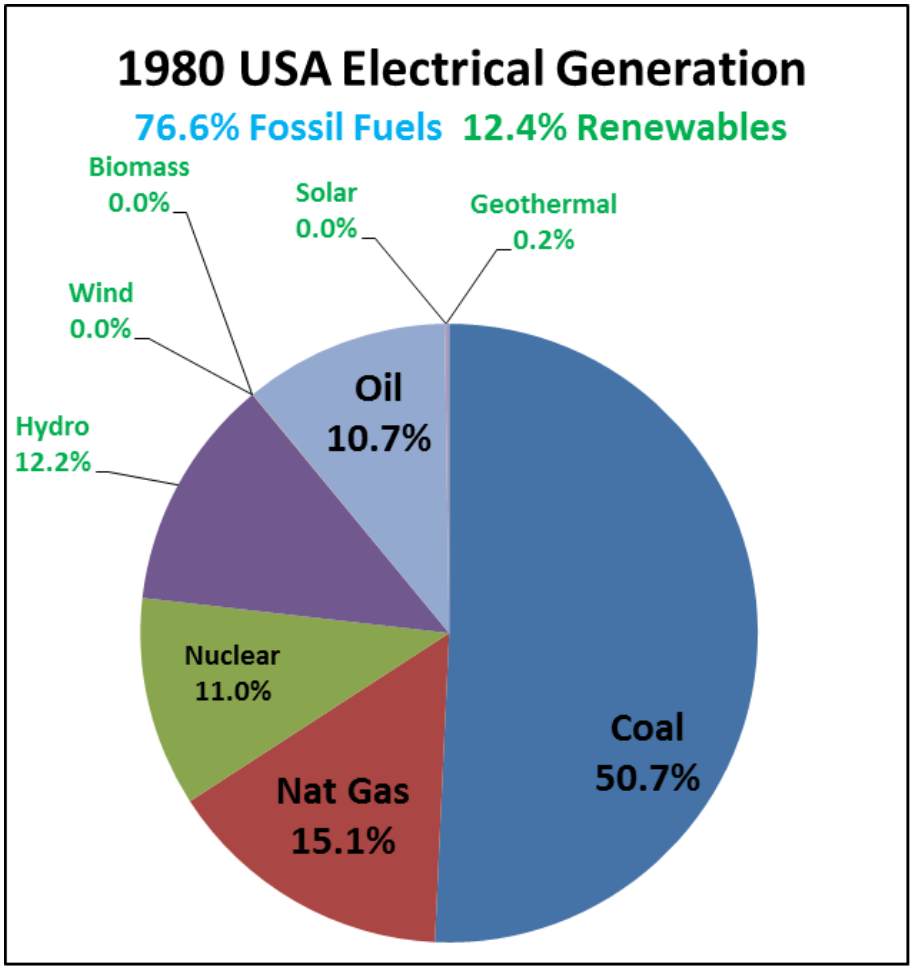


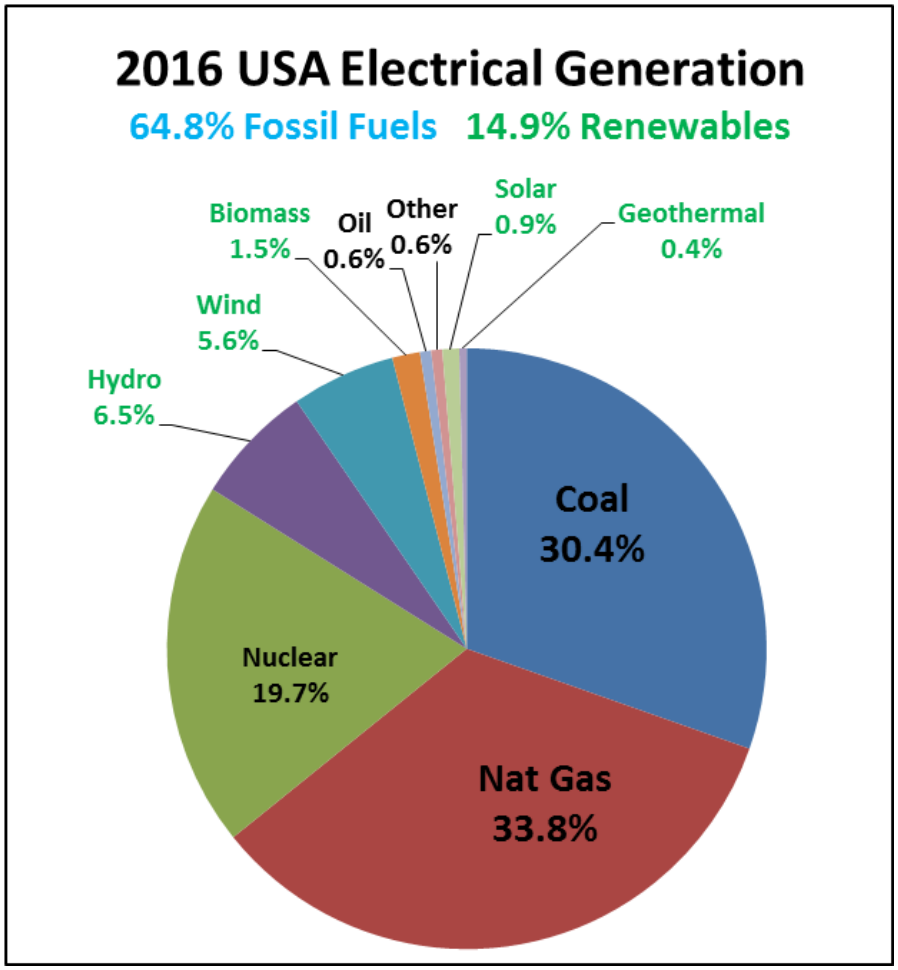
World Electricity Consumption



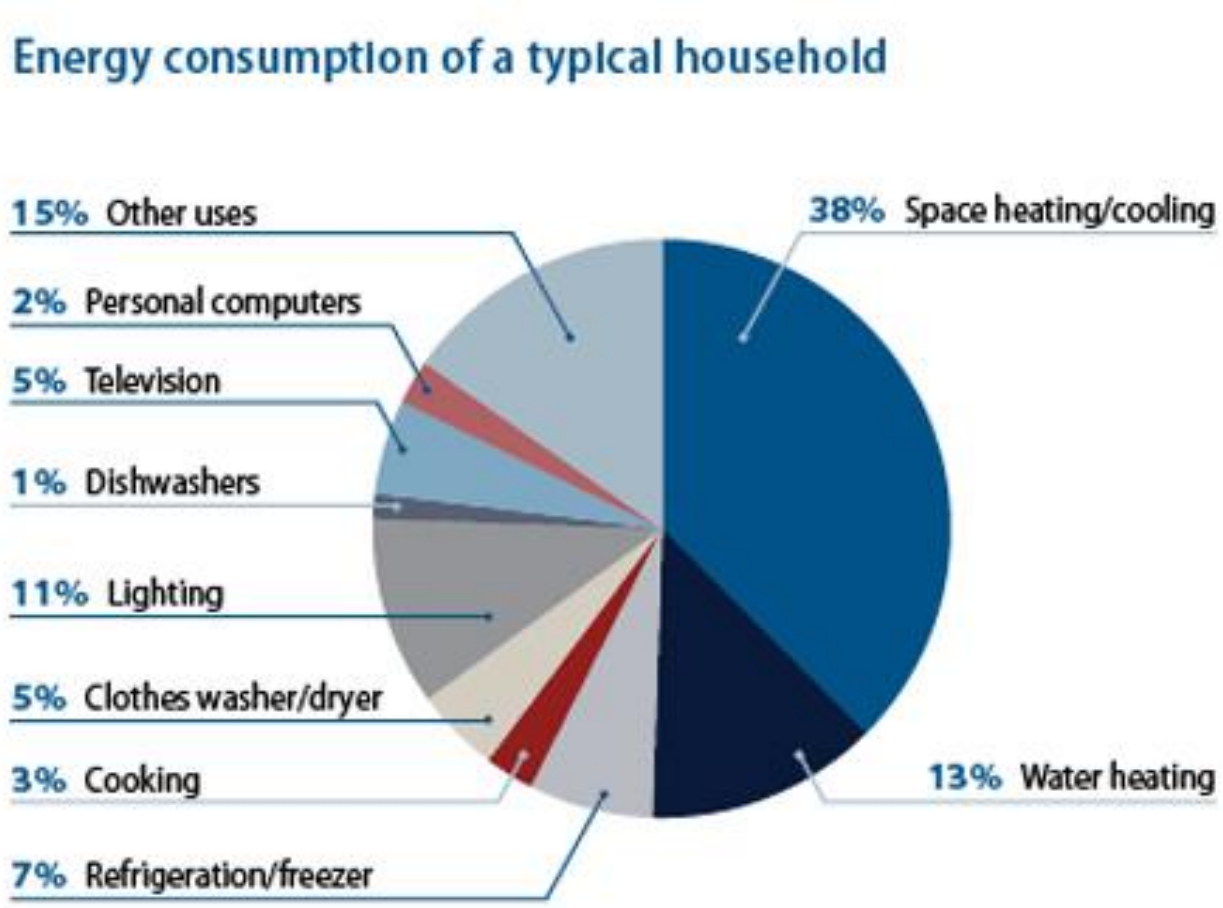


US Electricity

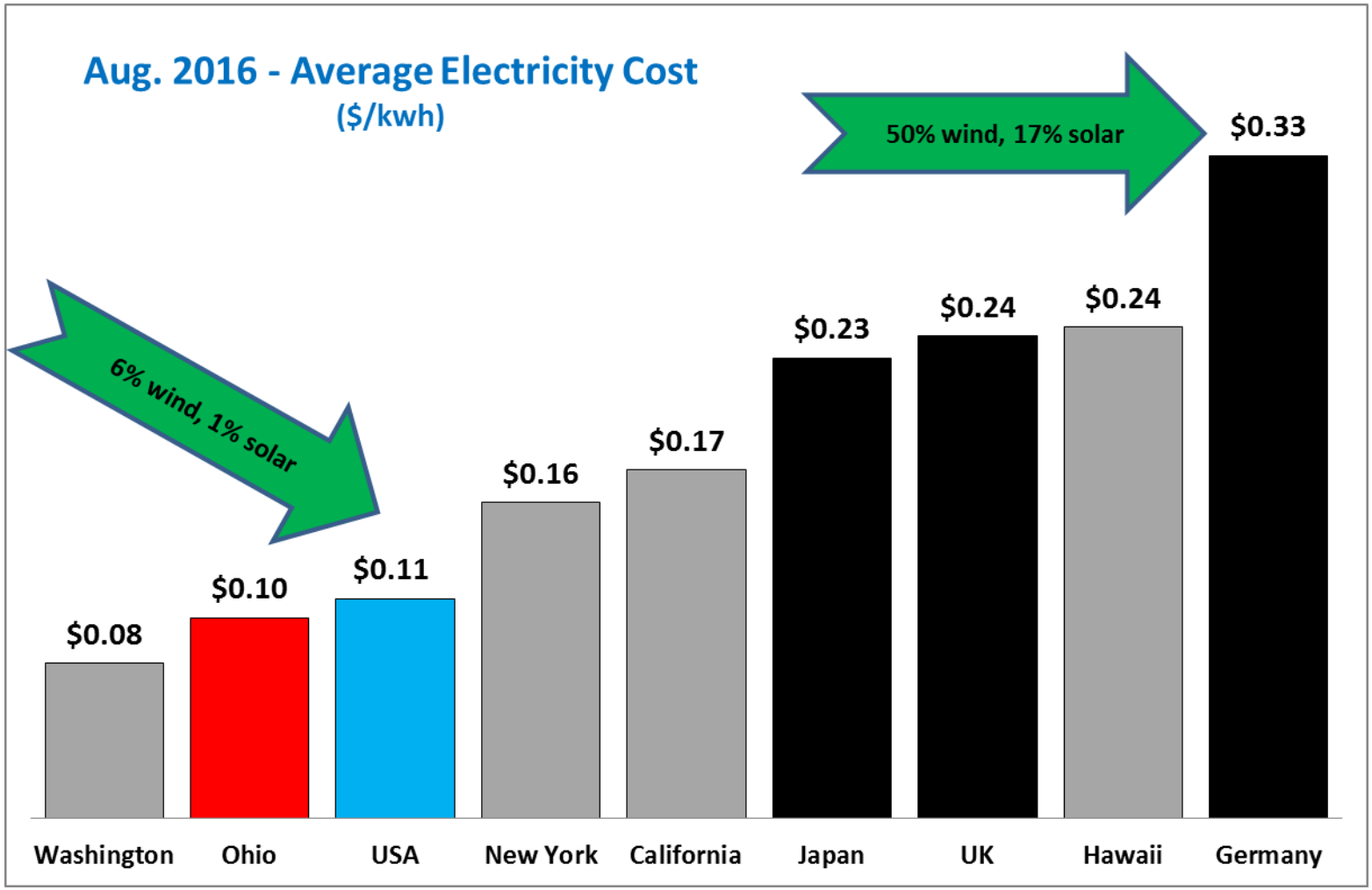




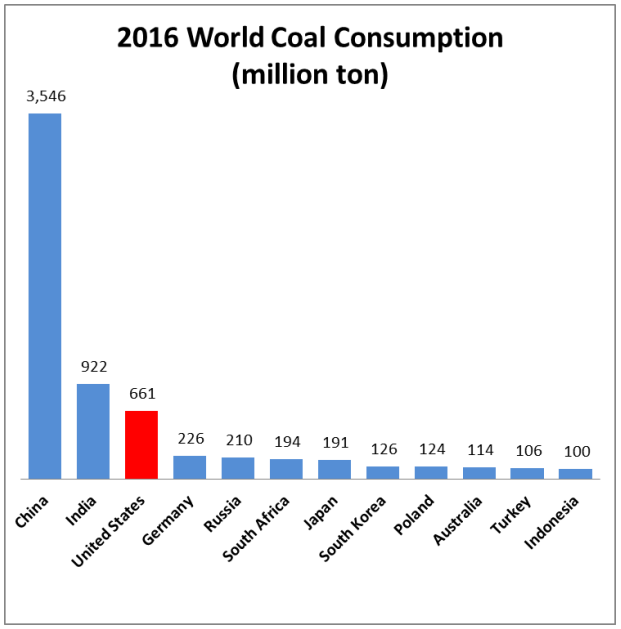
Typical Household Consumption



Electricity Cost Comparison



Electricity from Coal



30.4%

Pros:

- Electricity on demand (>90% typical)
- Economical (½ of wind, ¼ of solar cost)
- Abundant fuel (250+ years)
- Mature technology
- Solid fuel inventory

Cons:

- Air pollution
- Coal mining invasive to environment
- Waste disposal of by-products
- Large use of water

Change of U.S. Coal Generation

May, 2015 – E.P.A.
MATS law to reduce mercury,
6,000-8,000MW of coal units
predicted to retire

1980 – 51%
2014 – 39%
2015 – 33%
2016 – 30%

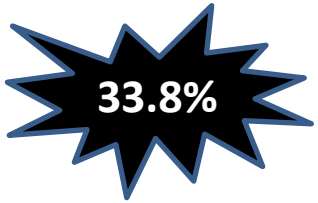
Natural gas prices
are beating coal

Business Reality
72,000 MW of coal retiring
(enough to power 45 million homes)

1997 - predicted that by 2040 coal would still be 50% of the mix.
2018 - predicting that by 2050 coal would still be 11% of the mix worldwide.
So, what expert opinions today will be proven wrong in the future?

When theory collides with reality, reality wins!

Electricity from Natural Gas



80-95% methane (CH_4)

Pros:

- **Cleaner emission,**
  - **No fly ash, SO_2 , or mercury,**
  - **CO_2 45% < coal**
- **More efficient at energy conversion than coal**
- **Low cost due to fracking**
- **Large supply due to fracking**

Cons:

- **Methane**
  - **21x more powerful than CO_2**
- **Pipelines**
  - **Explosive, Large infrastructure**
- **People oppose new lines**
- **Fracking problems**
  - **Water pollution**
  - **Water – large usage**
  - **Earthquakes**

Electricity from Nuclear

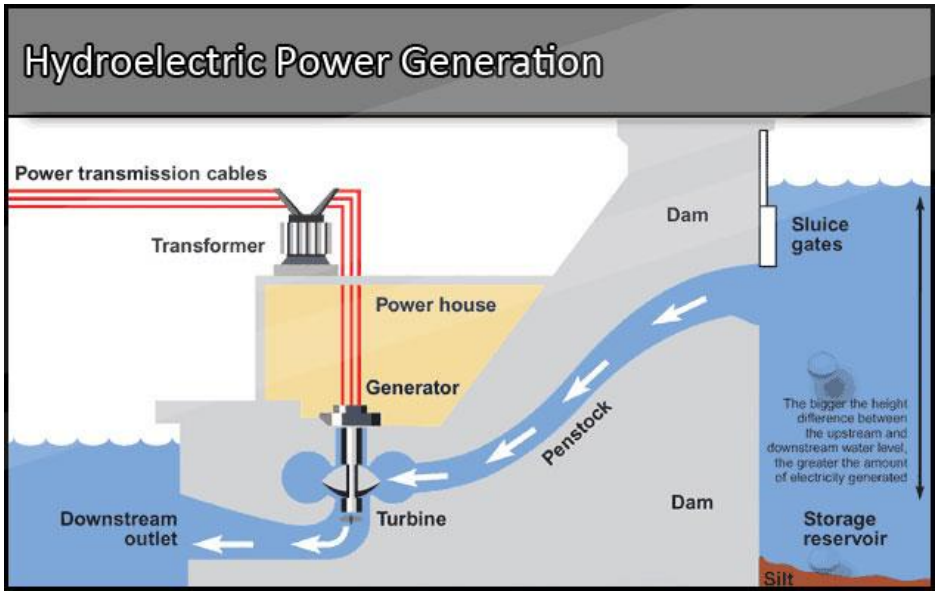
19.7%

Pros:

- Generation on demand
- Economical
- Little pollution

Cons:

- Radioactive release fear
  - 1979 - Three Mile Island
  - 1986 – Chernobyl
  - 2011 - Fukushima
- Radioactive nuclear waste has an extremely long life



Hydro Electric

6 .5%

Pros:

- Renewable
- Green (no pollution)
- Economical
- Reliable – on demand
- Safe

Cons:

- Environmental effect on river
- Expensive capital cost
- Need large vertical drop for large output

If opponents had their way ….

30.4% +

19.7%

+

33.8% +

6.5%

=

90.4%

We want our electricity back!

Conflict - a prosperous society relies on a robust electric systems.

Wind Power

5.6 %

Cons:

- **No wind – no power**
  - **20-50% capacity factor**
  - **very low when temps are hot**
- **High cost (heavily subsidized)**
- **Not aesthetic**
- **Kills birds**
- **Noisy**

Pros:

- **No pollution (almost)**

Solar Power

0.9 %

Pros:

- Renewable
- Abundant
- No pollution to operate
- Silent
- Low Maintenance

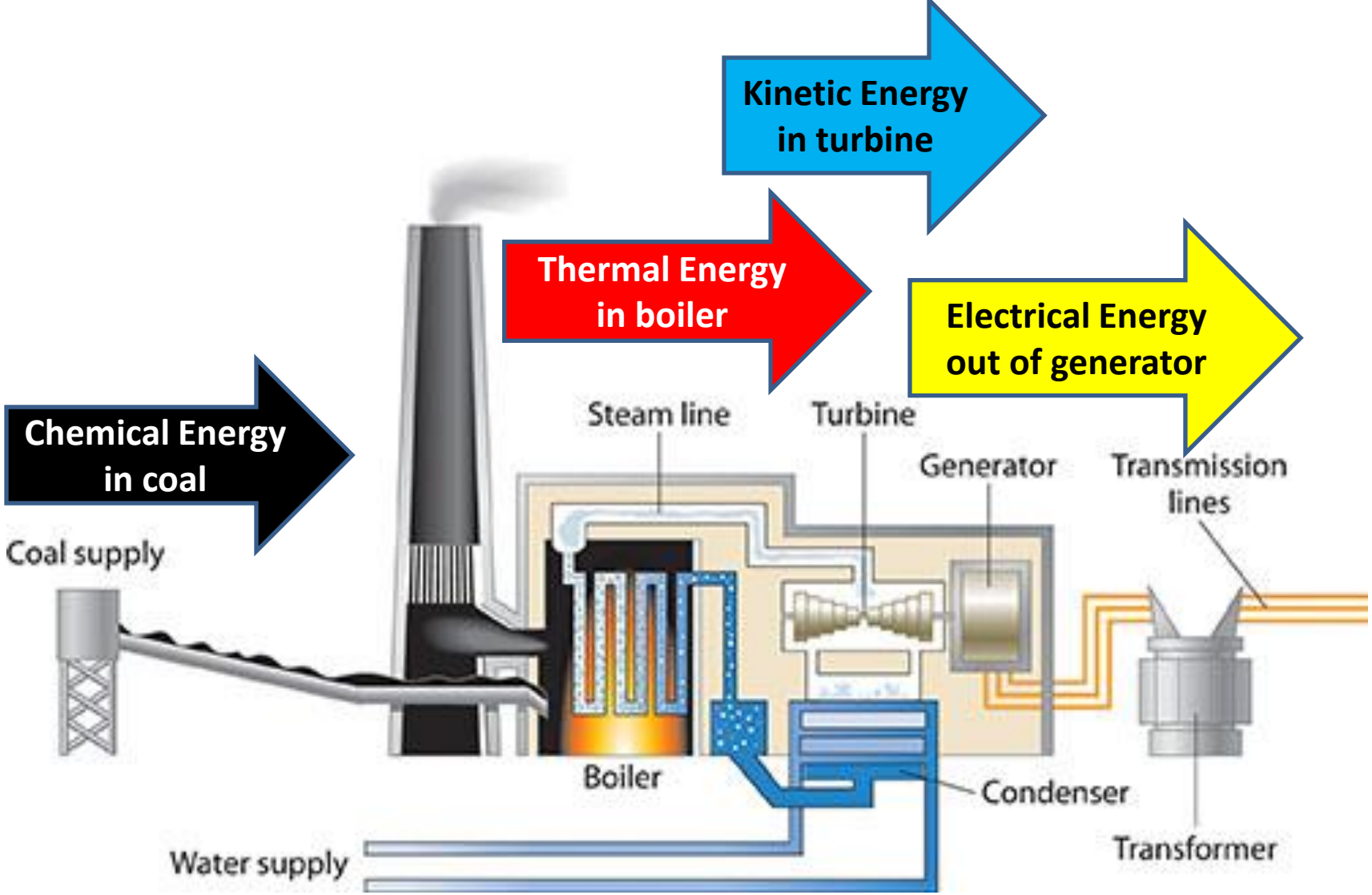
Cons:

- High cost (heavily subsidized)
- Intermittent
- Fossil fuel foot print to-
  - mine materials, manufacture, transport, construct, and maintain
- Large use of rare earth metals
- Requires large footprint
  - Environmentalists tried to stop a plant in Nevada due to the rare desert tortoises

Future?

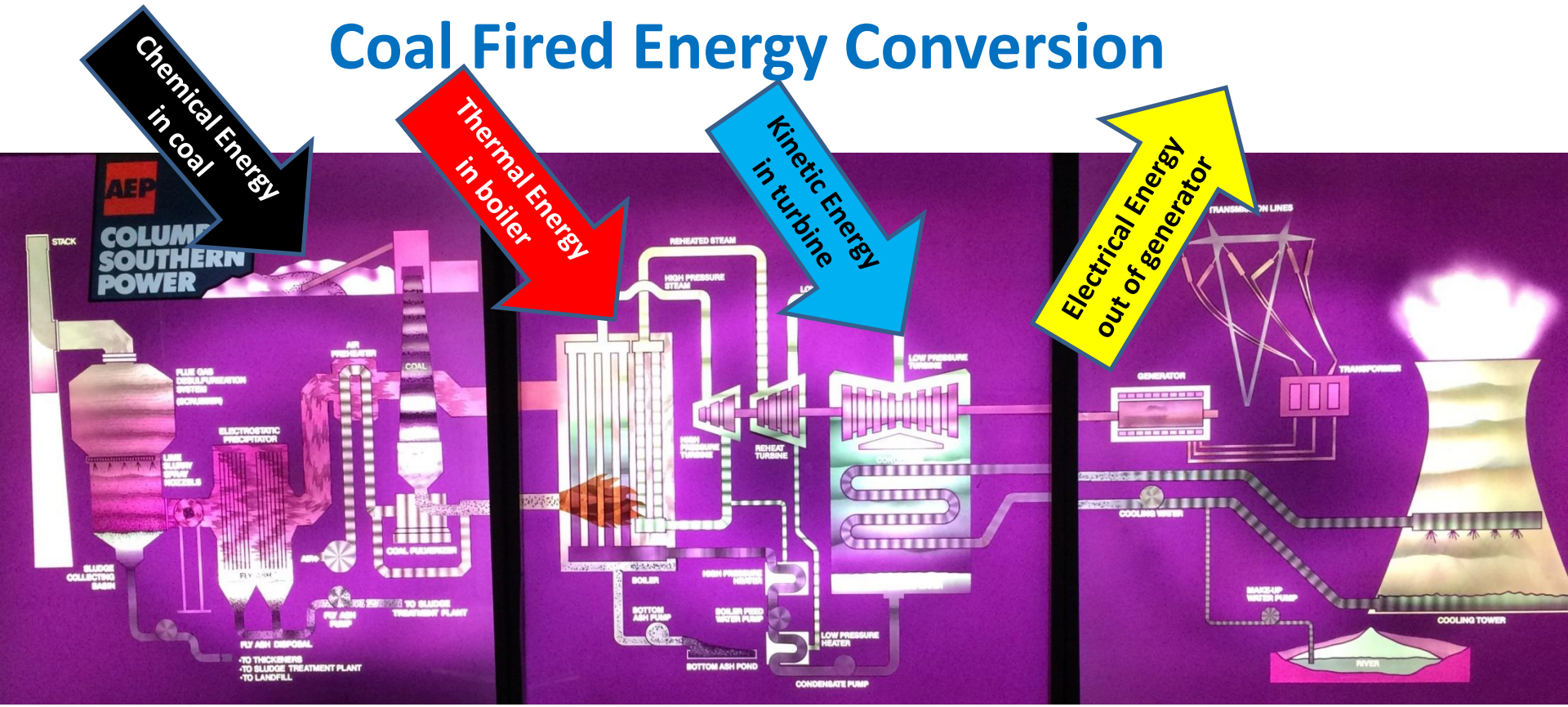
- Less coal & nuclear
- More natural gas & renewables
- Distributed battery storage
- Micro grids (DC in large buildings)
- Electric vehicles
- Energy efficiency
- Demand response
- Smart metering
- System automation and sensor
- Smart appliances

Coal to Electricity



Energy Conversion

Coal Fired Energy Conversion



A giant steam producing plant……

uses the steam to drive a turbine-generator.

Coal

30 day inventory

Moved by conveyors

Delivered by rail & truck

4-6 hour storage in silos near boilers

Air blown through mill

Powdered coal & air blown to boiler

Crushed in mills

Eastern Bituminous Coal

From Eastern and Southern Ohio

About 2-3 million tons per year

Boiler

Produces high energy steam

Unit 4 is 1005 def F, 3500 psi
Unit 5,6 is 1005 def F, 2700 psi

Steam to turbine

Water Wall – pipe welded together to form solid wall with water flowing in it.

Hot flue gas out

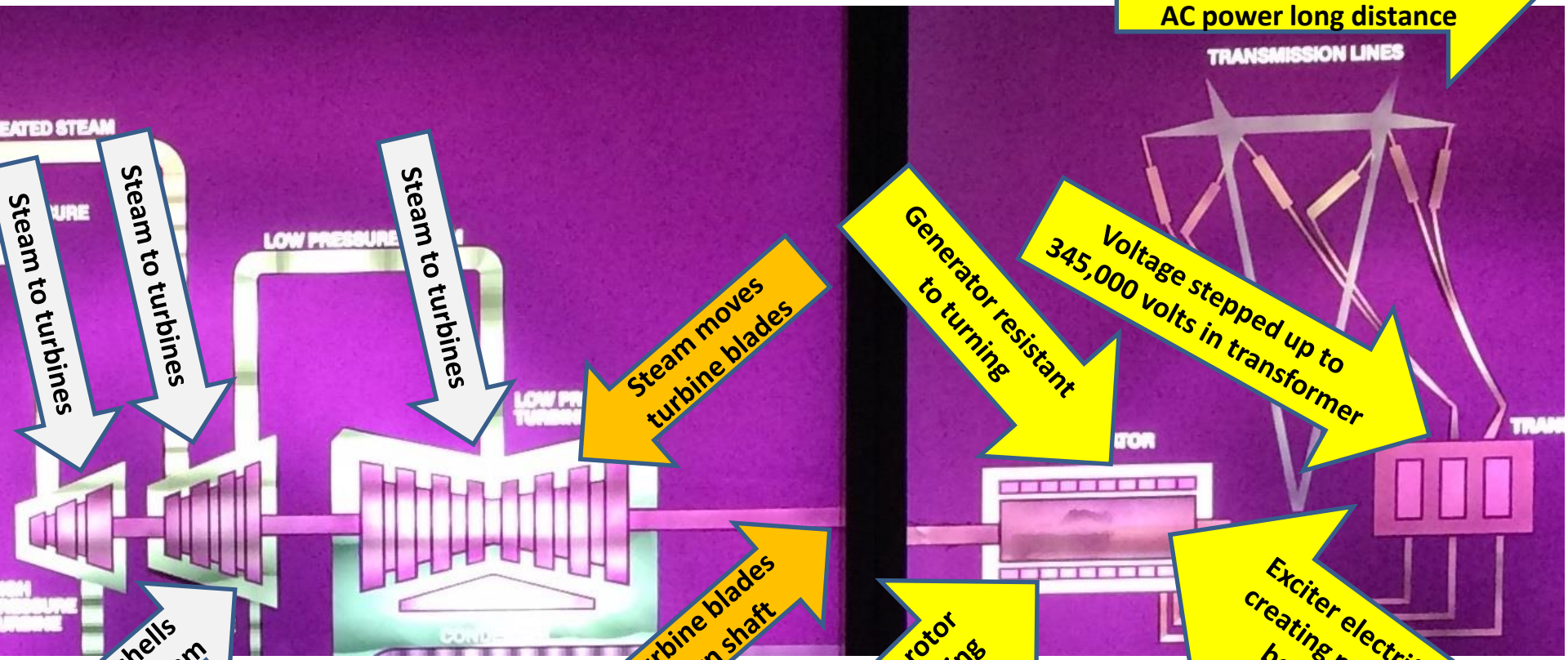
Suspended fireball at 2700 deg F

Powdered coal & air blown from mills

Secondary air added for combustion

Pressurized and preheated water

Turbine - Generator



Steam to turbines

Steam to turbines

Steam to turbines

Steam moves turbine blades

Turbine blades turn shaft

Turbine shells contains steam

Generator resistant to turning

Voltage stepped up to 345,000 volts in transformer

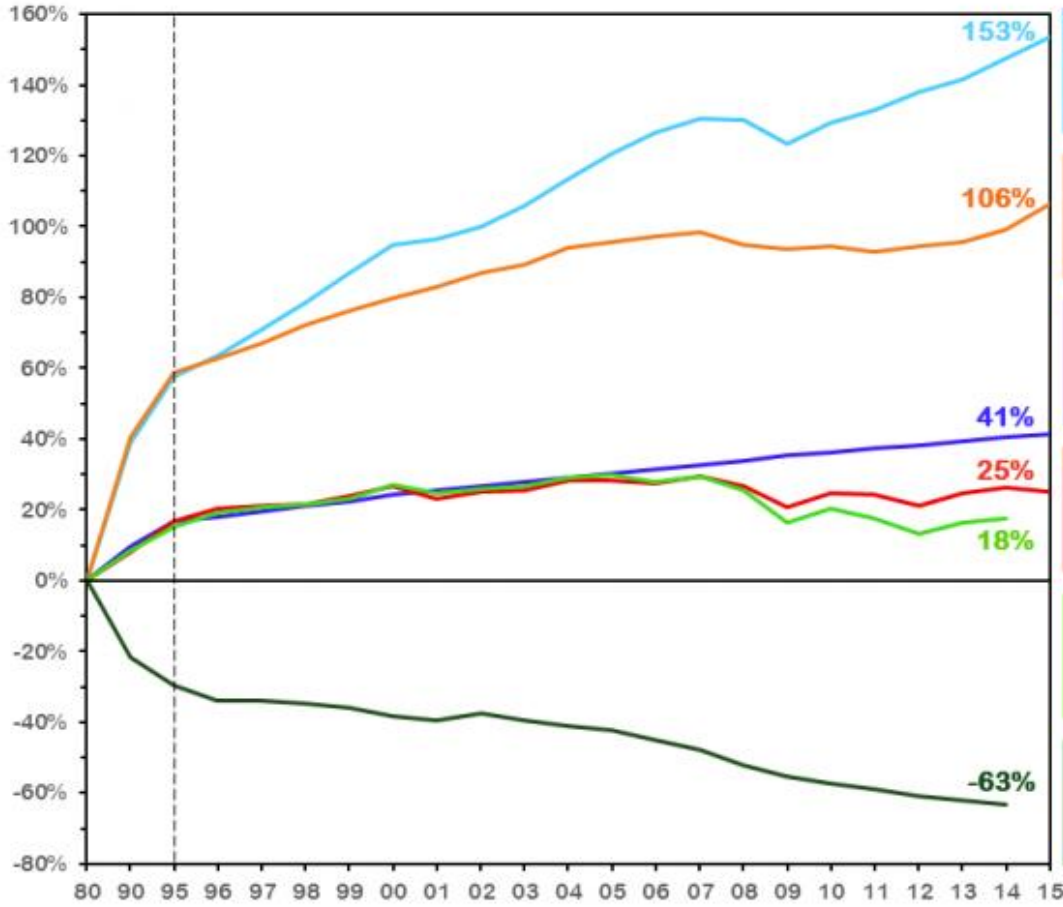
High voltage transmission lines are necessary to flow AC power long distance

Exciter electrifies rotor creating magnetic field between stator

Turning shaft rotates rotor creating a wave of flowing electrons (AC power)

Environmental Protection

Comparison of Growth Areas and Emissions, 1980-2015



United States

Source: http://www.epa.gov/airtrends/aqtrends.html

Reductions:
69% - Carbon Monoxide (CO)
99% - Lead (Pb)
55% - Nitrogen Oxides (NOx)
53% - Volatile Organic Componds
58% - Particulate Matter (PM)
81% - Sulfur Dioxide (SO2)

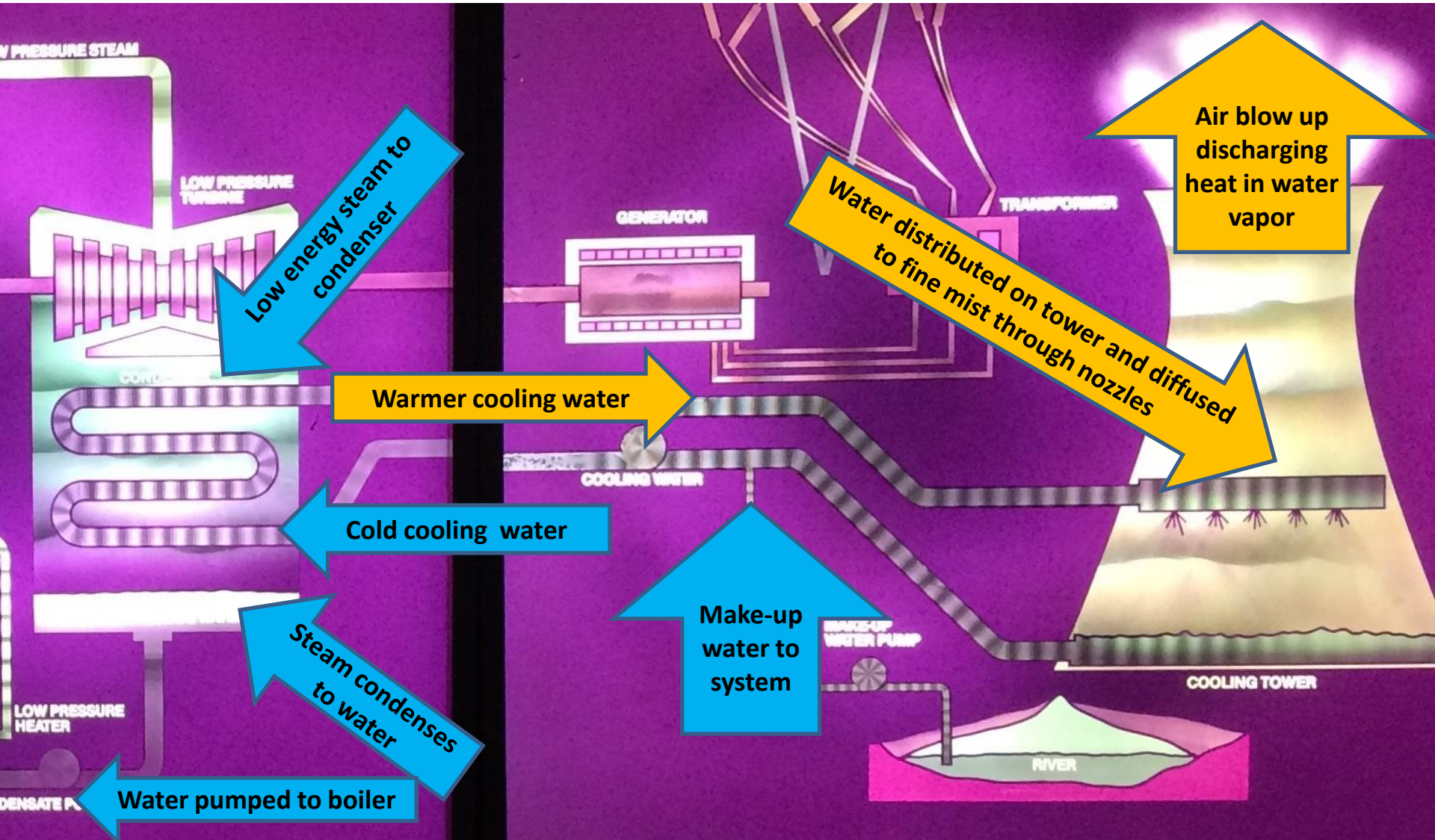
Deception

UK - **Air pollution** now leading cause of lung cancer. AIR pollution has been named as the leading cause of lung cancer, the World Health Organization's cancer agency said.
By Tom Rawle PUBLISHED: 16:53, Thu, Oct 17, 2013

Pollution control that protects the river or lake from over heating.

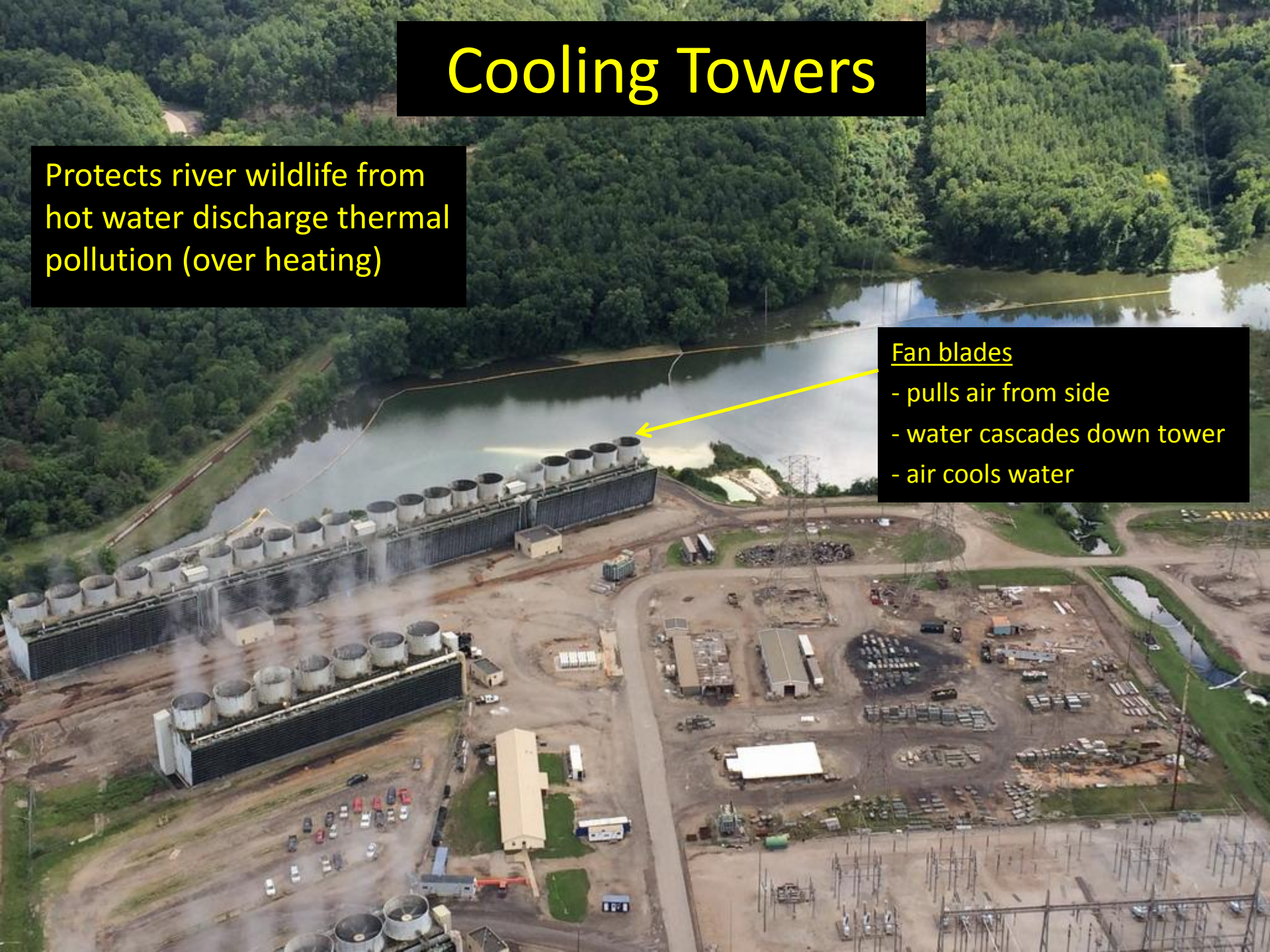
Circulating Water

- Cooling water loop
- Protects river from over heating



Cooling Towers

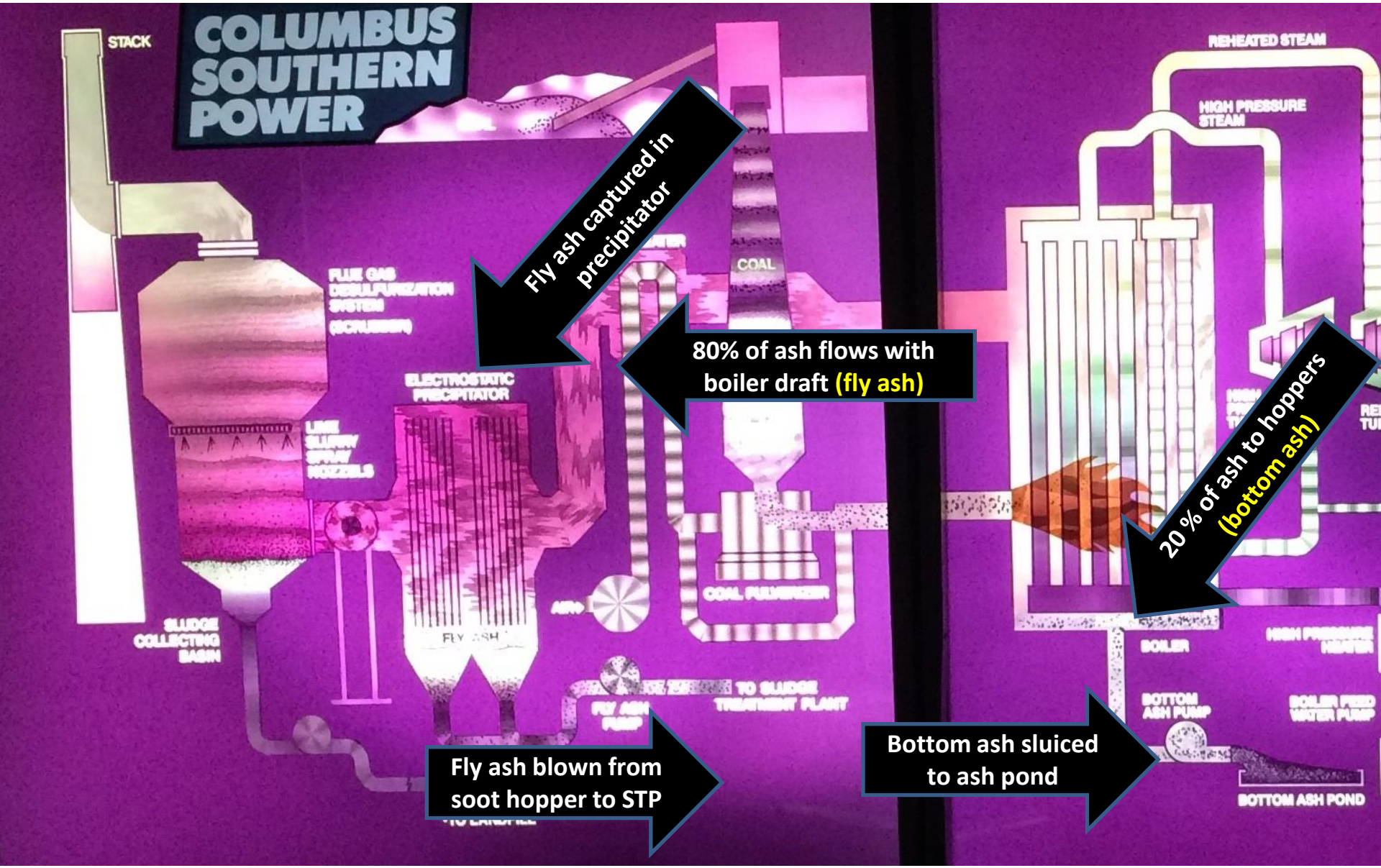
Protects river wildlife from hot water discharge thermal pollution (over heating)

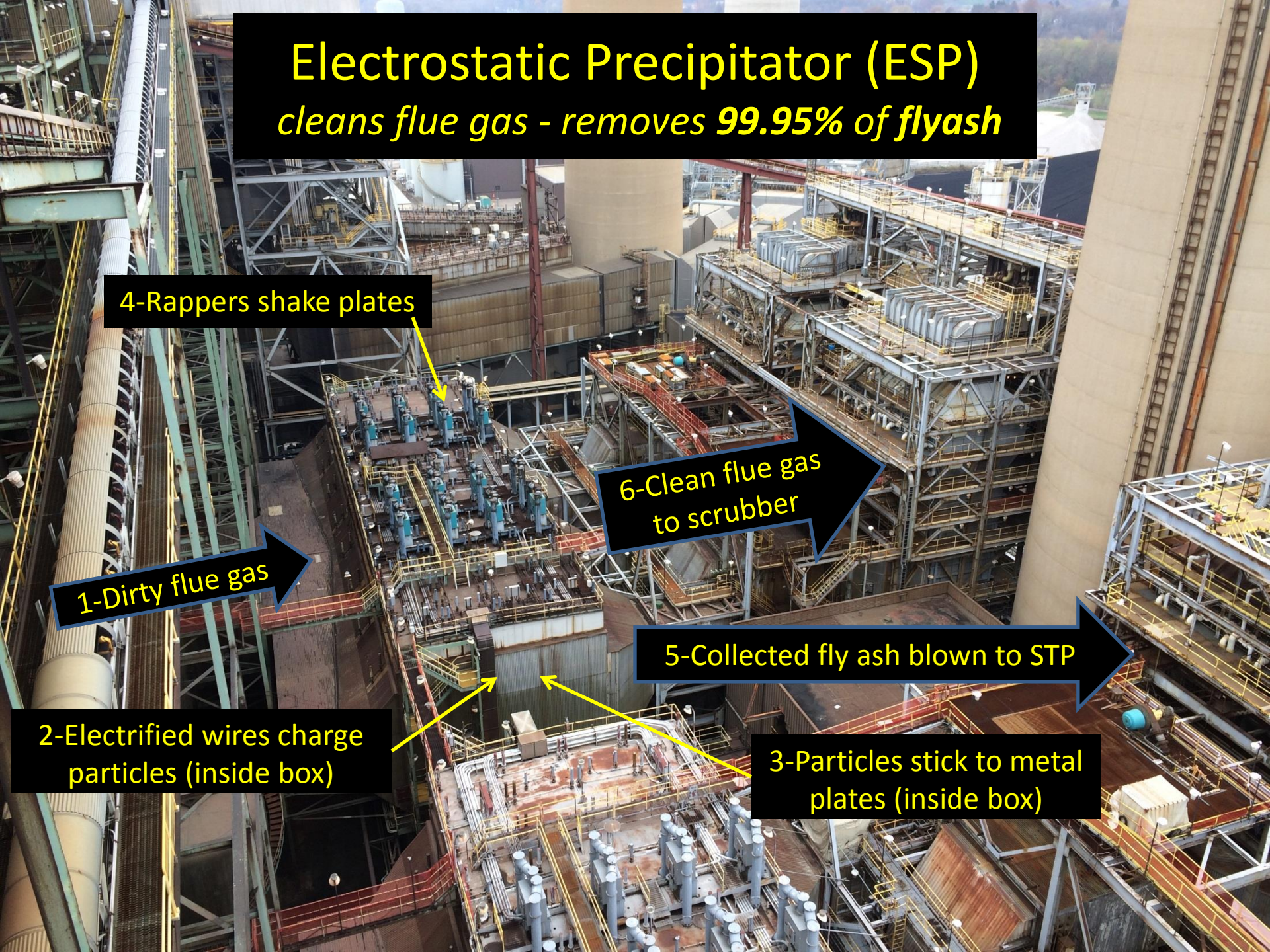


Fan blades

- pulls air from side
- water cascades down tower
- air cools water

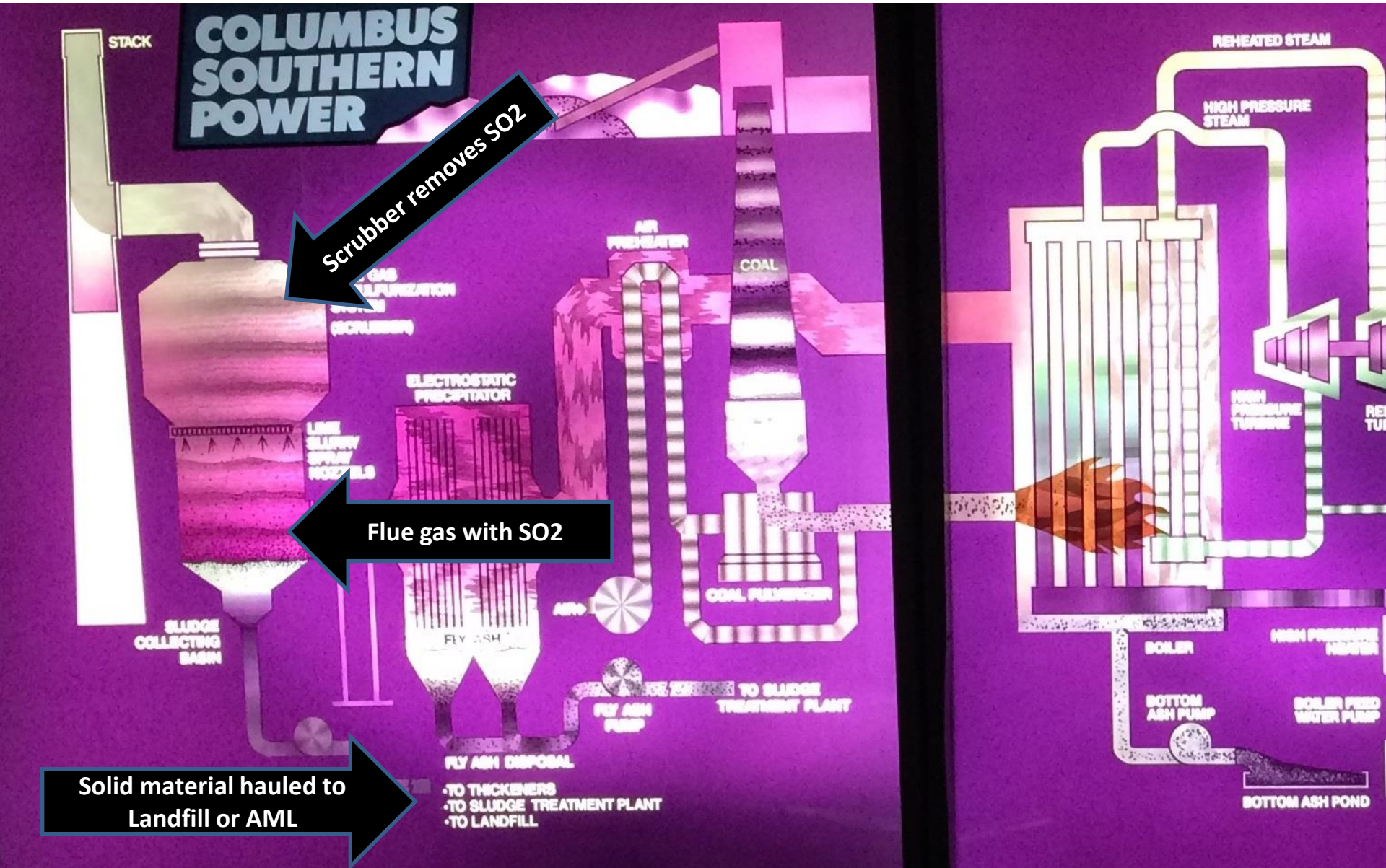
Combustion Residue - Ash




Electrostatic Precipitator (ESP)
*cleans flue gas - removes **99.95%** of **flyash***
4-Rappers shake plates
6-Clean flue gas to scrubber
1-Dirty flue gas
5-Collected fly ash blown to STP
2-Electrified wires charge particles (inside box)
3-Particles stick to metal plates (inside box)

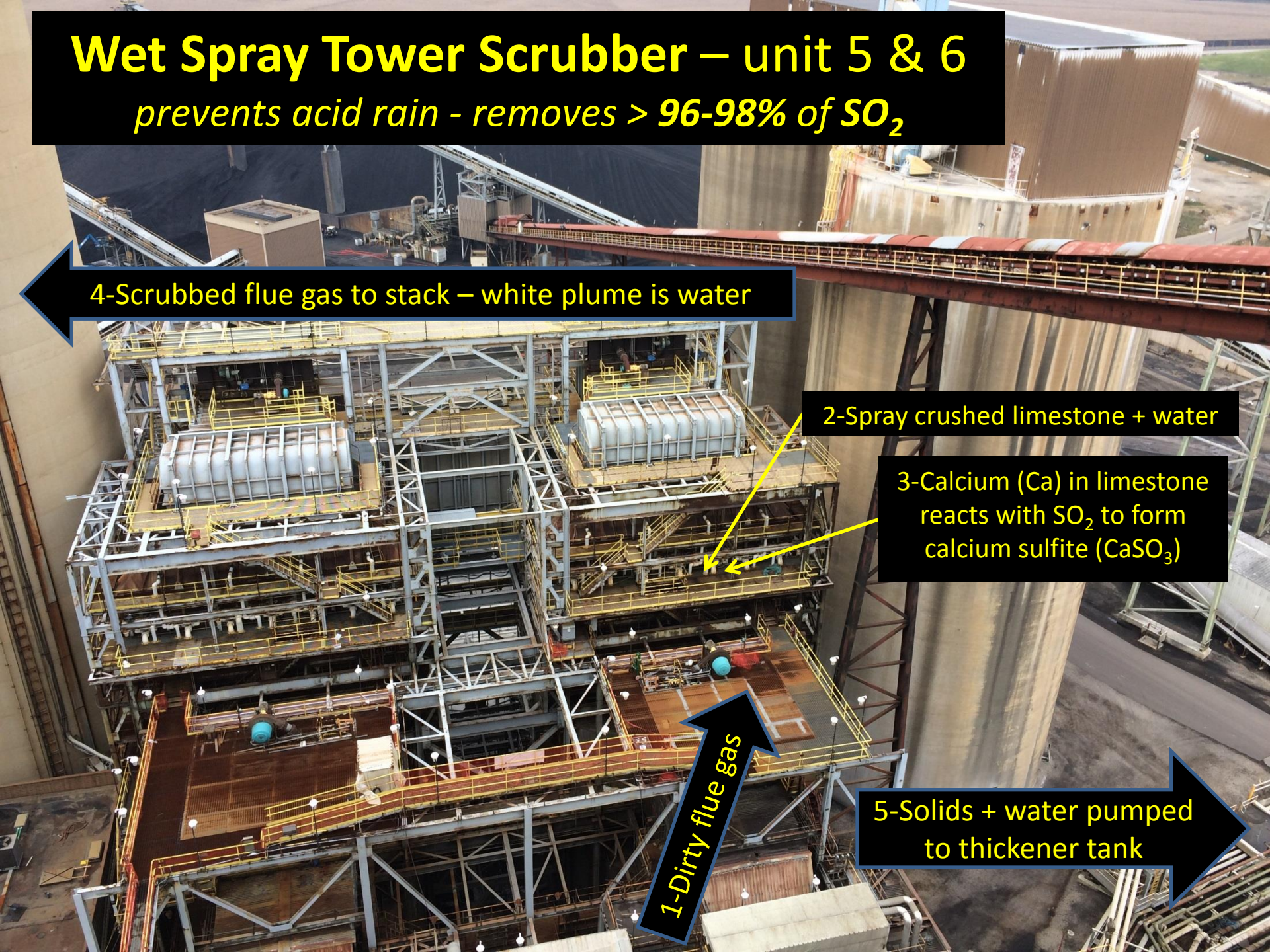
Combustion Residue – FGD & Gypsum

Scrubbers mitigate acid rain

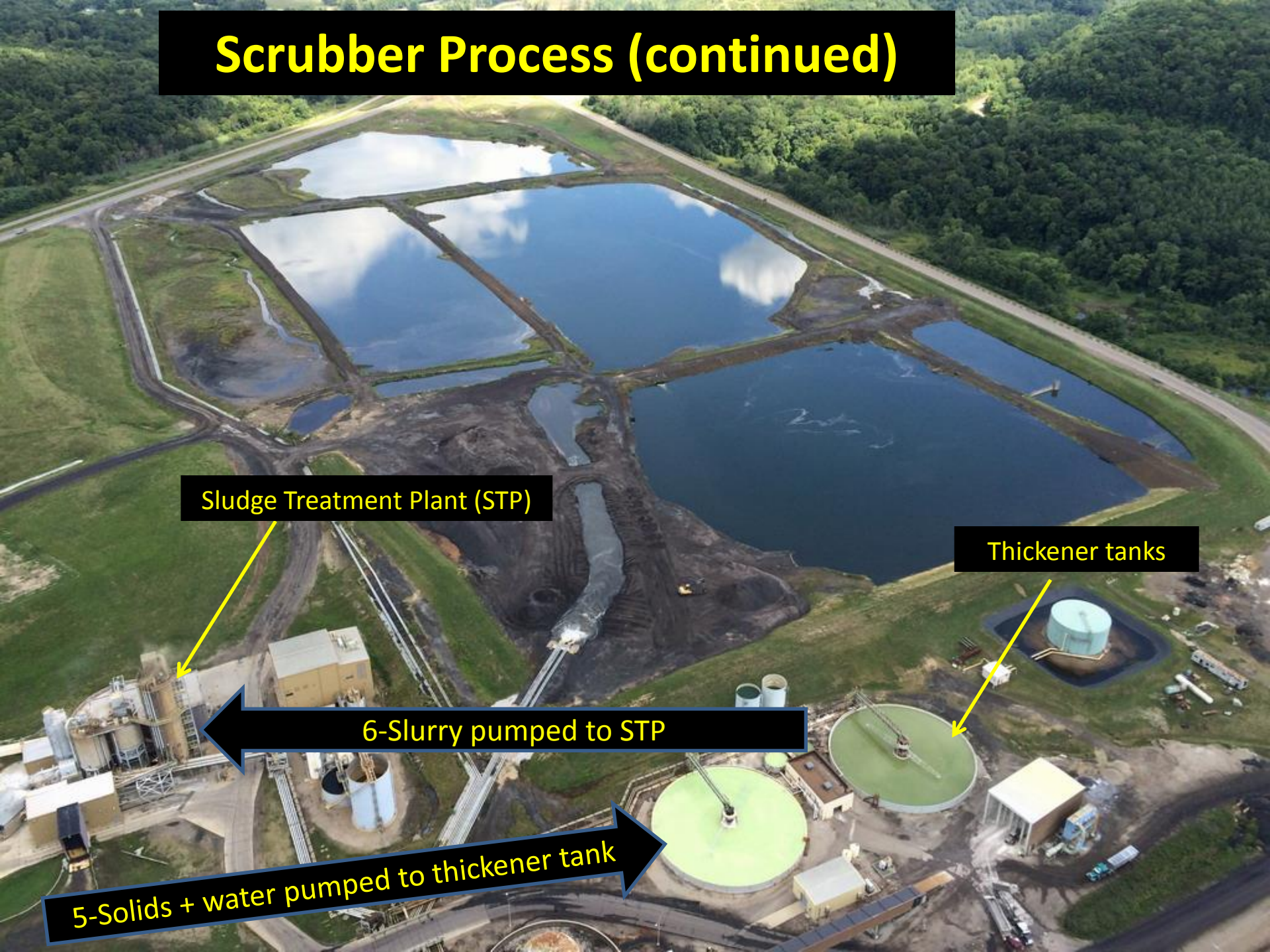


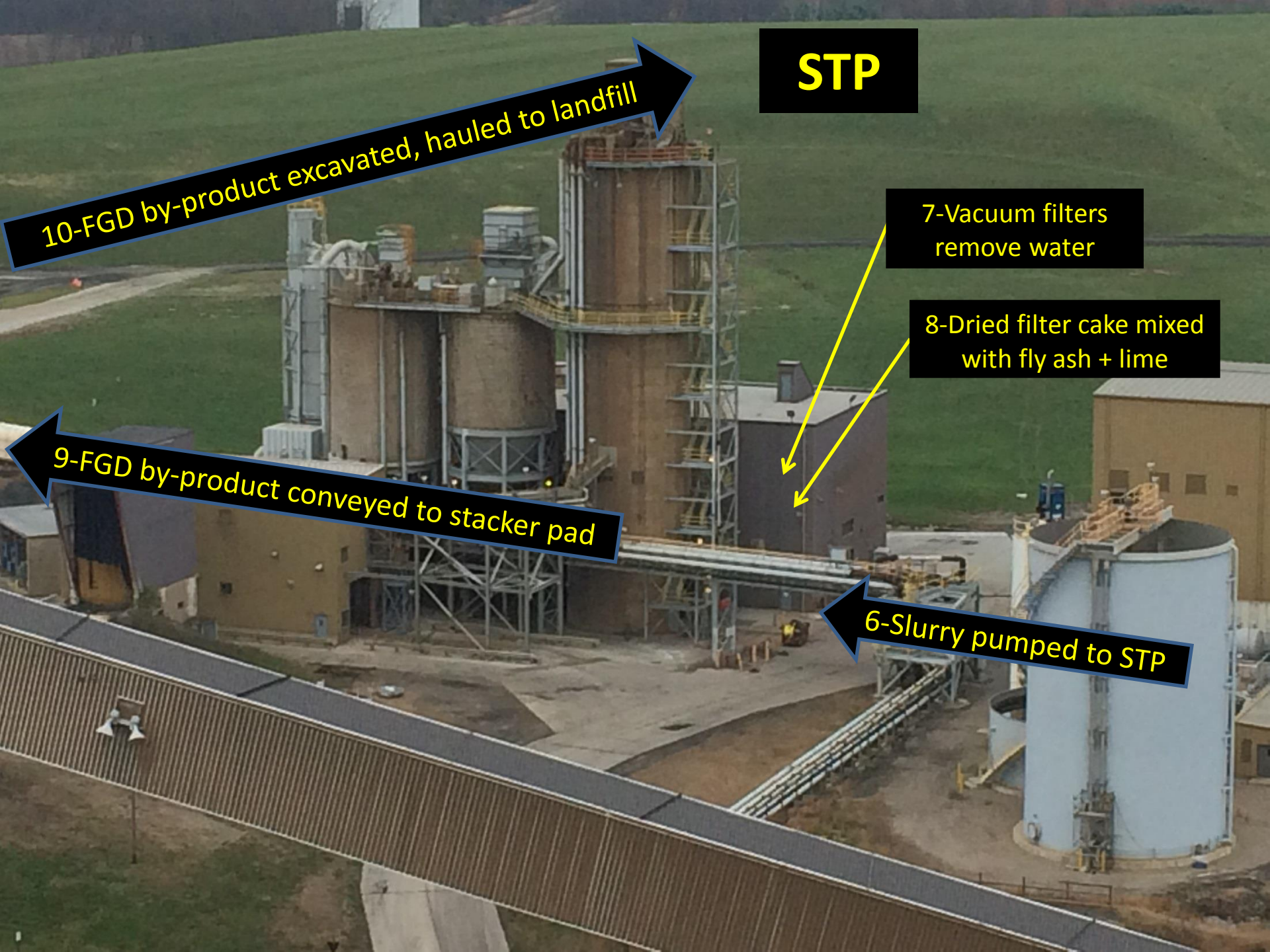
Wet Spray Tower Scrubber – unit 5 & 6

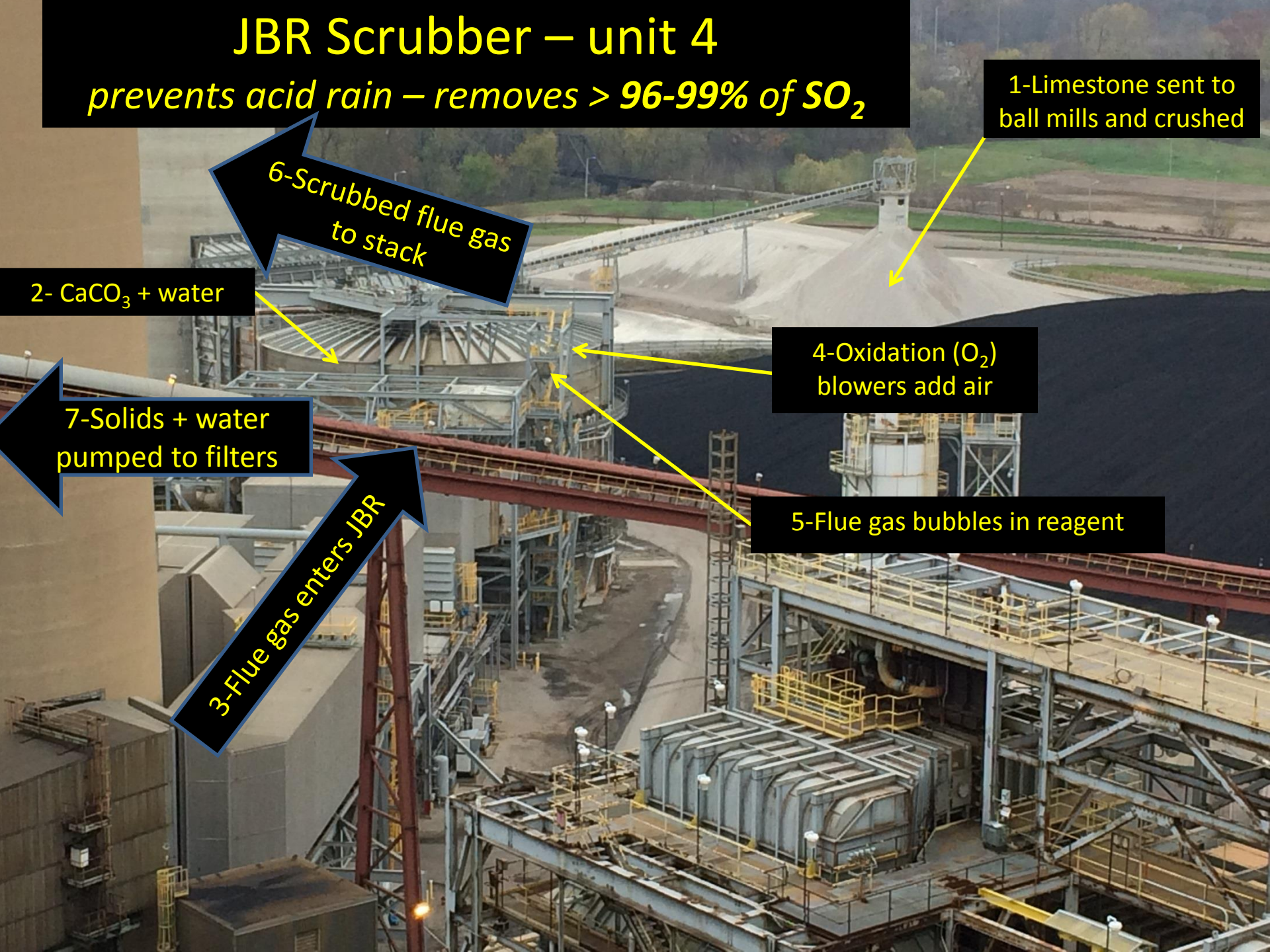
*prevents acid rain - removes > **96-98%** of **SO_2***



Scrubber Process (continued)




STP
10-FGD by-product excavated, hauled to landfill
7-Vacuum filters remove water
8-Dried filter cake mixed with fly ash + lime
9-FGD by-product conveyed to stacker pad
6-Slurry pumped to STP


JBR Scrubber – unit 4
*prevents acid rain – removes > **96-99%** of **SO_2***
1-Limestone sent to ball mills and crushed
6-Scrubbed flue gas to stack
2- $CaCO_3$ + water
4-Oxidation (O_2) blowers add air
7-Solids + water pumped to filters
5-Flue gas bubbles in reagent
3-Flue gas enters JBR

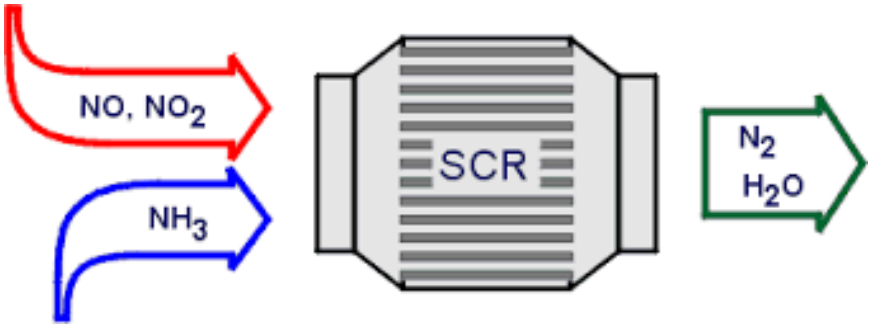

Gypsum Pad
9-Gypsum ($CaSO_4$) from filters
10-Gypsum excavated, haul to landfill
8-filters dry material in building
7-Solids + water pumped to filters

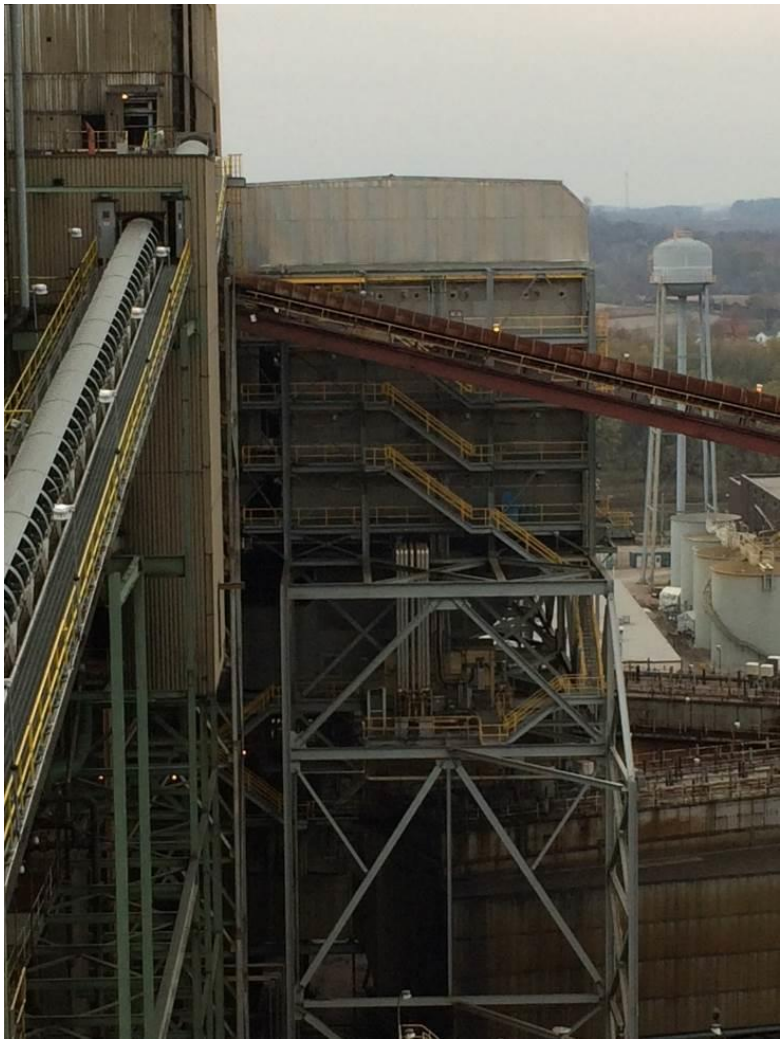
Selective Catalytic Reduction(SCR) – unit 4

*>> cleans air >> removes > **90%** of **NOx***

NO_x effects the ozone layer of the atmosphere and is GHG 310x stronger than CO_2

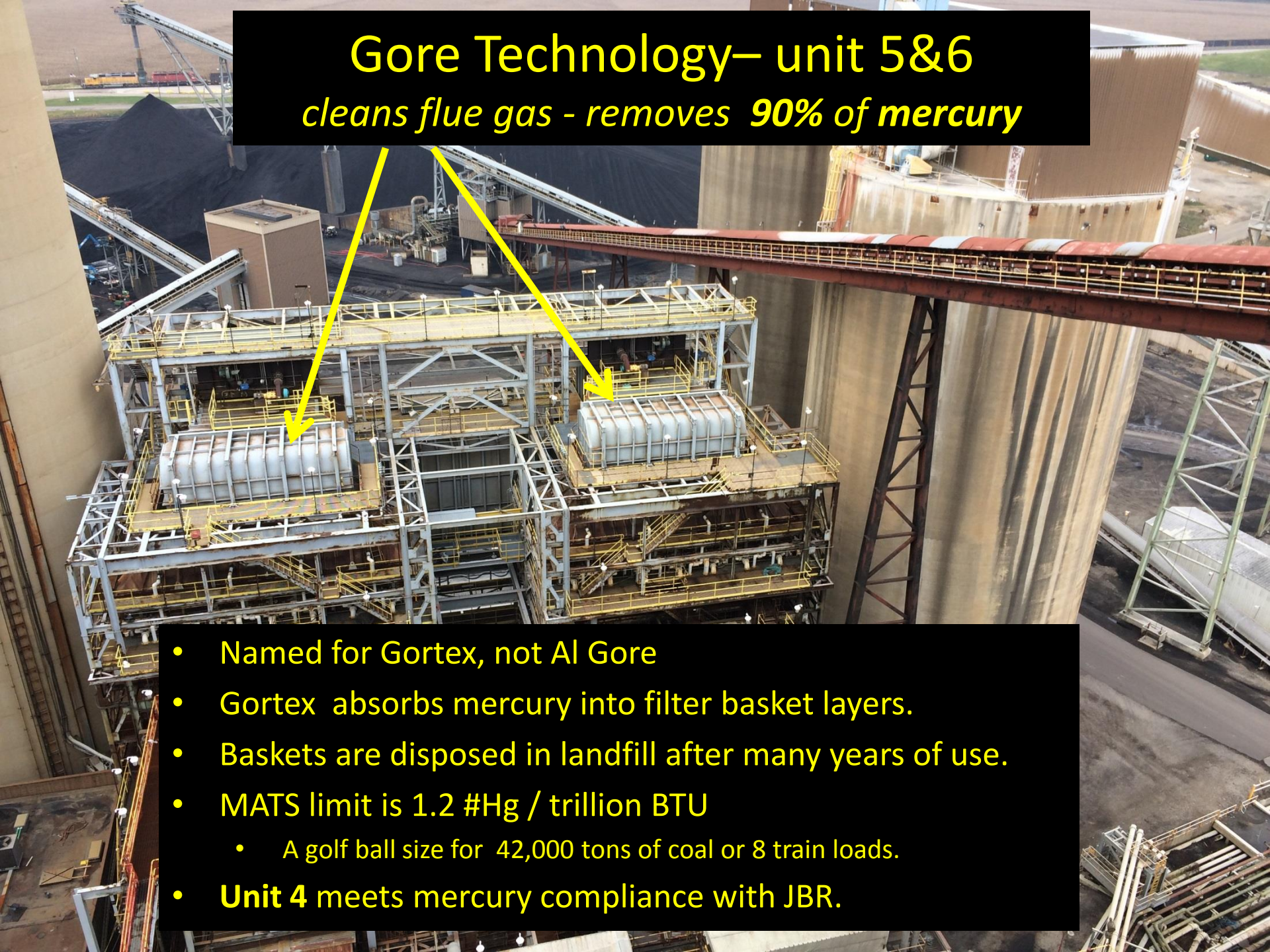
- Urea makes ammonia (NH_3) on demand
- Ammonia (NH_3) with catalyst breaks nitrous oxide (NO_x) into Nitrogen (N_2) and water (H_2O)
- **Unit 5 & 6** use Low-NO_x burners to reduce NO_x by 60%





Gore Technology– unit 5&6

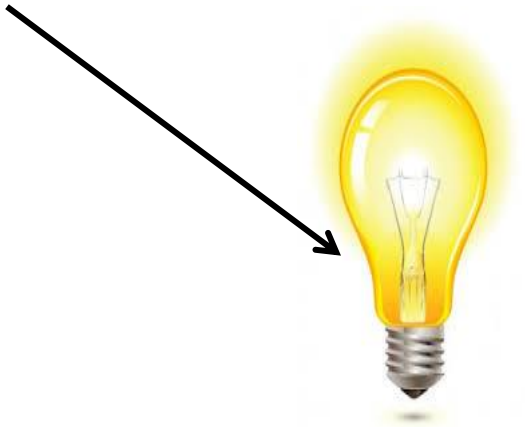
cleans flue gas - removes ***90%*** *of* ***mercury***



- Named for Gortex, not Al Gore
- Gortex absorbs mercury into filter basket layers.
- Baskets are disposed in landfill after many years of use.
- MATS limit is 1.2 #Hg / trillion BTU
  - A golf ball size for 42,000 tons of coal or 8 train loads.
- **Unit 4** meets mercury compliance with JBR.

Coal Is Called Dirty, however……

Unit	Problem	Pollution Control Equipment	Reduction
4,5,6	Hot water to river	Cooling Tower	100%
4,5,6	Electrostatic precipitator	particulate matter (flyash)	> 99.95%
4,5,6	Sulfur dioxide (SO2)	Scrubber	> 96%
4	Nitorous oxide (NOX)	SCR	> 90%
5,6	Nitorous oxide (NOX)	Low NOX burners	> 60%
5,6	Mercury in air	Gore Technology	>90%
all	Mercury in water discharge to river	various	< 12 ng *
* Equivelent of 12 drops of water in 22 Olympic size swimming pools			



27 million 60 W light bulbs

Let’s go see the plant