

WESTERN COAL GENERATION AND GRID RESILIENCY

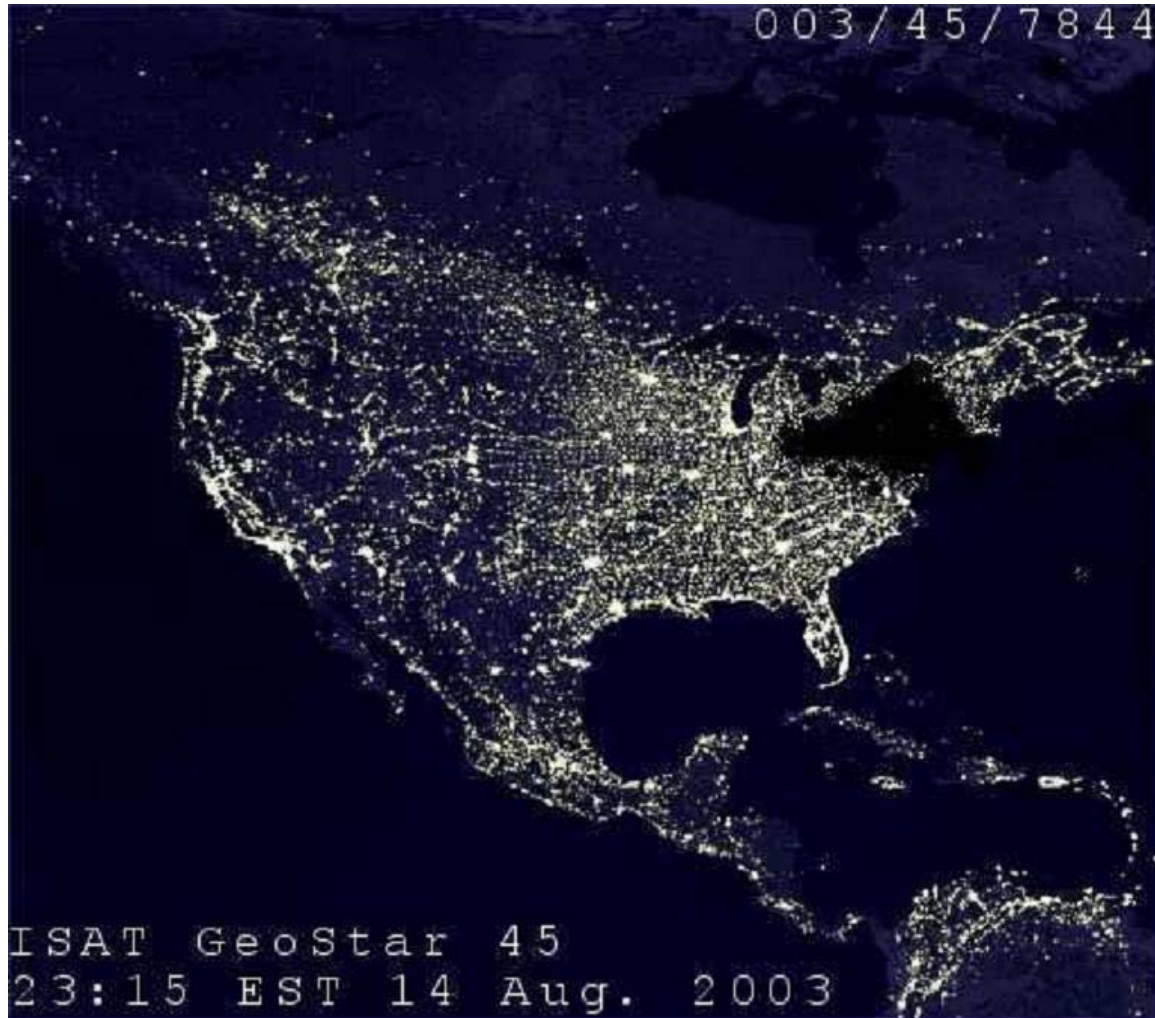
NERC Has Yet To Settle on a Definition of Resiliency

RESILIENCY

Our generation system's ability to respond to upset conditions in a way that ensures reliability

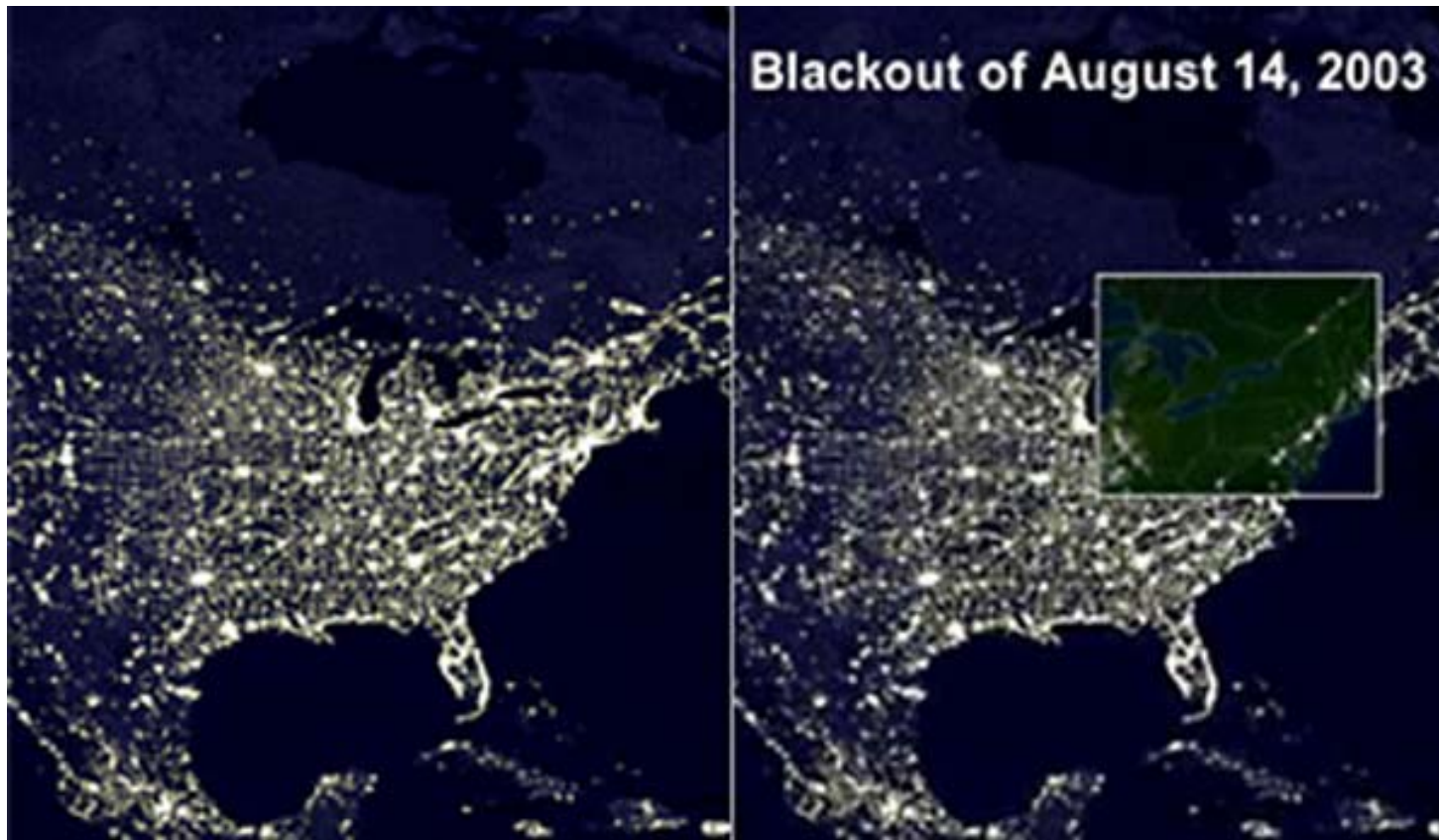
2003 Eastern Seaboard Blackout

- The 3,500 megawatt power loss affected 45 million people in eight states
- During the outage, more than 508 generating units at 265 power plants shut down



003/45/7844

ISAT GeoStar 45
23:15 EST 14 Aug. 2003









What Was the #1 Component or Commodity Needed To Recover From the Blackout?

- Repairs to Power Lines?
- Repairs to Substations?

ELECTRICITY....

Megawatts!

DURING THE POLAR VORTEX OF 2019

Gas Companies asked consumers to lower their thermostats to 55 degrees.

They instructed them to turn on electric space heaters to make up the difference.

Why?

And where did that electricity come from?

Electricity Production Must Be More Than Reliable

- **It Must Be Resilient**

ANOTHER DEFINITION

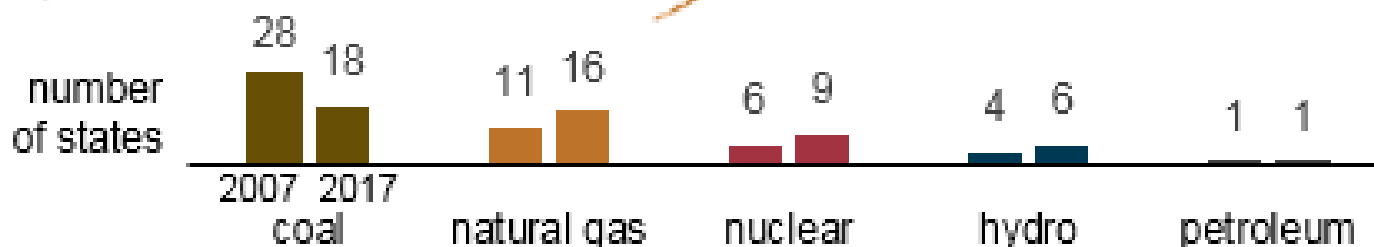
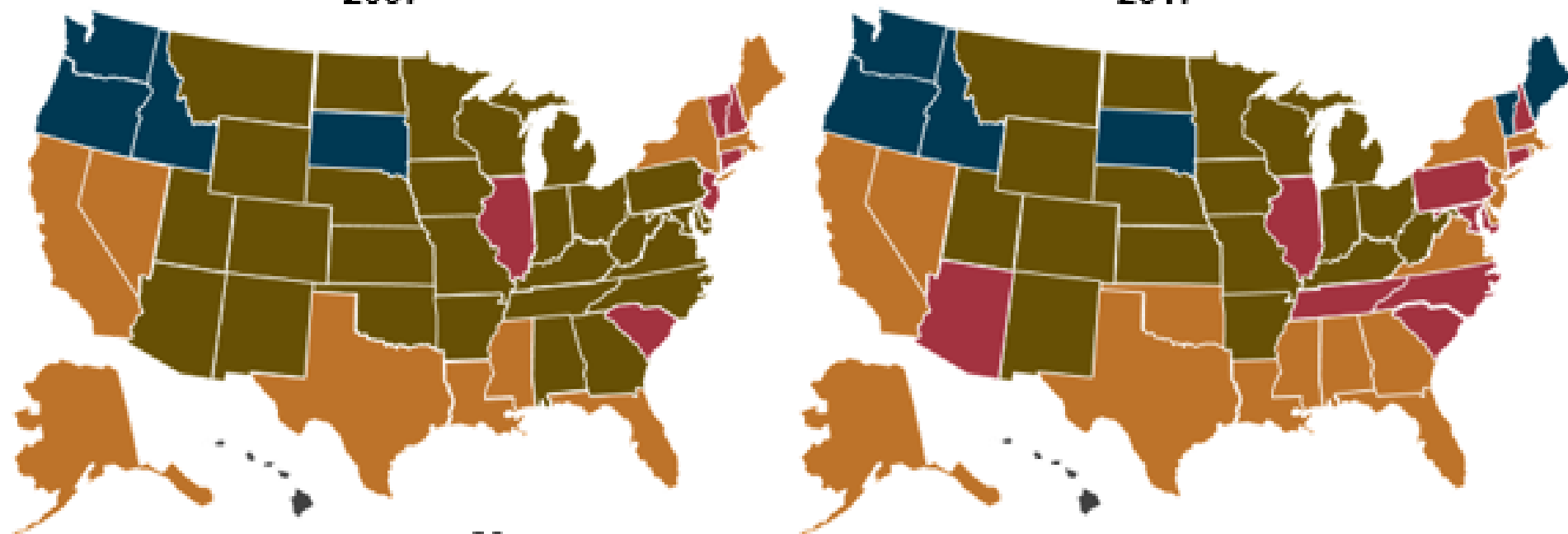
EQUIVALENT AVAILABILITY FACTOR

A Measure of Maximum Generation Available Over Time

Most prevalent utility-scale electricity generation fuel by state (2007 and 2017)

2007

2017



MY CAUTIONARY TALE IS NOT ABOUT COAL UNIT RETIREMENTS

It is about the health and equivalent availability of units in the West NOT scheduled for retirement



OUR NATION'S COAL FLEET IS THE RELIABLE OLD PICKUP TRUCK OF ENERGY GENERATION

Gas Plants (HRSGS) are at the mercy of pipelines and supply

The Nuclear Fleet is Nearing End of Life

(Three Mile Island)

**DURING THE NEXT UPSET
CONDITION OF THE GRID,
WHERE WILL THE MEGAWATTS
COME FROM?**

What If I Drove This Truck Differently?

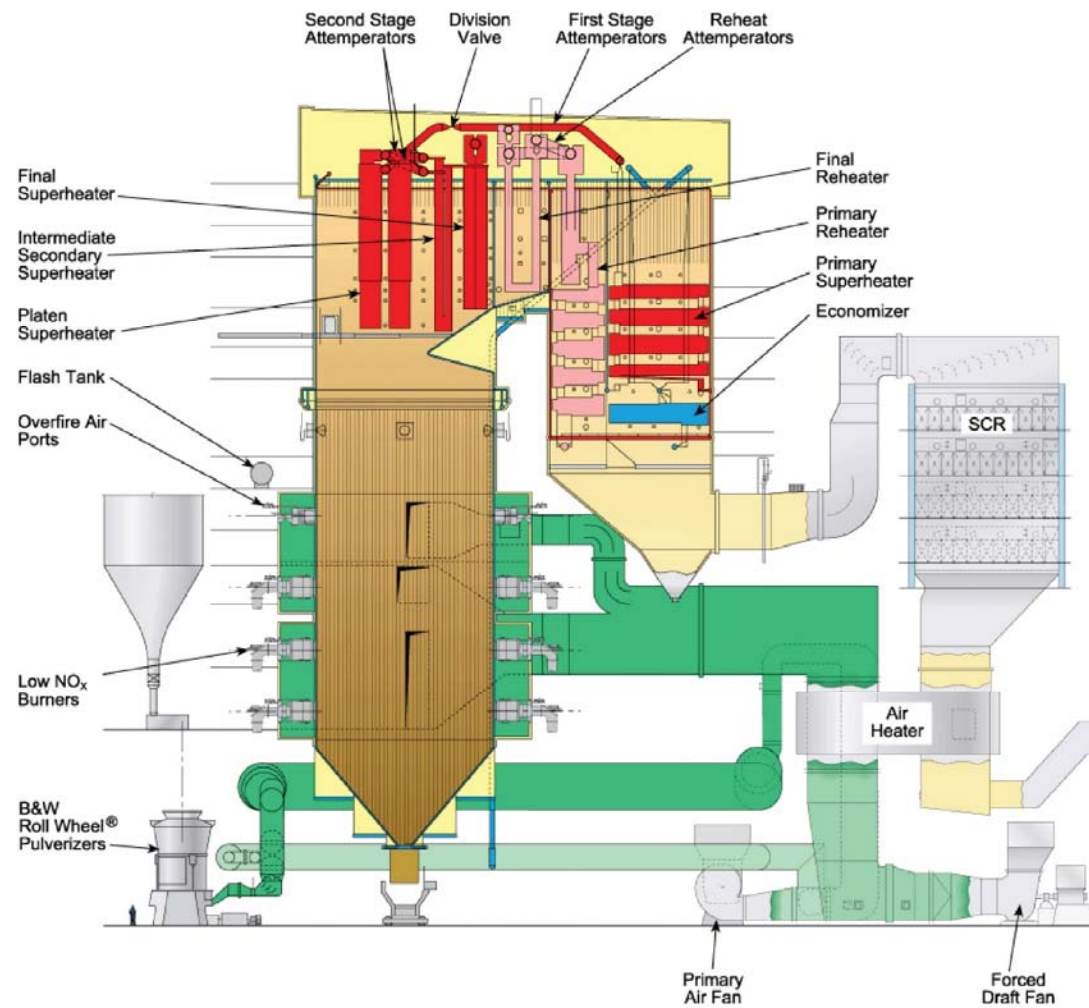
Accelerator to the Floor
Stomp the Brake

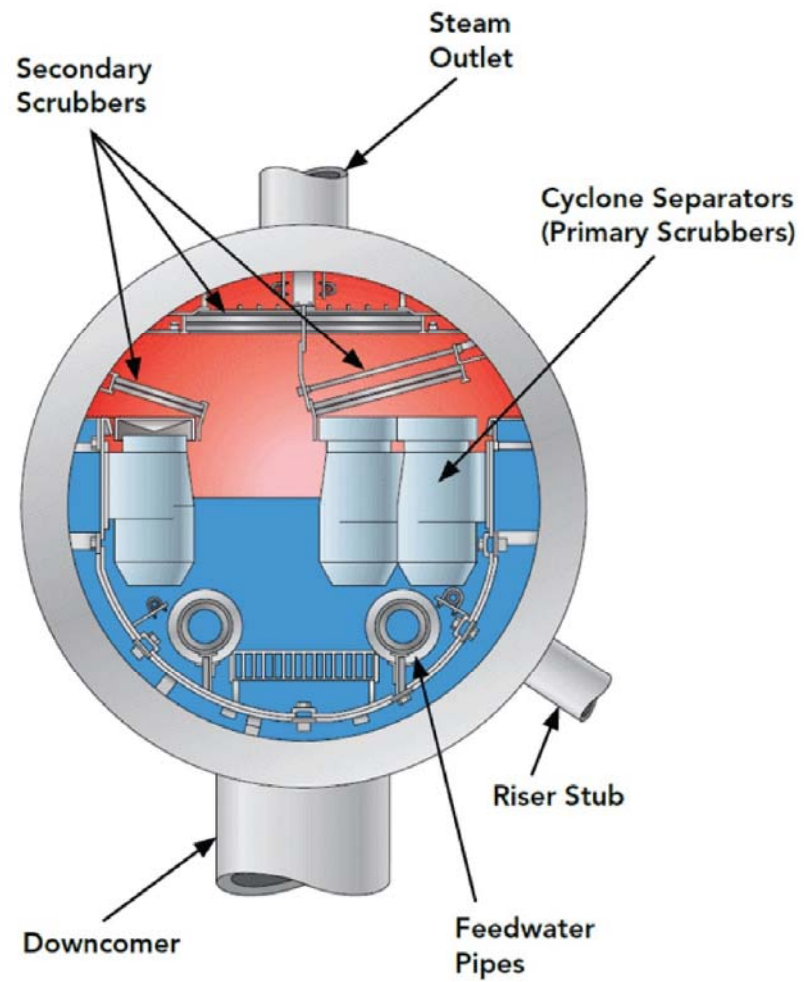


Partly Because of Renewables We Are
Stomping the Gas And Stomping the Brake of
Our Coal Fleet



What's Going On Inside this Mammoth Facility to Generate those Precious Megawatts?

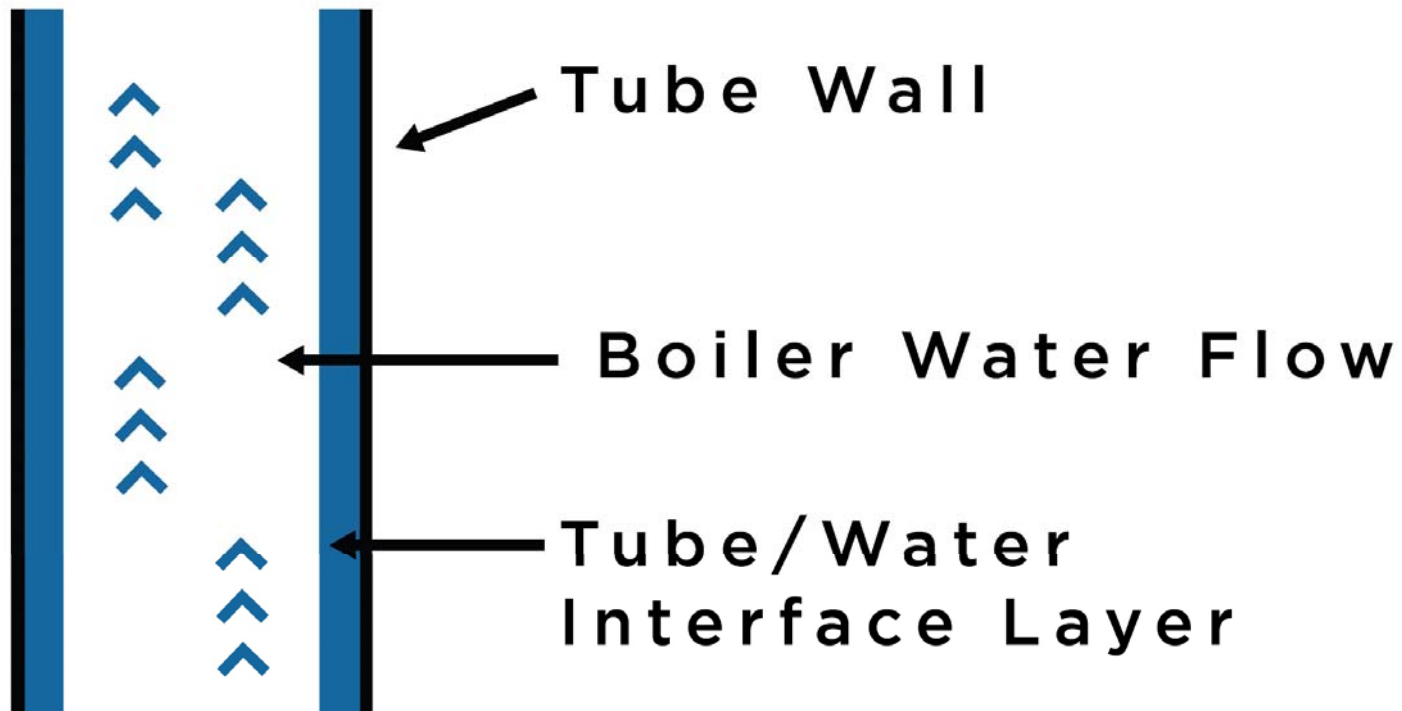




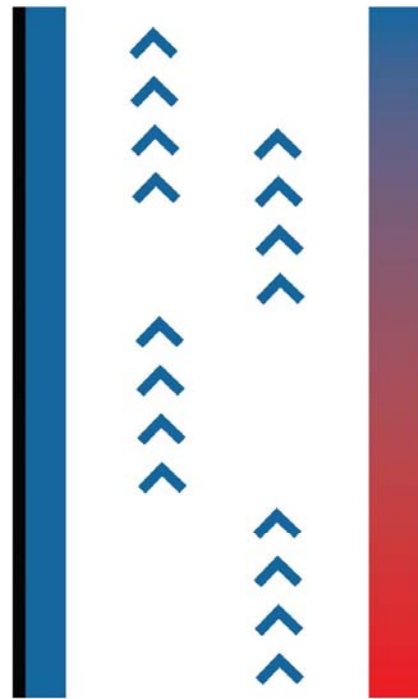
POTENTIAL CHEMISTRY/METALLURGY FAILURE MECHANISMS ABOUND

For this discussion we will focus on one type

Boiler Tube

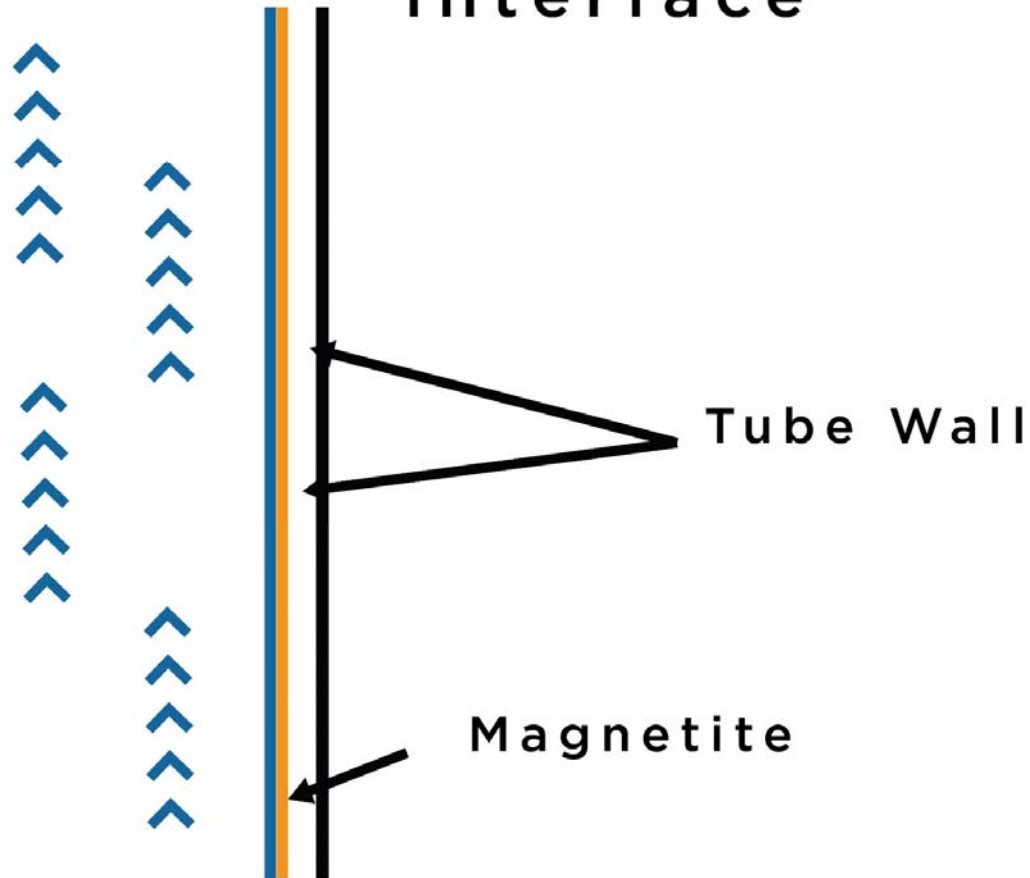


Tube Temperature Versus Flow

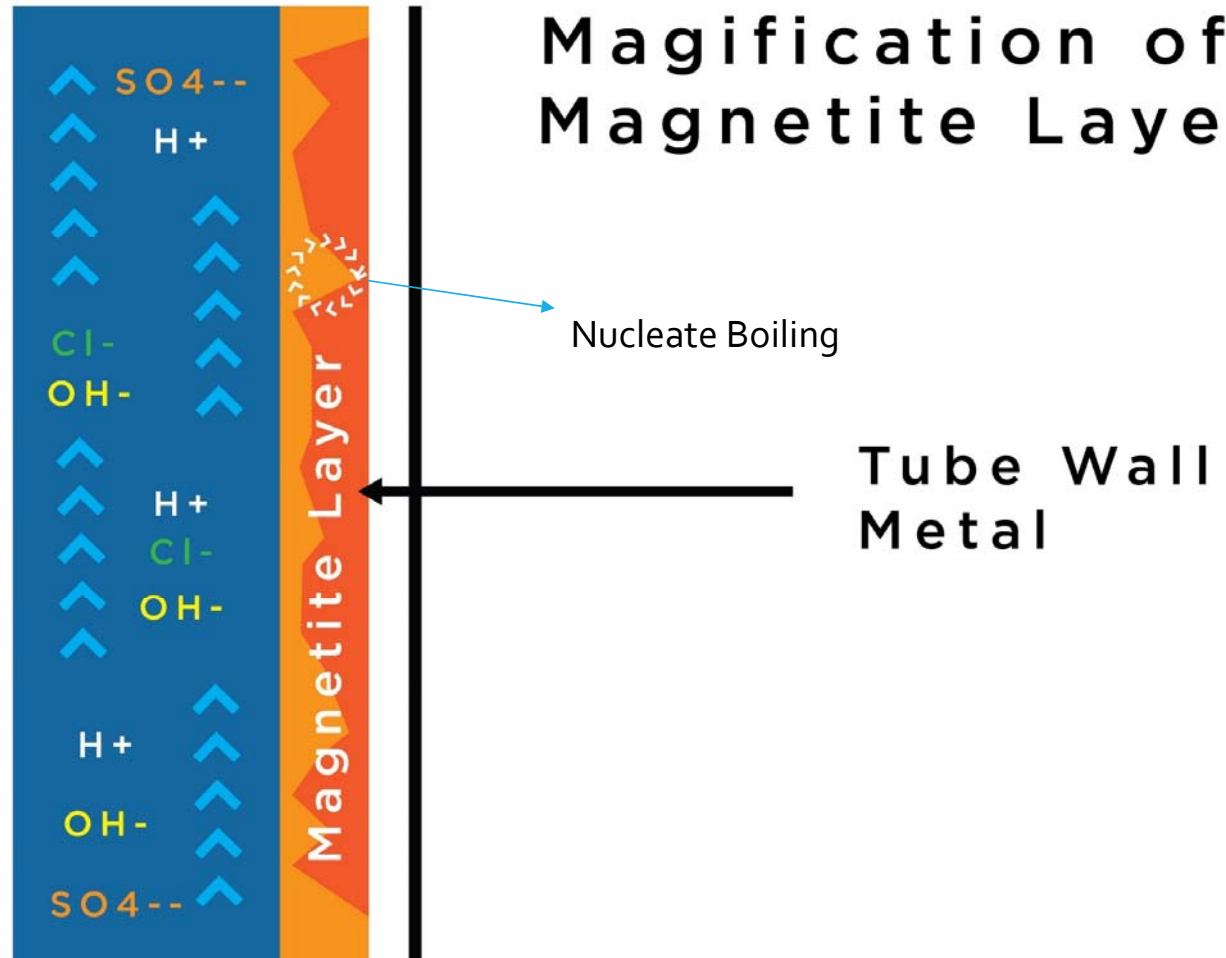


Proper Flow is **ESSENTIAL** to
Maintain Tube Temperature

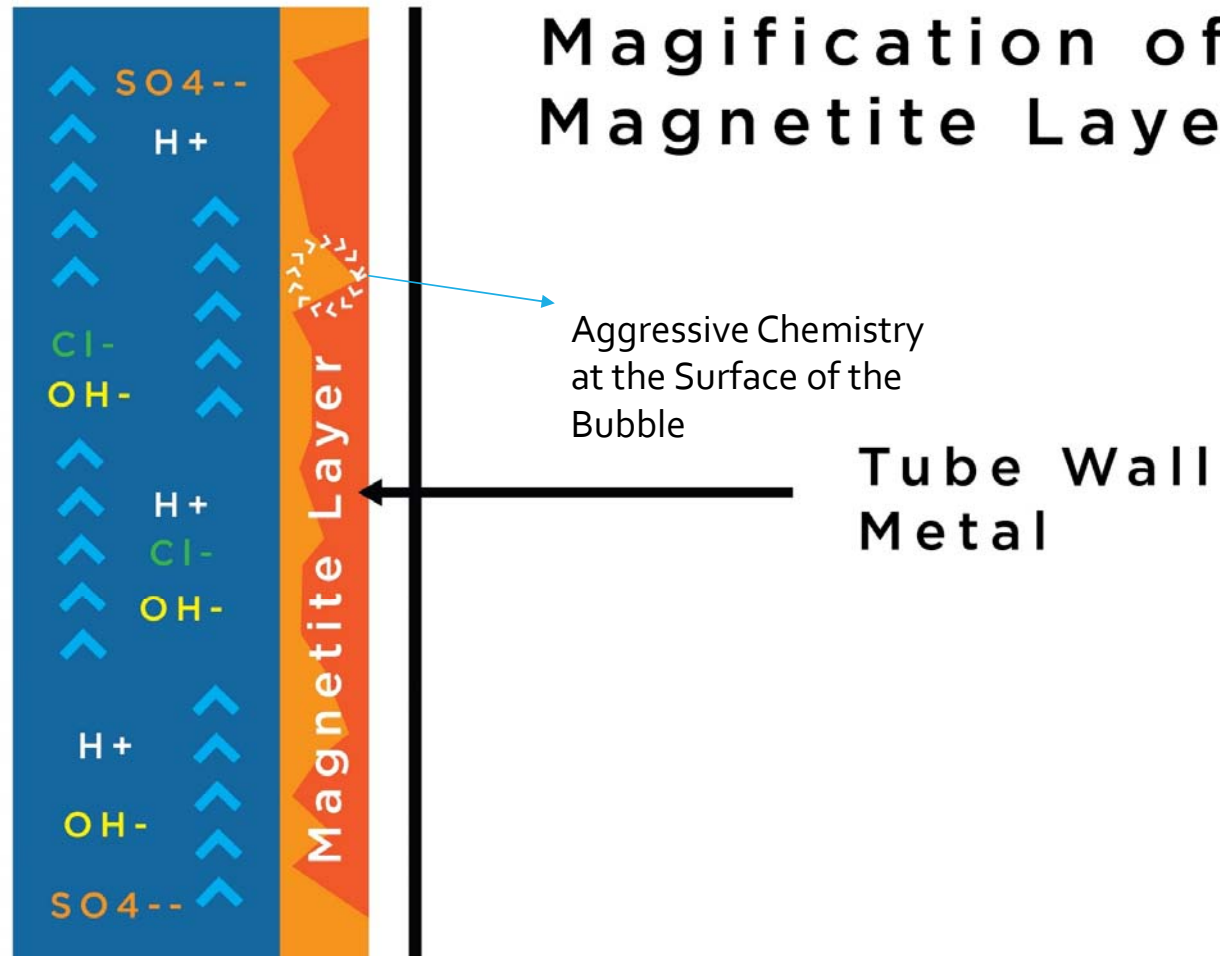
Boiler Tube Wall / Water Interface



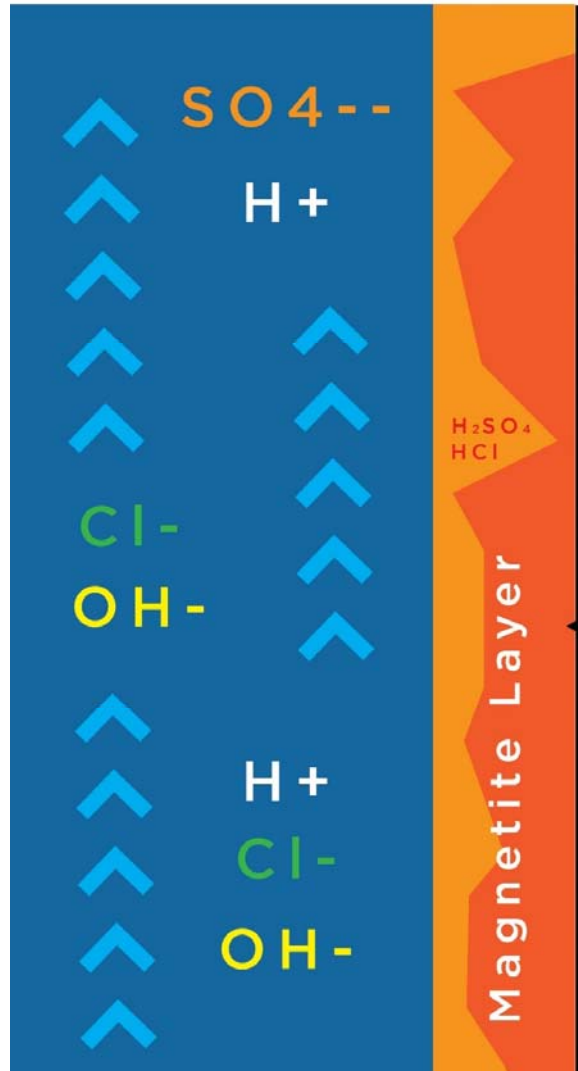
Magnification of Magnetite Layer



Magnification of Magnetite Layer



Magification of Boiler Chemistry



Tube Wall
Metal

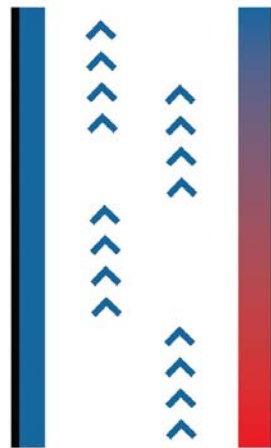
Under Cyclic Operation Conditions, Generating Unit
Cycle Chemistry Upsets Become More Prevalent.

At the Same Time We Have Less Than Optimum Chemistry in the Boiler Feedwater

- Examples:
 - Iron and Copper Are Being Dissolved
 - Called Corrosion Products
 - Leads To Corrosion Product Transport

Corrosion Product Transport + Dirty/ Occluded Tubes

Tube Temperature Versus Flow



Proper Flow is ESSENTIAL to
Maintain Tube Temperature

YET WE HAVE ONLY DISCUSSED ONE TYPE OF FAILURE MECHANISM

And that mechanism may lead to Economic Failure
But not catastrophic failure

We Have Not Even Discussed:

- Hydrogen Damage
- Creep
- Small Particle Impingement

SADLY, THE IMMEDIATE DAMAGE IS ONLY PART OF THE CONCERN

What Chronic Damage Has Been Done to Our
Non-Retirement Coal Fleet??

POLICY MAKERS AND UTILITY EXECS.

SHOULD TAKE THESE POTENTIAL FAILURE MECHANISMS INTO
ACCOUNT WHEN MAKING DECISIONS THAT IMPACT RESILIENCE

- https://www.ehstoday.com/sites/ehstoday.com/files/uploads/2013/08/blackout_o.jpg
 - <https://s.hdnux.com/photos/14/55/14/3330868/4/rawImage.jpg>
 - <https://cdnassets.hw.net/dims4/GG/490788d/2147483647/resize/300x%3E/quality/90/?url=https%3A%2F%2Fcdnassets.hw.net%2Fb9%2F81%2Fe2985daa4f9f911376f651faf15d%2F42-16475125-blackout2003-hero-tcm47-2000029.jpg>
 - https://en.wikipedia.org/wiki/Northeast_blackout_of_2003
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