Finally…

…my turn

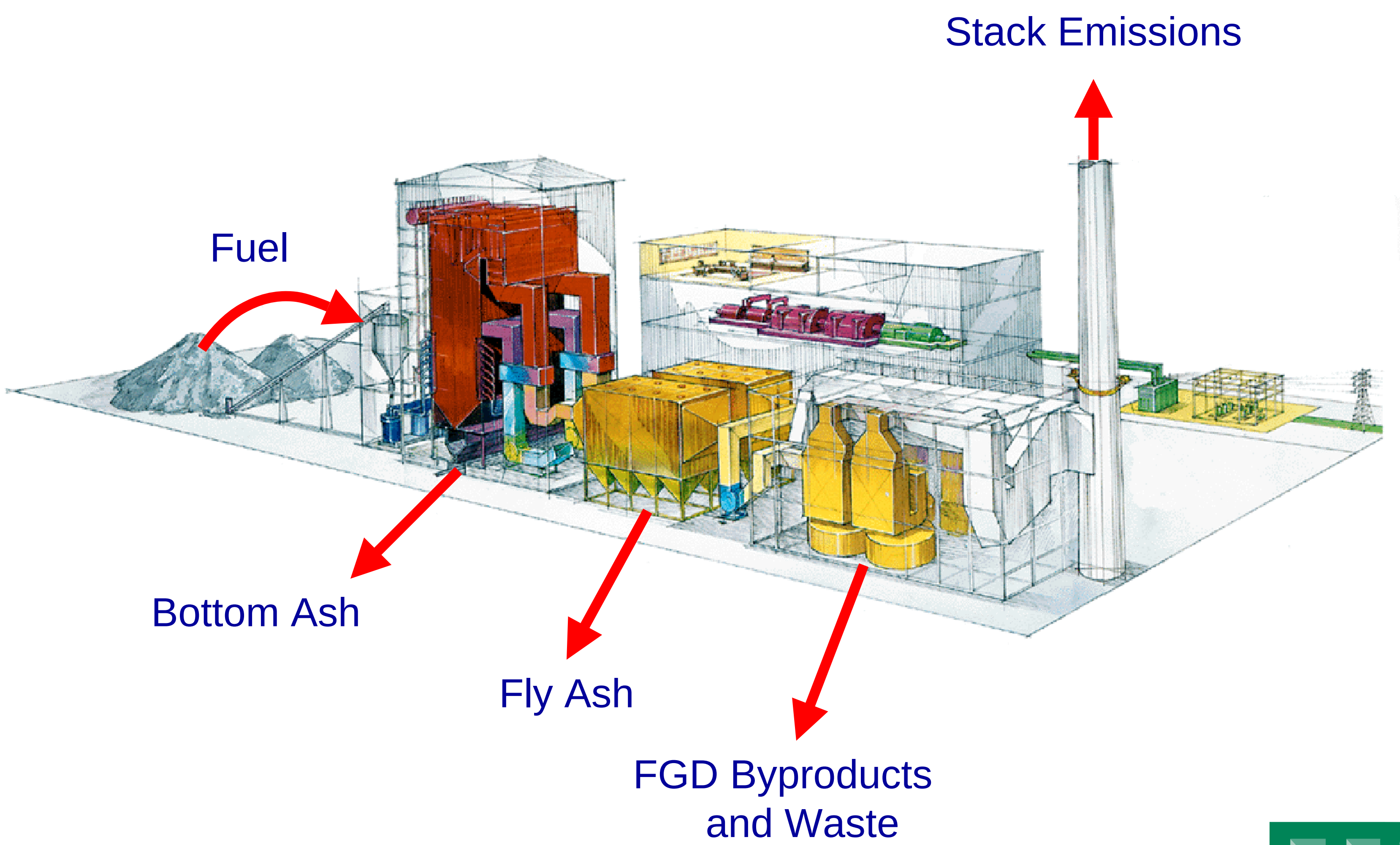
Overview

- Key issues regarding control technology options and decisions
- Single and multi-pollutant control technologies
- An "example"

Summary

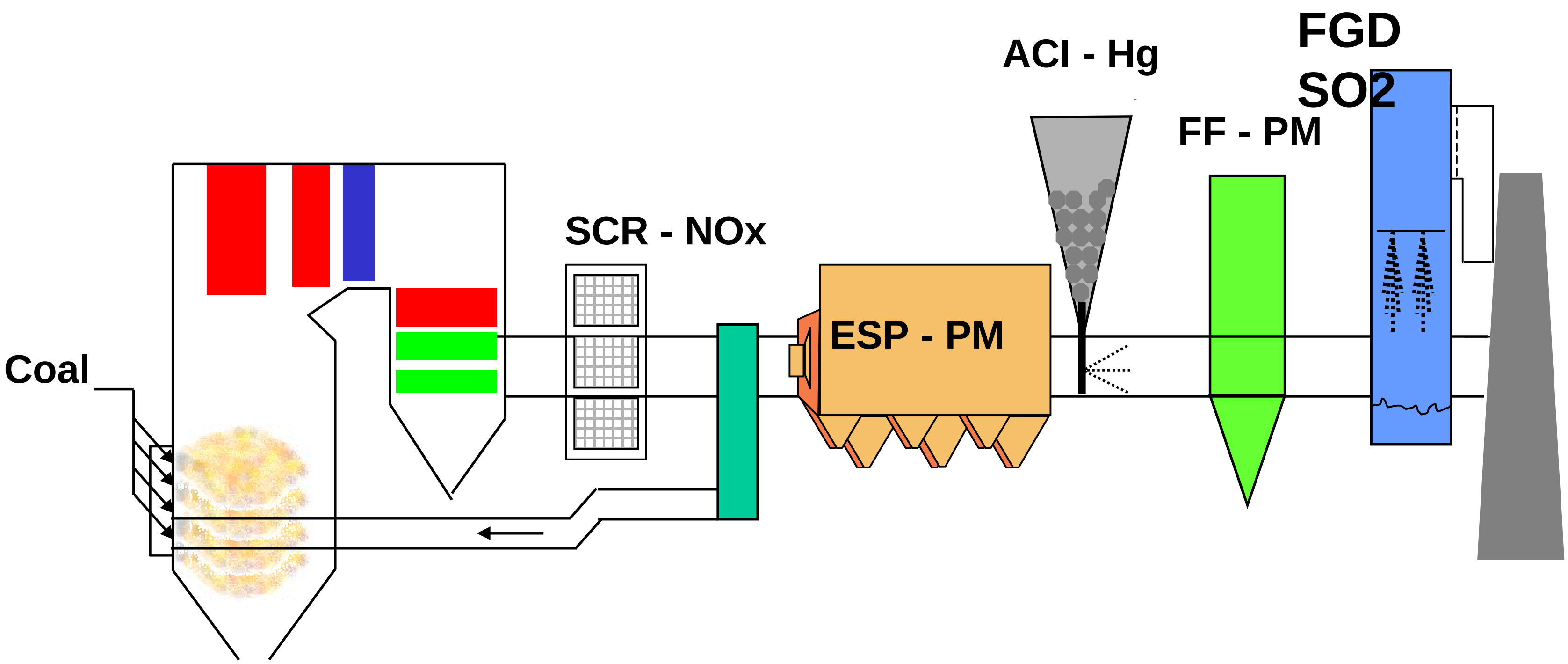
- **Technology choices challenging in light of…**
  - **Regulatory landscape**
  - **Technical impacts between technologies**
  - **Plant economic performance/life**
  - **"commercial" vs. new technology risk**
  - **New technology paradigm shift**
- **Technology options are many…**
  - **Combined single–pollutant control technologies (e.g. SCR, FGD, ESP, ACI)**
  - **Multi-pollutant control technologies (e.g. Powerspan, etc.)**
  - **Generation technologies /fuels (e.g. IGCC, GTCC, etc.)**
- **Northeast "example"**
  - **Decision driven by**
    - **Compliance timing**
    - **Technology risk profile**
    - **Plant specific characteristics**

Power Plant Emissions



Energy and Environmental Strategies

Flue Gas Path



Technology challenges…

Impact of SCR on Hg Removal

- Bituminous coals:
  - Significant oxidation for high Cl coals;
  - Oxidation decreases over time;
  - Oxidation reduced by presence of NH_3
- PRB coals:
  - Minimal oxidation
- Bottom Line
  - current R&D to provide further knowledge

Impact of SCR and ACI on flyash

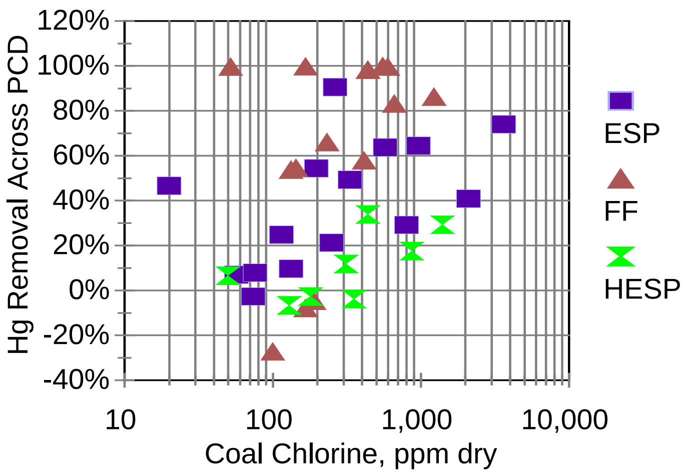
- Ash contamination by
  - NH_3
  - AC
  - Hg

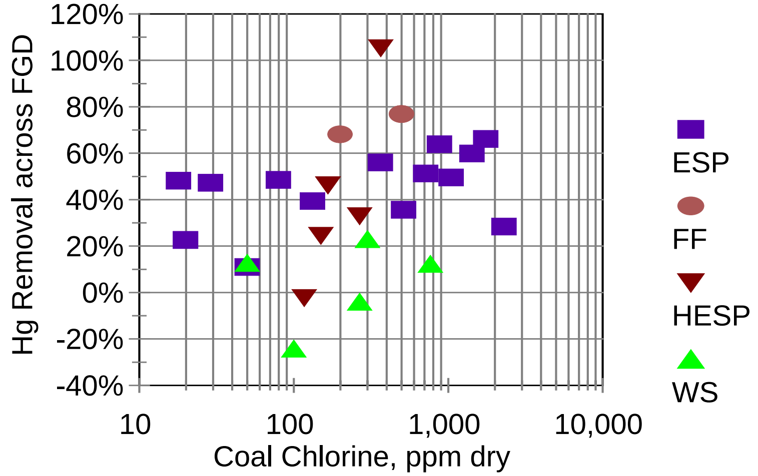
Can render it unacceptable for recycling

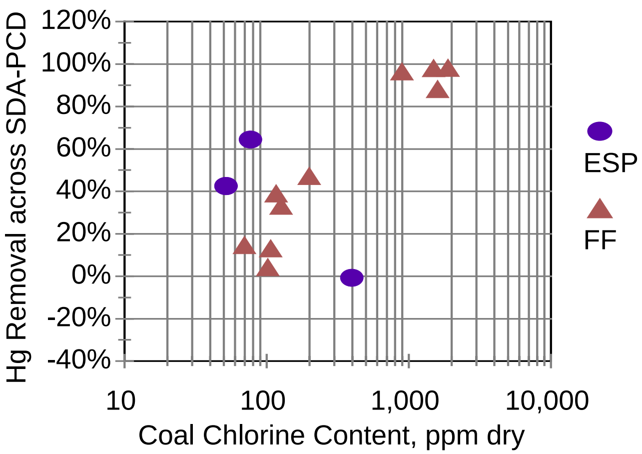
Impact of Dry FGD on Hg Removal

- Test results show poor Hg removal when AC is added in or downstream of SDA:
  - Removal of SO_3 and HCL limit uptake on carbon particles.
- Ongoing R&D/testing

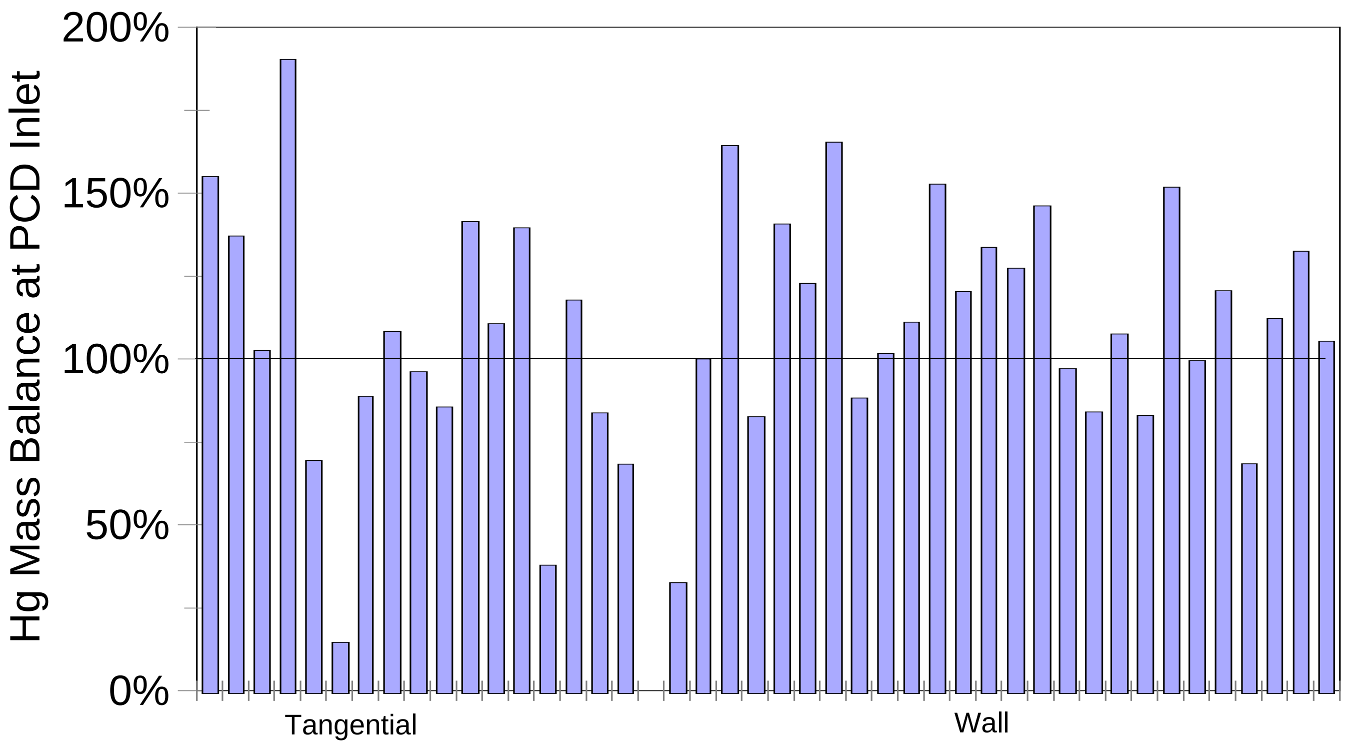
Mercury Removal across APCDs







Uncertainty in mercury measurements



Energy and Environmental Strategies

“New" technology paradigm shift

- **In the not so distant past, new technologies came in to the market place mainly with increasingly higher performance attributes (e.g. SCR “better” than SNCR “better” than LNBs)**
- **Today “commercial” technologies can give us 90+% reductions on NOx, SO2, PM, (even Hg ???) emissions**
- **Hence, “new” technologies must find other arguments to compete**
- **Such “arguments” are more difficult as compliance dates are nearer, environmental regulations are confusing, wholesale power market dynamics are evolving (deregulation…), fuel (gas) options have emerged, new generation technologies (IGCC) become alternatives…**

Technology vendors today must not only develop “good” products but also “market” them successfully

Technology “consumers” must be ever more educated to be able to make good technology decisions

Less incentive for technology “push” from environmental community

Conventional Control Technologies

NOx Control Technologies

- Combustion modifications
  - LNBs, OFA, FGR, Reburn
    - >250GW
    - 20% - 70%
- Post-combustion
  - SNCR
    - 10-12GW
    - 20% - 50%
  - SCR
    - ~110GW
    - 80% - 95%

SO2 Technologies

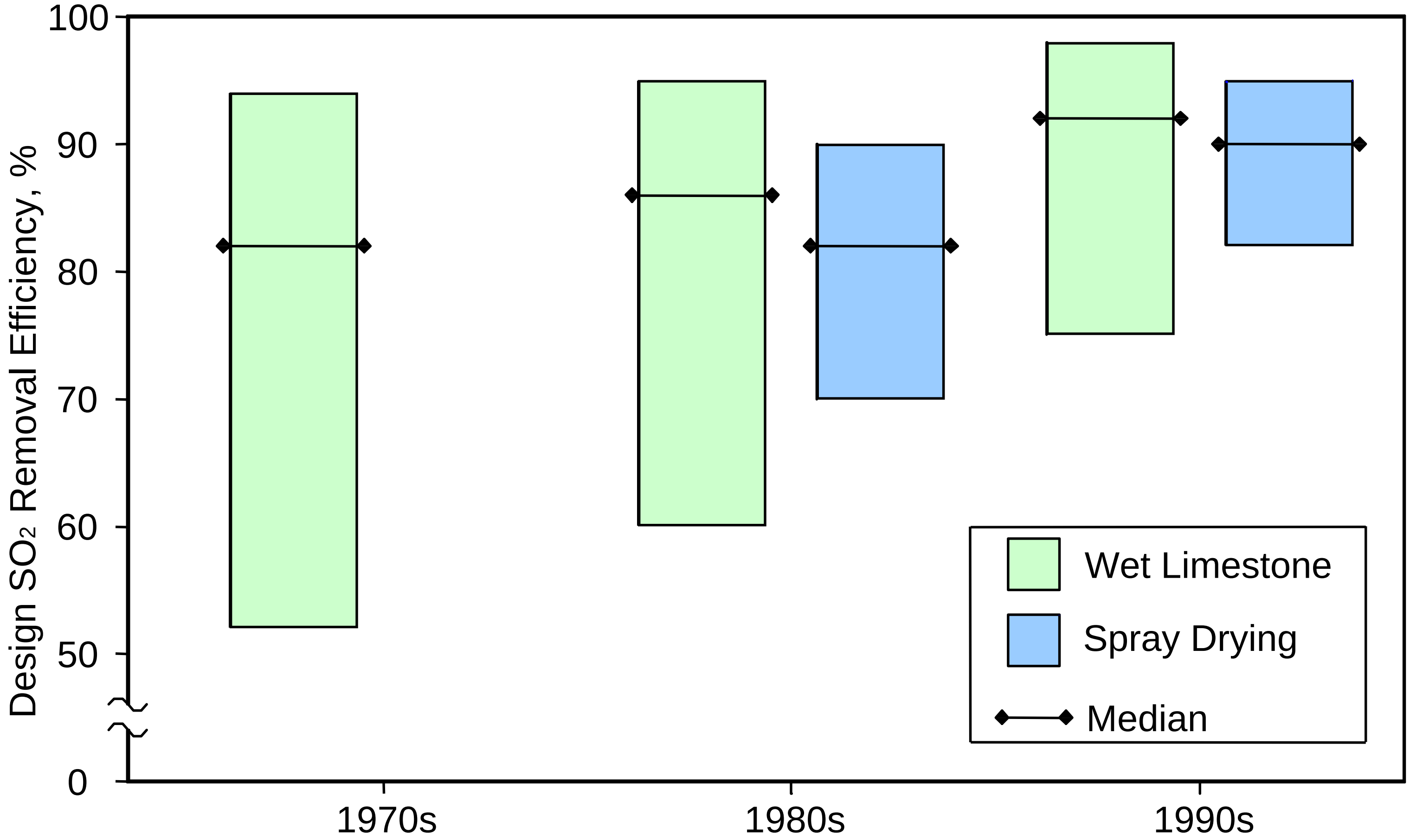
Capacity (MWe) Equipped with FGD

source - EPA

Technology	United States	Abroad	World
Wet	82,092	114,800	196,892
Dry	14,081	10,654	24,735
Regenerable	2,798	2,394	5,192
Total FGD	**98,971**	**127,848**	**226,819**

FGD Performance

source - EPA



PM Control Technologies for Power Plants

- Electrostatic precipitators (ESPs)
  - 72% of U.S. coal-fired boilers, total PM up to 99.9%, fine PM 80-95%
- Baghouses
  - 14% of U.S. coal-fired boilers, total PM up to 99.9%, fine PM 99-99.8%
- PM scrubbers
  - 2% of U.S. coal-fired boilers, total PM 95-99%, fine PM 30-85%
- Cyclones

Hg Control

Effect of existing control technologies

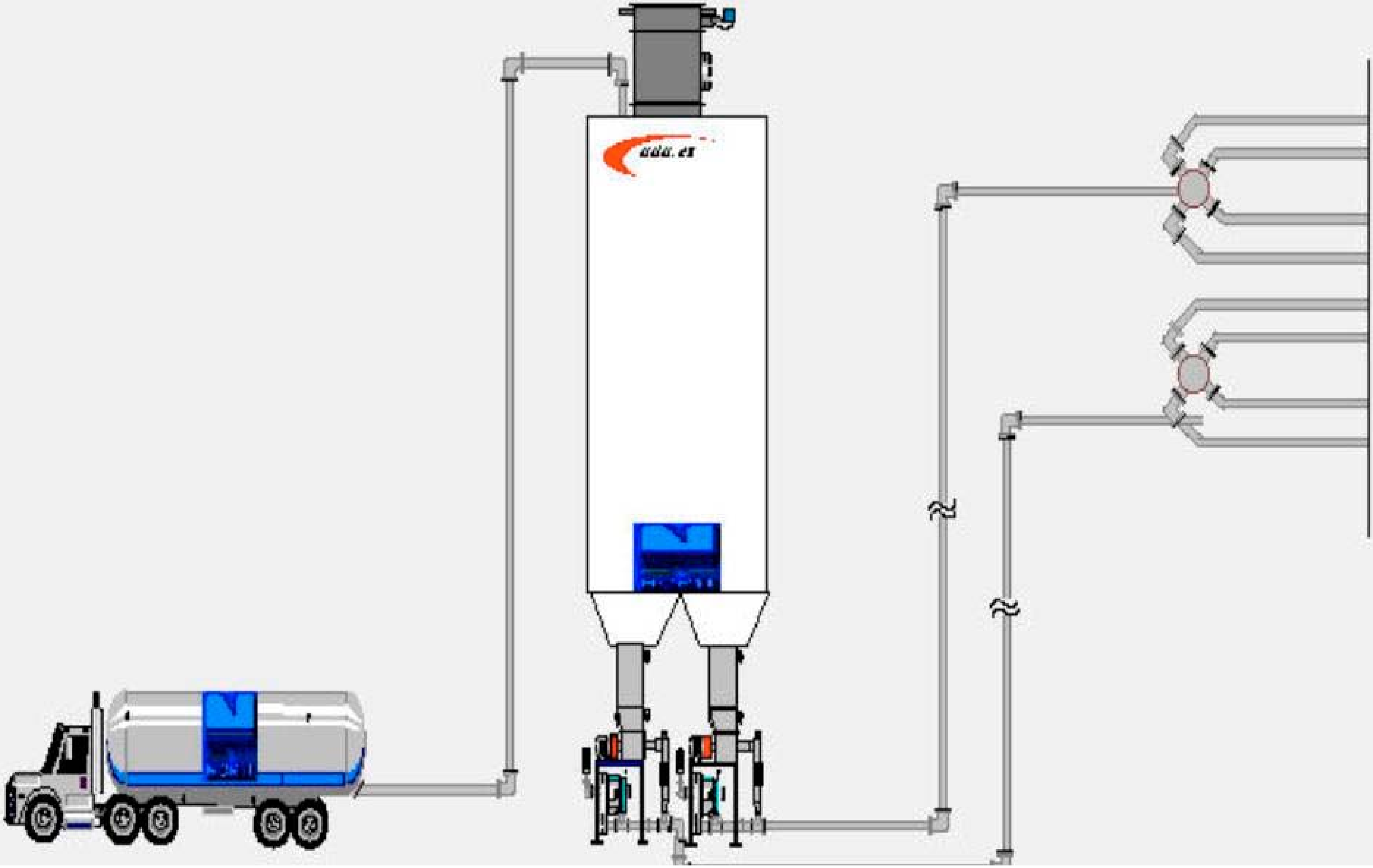
Control Technology	Effect on Oxidized Hg	Effect on Elemental Hg	Effect on Particulate Hg
ESP	Little if any	Little, if any	Efficient removal
Fabric Filter	Adsorption on fly ash (western fuel) Decrease due to oxidation in some cases	Adsorption on fly ash (high LOI ash) Decrease due to oxidation in some cases	Efficient removal
Flue Gas Desulfurization	Efficient removal	Little if any removal Increase due to reduction of adsorbed oxidized mercury in some cases	No effect
SCR	Increase due to oxidation	Decrease due to oxidation	Increase in some cases
SNCR	No effect	No effect	No effect

Mercury-specific control Technologies

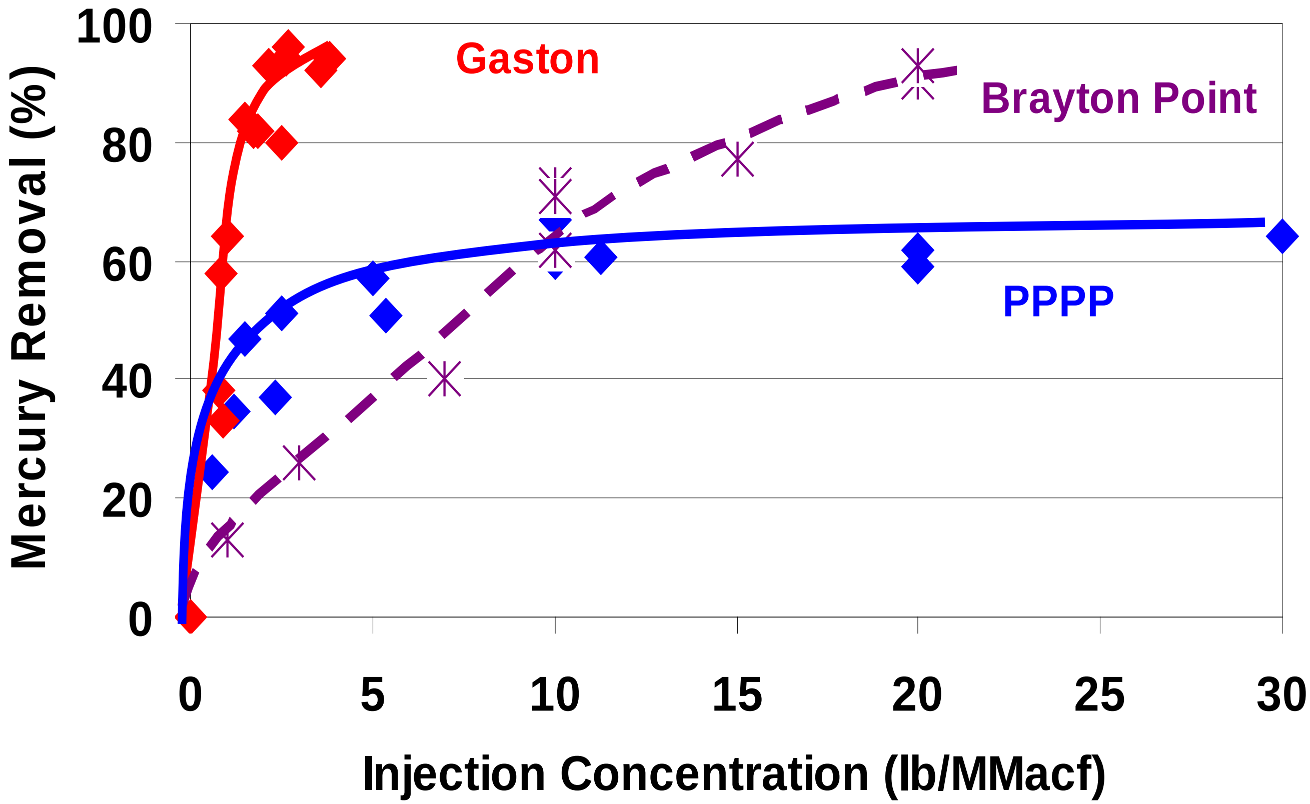
DOE Demonstration Projects

- **Plants without "wet scrubbers"**
  - **Dry Sorbent Injection (e.g. ACI)**
- **Plants with "wet scrubbers"**
  - **Hg oxidation before FGD**

Sorbent Injection System



Mercury Removal Trends with ACI



Source: ADA Environmental Solutions (2003)

Emerging Technologies

- Reduce costs
- Increase performance
- Increase flexibility

Selected Advanced/Emerging Technologies

WGI-EPRI – AQIV 2003

Technology	Process Description	Commercial status	Controlled pollutants	Removal efficiency	Published costs
ECO **Powespan**	Elecro-Catalytic Oxidation followed by scrubber and wet ESP	Pilot and demonstration tests completed 50MW unit under construction	NOx SO2 Hg metals	55-80 45 >80 >90	$150-200/kw
LoTOx **BOC Gases**	Ozone injection for NO and Hg oxidation and removal by wet scrubber	Completed 25MW demo - NOx only	NOx Hg	90-95 90+	NA
Pahlman Process **Enviroscrub**	Dry injection of Pahlmalite sorbent	Pilot work ongoing NOx-SO2 demonstrated separately	NOx SO2	95+ 99	$150/kw
AIRborne **B&W** **AIRborne Technologies**	Dry sodium injection or wet sodium scrubbing with multiple options for fertlizer products	CCPI project - 525 MW start-up 2007	NOx SO2 HCl metals	40 85-95 90 NA	$170/kw
K-fuel **KFx**	High energy fuel from low quality coal feed stocks	Testy burns completed of K-fuel in WY	NOx SO2 Hg	33 50 70	NA
Mitsui-BF process **Marsulex**	Carbon bed absorption with regeneration NH3 injection for NOx control	Several installation oversees	NOx SO2 Hg PM	60-80 80-99 85-90 <15mg/Nm3	$110-140/kw
GSA **FLSmith/Airtech**	CFB Absorber with lime injection	Commercial largest unit to date is 125MW	SO2 SO3 Hg	>95 >95 50-90	$150/kw

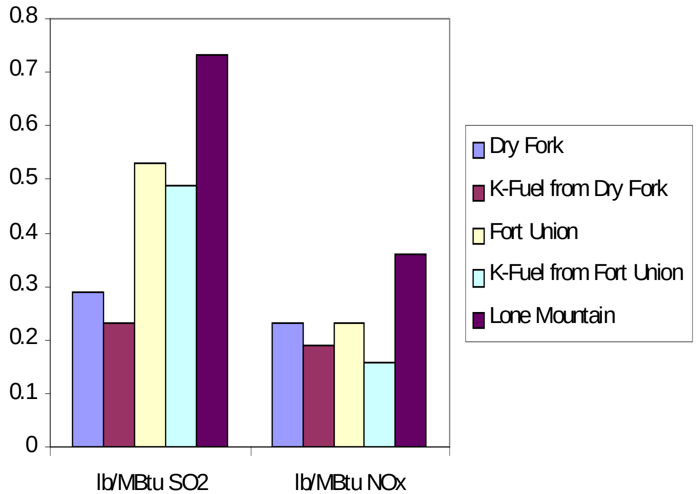
NOx-SO2-Hg
Electro-Catalytic Oxidation™ (ECO)

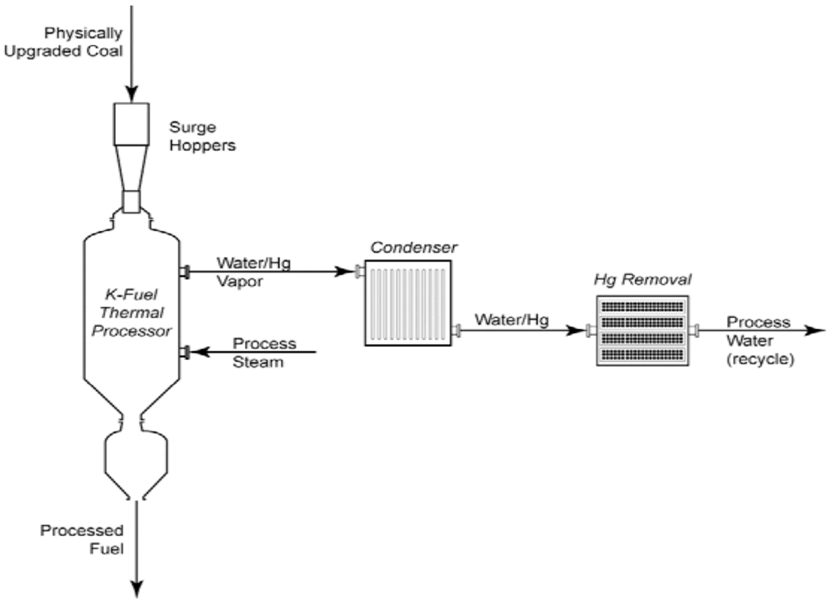
source - EPA

– Process
  - Barrier discharge reactor oxidizes gaseous pollutants
  - Products of the oxidation are captured in ammonia scrubber and wet ESP
  - Ammonium nitrate and sulfate (fertilizers) byproducts

- Status
  - Pilot scale test at approximately 2-4 MW equivalent
  - Projected reductions: 90, 98+, 80-90, and 95% of NO_x, SO_2, Hg, and fine PM
  - DOE-sponsored testing to evaluate mercury removal performance

K-Fuel®





- **K-fuel is a beneficiated coal derived from western subbituminous coals that is lower in ash, higher in BTU value, and produces lower pollutant emissions than parent coals.**
- **Test burns at the SRI - significant reductions in NOx and SO_2**
- **First commercial plant being built at the Black Thunder mine in Wright, Wyoming; completion by 2004; capable of producing more than 700,000 tons per year of K-Fuel**

An example

Compliance with regulations in the Northeast

Background

- Environmental requirements for coal-fired plants (*state regulations – post OTC NOx budget, title IV*)
  - Multi–pollutant
  - 2006 compliance
    - Must minimize R&D risks

- The Station
  - Real Estate constraints
    - Configuration options reduced

Environmental Requirements

- **The regulations**
  - **Multi-pollutant controls**
  - **Compliance 2006**

- **NOx - 1.5 lb/MWh (~55% reduction from SNCR)**
  (~75% reduction from LNBs)

- **SO_2 - 3.0 lb/MWh (~75% reduction)**

- **CO_2 - 1800 lb/MWh**

- **Hg - 85% - 95% (two phases)**

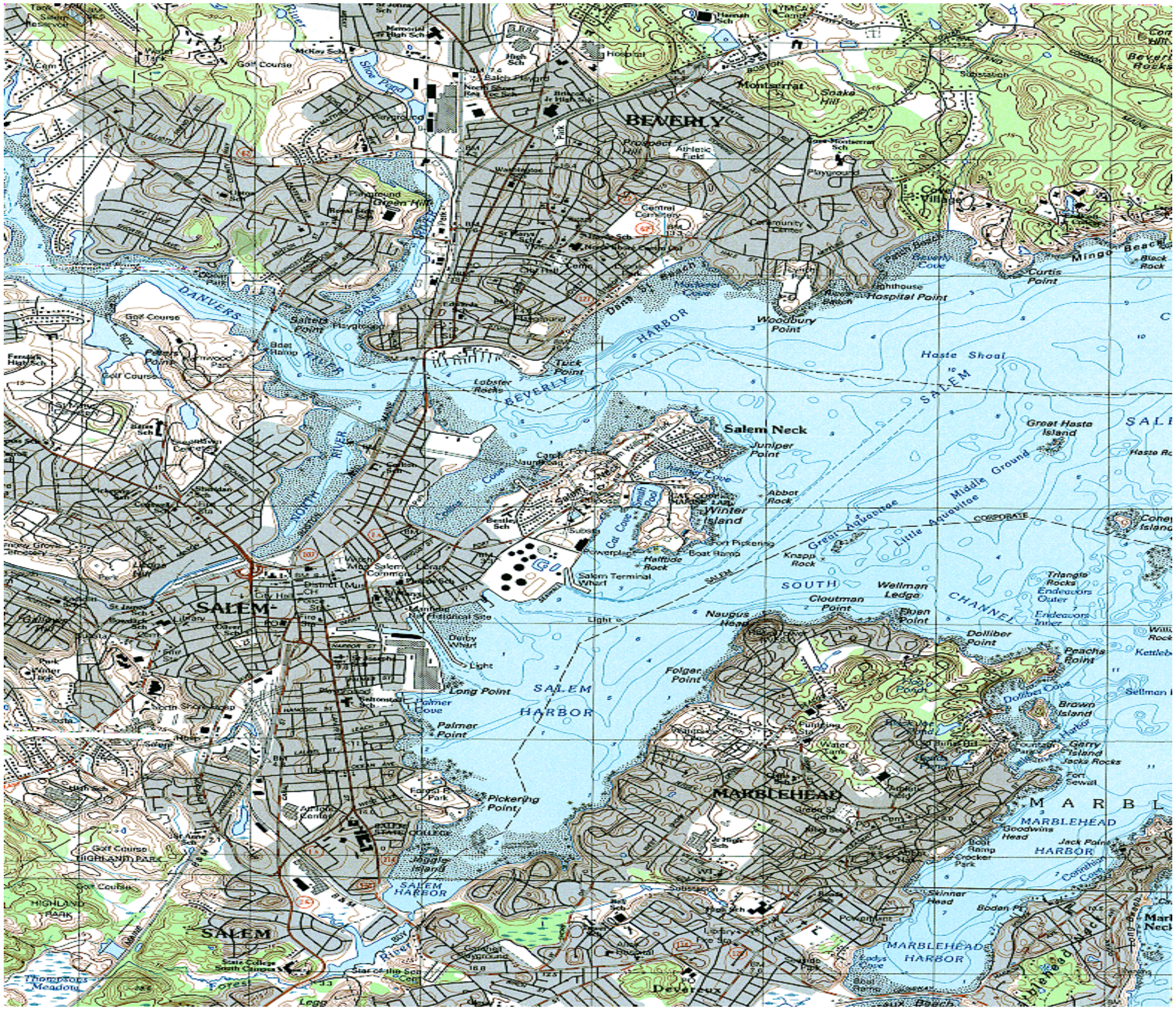
Other Environmental "Forces"

- **Strong anti-coal pressure**
- **Solid waste disposal**
  - **Few options**
  - **High cost**
- **Bottom line…**
  - **Low emission (high reductions) targets**
  - **Short time frames**
  - **Multi pollutant considerations**
  - **Still some uncertainty**

The Station

- 4 units - ~750MW
  - Units 1,2 - ~80MW coal
  - Unit 3 – 150MW coal
  - Unit 4 – 450MW oil
- Coal units
  - Low sulfur (<1%) coals
  - Wall-fired boilers
  - Low NOx burners
  - OFA (unit 3)
  - SNCR

The Station (cont'd)



The Station (cont'd)

- Large ESPs (>450 SCA)
- Other performance information
  - NOx: 0.45-0.55 lb/Mbtu (w/o SNCR)
  -
  - SO2: <1.2 lb/Mbtu

    ~0.3 lb/Mbtu (w/ SNCR)
  - Hg: 80-90% capture (baseline)
    - ICR phase III participant
    - MA Hg test program (2000-2002)
    - DOE Hg control full-scale demo
  - Carbon-in-ash: 20-30%

The Station (cont'd)

Summary…

- Older vintage, small units, space-constrained plant
  - Some technical options not viable/economic
- "Neighborhood" challenging for power plant
  - technical choices must be "compatible" w/ political realities
- Baseline emissions low
  - Important consideration for overall compliance strategy

Options

- Conventional, individual unit technologies
  - SCR
  - FGD (wet or dry)
  - Hg Sorbent injection
- New multi-pollutant technologies
  - Powerspan
  - Airborne
  - Enviroscrub
- "Hybrid" innovative application of commercial technologies

Options (cont'd)

- Conventional, individual unit controls
  - Space constraints
  - High cost
- New multi-pollutant technologies
  - Technology risk
  - Uncertain cost
- Innovative application of commercial technologies
  - Lower technical risk
  - Lower cost (~$35M) savings

Proposed Project

- Emission Control Technologies
  - NO_x control using clean-side SCR
  - SO_2 control using SDA
  - PM control using existing ESPs and new FF
  - Acid gas control using the SDA and new FF
  - Mercury control using the SDA/FF (ACI if necessary)

- Multi-pollutant Control
  - Single pollution control train for multiple emissions from three three coal units

- Byproduct Utilization, Treatment and Disposal
  - Fly ash beneficiation with integrated mercury control technology
  - The FF may allow possible reuse of SDA byproducts

Summary

- Project approach utilizes combination of innovative application with proven, low risk technologies
- Overall emissions reductions capabilities beyond MA requirements
- Cost savings of ~$35M vs. conventional deployment of NOx, SO2 controls
- Ash beneficiation carries large incentive (high disposal costs in the Northeast)

Thank you!

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