

Presented to  
*Mercury Control Technology R&D  
Program Review Meeting  
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**Mercury Removal in a Non-Thermal Plasma Based  
Multi-Pollutant Control Technology for Utility  
Boilers**

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## **Electro-Catalytic Oxidation (ECO®) Technology**

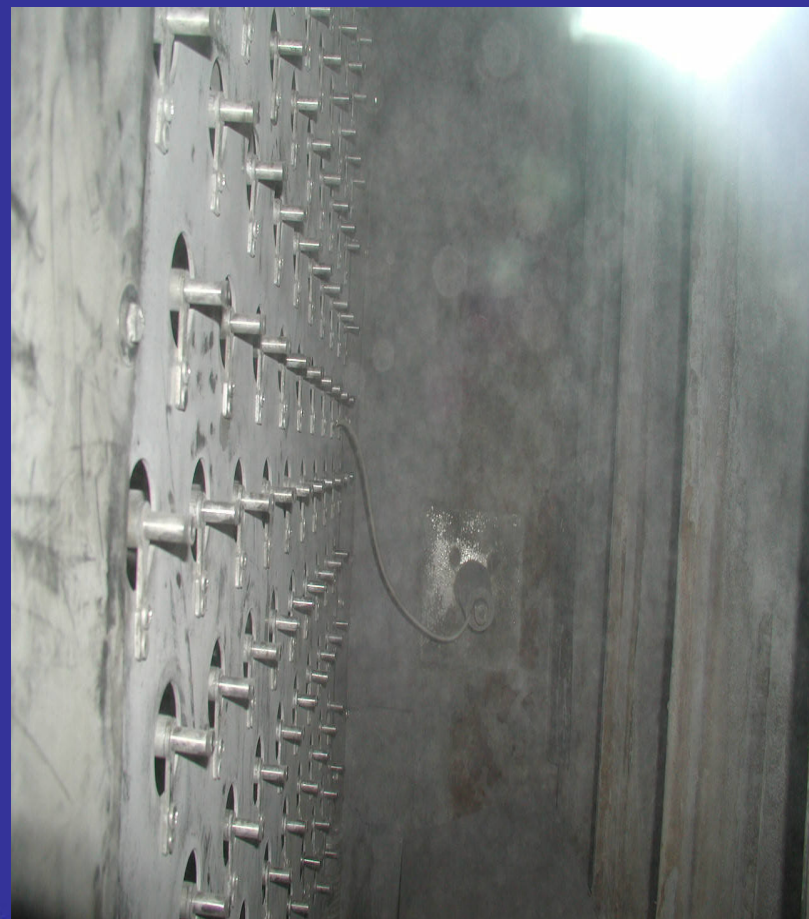
- **Integrated control technology for coal-fired boilers designed to achieve high removal of:**
  - **SO<sub>2</sub> (98%)**
  - **NO<sub>x</sub> (90% based on 0.4 lb/MMBTU inlet NO<sub>x</sub>)**
  - **PM<sub>2.5</sub> (>95%)**
  - **Hg (80 to 90%)**
- **Pilot testing on slip stream from coal fired boiler**
  - **Started in Feb '02**
  - **Consistently meets removal goals**

## **DOE Funded Pilot Test Program**

- **\$2.8 million cooperative agreement with U.S. DOE (NETL) for optimizing mercury removal in ECO**
- **Goal is to demonstrate Hg removal while maintaining high removal of SO<sub>2</sub>, NO<sub>x</sub> and PM**
- **PS Analytical Sir Galahad semi-continuous monitoring of gas phase mercury**
- **Ontario-Hydro gas phase Hg measurement**
- **Measurement of mercury in ash and liquid streams**

## Barrier Discharge Reactor

- High energy electrons create oxidizing radicals (O, OH) from  $O_2$  and  $H_2O$
- Radicals oxidize pollutants
  - HgO from Hg
  - $H_2SO_4$  from  $SO_2$
  - $NO_2$  and  $HNO_3$  from  $NO_x$
- Coaxial electrode design



## Ammonia Scrubber

- **Ammonia based scrubbing**
  - Removes  $\text{SO}_2$ ,  $\text{HNO}_3$ ,  $\text{NO}_2$
  - Produces fertilizer co-product
- **Consists of:**
  - Gas cooling and saturation
  - Scrubbing
  - Ammonia vapor absorption
- **Operate to prevent release of Hg**





## Wet Electrostatic Precipitator

- **Collects:**
  - **Hg<sup>2+</sup> not captured in scrubber**
  - **Aerosols (NH<sub>4</sub>HSO<sub>4</sub>, NH<sub>4</sub>NO<sub>3</sub>, NH<sub>4</sub>Cl) produced in the scrubbing process**
  - **Fine particulate matter (PM<sub>2.5</sub>)**
  - **Air toxic compounds**

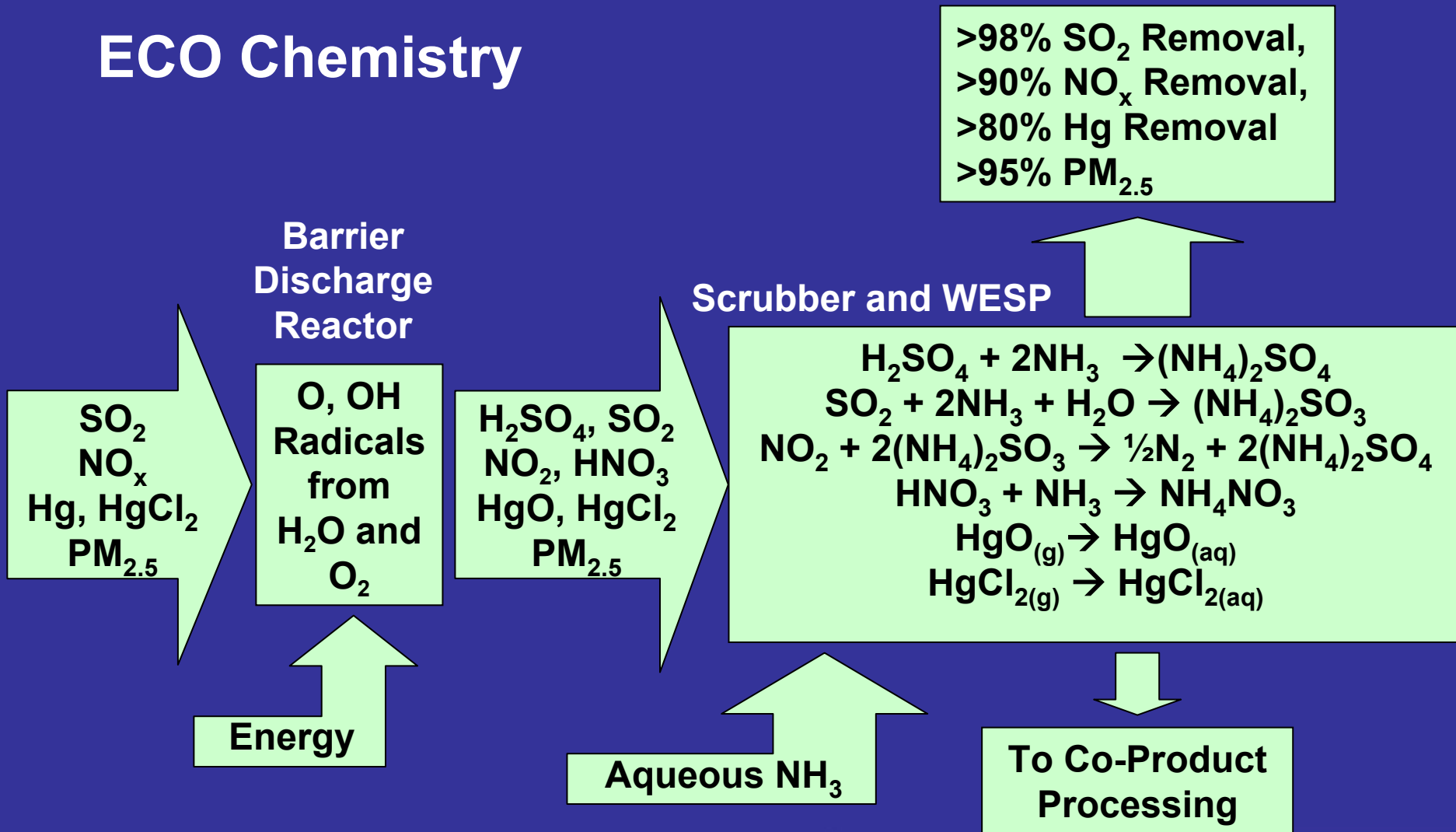


## Co-Product Processing

- Ammonia addition to maintain pH at ~6
- Filtration to remove ash and insoluble metals
- Sulfur impregnated activated carbon (Mersorb LW) to remove Hg from ammonium sulfate-nitrate co-product

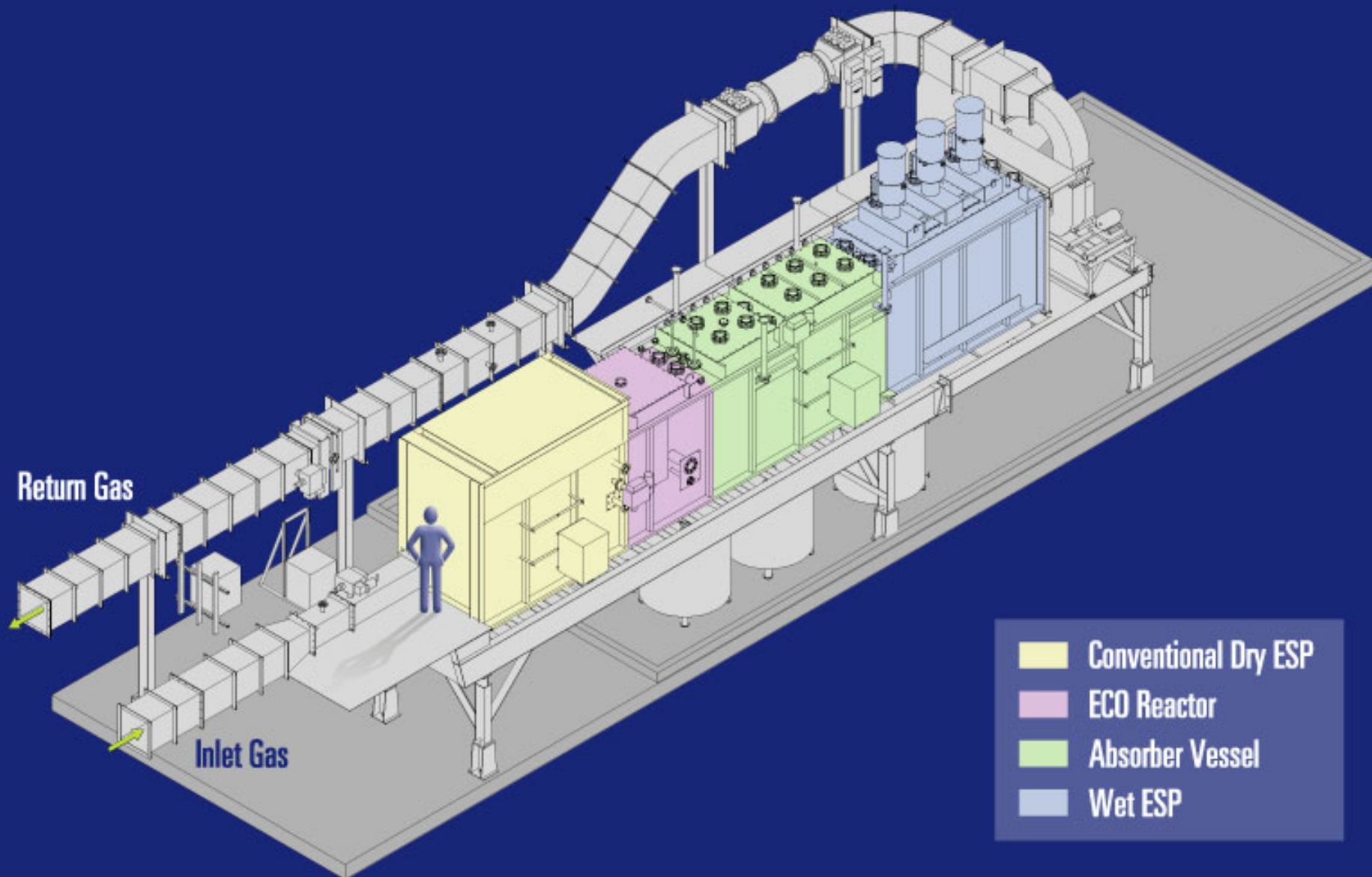


# ECO Chemistry





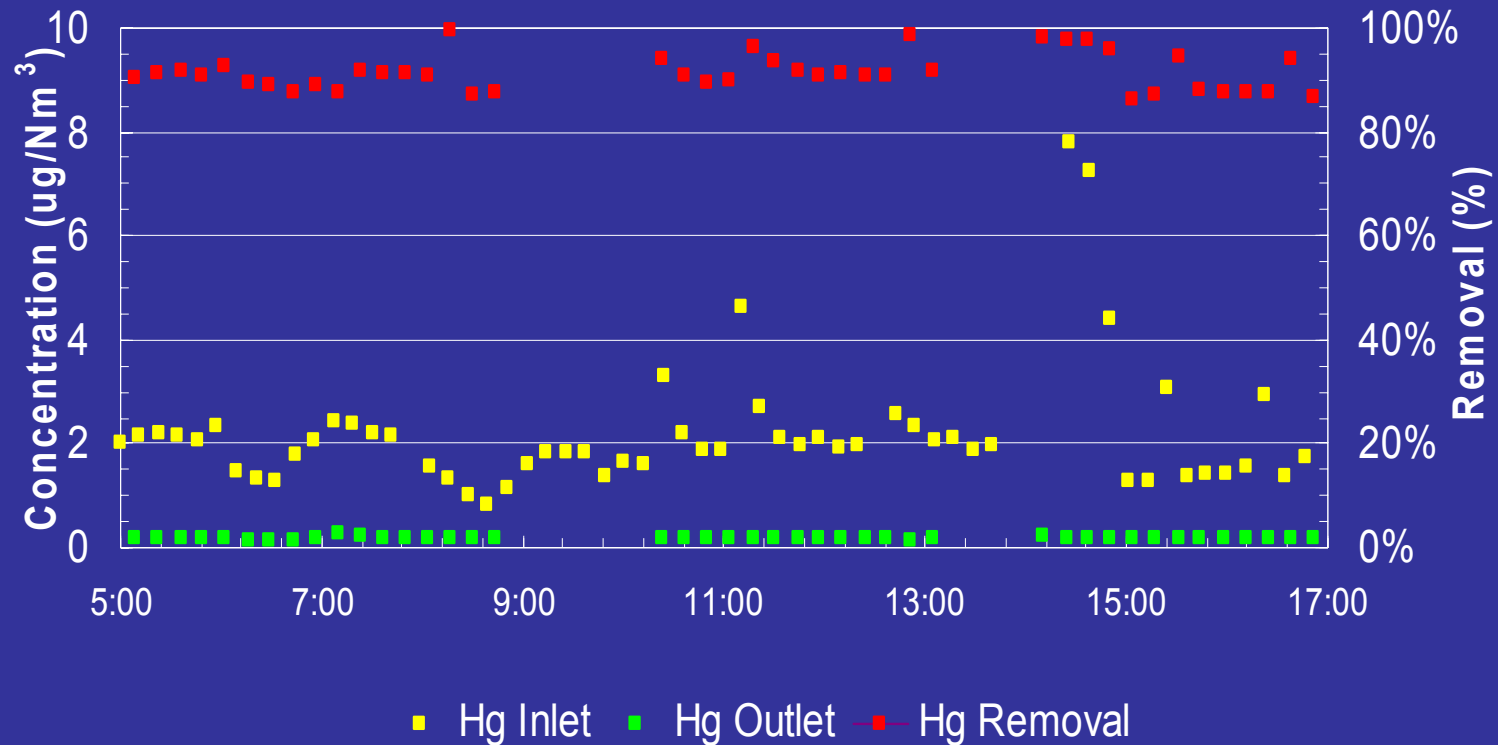
# ECO™ Pilot Unit at FirstEnergy's R.E. Burger Plant



## Pilot Testing

- **1-2 MW slipstream from a 156 MW boiler, flue gas drawn from Plant's ESP inlet**
- **PS Analytical Sir Galahad with Baldwin Environmental sample conditioners and probes for measurement**
- **Routinely achieved >80% Hg capture**
  - **Verified by Ontario-Hydro testing**

## Pilot Data: >85% Hg Removal



Consistent with Ontario-Hydro result of 88% removal

## Ontario-Hydro Test Results

- **Performed by Air Compliance Testing**
- **Concentrations in ug/Nm<sup>3</sup>**

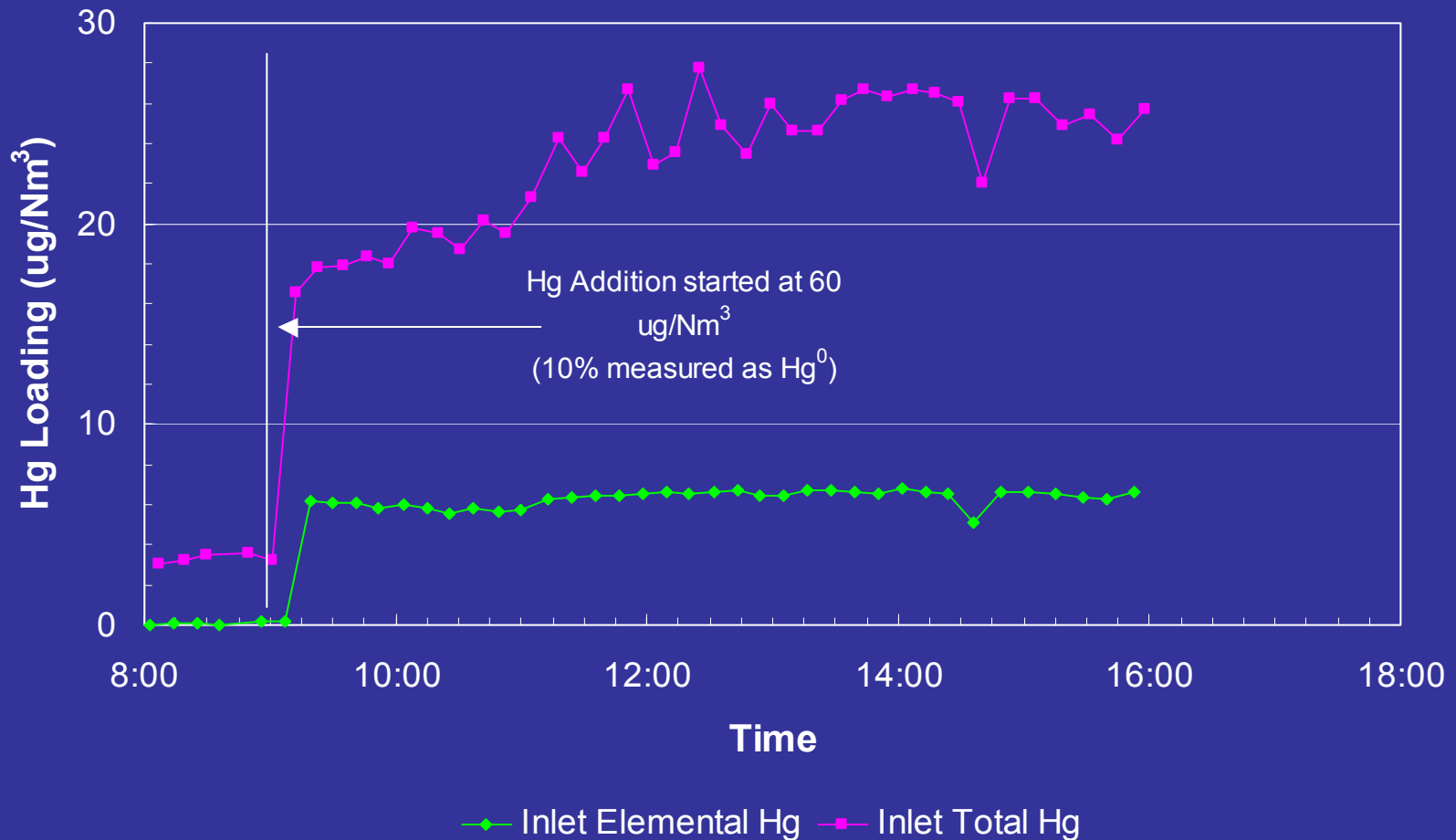
<b>Hg Fraction</b>	<b>ECO Inlet</b>	<b>ECO Outlet</b>	<b>Removal</b>
<b>Particle Bound Hg</b>	<b>0.62</b>	<b>0.016</b>	<b>97.4 %</b>
<b>Oxidized Hg</b>	<b>5.81</b>	<b>0.022</b>	<b>99.6 %</b>
<b>Elemental Hg</b>	<b>0.16</b>	<b>0.75</b>	
<b>Total Hg</b>	<b>6.59</b>	<b>0.79</b>	<b>88.0 %</b>

## Pilot Testing with Hg Addition

- Native Hg is >90% Hg<sup>2+</sup>
- Addition of Hg<sup>0</sup> results in:
  - Small increase in Hg<sup>0</sup> (~10% of added Hg)
  - Large increase in Hg<sup>2+</sup> (~30-40% of added Hg)
  - Large fraction of added Hg not reported in gas phase measurement (~60 to 70%)



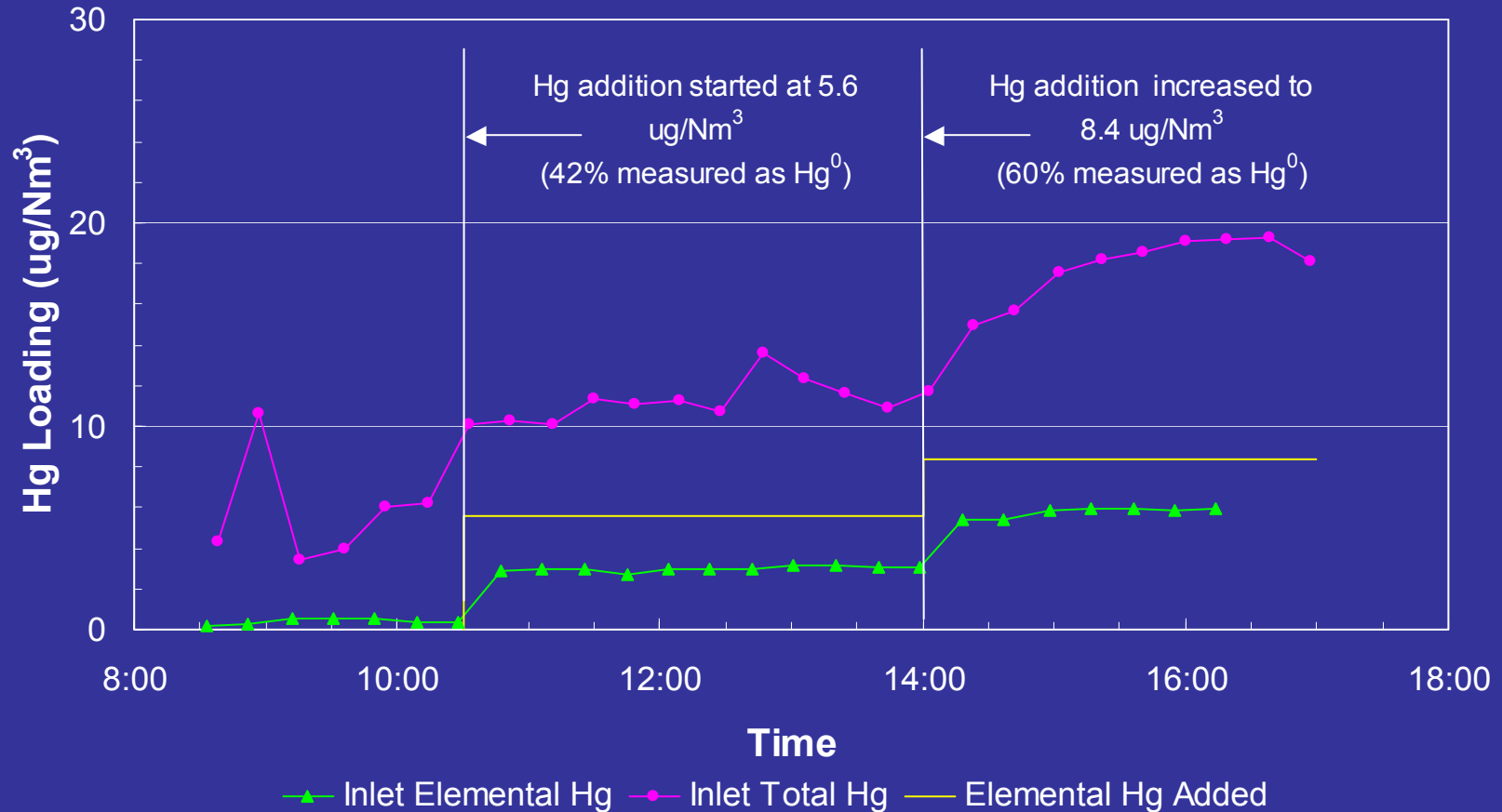
## Hg Addition with Flue Gas from ESP Inlet



## Pilot Testing

- Apogee QSIS probe installed for sampling inlet gas reduced effect of ash on Hg measurement
  - Bulk of added Hg still measured as Hg<sup>2+</sup>
- Ductwork to draw flue gas from plant's ESP outlet installed in July '03
  - Removed pilot cyclone separator, de-energized pilot dry ESP
- Reduced ash loading by more than a factor of 10
- Able to inject and measure Hg<sup>0</sup>

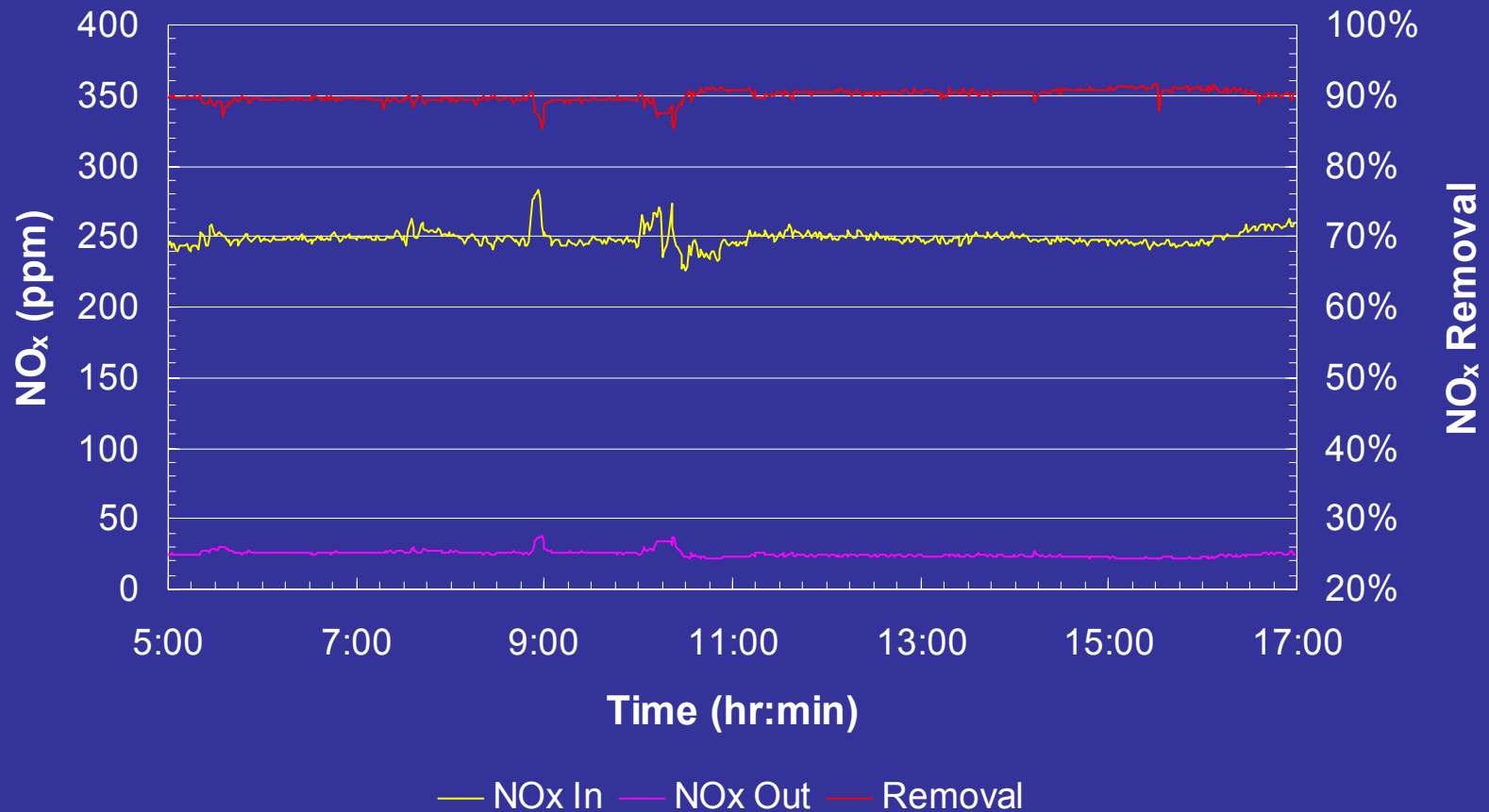
## Hg Addition with Flue Gas from ESP Outlet



## Continued Pilot Testing

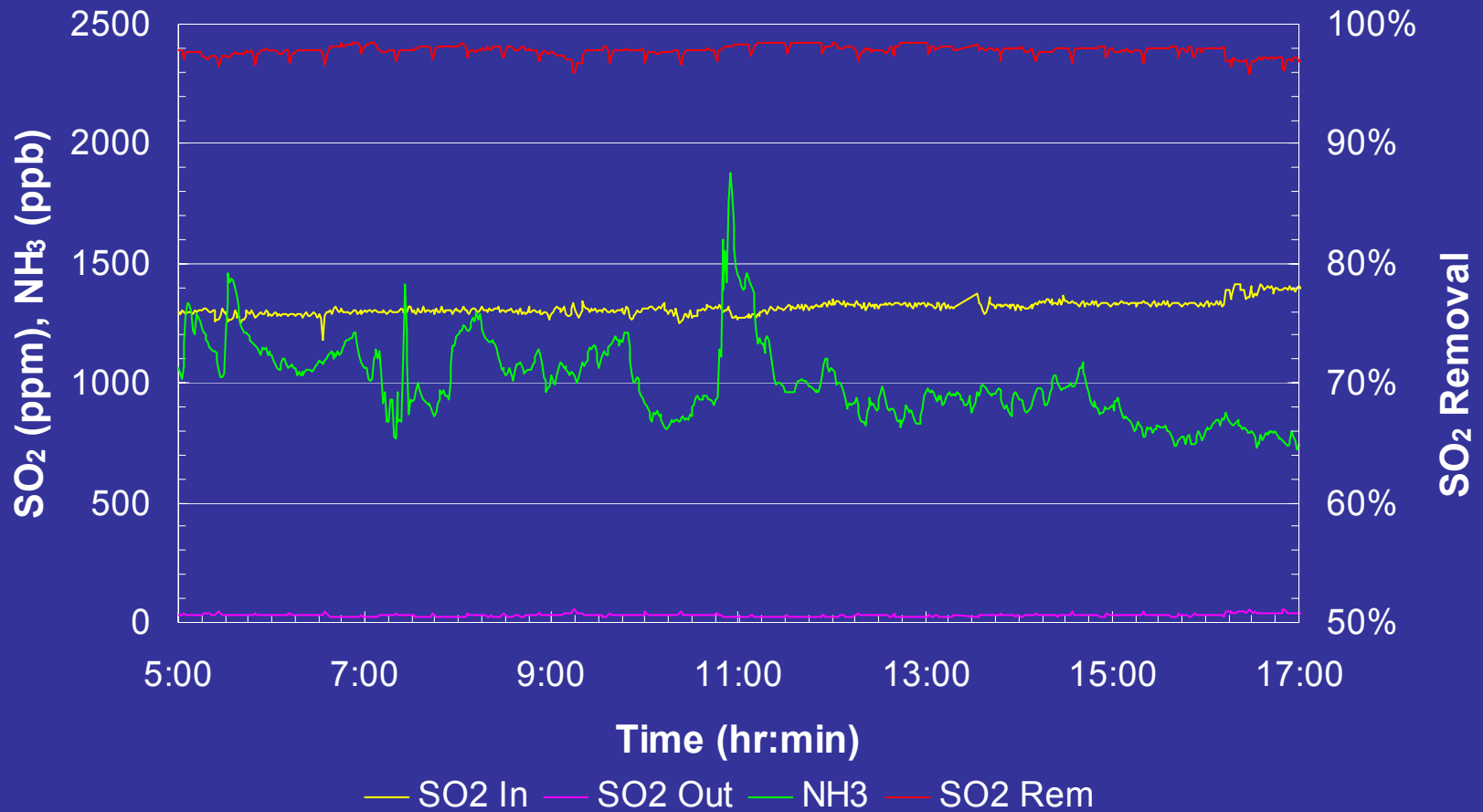
- **Tests with addition of elemental Hg to gas stream**
  - **Demonstrate oxidation and capture of elemental Hg**
- **Hg material balances on process streams**
  - **Testing to determine fate of Hg throughout ECO process**
- **Independent measurement of Hg (Ontario-Hydro), metals (method 29), and particle size distribution**

## Pilot Data: 90% NO<sub>x</sub> Removal





## Pilot Data: 98% SO<sub>2</sub> Removal



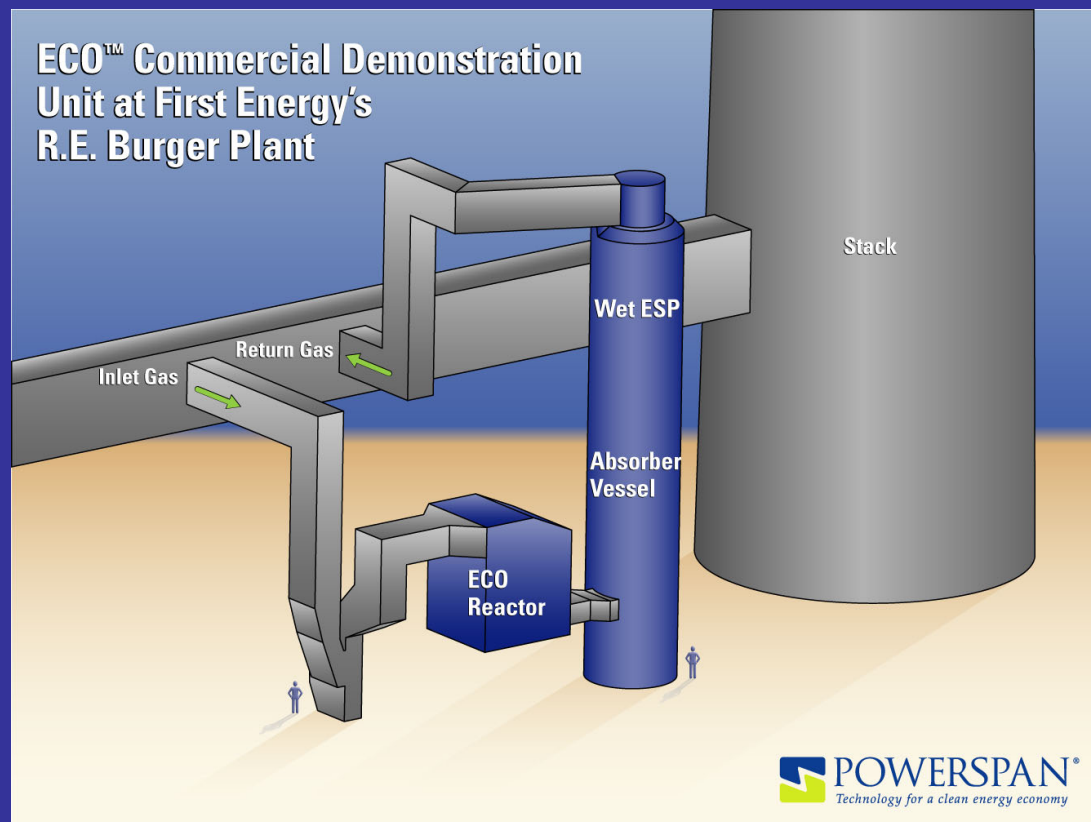
## Pilot Data: Co-Product Processing

- Activated carbon treatment reduces Hg concentration from  $>200$  ppb to less than minimum detectable levels ( $<20$  ppb)
- Ammonium sulfate-nitrate crystals contained less than minimum detectable levels of Hg



## Commercial Demonstration Unit

- Installation at FirstEnergy's R.E. Burger Plant
- 50 MWe slipstream from a 156 MWe boiler
- Vertical scrubber and wet ESP in a single vessel
- Operation in first quarter 2004



## Further Information

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