FirstEnergy

DOE/NETL Mercury Control Technology Conference
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ECO Multi-Pollutant Control for Coal-fired Boilers

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Acknowledgements

- **ECO Development Partners**
  - DOE/NETL
  - Powerspan Corp.
  - FirstEnergy Corp.
  - Ohio Coal Development Office/Ohio Air Quality Development Authority

Electro-Catalytic Oxidation (ECO) Overview

- Multi-pollutant control technology removes:
  - **SO_2 and SO_3**
  - **NOx**
  - **Hg and other metals**
  - **Fine particulate matter ($PM_{2.5}$)**
  - **Hazardous air pollutants (HAPs), such as HCl and HF**
- Produces ammonium sulfate fertilizer, which is sold
- No liquid discharge, no landfill waste
- Reduces outages for installation and maintenance
- Potential to add cost-effective CO_2 capture capability

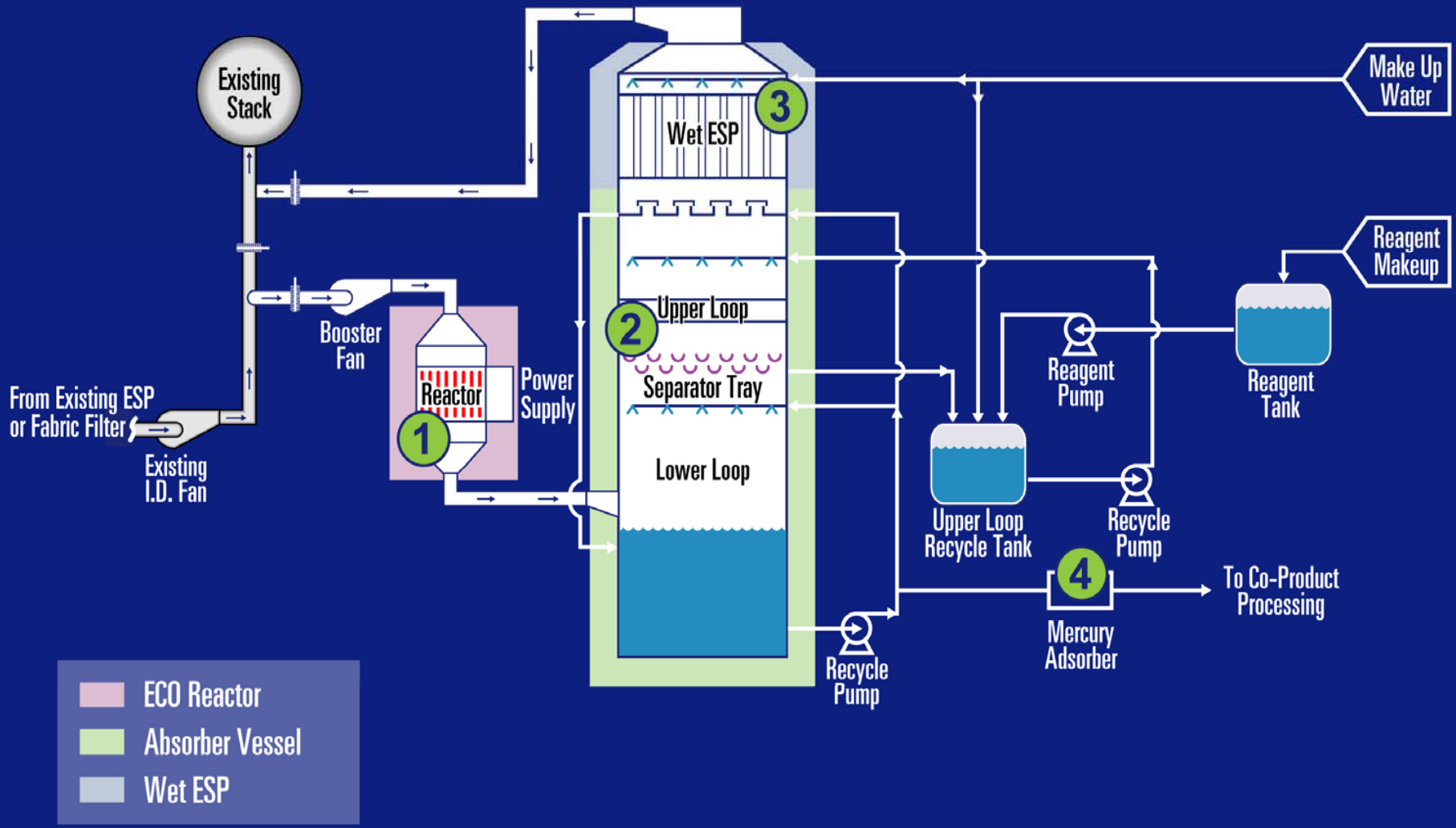
ECO® Technology – **What it does**

- Multipollutant Control Process that reduces
  - SO_2
  - NOx
  - Hg
  - Fine Particulate Matter (Pm2.5)
  - Hazardous Air Pollutants (HAPs)
  - Acid gases (like SO_3)
- And produces ammonium sulfate fertilizer
  - Ammonium sulfate fertilizer is safer alternative than ammonium nitrate that can be used in explosives and anhydrous ammonia which is a toxic gas
  - Ammonium sulfate unlike other fertilizers does not require deep-tilling that releases a ton of CO_2/acre
  - Ammonium sulfate provides the sulfur nutrient needed for plants like corn, soybeans and alfalfa

ECO® Technology – **How it does it**

- Gas processing steps:
  1. Dielectric barrier discharge reactor
  2. Ammonia-based absorber tower
  3. Wet Electrostatic Precipitator (WESP)
- Mercury is removed from liquid stream and collected in compact charcoal filter
- Ammonium sulfate fertilizer is resulting co-product which can be readily absorbed by U.S. fertilizer market
- Use of ECO® also preserves flyash sales to the concrete industry, which abates CO_2 that would be created by making more cement. Use of more standard technologies could ruin flyash for sale by adding ammonia or activated carbon.

ECO® Process Flow

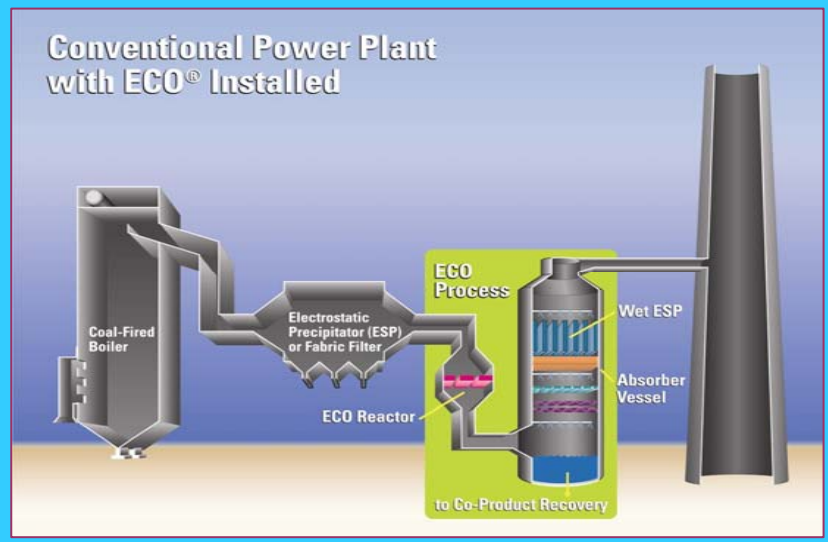


ECO Burger Commercial Unit

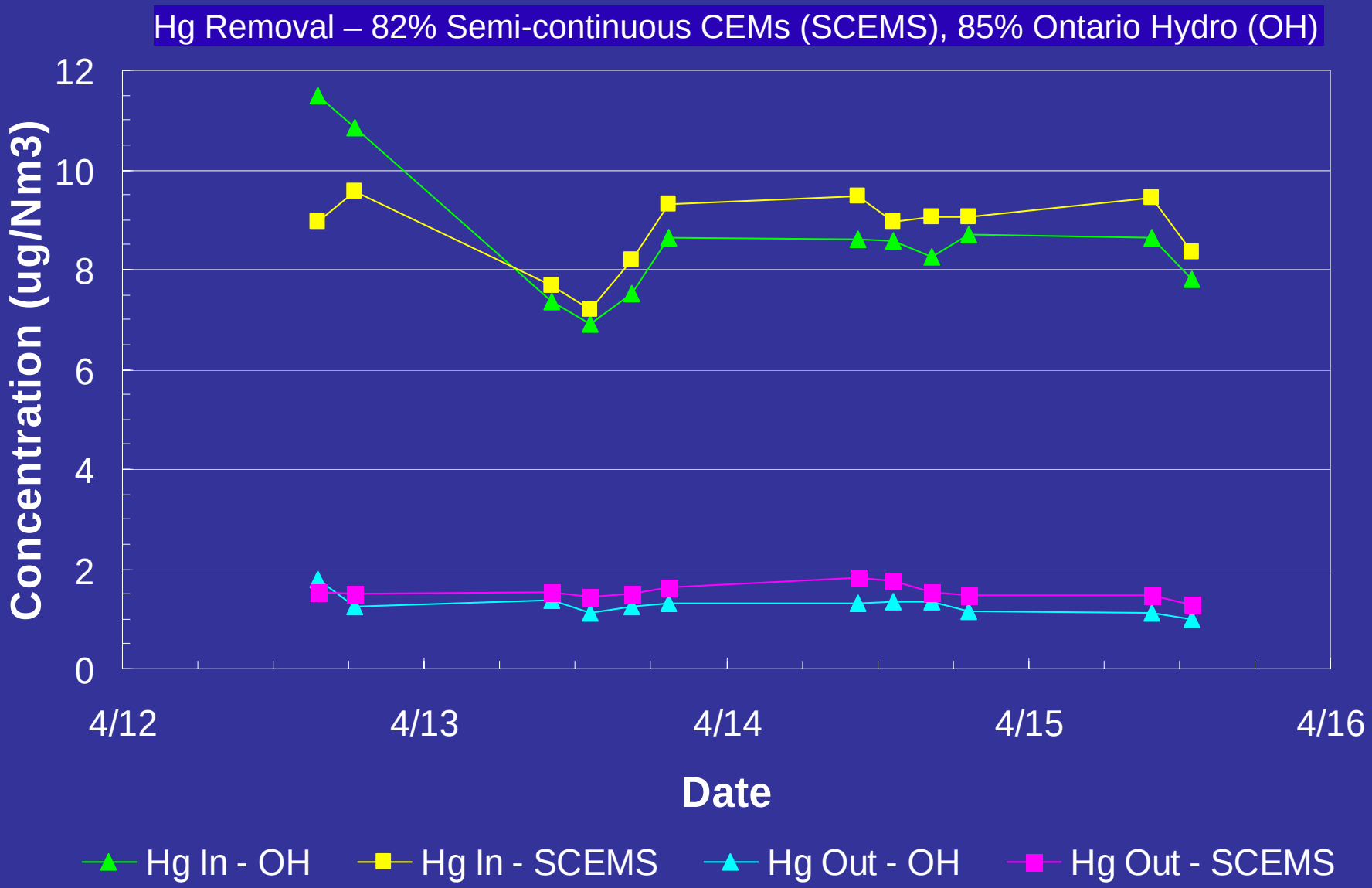
- 30 MW ECO at FirstEnergy's Burger Plant, operating >3 yrs
- Demonstrated commercial components and scalability
- 180-day performance test completed successfully; ECO qualified as BACT
- EPRI study concluded ECO as reliable as conventional technology (≥99% available)
- FirstEnergy plans full-scale ECO system for Burger Units 4 and 5 - 312 NMW

ECO Mercury Control

- **Elemental mercury oxidized in ECO reactor to $HgCl_2$ or HgO – co-benefit of NOx control. Reactor oxidizes 35-50% of Hg^O**
- **$HgCl_2$ captured in ammonia scrubber. HgO captured in wet ESP**
- **ECO has been commercially demonstrated to capture 90+% oxidized mercury and 80-85% total mercury.**
- **Tekran mercury analyzers used to determine inlet and outlet mercury concentrations. RATA test confirms readings.**
- **All pollutants captured from the flue gas by ECO go into the liquid, including mercury**



Total Hg Measurement Comparison

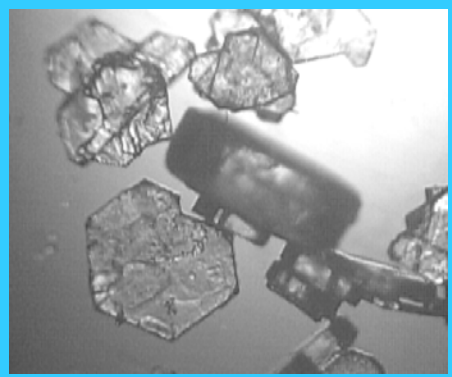


Actual BCU Operating Data 2006

Run	Date and Time			Inlet			Outlet			Hg Removal		
#	Operating Period			Hg^0	Hg^T	Hg^0/Hg^T	Hg^0	Hg^T	Hg^0/Hg^T	Total	Hg^{+2}	Total
	Start	Stop	Hrs of Ops	(ug / Nm³)	(ug / Nm³)	(%)	(ug / Nm³)	(ug / Nm³)	(%)	(%)	(%)	(lbm)
1	1/5 11:00	1/12 12:00	170.0	0.4	5.0	9.0	1.2	0.8	160.2	85.8	93.2	0.20
2	1/17 15:00	1/22 19:00	125.0	0.7	4.9	14.6	0.7	0.7	102.7	85.7	101.2	0.09
3	2/2 3:00	2/9 12:00	169.1	0.4	4.1	9.5	0.7	0.9	77.4	73.9	86.6	0.16
4	2/16 6:00	2/23 4:00	167.0	0.7	5.8	11.3	0.5	0.5	86.1	90.6	102.1	0.24
5	3/3 0:00	3/9 13:00	153.2	0.7	6.8	10.7	0.6	0.6	92.6	90.2	101.6	0.26
6	3/14 12:00	3/23 13:00	213.3	0.6	6.8	9.1	0.8	0.9	90.7	86.0	94.9	0.34
7	4/3 5:00	4/7 12:00	100.7	0.5	6.0	8.7	0.8	0.8	97.9	86.5	95.0	0.15
8	4/17 10:00	4/20 15:00	78.0	0.6	8.6	7.5	1.1	1.1	102.4	86.7	94.1	0.15
9	4/25 13:00	5/4 10:00	213.5	0.7	9.9	7.5	1.0	1.0	92.5	89.5	96.7	0.52
10	5/9 10:00	5/16 10:00	168.1	0.5	5.6	8.7	0.7	0.7	97.4	87.5	96.2	0.15
11	5/30 10:00	6/2 11:00	73.6	0.6	5.6	10.9	0.9	0.9	103.8	79.5	94.7	0.07
12	6/7 19:00	6/15 11:00	185.0	0.5	5.4	8.9	0.7	0.8	90.7	84.1	93.5	0.26
13	6/22 12:00	6/29 14:00	170.8	0.6	6.9	8.6	0.8	1.1	72.0	82.6	91.7	0.23
14	7/11 17:00	7/20 12:00	212.0	0.4	6.0	7.4	1.9	1.9	96.8	71.0	73.6	0.18
15	7/25 8:00	7/28 18:00	78.6	0.5	5.6	9.0	0.7	0.7	92.4	74.8	95.6	0.09
16	8/2 14:00	8/10 3:00	182.0	0.4	5.9	7.1	0.5	0.5	94.7	90.9	98.1	0.22
17	8/15 13:00	8/24 13:00	217.0	0.4	5.6	6.4	0.4	0.5	89.7	91.1	97.5	0.19
18	9/7 2:00	9/14 9:00	175.9	0.4	6.8	6.4	0.7	0.8	93.0	88.5	94.6	0.26
19	9/19 22:00	9/27 14:00	185.0	0.4	6.1	7.2	0.4	0.5	94.4	92.3	99.6	0.23
20	10/3 10:00	10/11 15:00	198.0	0.4	6.5	6.7	1.3	1.4	92.2	79.5	84.8	0.25
21	10/17 8:00	10/25 0:00	184.8	0.6	6.4	9.0	0.5	0.6	87.9	90.8	99.5	0.25
22	10/31 5:00	11/9 13:00	218.2	0.5	5.4	8.6	0.5	0.5	100.1	87.9	99.2	0.28
23	11/14 17:00	11/21 10:00	151.1	0.4	5.4	7.4	0.7	0.8	97.2	84.3	92.8	0.16
24	11/28 19:00	12/7 6:00	203.6	0.6	5.9	10.5	0.9	0.9	96.1	84.3	94.3	0.23
25	12/12 2:00	12/18 20:00	158.5	0.7	5.5	13.1	0.8	0.8	96.7	84.7	98.7	0.16

ECO Mercury Control

- **ECO liquid is filtered through compact carbon bed to remove captured Hg to below detectable limits**
- **Mercury-free liquid processed to dry fertilizer and sold**
- **After approximately 1 year, carbon filters replaced, and saturated filters disposed in a hazardous waste landfill**

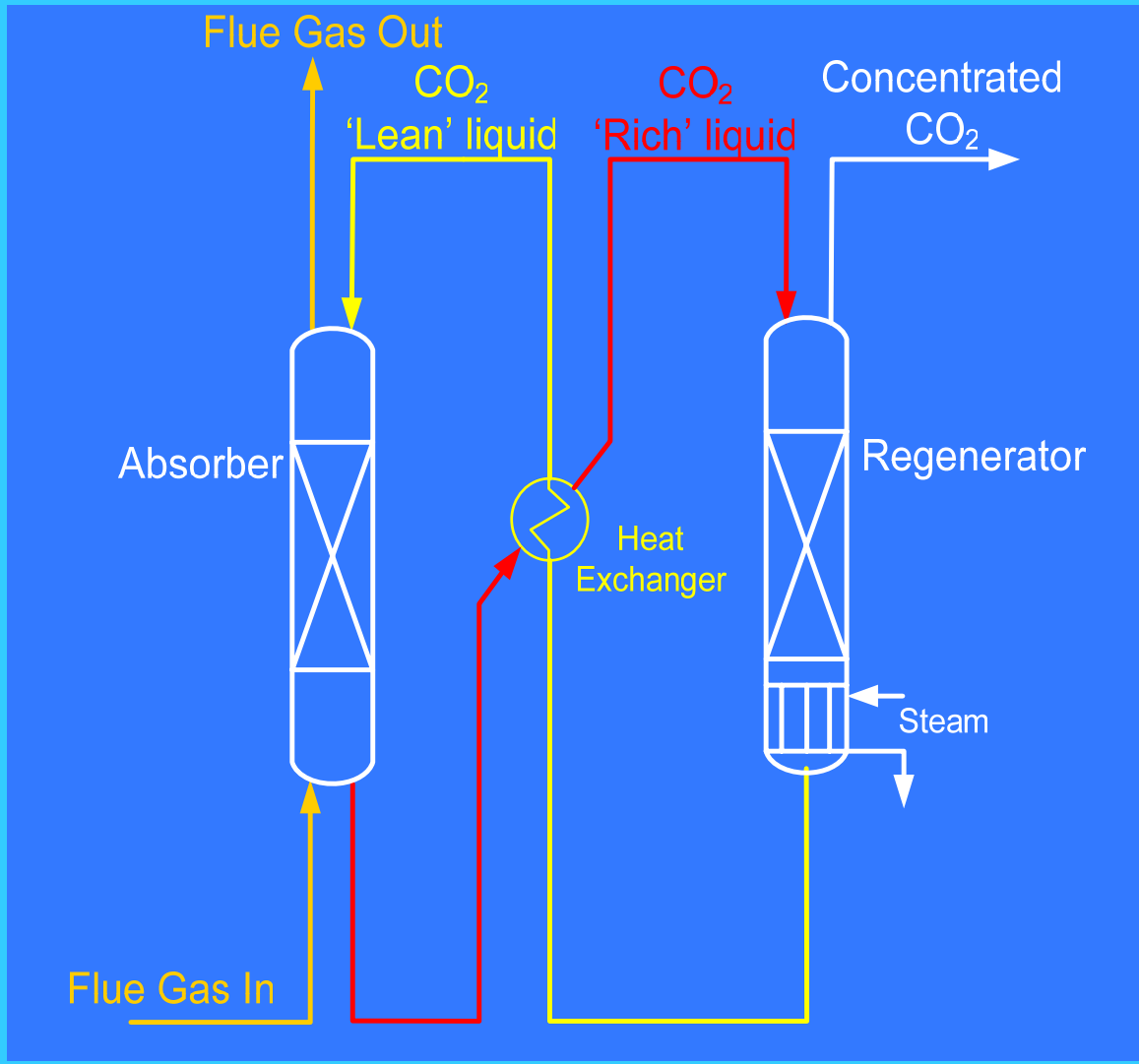


Crystalline Structure

ECO Crystals

ECO_2 Capture Process

- CO_2 Absorption: Flue gas – solution contact
- Solution heating for regeneration
- CO_2 release from heated solution
- Solution cooling for re-use



Powerspan CO_2 Development with DOE

- Joint research and development program on CO_2 capture with ammonia (NH_3)
- Lab tests show NH_3 has several advantages over commercially available amine (MEA) process:
  - **higher CO_2 loading capacity**
  - **lower energy consumption for regeneration**
  - **lower cost reagent**
- Powerspan and DOE testing shows 90% CO_2 removal with ammonium carbonate solutions

ECO_2 Development Plans

- Conduct pilot scale tests of CO_2 removal
  - Integrate with ECO process at FirstEnergy's Burger Plant by mid 2008
    - **Sequester with MRCSP**
    - **First project in U.S. to capture and sequester CO_2**
  - ~20 ton/day CO_2 / ~ 1 MW equivalent
- Evaluate process performance and economics for scale-up
- Conduct commercial scale test of ECO_2 with CO_2 sold for enhanced oil recovery (up to 2,000 ton/day CO_2 - ~100 MW)

Final Well Depth 8,385'