Overview

- Problem & Solution
- Regulations
- Virtual Sorbent Bed
- Competitors
- Market Size & Strategy
- Financials
- Risks & Assumptions
- Path Forward
Problem

- Mercury is a persistent, bio-accumulative nerve toxin.
  - In high doses, mercury kills.
- Four (4) tablespoons of mercury distributed among the entire population of Canada (32 million) would result in toxic levels of mercury.
- Coal Plants are releasing 48 Tons of mercury every year in the United States alone.
- U.S. EPA states that a safe dosage is: 0.1 µg/kg body weight/day
Solution

- The United States has announced new regulation
  - Released March 15\textsuperscript{th}, 2005
- These regulations require a reduction in coal-fired power plant emissions
- Advanced technology will be used to achieve emission reduction
Regulations
Regulations - The Clean Air Mercury Rule (CAMR)

- 1st phase cap of 38 tons per year in 2010
  - 21% decrease in emissions
- 2nd phase cap of 15 tons per year in 2018
  - 69% decrease in emissions
- CAMR applies to a wide range of generating units
- No provisions for “grandfathering” for age
Regulations - The Clean Air Mercury Rule (CAMR)

- Cap-and-trade system for reducing emissions

- Emissions limits (per generating unit):
  - **Bittuminous coal**: $21 \times 10^{-6}$ lb/MW·h
  - **Subbituminous coal**
    - Wet FGD: $42 \times 10^{-6}$ lb/MW·h
    - Dry FGD: $78 \times 10^{-6}$ lb/MW·h
  - **Lignite coal**: $145 \times 10^{-6}$ lb/MW·h
The Opportunity

- EPA only defined emissions limits and not the technology
- Any technology that can meet the regulations effectively is needed
- The VSB shows promise as a leading candidate
Virtual Sorbent Bed
Virtual Sorbent Bed (VSB) Background

- The VSB is a new technology designed to capture mercury in power plants.
- Works as an addition to an existing technology, the Electrostatic Precipitator (ESP).
- Currently, 70% of all power plants already have ESP’s installed in them.
Side View of ESP
Diagram of How the VSB Works

Inflow: Mercury-Laden Exhaust Gas

Controller For Carbon Sinusoidal Pathway

Negatively Charged ESP Wall

Outflow: Treated Exhaust Gas

Positively Charged ESP Wall

Sinusoidal, charged gas flow

Injection Port for Activated Carbon
Advantages

- **Cost**: modifying existing ESP's should be cheaper than adding entirely new equipment.
- **Efficiency**: activated carbon based technologies are the most efficient technologies currently practiced.
- **Compatibility**: expected to work well with most power plants on the market.
- **Size**: small size makes it easier to install, space constraints less of an issue.
- **Cross-flow pathway**: of the activated carbon results in greater contact with the Hg-contaminated gas.
Competitors
## Top Competitors

<table>
<thead>
<tr>
<th>Technology type</th>
<th>Efficiency</th>
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<tbody>
<tr>
<td>FGD+C-ESP</td>
<td>80</td>
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<tr>
<td>FF+ESP</td>
<td>90</td>
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<tr>
<td>Fabric Filter (FF)</td>
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<tr>
<td>Spray Dryers Absorbers (SDA) +FF</td>
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<tr>
<td>Electro-Catalytic Oxidation (ECO) Powerspan</td>
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<tr>
<td>Technology type</td>
<td>Cost</td>
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<tr>
<td>----------------------------------------</td>
<td>------</td>
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<tr>
<td>VSB</td>
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<tr>
<td>FGD+C-ESP</td>
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<td>FF+ESP</td>
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<td>Fabric Filter (FF)</td>
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<td>Electro-Catalytic Oxidation (ECO)</td>
<td>DNK</td>
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<tr>
<td>MerCap™</td>
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*DNK = Do not know*
Market Size
Market Size

The **Virtual Sorbent Bed** (VSB) is an attractive mercury pollution prevention technology for existing electrostatic precipitators (ESP), since these two technologies are compatible and can create **significant economical savings** through cooperation.

![Pie chart showing 1122 ESPs existing in coal-fired power plants, with 80% (901 units) being cold-side ESPs](chart.png)
The First Target Segment is Plants with Cold-Side ESP and Bituminous Coal (694 ESP units)

- Bituminous Coal: 694
- Subbituminous Coal: 182
- Lignite Coal: 25
- Bituminous Coal: 178
- Subbituminous Coal: 43
- Lignite Coal: 0

Cold-Side: 901
Hot-Side: 221
Strategy and Financials
EnPRO’s Market Strategy

- Patenting and Licensing
- Partner with an Architectural Engineering Firm and/or an ESP manufacturer
  - Need specialized knowledge and additional resources.
  - Changes target market and how it is reached
  - Selling to distributor not to end-user
## Financials - Approximations

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<th>Strategy</th>
<th>Percentage</th>
<th>Total</th>
<th>Present Value</th>
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<td>- As Is</td>
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<td>Licensing - Medium End</td>
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<td>- Little Continued Work</td>
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<tr>
<td>- Exclusive License</td>
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- Assumed $500,000 Additional Value Added/ Unit
- Over 20 years
Risks and Assumptions
Risk Analysis

Technological Risks

- Sound in theory, but limited engineering data
  - Prototype design
  - Limited testing
- Unknown VSB efficiency
  - Estimate based on Activated Carbon control technology
- Unconfirmed VSB costs
  - Installation, Operating, Maintenance
- Developing in time for market demand
  - Market demand in 2010 and 2018
- Effects on other equipments’ operations
  - Impact on the present role of the ESP
  - Operation of power plant’s system overall
Risks (Cont’)

Marketing & Economic Risks

- Marketing based on concept
  - Sell VSB to clients with limited operational data
- Marketing late, compared to other competitors
  - “First come first serve”
- Managing mercury (Hg) as a by-product/waste
  - VSB focuses on removing Hg, not managing

Other Risks

- Unknown VSB dimension and space consumption
- VSB operates safely
- Sufficient funding to successfully develop VSB
Assumptions

Regulatory
- Coal-fired power companies will respond to mercury regulation

Technological
- VSB has high efficiency (90+)
  - Based on Activated Carbon technology
- VSB will develop in time for the market
  - Operating VSB unit for 2010 market
  - Fully tested and verified for 2018 market
- VSB will not affect the functions of other power plants’ equipments, including ESP
Assumptions (Cont.)

**Economic**
- Resource & Market size are **limited**
  - Costly to invest in any control technology
- Primary VSB market: **Plants with ESP installed**
- VSB unit price is $500,000
- Coal supply will continue to be **available and in demand**

**Other Assumptions**
- VSB is entering a **very competitive market**
- Profit and risks will determine the market strategy (i.e. licensing)
Path Forward

- Further Development of the Technology
- Additional Investigation into Financials
- Project should be continued
- Partner with chemical Engineering Capstone
- Marketing and Partnering
Questions