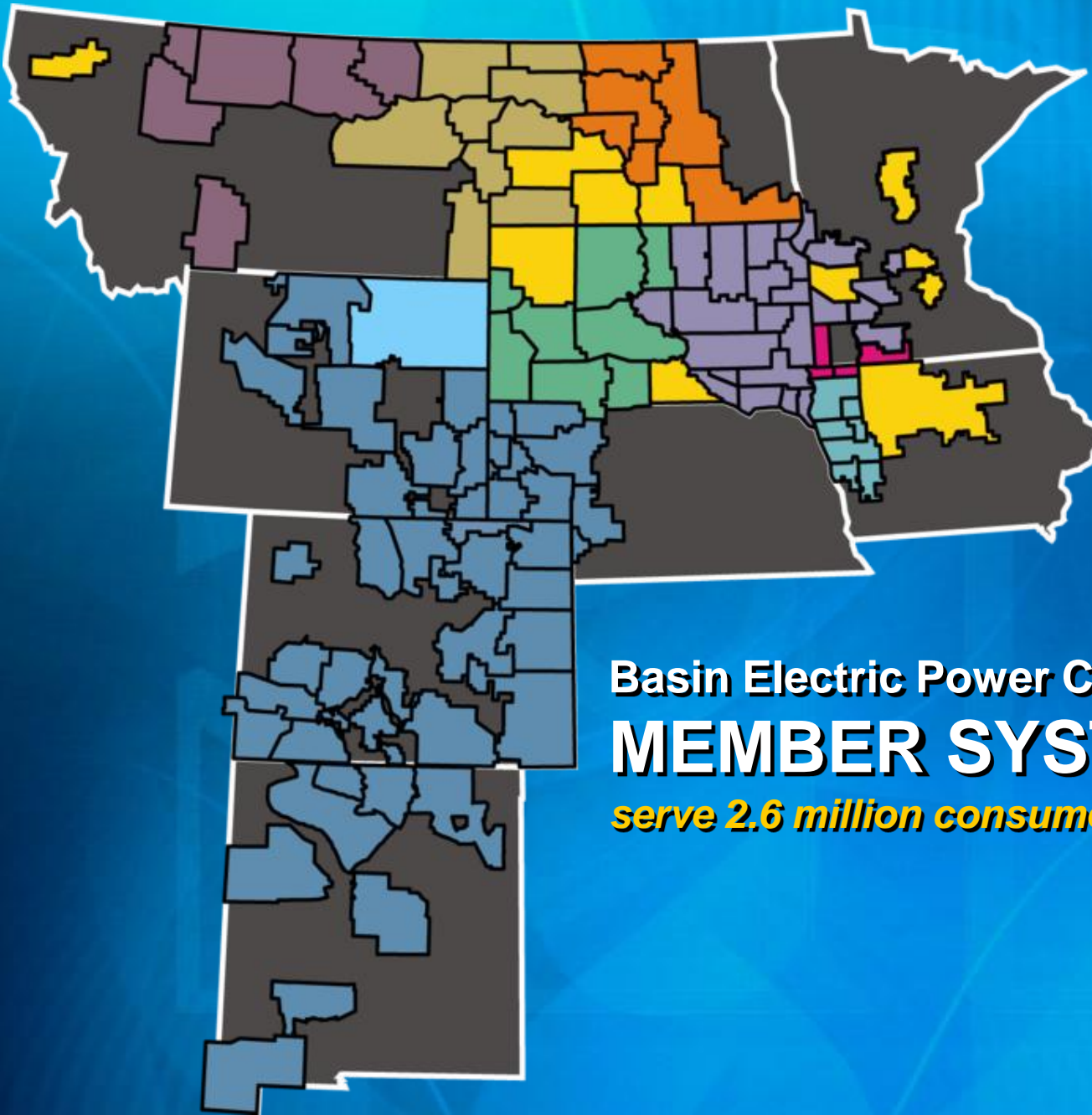


**Basin Electric Post
Combustion
CO₂ Capture
Demonstration Project**

McIlvaine Hot Topic

June 25, 2009

Lyle Witham



Basin Electric Power Cooperative
MEMBER SYSTEMS
serve 2.6 million consumers

Basin Power Supply Facilities

- **2817 MW**

– Coal	2278 MW	80.6%
– Oil	104 MW	3.7%
– Gas	277 MW	9.8%
– Wind	136 MW	4.8%
– Recycled Heat	33 MW	~1.2%

} Renewable

Key Questions

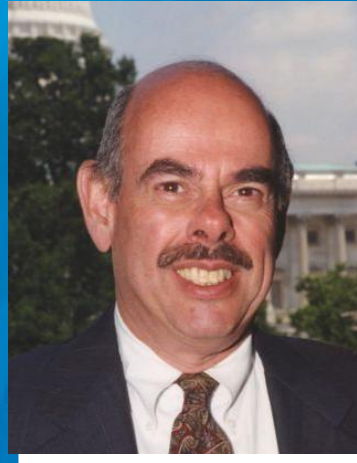
- **Federal legislation**
- **EPA rulemaking**
- **CCS technology**
- **Economics (cost per ton)**
- **Geological sequestration**
- **EOR as bridge**

Key Elements in Legislation

- Incentives for technology development
- Credit for early adopters
- Time to develop the technology
- Price ceiling for carbon (safety valve)
- Free allocations vs. auction
- Regulatory certainty
- All sectors must be included
- Worldwide effort

Waxman-Markey Bill

- Cap and Trade
- Includes RES
- \$1 billion/year in CCS grants
- Allocations
- Offsets



Henry Waxman (CA)



Ed Markey (MA)

Climate Change

- **Growing scientific and public opinion that CO₂ emissions are contributing to climate change...**
- **Priority of Obama Administration ...**
- **U.S. responsible for 1/4 of global CO₂ emissions...**
- **Electricity sector responsible for 1/3 of U.S. CO₂ emissions...**
- **General agreement that technology solutions are needed...**

Climate Change

- Basin Electric supports reasonable climate change legislation
- We want to be a part of the solution, not part of the problem

Leadership Approach

Dakota Gasification Company



DGC is unique

- **Only commercial coal gasification facility producing synthetic natural gas**
- **Liquids production**
- **Fertilizer production**
- **CO₂ capture and sequestering**

Dakota Gasification Company (DGC)

World's Largest Carbon Sequestration Project

Weyburn, Saskatchewan

16 Million Tons Sequestered To Date

5 million tons/year
Pipeline capacity

CO₂ PIPELINE ←

Current flow rate:
3 million tons/year

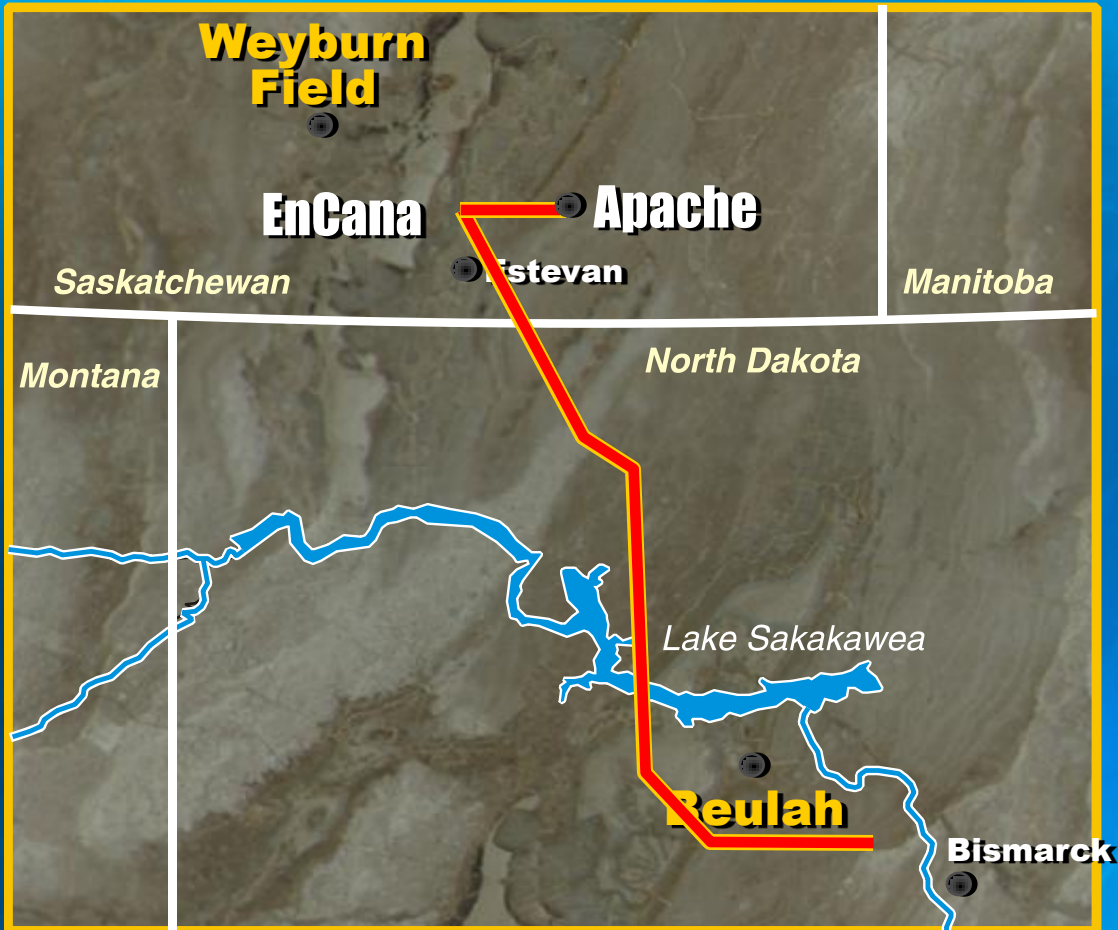
Compressors



CO₂ ↑



EnCana and Apache



Carbon Capture Demonstration Project

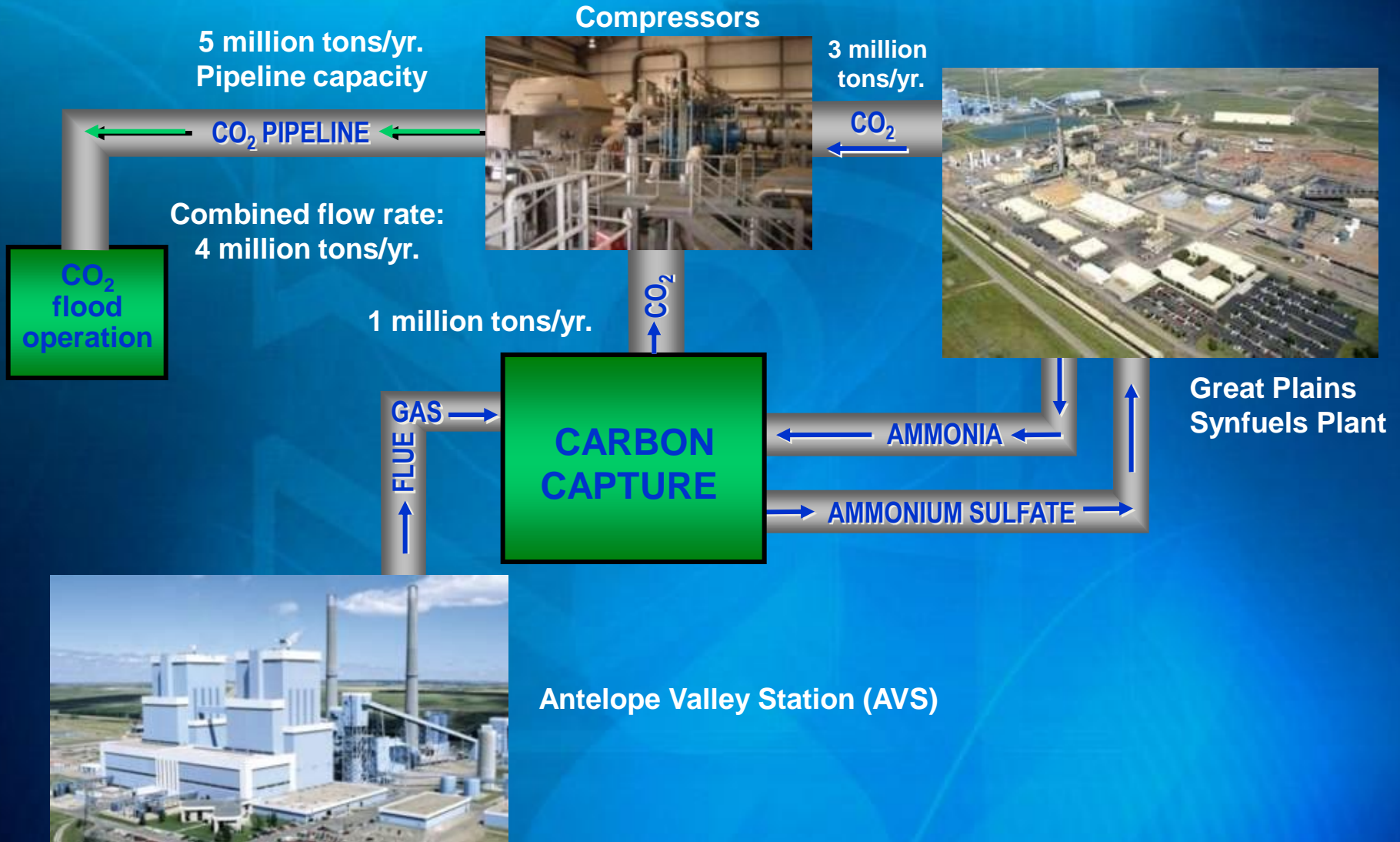
Objectives

- demonstration of carbon capture leading to commercialization**
- no net increase in emissions**
- reduce CO₂ emissions – 90% removal from slipstream**
- provide economic analysis and performance of technology**
- carbon restraint environment pathway for coal**

Carbon Capture – AVS

- **Demonstration/Commercialization Project**
- **AVS –two 450 MW units, lignite, dry scrubbers/baghouse**
- **120 MW slipstream**
- **57 MMSCF or 3,000 tons/daily**
- **CO₂ – used in Enhanced Oil Recovery (EOR)**
- **Partner with PCOR**
phase III – EERC – University of North Dakota

Carbon Capture Optimization Project



Advantages to AVS Post Combustion Demonstration Plant

- **DGC facility has established CO₂ transport technology within Williston Basin**
- **DGC facility produces ammonia which can be used CO₂ removal process**
- **DGC facility has ammonium sulfate production capacity to handle sulfur resulting from additional SO₂ removal for CCS**

CO₂ Pipeline



- 205 miles
- 14" and 12" carbon steel pipe
- Strategically routed through Williston Basin oil fields

Powerspan Corporation

- **Founded in 1994, privately held**
- **Develop and commercialize emission control systems**
- **ECO – Electro-Catalytic Oxidation, begin in 1998**
- **ECO₂ Carbon Capture Technology – only patent issued to date on CO₂ capture using ammonia**
- **Exclusive right to license the patent**
- **ECO₂ pilot plant – Burger Plant, Ohio**

ECO[®] Capability

- **Commercially available, ammonia-based, multi-pollutant control for SO₂, SO₃, NO_x, Hg and other metals, PM_{2.5}, HAPs (i.e. HCl, HF)**
- **Emission levels like natural gas plants**
 - **ECO has capability of near zero emissions; 1-2 ppm outlet SO₂/NO_x; particulate matter < 0.005 lb/mmBtu – Equivalent or better than IGCC.**
- **No major waste streams – byproducts recycled**

ECO₂ Pilot

- **Pilot scale tests of CO₂ removal**
 - **Integrated with ECO process at FirstEnergy's R.E. Burger Plant**
 - **Designed for 90% removal**
 - **~20 ton/day CO₂ / ~ 1 MW equivalent**
- **Evaluate process performance and economics for scale-up**
- **Demonstrate ammonia vapor control**
- **Verify process performance and control under varying conditions**



Feasibility Study

- **3 month study – March-May 2008**
- **Station power requirements**
– **electrical power, steam and compression**
- **No fatal flaws identified**
- **Cost - \$300 million (+/- 30 percent)**
- **Cost to capture and compress \$45-50/ton**
- **Project Schedule – FEED, 6 months;**
detailed engineering, procurement and
construction - 36 months

FEED Study

Tentative start – August 2009

- **Cost analysis (+/- 15 %)**
- **Balance of plant**
- **Design specifications**
- **Performance specification**
- **Optimization studies**
- **Refined schedule**
- **Cost – \$5 million**

Carbon Capture Demonstration Project

- **Challenges**
 - **Great Risk - first to commercialize the newest technology**
 - **Station Power for CCS**
 - **<10 ppm SO₂ inlet required**
 - **Cooling water for CO₂ absorption**
 - **Integration with existing infrastructure**
 - **Steam for CO₂ stripping**
 - **Permit Modification**
 - **Cost - \$300 million +**

Carbon Capture & Storage

- **Opportunities**
 - **EOR is a driver for our AVS CCS project**
 - **EOR is a bridge for understanding future sequestration in saline aquifers & unrecoverable coal seams**
 - **Our industry needs Carbon Capture Technology demonstrated**
 - **PCOR phase III will advance CCS knowledge (MMV)**

Demonstration Plant Economics

	<u>\$/ton</u>	
Capture Cost	(\$35)	(\$45)
Transport Cost	(\$10)	(\$15)
Total Cost - CO ₂	(\$45)	(\$60)
Revenue	\$35	\$20
Net Gain (Loss)	(\$10)	(\$40)

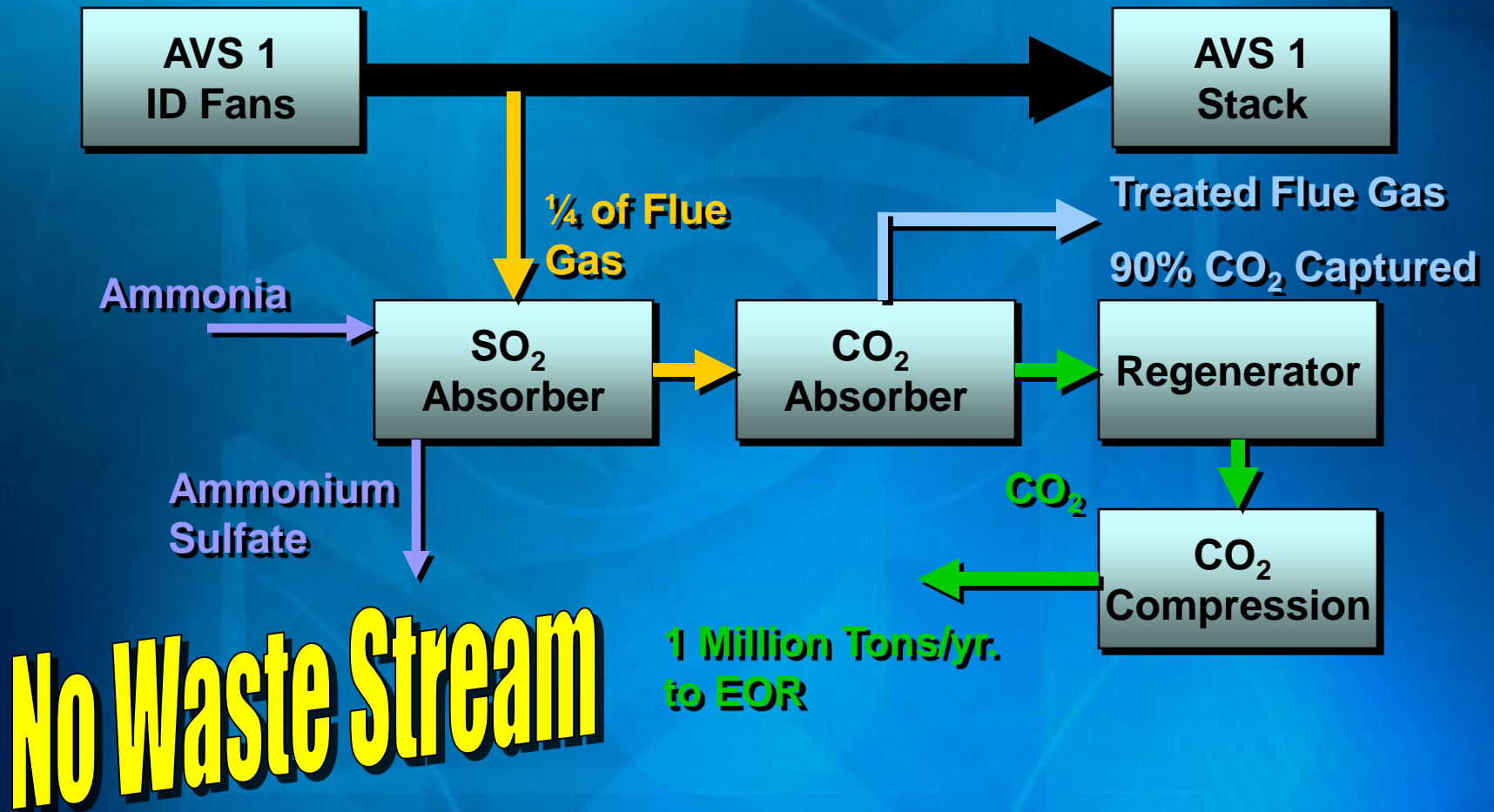
CO₂ Capture - AVS

- **Dakota Gasification Company**
 - Experience
 - Infrastructure
 - Pipeline capacity
 - Ammonia production
 - Ammonium sulfate production
 - Close proximity to AVS
 - Market for CO₂

Milestones

- **Request For Proposal – June 1, 2007**
- **Sent to 10 companies, RFP placed on website**
- **Proposals Due – September 4, 2007**
- **Technology Selection – February 2008**
- **Feasibility Study – Spring 2008**
- **Pilot Study Review**
- **Front End Engineering Design Study**

Powerspan Process



CO₂ Capture

- **Amine**
 - Purchase from technology provider
 - Reclaimer waste produced during amine clean up
- **Ammonia**
 - Supplied from DGC
 - Purge to ammonium sulfate stream
 - No waste produced

Electrical Power Impact

- **Decrease in Net Generation**
 - **Steam Extraction**
 - **Electricity to Capture**
 - **Electricity to Compress to 2700 psig**
- **Water Consumption**
- **Waste Stream**

Summary

- **AVS CO₂ Capture – In Development**
- **Amine and Ammonia CO₂ Capture**
- **Plant Impacts of Post Combustion Capture**
 - **Space**
 - **Flue Gas**
 - **Steam/Condensate**
 - **Cooling**
 - **Waste Streams**
 - **New Chemicals**
 - **Net Electrical Generation**

Questions?