Testimony of Frank Alix before the Senate Committee on Commerce, Science, and Transportation; Hearing on Climate Change Science and How it Empowers our Response to Climate Change, March 12, 2009

Good morning Mr. Chairman and Members of the Committee. Thank you for the opportunity to share my perspective on how science informs climate change mitigation strategies. My name is Frank Alix and I am CEO of Powerspan Corp., which is a clean energy technology company headquartered in New Hampshire.

My testimony today will focus on the importance of carbon capture and sequestration (CCS) as a climate change mitigation strategy, the prospects for commercial deployment of carbon capture technologies on coal-fired power plants, and the actions the government can take to accelerate CCS deployment**.**

We all know that coal is abundant and cheap. It supplies 50% of electricity generated in the U.S. and 80% in China. The economies of the Midwest, South, Southwest, and Plains States depend heavily on low cost electricity from coal. Therefore, CCS is the most important climate change mitigation strategy we can pursue.

According to the EIA, 36% of U.S. CO_2 emissions in 2006 came from coal consumption. Broadly deploying CCS with 90% capture efficiency could reduce those emissions to 4-5%. EIA predicts that CCS will have to provide at least 30% of CO_2 emission reductions needed worldwide to stabilize GHG concentrations in the atmosphere. Since the transportation sector accounts for another 34% of U.S. CO_2 emissions, transforming this sector with electric vehicles powered by low carbon electricity sources could reduce our CO_2 emissions by another 20-30%. Therefore, CCS could potentially provide over half of the emission reductions required to meet our climate change mitigation goals.

Powerspan has been developing and commercializing advanced clean coal technology since its inception in 1994. Our approach to CO_2 capture, called ECO_2®, is a post-combustion process for conventional power plants designed to capture 90% of CO_2 emissions. The technology is suitable for retrofit to the existing coal-fired generating fleet and for new coal-fired plants. ECO_2 is a regenerative process that uses an ammonia-based solution to capture CO_2 in the flue gas. Once the CO_2 is captured, the solution is regenerated to release CO_2 in a form that is ready for compression and pipeline transport for geological storage.

Pilot scale testing of our ECO_2 technology began in December 2008 at FirstEnergy's Burger Plant in Southeastern Ohio. The ECO_2 pilot was designed to treat a 1-megawatt (MW) flue gas stream and produce 20 tons of CO_2 per day. Initial testing has demonstrated 80% CO_2 capture efficiency, which is a promising start. We recently completed two minor design modifications that we expect will increase the CO_2 capture rate to 90%.

The ECO_2 pilot plant was built using the same type of equipment that we plan to use in commercial systems. Therefore, successful operation of the pilot unit will confirm our design assumptions and cost estimates for large-scale carbon capture and sequestration (CCS) projects. Although commercial scale CCS projects still have some risk, that risk is manageable because the major equipment used in the ECO_2 process—large absorbers, pumps, heat exchangers, and compressors—have all been used in other commercial applications at the scale required for CCS. The advanced technology in ECO_2 is innovative process chemistry. Commercial application of this unique technology holds no special challenges and therefore has a high probability of commercial success.

Our experience in the emerging market for commercial-scale CCS projects supports our optimism. In 2007, Basin Electric Power Cooperative conducted a competitive solicitation for a post-combustion CO_2 capture technology to retrofit their Antelope Valley Station, which is a coal-fired power plant located adjacent to their Great Plains Synfuels Plant in Beulah, North Dakota. Their synfuels plant currently hosts the largest CCS project in the world, with three million tons of CO_2 captured annually and sold for enhanced oil recovery (EOR) in the Weyburn fields of Saskatchewan. The Antelope Valley project will install CO_2 capture equipment on a 120-MW flue gas slipstream taken from a 450-MW unit. Basin Electric has targeted 90% CO_2 capture efficiency to provide an additional 1 million tons of CO_2 annually for EOR. Six of the leading vendors of CO_2 capture technology responded to the Antelope Valley solicitation and after a detailed evaluation, Basin Electric selected Powerspan. This commercial CCS project is scheduled to startup in 2012.

Since being selected for the Antelope Valley project, a feasibility study has confirmed that there are no technical limitations to deploying ECO_2 at the plant. The study estimated ECO_2 costs of less than \$40 per ton for 90% CO_2 capture and compression (in current dollars, with +/- 30% accuracy). A similar study of ECO_2 recently conducted for a new 760-MW supercritical pulverized coal plant estimates CO_2 capture costs of under \$30 per ton, including compression. A third engineering study focused on ECO_2 scaling risk determined that the ECO_2 pilot plant will provide sufficient design information to confidently build commercial scale systems up to 760-MW, supporting that ECO_2 technology scaling risk is manageable. Independent engineering firms led the feasibility, cost, and scaling studies for our prospective customers. As a sign of our confidence in commercial deployment of ECO_2 systems, we will back our installations with industry standard performance guarantees.

Despite the promise indicated by the Basin Electric project, strong government action is needed to ensure timely deployment of CCS technology to support climate change mitigation goals. Government actions should focus on three areas: 1) a strong, market-based cap on GHG emissions, 2) a CO_2 emission performance standard for new coal-based power plants, and 3) early deployment incentives for commercial scale CCS systems. Due to limited time, I will only elaborate on my third point, the need for CCS incentives.

Incentives are needed to ensure early deployment of CCS because CO_2 capture technology is not yet commercially proven and early CO_2 prices will not be sufficient to offset CCS costs. To be most effective, CCS incentives must provide long-term CO_2 price certainty to facilitate project financing, and must be awarded competitively, preferably by reverse auction, in order to minimize cost while also providing a market signal on the real costs for early CCS installations. Knowing actual CCS costs is extremely important to plant owners, investors, technology developers, and regulators in evaluating future investment and regulatory decisions. Competitively awarding CCS incentives is also consistent with how renewable portfolio standards are normally administered.

Early deployment of CCS technology will also create jobs and promote economic growth. CCS projects require 3 to 4 years to implement and create significant economic activity over their duration. For example, a single CCS project would cost between $250-750 million in capital expense and create up to 500 jobs at its peak, with the majority of materials and labor sourced in the US. However the government's cost of the CCS incentive program would not be incurred until CO_2 sequestration begins upon project completion. In addition, by incenting early deployment of CCS, the US can assume a leading position in this critical sector and create a thriving, high-tech export business, and the quality jobs that come with it.

In summary, CO_2 capture technology is commercially available from several qualified vendors with standard commercial guarantees. Independent studies show that early commercial installations of CO_2 capture technology are likely to be successful. The cost of widespread deployment of technologies such as ECO_2 appears manageable, particularly when compared to the cost of other low-carbon electricity solutions. And once we gain commercial CCS experience, future costs will no doubt decrease substantially.

The most important reason to promote early deployment of CCS is that post-combustion CO_2 capture technologies will preserve the huge investment in existing coal-fired power plants and allow us to effectively use abundant, low cost, coal reserves in the US and developing nations, even in a climate constrained world. If we are not successful in commercializing CCS technology in the near-term, it will be difficult for the world to meet its long-term goals for climate change mitigation.

Thank you Mr. Chairman. I would be pleased to answer any questions.

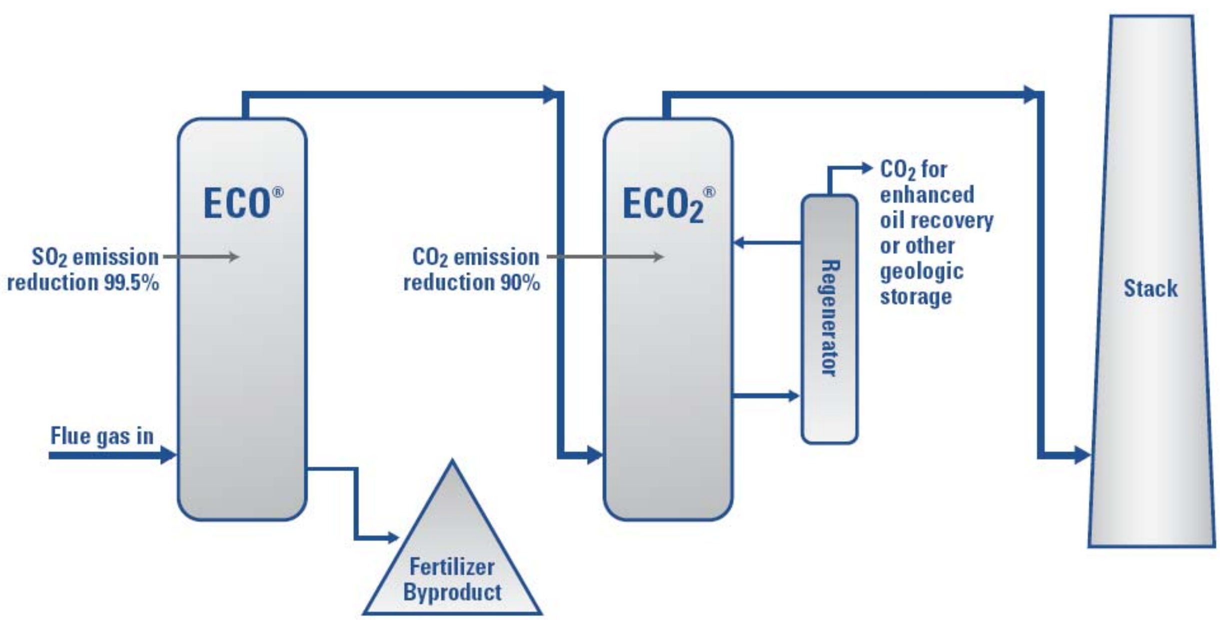
ECO_2® Technology for CO_2 Capture from Existing and New Coal-Fired Power Plants

Summary

Powerspan Corp.'s CO_2 capture process, called ECO_2®, can be applied to both existing and new coal-fired electric power plants to capture 90 percent CO_2 from the flue gas. The process is designed as an add-on system that could be deployed when needed and is particularly advantageous for sites where ammonia-based scrubbing of power plant emissions, such as our ECO® multi-pollutant control technology, is employed. The technology is currently being piloted on a 1-megawatt (MW) slipstream at a power plant in Ohio. The ECO_2 pilot unit employs the same type of equipment that will be used in commercial systems. Because the innovation of ECO_2 is in its process chemistry, not in new industrial equipment, the risk in scaling from the pilot scale to commercial scale carbon capture and sequestration (CCS) projects is manageable. Commercial scale ECO_2 demonstrations (120-MW; one million tons of CO_2 capture annually) are planned to be online in 2012, with the captured CO_2 to be used for enhanced oil recovery operations.

Technology Description

ECO_2 is a scrubbing process that uses an ammonia-based (not amine) solution to capture 90 percent CO_2 from the flue gas. The CO_2 capture takes place after the nitrogen oxides (NOx), sulfur dioxide (SO_2), mercury and fine particulate matter is captured using ECO technology or other air pollution control system. Once CO_2 is captured, the resulting solution is regenerated to release CO_2 and ammonia. The ammonia is recovered and returned to the scrubbing process, and the CO_2 is processed into a form that is sequestration ready. Ammonia is not consumed in the scrubbing process, and no separate by-product is created.



Incorporation of Powerspan's ECO_2® carbon capture process with the commercially available multi-pollutant control ECO® process

Technology Development

Powerspan has been developing the CO_2 capture process since 2004 in conjunction with the U.S. Department of Energy (DOE) National Energy Technology Laboratory under a cooperative research and development agreement. In December 2007 Powerspan announced it exclusively licensed a patent for the process from the DOE. The patent granted to the DOE represents the only patent issued in the U.S. to date covering a regenerative process for CO_2 capture with an ammonia-based solution. Powerspan has conducted extensive bench-scale testing to establish the effectiveness of the process for CO_2 capture, and has made improvements to the subject patent. The testing has also established the design parameters for the ECO_2 pilot unit in operation at FirstEnergy's R.E. Burger Plant in Shadyside, Ohio.

ECO_2 Pilot Project

Commissioning was completed and ECO_2 pilot testing began at FirstEnergy's Burger Plant in December 2008. The ECO_2 pilot processes a 1-MW slipstream drawn from the outlet of the 50-MW Burger Plant ECO unit. It is designed to produce approximately 20 tons of sequestration ready CO_2 per day while achieving a 90 percent capture rate. The pilot system is expected to run through 2009.

The ECO_2 pilot will demonstrate CO_2 capture through integration with the ECO multi-pollutant control process. Operation of the pilot will confirm process performance and energy requirements. The pilot program will also provide the basis for cost estimates while preparing the technology for the commercial scale CCS demonstrations planned to be online in 2012.

Scalability of ECO_2 to Commercial Scale Projects

Although the ECO_2 process is new and proprietary, the innovation is in its process chemistry. The equipment required for operation of commercial ECO_2 systems (e.g., large absorber, regenerator, heat exchangers, pumps, gas dryer, etc.) are commercially available at the required scale. Therefore, once the pilot scale demonstration of the ECO_2 process is completed, the scale up risk to commercial size systems is manageable. An independent engineering study focused on ECO_2 scaling risk determined that the ECO_2 pilot plant will provide sufficient design information to confidently build commercial scale systems up to 760-MW, supporting that ECO_2 technology scaling risk is manageable.

ECO_2 Commercial Demonstration Projects

Basin Electric Antelope Valley Station—In March 2008, Basin Electric Power Cooperative and Powerspan announced the selection of the ECO_2 process for a 120-MW commercial demonstration at Basin Electric's Antelope Valley Station located near Beulah, North Dakota. The selection of the ECO_2 process is the result of the first competitive solicitation process for a CO_2 capture demonstration at a coal-fired power plant in the U.S. The Antelope Valley project is designed to capture approximately one million tons of CO_2 annually which will be fed into an existing CO_2 compression and pipeline system owned by Basin Electric's wholly owned subsidiary, Dakota Gasification Company. Dakota Gasification Company is the only company in the U.S. that captures CO_2 from coal and delivers it for enhanced oil recovery operations. Since 2000, Dakota Gasification has been delivering CO_2 from its coal gasification facility, the Great Plains Synfuels Plant, to oil producers in Saskatchewan, Canada.

In June 2008, Powerspan successfully completed a feasibility study, which confirmed that there are no technical limitations in deploying the ECO_2 process at the plant. In January 2009, the project was approved for up to a $300 million loan from a USDA Rural Utilities Service program for early

CCS demonstration. Based on successful completion of detailed engineering studies and obtaining of necessary permits, the Antelope Valley project is expected online in 2012.

NRG Energy WA Parish Plant—In November 2007, NRG Energy, Inc. and Powerspan announced their memorandum of understanding to commercially demonstrate the ECO_2 process at NRG's WA Parish plant near Sugar Land, Texas. The 125-MW equivalent CCS demonstration will be designed to capture and sequester about one million tons of CO_2 annually. The ECO_2 demonstration facility will be designed to capture 90 percent of incoming CO_2 and the captured CO_2 is expected to be used in enhanced oil recovery in the Houston area. The Parish plant is expected to be online in 2012.

About Powerspan and ECO Multi-Pollutant Control Technology

Powerspan Corp., based in New Hampshire, has been developing and commercializing advanced clean coal technology since its inception in 1994. Powerspan's most significant technology success to date has been the development and commercialization of its patented Electro-Catalytic Oxidation (ECO) technology, which is an advanced multi-pollutant control technology to reduce emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), and fine particulate matter ($PM_{2.5}$) in a single system.

For over five years, Powerspan has successfully operated a 50-MW scale ECO commercial unit at FirstEnergy's R.E. Burger Plant in Ohio. This unit has demonstrated that the ECO process is capable of achieving outlet emissions below current Best Available Control Technology standards for coal-fired power plants. The ECO process also produces a valuable fertilizer product, avoiding the landfill disposal of flue gas desulfurization waste. Furthermore, the ECO system uses less water because it requires no wastewater treatment or disposal.

In June 2007, American Municipal Power-Ohio (AMP-Ohio) announced its commitment to install our ECO-SO_2 multi-pollutant control technology on its proposed 1,000-MW American Municipal Power Generating Station in southern Meigs County, Ohio. In January 2009, AMP-Ohio announced the selection of Bechtel as its engineering, procurement and construction firm, and granted the firm a limited notice to proceed on the project. AMP-Ohio will use our ECO-SO_2 technology as an SO_2, mercury, and fine particulate matter control option for its strong environmental performance and potential to add our ECO_2 carbon capture technology.

1. Competitive Award: CCS incentives should be awarded competitively based on a reverse auction (incentives awarded to the low cost bidders per ton of CO_2 captured and sequestered) for the following reasons:

   - This would preserve the primary objective of a cap and trade program, which is to minimize cost of compliance, while also providing a market signal on the real costs for early CCS installations.
   - Current climate legislation proposals, which arbitrarily set CCS incentive prices, would result in less cost-effective CCS technologies being subsidized, while plant owners/developers and regulators gain little or no information on what real CCS costs are.
   - Arbitrarily setting CCS incentive prices would distort the market and support technologies that may not otherwise survive in a non-subsidized market. It would also create a windfall profit opportunity for the lowest cost CCS solutions and unnecessarily increase the cost of CCS incentives to the government.
   - Knowing actual CCS costs is extremely important to plant owners, technology developers, investors, and regulators in evaluating future investment and regulatory decisions.
   - Competitively awarding CCS incentives is consistent with how renewable portfolio standards are normally administered. Market participants—power suppliers, regulated distribution companies, and state regulators—understand this process. States set a standard for the amount and type of renewable energy desired, and the potential suppliers respond to competitive solicitations to provide the renewable energy. The federal government could effectively implement the same type of approach for CCS projects/incentive awards.

2. Long-term Price Certainty, Factoring in CO_2 Emission Allowance Value: CCS incentives need to provide long-term price certainty and factor in the value of CO_2 emissions allowances because:

   - CCS projects will likely be financed over 15 to 30 years. Current climate legislation proposals award CCS incentives over a fixed period of time (i.e. 10 years) that is too short to finance most projects.
   - CCS incentives would be most economical for the government if they factor in the increasing value of CO_2 emission allowances over time.
     - For example, if the CCS project developer needs to assure a price of $40 per ton of CO_2 over 20 years to finance the project, the government could guarantee that price as an annual subsidy over the required term, after the value of avoided CO_2 emissions are subtracted. As the value of CO_2 emissions allowances rise, the amount of annual CCS subsidy the government is required to pay would decrease, while the project developer would still obtain the required price assurance to finance the project.
   - As the value of CO_2 emission allowances rises over time, the percentage of allowance auction proceeds received by the government that are needed to support the CCS incentives will decrease.

- Current climate legislation proposals do not account for the added value of CO_2 emission allowances created by the CCS project or the fact that emission allowance values would be increasing over time. This approach creates a potential windfall profit opportunity for the early CCS adopters and unnecessarily increases the cost of CCS incentives to the government.

3. CCS Project Size: The primary objective of CCS incentives is to demonstrate CCS technology at commercial scale to accelerate market acceptance and deployment. In order to demonstrate CCS as commercially viable, a minimum project size criteria should be established:

   - Experts such as MIT, DOE, and EPRI have established a minimum size of 1,000,000 tons of CO_2 per year for CCS projects to be considered "commercial scale." Once the minimum CCS project size is met, preference should be given to larger projects.

4. CO_2 Capture Rate: In order to meet the objective of stabilizing GHG concentrations in the atmosphere, large stationary CO_2 sources will need to capture and sequester a high percentage of their CO_2 emissions (i.e. $\geq$ 90%). Therefore, CCS incentives should establish a minimum standard for CO_2 capture (e.g., 80%) and should favor projects that capture higher percentages of CO_2.

   - Available technology from leading suppliers has shown the ability to capture 90% CO_2. Therefore establishing a minimum CO_2 capture rate as high as 80-90% is technically feasible and commercially acceptable.

   - CCS projects will normally require 3-4 years to implement. An incentive program that encourages CCS to be demonstrated in sequential steps (e.g., 50% then 80%) would unnecessarily delay deployment of the high capture rate CCS projects needed to combat climate change and increase the cost of CCS incentives to the government.

5. Amount of CCS Incentives; Timing of Auctions; Technology Diversity: The amount of CCS incentives in tons of CO_2 should be based on the following factors:

   - The need to demonstrate CCS at commercial scale in a number of different configurations for both plant type and geological storage type. All large industrial sources of CO_2 should be considered equally. However, the government should not try to pick technology winners and losers. The primary driver in CCS incentive awards should be lowest cost per ton, with at least three different CO_2 capture technologies selected to promote technology diversity. This would facilitate the creation of a competitive supplier market of the most cost-effective technologies.

   - The need to avoid early market responses to a CO_2 emission cap, such as a rush to gas-fired power generation, which may not be sustainable after CCS is commercially proven and CO_2 allowance prices rise to where CCS would be deployed without incentives.

   - The need to spread out incentives so that multiple CCS projects are awarded each year for at least five years as the current pace of technology evolution is great and the CCS incentive program should take advantage of and benefit from this rapid pace of improvement.

- The near-term need to stimulate the economy. CCS projects normally require 3-4 years to implement and create a great deal of economic activity over their entire duration. However the cost of the CCS incentive program does not begin until CO_2 sequestration is started upon project completion. For example, a 5,000,000-ton per year CCS project could cost $750 million in capital expense to implement over the first 4 years. However, with a $20 per ton net CCS incentive, it would only require government support of $100 million beginning in year 5 and decreasing annually from there.

6. Qualifying Criteria: Projects that apply for CCS incentives should meet certain qualifying criteria. Qualifying projects should:

- Be new (existing projects that capture and sequester CO_2 should not qualify).
- Certify that they have all required permits or will have within 12 months of award.
- Certify that they have all required financing or will have within 12 months of award.
- Certify that they are scheduled to break ground within 12 months of award and have scheduled project completion within 4 years after ground breaking.
  - Projects that receive CCS incentive awards but are not able to complete permitting, financing, and groundbreaking within 12 months of award should forfeit the CCS incentive (but may apply again).
- Not be in any way disadvantaged by having received other types of government support such as loan guarantees, grants, and tax incentives.

7. Sequestration Issues: Existing CO_2 pipelines used for enhanced oil recovery (EOR) operations can support several new, large-scale CCS projects. The CCS incentives should be structured so as not to disadvantage these opportunities in any manner as they will likely be the lowest-cost and nearest-term projects available to demonstrate commercial scale CCS. However, in order to incentivize broader CCS deployment, the following sequestration issues need to be resolved:

- Legal and permitting requirements for geological sequestration including standards for measurement, monitoring, and verification (MMV).
- Long-term liability for sequestered CO_2.
- Incentivizing CO_2 pipeline construction at optimum scale. CO_2 pipelines benefit from economies of scale up to about 24 inches in diameter. This size would provide CO_2 capacity for 3-4 large-scale CCS projects (nominally about 15 million tons per year; equivalent to ~2,000 MW capacity at 90% CO_2 capture). Therefore preference should be given to CCS projects that create extra capacity by constructing pipelines or other infrastructure that could be used by multiple CCS projects.