Date of the hearing: June 15, 2007
Name of the panelist: Dr. Wei-Ping Pan
Panelist's title and organization: Director and Sumpter Professor, Institute for Combustion Science and Environmental Technology, Western Kentucky University
Testimony before the U.S.-China Economic and Security Review Commission
Title of Hearing: China's Energy Consumption and Opportunities for U.S.-China Cooperation to address the Effects of China's Energy Use

In my seven minutes I would like to highlight the activities and potential impact of my clean coal technologies work within Western Kentucky University's China Environmental Health Project, an initiative that receives major support from the U.S. Agency for International Development (USAID). The project's goal is to improve public health in China through activities promoting access to clean air and potable water through applied scientific research with Chinese university partners.

The CEHP has three components: clean coal technologies, karst water, and community outreach/information dissemination. I work with Anhui University of Science and Technology on the clean coal technologies component and Dr. Chris Groves at WKU leads the CEHP karst water activities in partnership with Southwest University of China. Dr. Jennifer Turner of the China Environment Forum at the Woodrow Wilson International Center for Scholars in Washington, D.C. and Ms. Amelia Chung from the International Institute of Rural Reconstruction head up the community outreach/information dissemination activities. WKU gratefully acknowledges the considerable support U.S. Senator Mitch McConnell of Kentucky has given to our CEHP work.

My talk will focus on the following four points that are detailed in my written testimony:

1) Western Kentucky University's China Environmental Health Project (CEHP) is filling an urgent need in China to enhance scientific capacity to accurately measure coal emissions, which are the leading cause of respiratory illnesses and a growing source of ecological harm within China and beyond.

2) The coal component of CEHP aims to obtain accurate data on coal-fired pollution emissions in Huainan city in Anhui Province. Key to success of this data collection is the strong collaborative partnership we have formed with both provincial and municipal government agencies. The collection of this information could not only help promote transparency on pollution emissions in China—supporting new laws on environmental information dissemination—but also could generate awareness among policymakers on the health dangers of coal.

3) While the data collection work could have an immediate impact on informing policymakers to take action on the air problem, one other key contribution the China Environmental Health Project is making is the training of Chinese researchers and students in air quality monitoring, environmental health surveys, and sampling and

modeling techniques. U.S. students at WKU are also benefiting in conducting research on real world emission factors in China.

4) Beyond data collection and training, WKU is seeking new funding resources to build on our current work. Namely, we wish to explore whether carbon sequestration could help Huainan power plants decrease emissions by turning them into potentially profitable and environmental safe nitrogen fertilizer.

1. China's Coal Emission Challenge—CEHP Addressing a Crucial Need

China is the biggest producer and consumer of coal in the world. More than 70% of the total energy in China is produced from coal combustion. Despite investment into renewable and nuclear power, this heavy dependence on coal is expected to continue for the next 50 or more years. The available statistics on China's dismal air quality are dated, anecdotal, or limited in scope—China has not publicly disclosed CO_2 or mercury emissions data since 2001. Overall air pollution trends represent growing economic, ecological, and human health threats both within and outside China.

• Some 300,000 to 400,000 people die prematurely in China every year due to respiratory illnesses triggered by air pollution.
• Coal burning in China emits 25 percent of global mercury and 12 percent of global CO_2.
•China's State Environmental Protection Agency estimates that nearly 200 cities in China fall short of the World Health Organization standards for airborne particulates.

Western Kentucky University's China Environmental Health Project is carrying out its coal monitoring and training work in the city of Huainan in Anhui Province, the country's so-called "Coal-Powered Three Gorges." Huainan has a coal reserve of 44.4 billion tons, which is 32% of the reserve in eastern China and 19% of the national total. Anhui is an important Chinese energy base relying on coal, electric power, and chemical industries for its development. The total quantity of Huainan coal consumption in 2004 was 12 million tons, making up 90% of the city's energy consumption. This coal has enabled urbanization and industrial development in Huainan at an unprecedented scale, but at a cost—its ambient air quality has been rapidly deteriorating.

The production of industrial liquid, solid, and gas wastes from coal use makes up about 98% of the city's industrial pollution emissions. In 2004, the city's total air emissions were 97 billion m^3, which included 92,300 tons of sulfur dioxide (SO_2) and 36,000 tons of smoke-dust. The annual average concentration value per day of SO_2 was 0.024 mg/m^3; while nitrogen oxide (predominantly NO_2) and PM_{10} were 0.026 mg/m^3 and 0.111 mg/m^3, respectively. These three pollutants have lowered Huainan's air quality to China's Grade II (moderately deteriorated) level. Trends of major pollutant emission levels in Huainan since 1995 are listed in Figure 1.

Chinese researchers project that the total emitted amount of SO_2, NO_2, PM_{10}, and smoke-dust will significantly increase with total coal consumption over the next ten years. For example, in 2004, measured averaged SO_2 emitted was 0.024 mg/m^3 per day and it

reached 0.041 mg/m^3 during the reported period of July – December 2006. The rising emission levels of SO_2, NO_2 and PM_{10} in 2006 are given in Figure 2.

Huainan's increasingly degraded air quality is causing serious public health problems for the city's residents, such as asthma (impacting up to 2% of the total population—most likely a higher percentage among the more vulnerable communities); chronic bronchitis (2% of the population); conjunctivitis (20% of eye illness); coryza (2% of the population). Large numbers of people also suffer from occupational diseases related exposure to toxic air.

2. CEHP Air Quality Monitoring Research and Technology Training Activities

The U.S. Agency for International Development (USAID) is supporting the coal component of the China Environmental Health Project (CEHP) through cooperation between Western Kentucky University (WKU) and Anhui University of Science and Technology (AUST) to improve air quality monitoring and control in Huainan. This includes:

(1) Building up Huainan's monitoring system for SO_x, NO_x, PM_{10}, and other air toxins resulting from coal-fired power and chemical plants;
(2) Training Chinese researchers in the latest environmental protection technologies; and;
(3) Assisting AUST medical school researchers in studies of coal emission impacts on the health of various communities.

WKU is providing state-of-the-art technologies to train Chinese researchers and students about sampling and analysis of various pollutants (e.g., SO_x, NO_x, PM_{10}, Hg, and Se), and will assist AUST in monitoring three power plants in Huainan using U.S. EPA methods to ensure quality of the sampling data. The partners also will test the air in some of Huainan's industrial and mining areas, business districts, and residential communities. In addition, WKU training will enable AUST researchers to:

(1) Investigate the sources, distribution and polluting level of PM_{10} and $PM_{2.5}$ in Huainan's atmosphere as well as the behavior of the pollutant polycyclic aromatic hydrocarbons (PAH) in PM_{10} and $PM_{2.5}$;
(2) Study how coal-smoke-induced particles affect human health;
(3) Analyze the effectiveness of various air pollution control devices; and,
(4) Study the effect of coal pre-washing on dust emissions.

Continued dialogue and information exchange among AUST and WKU's faculty and students also are promoted through this project.

3. CEHP Collaborating with Local Governments and Informing Policymakers

The China Environmental Health Project aims to obtain accurate data on coal-fired pollution emissions in Huainan, as well as generate awareness among policymakers on the health dangers of coal. A strong regulatory environment and reliable monitoring are the cornerstones of a system that can force polluters to reduce emissions. For example, better monitoring capacity can permit the adoption of some market and information

disclosure type regulations such as: voluntary reporting, emissions trading, and tax-related incentives. CEHP's goal of promoting information transparency is timely, for on April 11, 2007, SEPA signed a new *Decree on Environmental Information Disclosure (Trial*), which will go into effect on May 1, 2008. This is the first formal regulation on information disclosure by a Chinese government agency following the State Council's release of the *Regulation on Governmental Information Disclosure*. Additionally, the CEHP research findings could help catalyze city policymakers to adopt measures to reduce public health problems caused by coal combustion.

The Huainan municipal government is encouraging and actively collaborating with CEHP activities. The city has notably posted information on this collaboration program between Western Kentucky University and AUST on their official city network website (see Figure 3). The *Huainan Daily Newspaper* also reported our "China Environment Health Project" on December 5, 2006. CEHP plans to promote local news reporting on the project as data collection and analysis continues throughout the project.

WKU and AUST monitoring work is benefiting greatly from collaboration with the Huainan Environmental Automatic Monitoring Center (HEAMC), which is supported and funded by the Anhui Provincial Environmental Protection Bureau. This comprehensive monitoring system has automated environmental monitoring, information exchange, and data network transfer, which gives scientists easy access to considerable data covering not only the emissions but also the technologies used in coal extraction and burning in the city. The monitoring center is the core of the whole system, which has six sub-components: (1) environmental quality monitoring; (2) pollutant source monitoring; (3) remote smoke monitoring (video); (4) geography information sharing; (5) an environmental emergency system; and (6) an office automation system. Features of the Huainan Environmental Automatic Monitoring Center include:

• The system possesses a broad range database and equipment to carry out its monitoring work. These include providing information about the state of local coal technology, such as coal washing, coal mixing, briquette and coal water slurry technologies, flue gas desulfurization application in the local electric power ecology industry, and a synthesized oil project in Huainan city.

• The capability to automatically monitor air quality of the city every thirty minutes. The system has five different local stations surrounding the city.

• A flue gas monitoring system for each stack at three power plants has been installed. At each plant the concentrations of CO_2, NO_x, SO_2, PM_{10} and other gas species are collected and GPS is used to transfer the data to the central control office.

The CEHP researchers will have the opportunity to collaborate with HEAMC to utilize the air emission data to establish the air quality model using the BENMAP software (freely available from U.S. EPA). In additional to monitoring SO_2, NO_x, CO and CO_2 in air samples, the amount of trace metal such as mercury (Hg), Se, Pb will also be collected by wet chemistry methods.

The physical/chemical properties of PM_{10} in air samples will also be analyzed to study the chemical transformation of PM (this is the most important factor on the study of public health) during different seasons. BENMAP software will be used to evaluate/analyze the collected data. Coal samples will be collected from the No. 1 Xie Mine, No. 3 Pan Mine, Guqiao Mine and Xieqiao Mine near Huainan. The fly ash and bottom ash will be collected at power stations and at the distance of 10km and 30km away from the three power plants under study. The trace element in the coal and ash will be analyzed and modeled. The distribution of pollutants in the city will be established.

Paralleling this coal study will be an environmental health survey in the communities surrounding the three power plants that will be conducted by the AUST Medical School. The China Environment Forum at the Woodrow Wilson Center is organizing an environmental health workshop at AUST in November 2007 for AUST medical school researchers and some Huainan officials. CEHP will bring some Chinese environmental health researchers to present the results of their own energy and health studies in China, as well as note how they have conducted effective outreach to local policymakers. Most notable will be Shanghai researchers who worked with the U.S. EPA in the late 1990s to conduct a three-year energy options and health benefits study (an Integrated Environmental Strategies project) that led the Shanghai government to greatly increase its investment into energy efficiency and clean energy. CEHP hopes this workshop will help strengthen the design and outreach in the AUST Medical School's study.

4. CEHP Training Researchers and Students to Build Long-Term Capacity

Western Kentucky University researchers have been collaborating with AUST counterparts since 1988. Although the data gathering under this new China Environmental Health Project (CEHP) was initiated in late 2006, the project has already catalyzed some valuable training activities. As a part of the CHEP project, Western Kentucky University and Anhui University of Science and Technology are carrying out training work that will strengthen the capacity of the AUST research community to improve air quality monitoring and control in Huainan and conduct environmental health studies. The training activities include:

(1) Working with AUST and the city government researchers to build up Huainan's monitoring system for SO_x, NO_x, PM_{10} and other air toxins at three power plants using U.S. EPA methods to ensure quality of the sampling data;
(2) Assisting AUST medical school researchers in studies of coal emissions impacts on the health of various communities and how to craft their study so as to make it accessible to policymakers; and,
(3) WKU is providing state-of-the-art technologies to train Chinese researchers and students about sampling and analysis of various pollutants.

Even before CEHP, Western Kentucky University researchers have been helping their AUST counterparts establish a stronger curriculum on environmental health and coal monitoring techniques. For example, a new class "Prophylaxic Medicine" was offered for the first time in the spring of 2007 spring semester. This course introduces the impact of

environmental pollution on human health and the prophylaxis and control of the correlative disease to the approximately 144 undergraduate students. There are 11 other classes with over 700 students that AUST has offered in the spring semester that are related to either air pollution or environmental health.

CEHP Expanding Monitoring Work and Exploring Carbon Sequestration Options
WKU and AUST researchers are currently seeking resources to expand and enhance their collaboration on coal-fired combustion air quality and related public health issues by: (1) increasing monitoring work at two more power plants, and (2) undertaking a study of carbon dioxide sequestration.

New Power Plant Monitoring Work: WKU's proposed 2008 coal work includes: (1) monitoring coal-fired related emissions, (2) developing a database for the information, and (3) disseminating data analysis to decision-makers. Using the Huainan city area as a demonstration site, this work builds on the first year's activities to provide training and enhance analytical capabilities at AUST to allow scholars and students improve Huainan's monitoring system for CO_2, SO_2, NO_x, PM_{10} and other air toxins from coal-fired power and chemical plants, and in turn to reduce the coal-burning related public health problems.

Expanding Study of Carbon Dioxide Sequestration from Coal-fired Combustion Systems in the United States and China: In this second area of planned work CEHP is informed by the emerging goals of recently established Asia-Pacific Partnership on Clean Development and Climate (APP-CDC). Scientists have predicted carbon dioxide (CO_2)—which makes up 63% of all greenhouse gas emissions—could increase the average global temperature of 1.8^{o}C by 2030. Since the beginning of the industrial era, CO_2 concentrations in the atmosphere have risen from 280 ppm to over 360 ppm. Much of this increase has occurred over the past ten years, when over 20 x 10^{12} tons of CO_2 have been released into the atmosphere as combustion exhaust. China is the largest coal producing and consuming countries in the world, producing an estimated 33×10^{8} tons of CO_2 in 2002. At current rates of growth this level is expected to reach an estimated 67×10^{8} tons by 2030. Reduction of CO_2 emissions resulting from energy utilization is thus a large task for China.

Since 2002, the Institute for Combustion Science and Environmental Technology (ICSET) at Western Kentucky University (WKU) has been participating with China and other countries in an ongoing carbon dioxide (CO_2) sequestration research project using an aqueous ammonia scrubbing technology. CO_2 produced from combustion sources, such as fossil fuel fired power plants, is captured from the flue gas. The CO_2 reacts with aqueous ammonia to form ammonium bicarbonate (ABC), an economical and environmental safe nitrogen fertilizer. Since ammonium bicarbonate (ABC) is water soluble, this fertilizer acts as a "CO_2 carrier" to "transport" CO_2 from the atmosphere to crops. Western Kentucky University researchers have found that after biological assimilation and metabolism in crops, up to 10% of the carbon is absorbed by the plants—leading to increased biomass production. The majority of the unused carbon source percolates into the soil as water-soluble bicarbonates move into alkaline aquifers

to form carbonate salts of calcium ($CaCO_3$) and magnesium ($MgCO_3$), Figure 4. These carbonates are environmentally benign and water insoluble salts, which are found in most natural caverns.

Driving Force for CO_2 Sequestration Research

The greatest value to be realized in developing successful strategies for CO_2 sequestration in China is the ability to reduce CO_2 emissions from the nation's coal fired power plants, leading to the significant reduction in greenhouse gases in the earth's atmosphere and making a positive contribution to the reduction of global climate change. By developing a non-hazardous method to capture CO_2 from power plant stacks, China's huge coal power plant industry would be able to save and trade valuable "carbon credits" and simultaneously produce a by-product that has economic neutrality or even gain for this industry in producing a stable nitrogen-rich and soil quality enhancing fertilizer. It is a win-win outcome.

Co-operative Agreement between Western Kentucky University and Anhui Agricultural University (AAU)

To create a feasible carbon sequestration pilot project in Anhui, Western Kentucky University has expanded its partners under CEHP to include the Anhui Agricultural University. This new CO_2 sequestration project sets out to evaluate the commercial-ready technology associated with the utilization of long-term effect ammonium bicarbonate (LEABC) fertilizer that could be obtained by aqueous ammonia scrubbing of flue gases produced by China's coal burning power plants. In this evaluation, LEABC will be applied to a total of six individual test plots, each 40 feet by 30 feet in size. Each test plot, three of which are to be located on the Anhui Agricultural University properties in China and three of which are to be located on the Western Kentucky University Farm, will be planted with a combination of three different crop types in alternate rows.

Conclusion

This USAID supported China Environmental Health Project is fostering partnerships between scientists and students in the United States and China, as well as involving Chinese provincial and local government officials, students, and citizens in promoting better monitoring of coal emissions. This project notably aims to generate awareness among policymakers on the health dangers of coal and hopefully will help catalyze city officials to adopt measure to reduce public health problems caused by coal combustion.

While not yet funded, the WKU and AUST researchers hope that the planned carbon sequestration initiative to help demonstrate a potentially profitable use of captured CO_2 represents a model could be used to not only promote cleaner skies, but also lessen the application of toxic fertilizers on China's crops. The CO_2 sequestration project could offer benefits both the United States and China in that it aims to not only reduce the emissions of CO_2 into the environment, but also to evaluate the potential of establishing an economically beneficial and environmentally safe land application of the fertilizer LEABC, which could contribute to a less polluting kind of agricultural production. Moreover, through the application of existing clean emissions technology, coal-fired electricity industries in both countries could benefit from carbon credits that they could sell or trade. In conclusion, this collaborative international research project also

showcases that WKU faculty and students do not just conduct research for the sake of conducting research, rather carry out work on global environmental issues by addressing local pollution concerns.

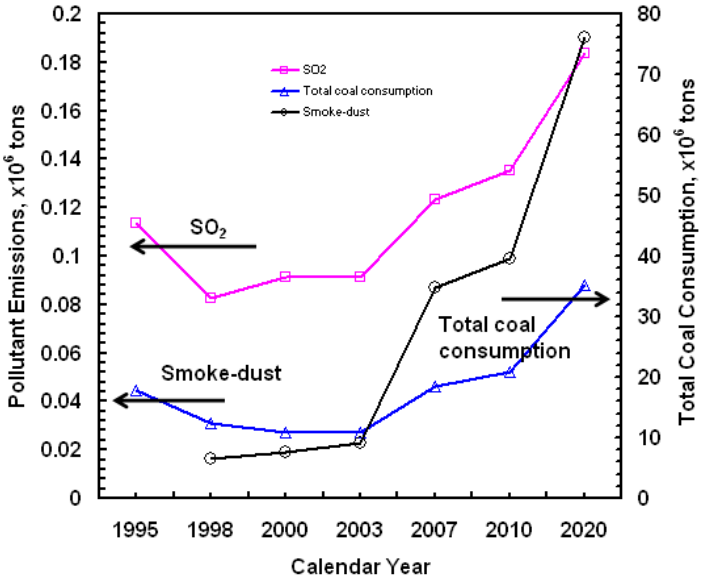


Figure 1 Trends of major pollutant emission level and total coal consumption in Huainan.

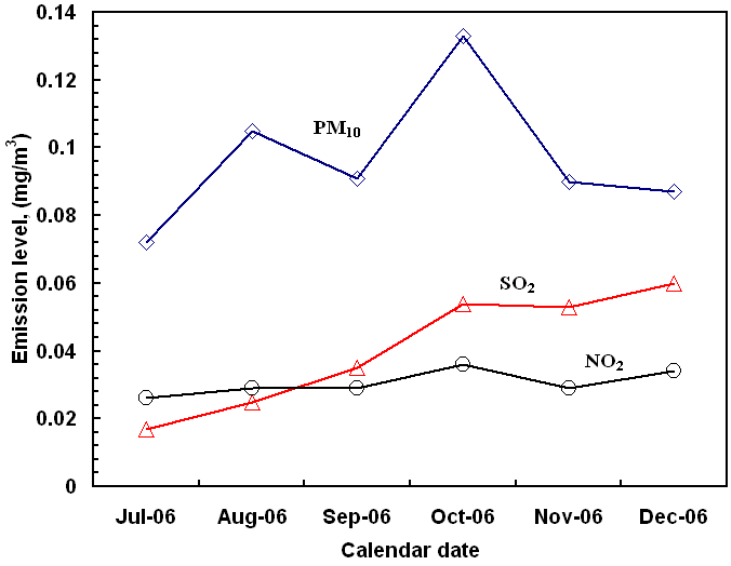
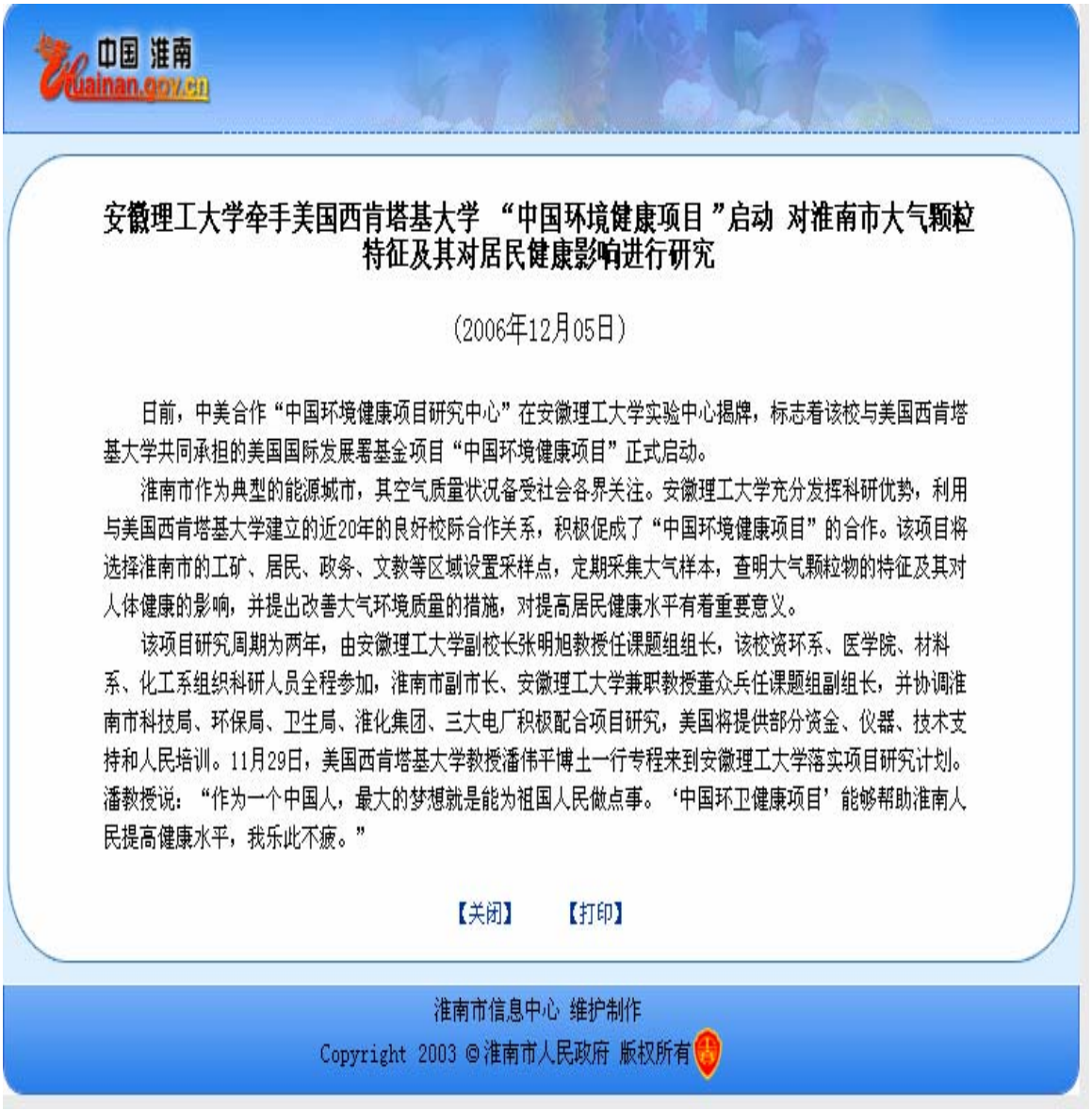


Figure 2. Measured emission levels of SO_2, NO_2 and PM in 2006 in Huainan.



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安徽理工大学牵手美国西肯塔基大学 “中国环境健康项目”启动 对淮南市大气颗粒特征及其对居民健康影响进行研究

(2006年12月05日)

日前，中美合作“中国环境健康项目研究中心”在安徽理工大学实验中心揭牌，标志着该校与美国西肯塔基大学共同承担的美国国际发展署基金项目“中国环境健康项目”正式启动。

淮南市作为典型的能源城市，其空气质量状况备受社会各界关注。安徽理工大学充分发挥科研优势，利用与美国西肯塔基大学建立的近20年的良好校际合作关系，积极促成了“中国环境健康项目”的合作。该项目将选择淮南市的工矿、居民、政务、文教等区域设置采样点，定期采集大气样本，查明大气颗粒物的特征及其对人体健康的影响，并提出改善大气环境质量的措施，对提高居民健康水平有着重要意义。

该项目研究周期为两年，由安徽理工大学副校长张明旭教授任课题组组长，该校资环系、医学院、材料系、化工系组织科研人员全程参加，淮南市副市长、安徽理工大学兼职教授董众兵任课题组副组长，并协调淮南市科技局、环保局、卫生局、淮化集团、三大电厂积极配合项目研究，美国将提供部分资金、仪器、技术支持和人民培训。11月29日，美国西肯塔基大学教授潘伟平博士一行专程来到安徽理工大学落实项目研究计划。潘教授说：“作为一个中国人，最大的梦想就是能为祖国人民做点事。‘中国环卫健康项目’能够帮助淮南人民提高健康水平，我乐此不疲。”

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Figure 3: Huainan government network reported the news about the “China Environment Health Project” that cooperated between ICSET of WKU of the USA and AUST. Dec. 5, 2006. CEHP plans to continue promoting information on the project’s work in the Chinese news media throughout the coming year.

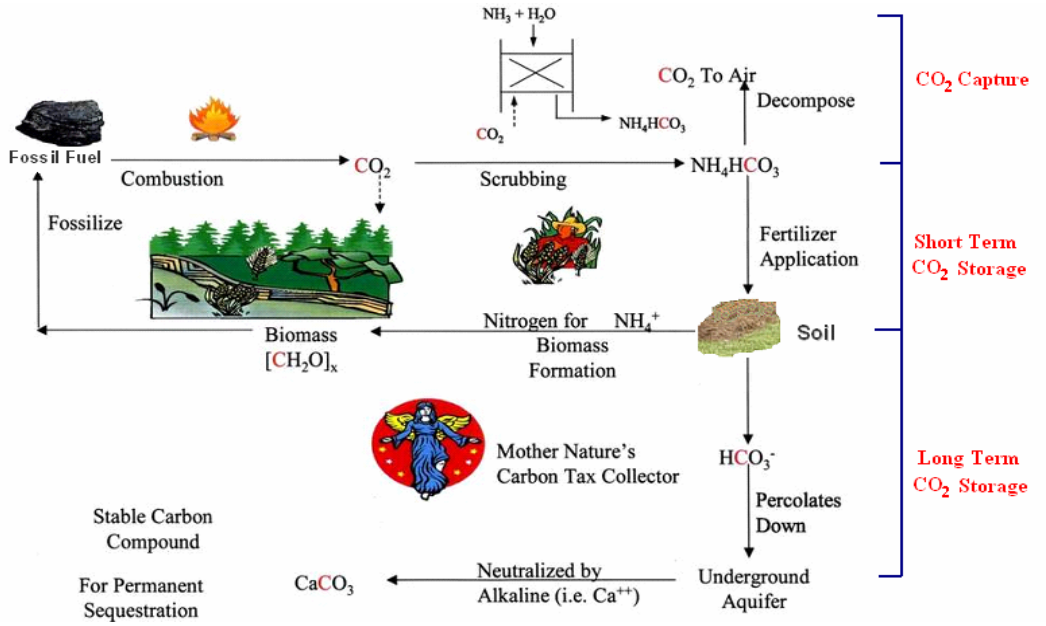

Figure 4. A schematic of three stages of sequestering CO_2 by the ecosystem