In recent years, many large metropolitan areas in China, including Beijing, Tianjin, and the Yangtze River Delta (Shanghai), have been experiencing persistent hazy atmospheric conditions that occur for long durations and across large areas. Fine particulate matter (PM$_{2.5}$) is considered a major contributor to these events and may seriously affect public health. Volatile organic compounds (VOCs) are considered one of the major precursors for secondary formation of this PM$_{2.5}$. Studies conducted in China report that VOC emissions from industrial sources have been increasing steadily every year. However, studies on VOCs were not begun in China until recently. Numerous issues have severely restricted the effective implementation of VOC pollution controls in China: the VOC definition is vague; the baseline emissions of VOCs are not clear; emissions quantification methods are not established; the VOC standards are not comprehensive; and

Progress on VOC Control and Management for the Petrochemical Industry in China

A joint collaboration between government agencies and the petrochemical industry in China led to the establishment of a workgroup to carry out research and address issues related to volatile organic compound (VOC) pollution control and management.
VOC control technologies are lagging. In response to these issues, the Chinese Central Government recently promulgated regulations to require further control of VOC emissions. In 2013, the State Council of the People’s Republic of China issued the “Action Plan on Prevention and Control of Air Pollution” (Action Plan), which establishes clear limits and controls of the total amount of VOC emissions and subjects industries with VOC emissions to certain emission fees. VOC control has never been paid such great attention before the promulgation of the Action Plan.

The VOC Pollution Control Workgroup
To assist in the full implementation of the Action Plan, the Appraisal Center for Environment and Engineering (ACEE), a major technical support institution of the Chinese Ministry of Environmental Protection (MEP), led a joint effort along with several major Chinese industrial companies, including the China Petroleum & Chemical Corporation (Sinopec), the China National Petroleum Corporation (CNPC), the China National Offshore Oil Corporation (CNOOC), and the China Shenhua Group Corporation. Through this joint effort, a VOC Pollution Control Workgroup was established to carry out research related to VOC pollution control and management.

Upon the completion of an extensive literature review of VOC regulations and practices around the world, site assessment of VOC emissions, and active communication with key stakeholders, the Workgroup compiled the findings into two documents: “Research Report on VOCs Definition and Characterization” and “Comprehensive Improvement Plan on VOCs Control and Management for Petrochemical Industry”. These reports established a definition of VOCs based on photochemical reactivity (similar to the U.S. definition). In addition, a phased-in approach and a refined management system were recommended to characterize VOCs for the purposes of testing and emissions quantification. These documents were recognized and commended by MEP.

VOC Control and Management through LDAR
In the course of the site assessment of VOC emissions, the workgroup decided to focus on VOC control and management for the petrochemical industry due to the following two considerations: petrochemical operations may potentially emit large quantities of VOCs in relatively high concentrations; and it is relatively easy to implement and enforce the requirements in the petrochemical industry.

China’s “Twelfth Five-Year Plan for Air Pollution Prevention and Control in Key Areas” clearly states that the petrochemical industry should fully implement leak detection and repair (LDAR) programs. These programs are best suited for valves and pumps, and also can be used for connecting components. Using fixed or portable monitoring equipment, petrochemical facilities can monitor VOC emissions from locations that are prone to leaks, fix any leak exceeding certain concentrations, and effectively control release of VOC pollution to the environment.

Currently, LDAR programs are being actively promoted in China. Zhejiang Province, Shanghai, Jiangsu Province, and the Beijing-Tianjin-Hebei region are encouraging the petrochemical industry to carry out LDAR programs as a pilot program. The Government of Ningbo City, Zhejiang Province even provides financial subsidies to encourage petrochemical enterprises to carry out an LDAR program regularly to reduce fugitive leaks of VOCs.

Sinopec and CNPC are also working on developing their own LDAR technology platforms. For example, a subsidiary of Sinopec is currently implementing a “Full Participation in Leak Checking and Plugging” work mode. They collect...
graphical data from instruments, seal point data, and establish a computer management program named “No Leakage Management System” by monitoring the network (see Figure 1). In addition, they also encourage staff to carry out on-site inspection work and ultimately implement the leak and repair process management program for the whole company.

The workgroup conducted on-site surveys at several major petrochemical facilities, including Jinling Petrochemical, Yamba, Bairun Chemical, Shanghai Petrochemical, SECCO Petrochemical, Zhenhai Refining & Chemical, LG Yongxing Chemical, and Formosa Petrochemical. The on-site surveys covered LDAR program applications and VOC pollution control measures, such as oil and gas recovery and catalytic combustion. A large collection of first-hand data were incorporated into the workgroup research report.

The implementation of a LDAR program can help to reduce the fugitive VOC emissions in petrochemical operations. However, problems remain, including a lack of consistent VOC testing standards and consistent recognition of the potentially achieved control efficiency. Therefore, the Chinese Central Government should enact a series of standard LDAR testing procedures, such as monitoring methods, leak standards, and repair requirements as soon as possible.

In addition, the benefits of LDAR are not simply limited to leak detection and repair. Through a LDAR technology platform, data about leaks and repairs can be statistically analyzed, which is helpful to determine the cause of leaks and to further enhance petroleum industry design specifications and material standards.

**Direction of VOC Control and Management in China**

On July 21, 2014, ACEE hosted a VOC Pollution Control Workgroup Forum with participants from China Petroleum & Chemical Corporation, China National Petroleum Corporation, China National Offshore Oil Corporation, and China Shenhua Group Corporation Ltd., as well as invited experts (see Figure 2).

At the end of the event, the ACEE responsible officer recommended that the VOC workgroup should further develop its organization and coordination functions, build alliances, and integrate research efforts. It was suggested that the workgroup learn more about the experiences of VOC control and management of its member enterprises, establish clear research focuses and priorities, and coordinate resources and division of labor to both promote the comprehensive management of VOCs in the petrochemical industry and contribute to the smooth implementation of the air pollution control Action Plan in China.

In its next phase, the workgroup will focus on four key aspects of VOC control and management in China: monitoring methods, statistical analysis, control measures, and management assessment.