U.S. Environmental Protection Agency (EPA)
Environmental Technology Verification (ETV) Program
ETV International Forum
Meeting Summary

July 13-14, 2005
Washington, DC

The Environmental Technology Verification (ETV) International Forum was held on July 13-14, 2005, at the Four Points Sheraton Hotel in Washington, DC. Approximately 200 people attended the Forum. Meeting participants included representatives from 14 countries: Austria, Belgium, Canada, Finland, Germany, India, Israel, Japan, Korea, Laos, Singapore, Thailand, The Netherlands, and the United States. Representatives from the United States, Canada, Korea, Japan, Singapore, and the European Union provided presentations on the various national and international verifications programs in existence and under development around the world. Vendors of ETV-verified technologies, such as ambient ammonia sensors, portable cyanide analyzers, lead in dust detection devices, residential nutrient reduction technologies, mobile sources devices, and mercury continuous emission monitors, exhibited at the forum. The forum was followed by a tour of the U.S. Environmental Protection Agency (U.S. EPA) Office of Research and Development's (ORD) testing and research facilities in Cincinnati, Ohio, on July 15.

Wednesday, July 13, 2005

WELCOME AND INTRODUCTION

Teresa Harten, Director, U.S. EPA ETV Program, welcomed attendees to the first ETV International Forum. She introduced Sally Gutierrez, Director, U.S. EPA National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio. NRMRL is one of three national laboratories within the U.S. EPA's ORD. Sally Gutierrez was appointed Acting Director of NRMRL in October 2004. She was just named Director. She is responsible for leading a complex research organization including research programs for control of contaminants in drinking water and air, research on redevelopment and remediation of Superfund sites and brownfields, restoration of impaired water bodies and ecosystems, and environmental sustainability. Her research staff consists of more than 300 engineers, chemists, hydrologists, microbiologists, economists, ecologists and modelers. Prior to her present appointment, Sally Gutierrez served as Director of the Water Supply and Water Resources Division within NRMRL, where she was responsible for leading a research program for treatment and control of microbes and chemicals in drinking water to support the U.S. EPA's responsibilities in the implementation of the Safe Drinking Water Act. She is a native Texan and holds a Master of Science from the University of Texas School of Public Health in Houston, Texas.

After expressing her excitement to be at the forum, Sally Gutierrez welcomed the attendees to the ETV International Forum on the behalf of the U.S. EPA. She stated that this forum is an important meeting, and its importance is signified by the number of people who registered for this conference. There are approximately 200 people attending this meeting and 14 countries have sent representatives. This signifies that verification is an important topic of international interest. Sally Gutierrez announced that there would be a tour of the U.S. EPA ORD's testing and research facilities in Cincinnati, Ohio, on July 15, 2005.

The United States has long recognized the need for and the value of determining the efficacy of treatment technologies designed to control environmental contaminants and monitoring devices that collect data for process control, overall environmental condition assessment, and compliance with regulatory standards. There is no doubt that many of the tough environmental challenges of the past 30 years in air and water pollution and land remediation have been overcome by conducting high quality verifications and demonstrations of a large number of technologies. A key part of these evaluations has been to determine the capital, operating, and maintenance costs, as well as the level of expertise that is required to operate these technologies. The U.S. EPA has achieved many of its desired public health and environmental goals through the effective use of technologies.

On July 12, 2005, there was a pre-forum session on the U.S. EPA's arsenic (As) drinking water treatment technology demonstration program, which provided a very clear and recent example of why verification is important. In one case, a technology vendor claimed that its technology could remove both As(III) and As(V) from the water. Evaluation of the technology showed that removal of As(III) was marginal, and the technology had to be modified to make it effective for the removal of arsenic from drinking water. This reconciliation between vendor claims and real-world performance is at the heart of the need for these verification programs. Verification also can become a key factor in the adoption of new and improved environmental technologies and monitoring devices whose performances are unknown in the marketplace. Many governmental and private entities subject to compliance with environmental standards cannot take the risk of entering into relationships with vendors whose technologies are new and unproven. By the same token, permitting authorities may not allow the installation of technology without expensive pilot testing within their jurisdictional boundaries. This becomes problematic when it impacts the use of very well thought out effective technologies that can help bring about environmental and public health protection at reasonable cost. It is not until independent high quality performance information is developed and distributed that we can begin to facilitate adoption of new technologies.

The U.S. EPA ETV Program was created in 1995 to accelerate the entrance and adoption of new and innovative technologies to the marketplace. This very visionary program has seen great success, with more than 300 different technologies verified to date. More than 80 testing protocols have been developed. One of the unique dimensions of the program is that these protocols have been developed through a very strong volunteer stakeholder consensus process. The program has verified technologies for treating various contaminants in drinking water, such as arsenic and cryptosporidium. Verifications have also been performed on technologies that control particulate matter, sulfur and ammonia in air; on-site sewage disposal systems; wet weather flow contaminant control devices; and devices and technologies applicable to the homeland security area. The homeland security verifications are a very good example of why this verification process is important. When the United States was first faced with the potential for intentional contamination of the environment, whether it was our buildings or the potential for

contamination of our water supplies, Sally Gutierrez immediately got calls from the public and others with questions regarding vendors and whether their technologies were effective or the performance claims were true. There was little information that could be provided to the public and others on how effective certain devices were. Since then, a number of verifications have been completed for various devices in the homeland security area.

One success story is some very recent work that has been done in diesel retrofit technology verification. Diesel retrofit technology vendors who went through the verification process have reportedly sold more than 1,200 retrofit technologies in less than 2 years since verification. If these retrofit technologies only penetrated 10 percent of the market, ETV estimates that between 700 and 2,400 premature deaths could be avoided in the United States alone. On a global level, the impact would be tremendous.

In the area of monitoring technologies, these technologies take front and center in many ways because they are measuring how well emission control processes are working and the actual emissions coming out of a pipe or a stack. Monitoring technologies are a priority of the U.S. EPA ETV Program. There have been many recent advances in real-time and continuous monitors for pollutants in air such as ammonia, particulate matter and hydrogen sulfide. In water, a number of multi-parameter probes and nutrient detection devices have been verified. For surfaces, monitors have been verified that more quickly determine whether dangerous lead levels are present, provide us with a new tool to help clean up certain buildings or other surfaces that may have lead in them, and maybe even allow us to better gauge the safety of buildings for reentry.

The value of verification performance information also has been recognized by many regulators and entities responsible for environmental permitting actions, such as states that implement drinking water protection programs. ETV-verified technologies are now allowed to be installed in some states without additional pilot testing. The savings from this are tremendous, because pilot testing is no longer required in some states before the technology can be used. This saves a tremendous amount of money in site-specific pilot testing and it allows for more expeditious installation of these technologies. There are many benefits to vendors. Vendors use the verification results in their marketing and sales activities, and they also have independent high quality data to present to potential clients.

As the U.S. EPA ETV Program moves into the future, a number of environmental protection case studies will be completed and published in late 2005. These case studies include estimated environmental and public health benefits of the program. The need for these estimates is a lesson that the program has learned. While a lot of energy was initially placed in the actual verification process, until recently very little effort had been invested in measuring or gauging the actual impact of the emission reductions or contaminant removals. The U.S. EPA ETV's experience could benefit other programs that are evolving globally to make this a part of the design of their programs.

The U.S. EPA has also recognized that verification is an area where we can begin to introduce and advance the concept of sustainability as it relates to technology. This is a new dimension that is being added to the U.S. EPA ETV Program. There is a need to begin to formulate some sustainability metrics that can be applied to the technology verification process. For example, a metric could be the amount of drinking water and backwash that could be minimized. Some of these technologies may utilize toxic

materials or persistent biocumulative materials, and there may be ways to minimize the use of these materials.

The U.S. EPA sees a great need for collaboration across the globe. The U.S. EPA ETV Program has been very fortunate to have interacted with many interested countries, including Japan, Korea, Canada, and Singapore. It is hoped that this meeting will further foster these collaborations and that consideration will be given as to whether there would be value in adopting standards (e.g., an ISO-type framework) that could be applied globally to improve the exchange of accepted technologies. Sally Gutierrez encouraged the participants to exchange ideas on some of these concepts. She stated that we all want to accomplish the verification of these technologies in the simplest, least costly and most effective manner. She voiced her hope that this meeting will bring everyone closer to unified thinking.

Finally, Sally Gutierrez thanked Evelyn Hartzell, Abby Waits, and Teresa Harten of the U.S. EPA ETV Program for their leadership and efforts in putting together this meeting and the members of the planning committee, including: Kenji Kamita, Deputy Director, Office of Environmental Research and Technology, Environmental Policy Bureau, Japan Ministry of the Environment (MOE); Bruce Bartley, U.S. EPA ETV Drinking Water Systems (DWS) Center Manager, NSF International; Andrew Trenholm, U.S. EPA ETV Air Pollution Control Technology (APCT) Center Manager, RTI International; Anna Phillips, Program Manager for Europe, U.S. EPA Office of International Activities (OIA); Dennis Cunningham, Southeast Asia Program Manager, U.S. EPA OIA; and Gary Waxmonsky, Acting Chief of Staff, U.S. EPA OIA. She also thanked NSF International and Environment Canada for graciously offering to host the reception after this day's meeting.

Teresa Harten thanked Sally Gutierrez for her comments and support of the U.S. EPA ETV Program. The U.S. EPA ETV Program has been in existence since 1995, so this is their 10th anniversary year. It is an auspicious year and the U.S. EPA ETV Program decided to celebrate it by having this international forum. Over the years, the U.S. ETV Program has interacted with many different countries. In addition to providing training workshops in India and Thailand, representatives from many countries have come to the United States and met with the U.S. EPA ETV Program staff and ETV Centers. She thought it was appropriate to have all the countries that are operating ETV programs around the world at this forum and provide them with an opportunity to discuss the technologies that are of interest and begin to talk about collaborating on a multilateral level. There are two charges for the speakers and for the audience. The first charge addresses the following three questions: What are the technologies of interest to each country and their programs? What are some of the exciting technologies that they are looking at? How do these technologies perform? One of the most rewarding aspects about working in the U.S. EPA ETV Program is the exposure to these new technologies that provide hope for improving the environment and for tackling some of the big environmental problems. The speakers in the technical sessions have been asked to summarize the technologies of interest and how they perform. The second charge is to discuss how the individual programs operate in terms of choosing the most important technologies to verify, how they operate in terms of developing the testing protocols, and how they operate in terms of actually testing the technologies (i.e., what are the quality assurance and auditing procedures used for the various testing events and the program wide operations). Teresa Harten then noted that there are a number of vendors at the meeting demonstrating their technologies. She invited the participants to visit the exhibits because they represent many of the exciting technologies that are available.

Teresa Harten announced that on Thursday afternoon there would be a panel discussion to summarize the presentations and thoughts generated during the forum, and to develop some action items and ideas for collaborative work on verifications. Some of the ways the different countries might start working together include: co-verifying technologies, developing protocols together, sitting on each other's stakeholders groups, and using an international system of standards such as ISO as a framework within which to operate and to develop protocols. There are many possibilities on which collaborations could be started and, ultimately, result in reciprocal programs. This forum is the first step and the U.S. EPA ETV Program is looking forward to help from the meeting participants in determining how the process can begin.

WHY IS VERIFICATION VALUABLE?

Sally Gutierrez served as the session chair and introduced each of the speakers.

Global Perspective

William Mansfield III is a Special Consultant to the Executive Director of the United Nations Environment Programme (UNEP), working in UNEP's Regional Office for North America in Washington, DC. He is a former Assistant Secretary General of the United Nations and Deputy Executive Director of UNEP. UNEP is the principal environmental arm of the United Nations, addressing primarily global and North-South environmental issues. During seven years with UNEP in Nairobi, Kenya, he participated in the international negotiations on a wide range of treaties and programs related to global environmental issues and activities. He is a former U.S. diplomat, having served at posts in Africa and Europe and a number of environmental assignments in the State Department, and at the U.S. EPA. Among his other environmental assignments, William Mansfield has served as Director of UNEP's Global Environment Facility office in Nairobi, as Senior Vice President for Operations at the Worldwatch Institute in Washington, DC, and as Special Advisor to the Executive Director of the Canadian, Mexican, U.S. Commission for Environmental Cooperation, located in Montreal, Canada.

William Mansfield thanked Sally Gutierrez for the opportunity to join in the discussions at this forum of the U.S. EPA's ETV Program, other such programs around the world, and ways to build on each other's efforts. He stated that the panel was requested to address the question: Why is verification valuable? As a representative of UNEP, William Mansfield was invited to address that question within the framework of a global perspective.

William Mansfield began his presentation by providing a look at the state of the global environment and the Earth's natural resource base to see if that would help to identify some of the technology needs facing our planet and the world economy. In his view, the technology needs of the 21st century, and where they will be needed, are going to be quite different from those of the 20th century. He stated that we should be alert to those likely differences.

William Mansfield pointed out that what we traditionally call the global environment is actually the foundation of the world economy. The air, water, soils, forests, croplands and fisheries that are our environment make up the world economy's natural resource base that sustains life on the planet, our economic prospect and our prosperity. The environment is our life-support system. Yet, while acknowledging the importance of the global environment, we are, nonetheless, already using and

degrading it faster than nature is able to restore and replenish it. We see this starkly in shrinking forests, eroding soils, collapsing fisheries, rising carbon dioxide levels and temperatures, melting glaciers and ice packs, dying coral reefs and disappearing species.

Several important global trends contribute to this deterioration. The first is the demands of a growing human population. In 1950, the world population was 2.5 billion. Today, the world population has grown to 6.3 billion. We will be at 9 billion in 2050. That is a 50 percent increase from today. The growth rate is slowing, but we are still adding 73 million people to the planet each year. Of that 73 million, and the additional 3 billion expected to arrive, 98 percent are and will be born in developing countries—countries already stretched to provide goods and services, jobs, education and health care to their populations. Many are living in great poverty, and to survive are living off and further degrading their natural environment.

A second major trend is the rapid expansion of the world economy, approximately nine times since 1950, growing from $6 trillion in outputs and services to $55 trillion in 2004. The massive resource consumption driving this expansion is huge compared to the size of the Earth's ecosystems, and the larger the economy becomes the more pressure it puts on the planet's resource base.

A third trend is the development of technology. Today's technologies in manufacturing, energy, transportation and agriculture were largely developed when the world had a shortage of people and an abundance of resources. As important as those technologies are to our prosperity today, many of them are resource intensive and wasteful. Many are not suited to a world with an abundance of people and shortage of resources. That is why moving to and verifying environmentally sound and sustainable technologies is absolutely essential and urgent.

The effects of these trends on the Earth's environment and natural resource base are now clearly seen as harmful. One-third of the world's cropland is losing precious topsoil, undermining its long-term productivity and threatening food security. Fifty percent of the world's rangelands are now overgrazed and degrading. Two-thirds of the world's oceanic fisheries are now fished at or beyond their capacity, and freshwater fisheries are in worse condition. Clean water is increasingly in short supply. Around the world, groundwater tables are being drawn down, and major rivers—such as the Colorado, the Nile, the Yellow River, the Indus, and the Ganges—are running dry at least part of the year before they reach the sea. Burning fossil fuels is causing the atmosphere to warm, resulting in more severe storms, changing rainfall patterns, melting glaciers and Arctic ice, rising sea levels, and allowing tropical diseases to move into northern regions.

These changes are not a good sign for the world economy or for global stability. Together, they signal a serious undermining of the Earth's natural resource base and, if they continue, portend crucial environmental, economic, political and social problems for our future. The most serious harmful impacts will fall disproportionately on the poorest parts of the world, which contain the most rapidly growing population. In our globalized world, wealthy countries will not be able to shield themselves entirely from the deteriorating environment and resource base.

What does this changing world situation signify for technology verification? To those of us in the international community it means that if we want our technologies to address the crucial global needs in

the years ahead, we must direct our technology development, assessment and verification to facing the critical issues of the planet and its mounting population. There is a tendency for industrialized countries to address their own problems, sometimes at the expense of the needs of the developing world. That is to some extent understandable, though in the long term it may not be advisable. It is natural to focus attention on pressing issues in your own community, and most companies have in the past traditionally found the best and most lucrative markets in the wealthy industrialized countries. That means much of the attention of our environmental technological development, and needs for verification, will focus on sustainable energy technologies, chemical processing technologies, information technologies, biotechnology, and nanotechnologies of interest to industrialized countries.

Based upon these trends, the world's needs for technological development will more and more be in the developing world, because that is where the world's problems will be most acute, and with some 4 billion potential customers, that is where the growing markets for technologies will be. These consumers, these markets, need many of the technologies of the wealthy countries, and we must find better ways to get those technologies to them. They will need even more technologies that will help them address the more basic environmental and developmental problems they are facing.

The key environmental challenges in the growing developing world fall into several major areas: air quality, energy efficiency and climate change, water resources, toxic substances and hazardous and solid wastes, and resource use and management. New prevention and control technologies are needed to deal cost effectively with local and global air quality problems in the developing world, such as air toxicity, indoor air pollution, acid deposition and ground-level ozone. Developing countries need new building materials and consumer products that minimize adverse impacts on indoor air quality; cars and trucks that emit fewer pollutants, and transport systems redesigned to address the increasing number of vehicles on the road; redesigned industrial and chemical production technologies with inherently low potential for air emissions; and cost-effective, efficient particulate, air toxicity, sulfur dioxide and nitrogen oxide control technologies capable of being retrofitted to existing power plants. Pollution prevention technologies are critical for the developing world, especially to reduce mounting quantities of toxic and hazardous wastes and to promote recovery, recycling and reuse. As industrialization increases, toxic substances produced by industrial and combustion process are swelling rapidly, as are chemical discharges. While end-of-pipe, burning and burying wastes are common, technologies are needed that help to avoid toxic and hazardous substances. Minimizing waste formation and promoting recovery, recycling and reuse and technologies that assist in cost-effective management of non-recycled wastes and their disposal are needed.

The 4 billion or more people in the developing world have a special need to take care of their renewable and nonrenewable resources more efficiently. Technologies that help to raise cropland and rangeland productivity, sustain forests and restore world fisheries, and promote aquaculture will be critical. Technologies are required to conserve the mineral stocks already in circulation, and to reduce demand for virgin resources and the environmental damage due to extraction.

In particular, two areas need urgent attention—climate change and water. Today's technologies are inadequate to solve the problems of greenhouse gas emissions and global climate change. The developing world will need new technologies that reduce energy requirements. Other measures include improving energy efficiency in road vehicles, lighting and heating conversion to low-carbon fuels, and reducing greenhouse gas emissions. The energy-inefficient infrastructure in Central and Eastern Europe badly

needs improving, while developing countries must develop low-carbon energy sources. They, as we, need accelerated commercial development of renewable fuels and technologies and improved thermal efficiency of coal-fired plants through clean-coal technologies.

The need for technologies to protect rapidly dwindling and degraded water resources, improve their quality, and reduce their cost is also urgent. The developing world needs technologies that prevent agricultural contamination of groundwater, cost-effective and reduced water use in sewage treatment, and more efficient irrigation technologies. Reducing the cost of water and wastewater treatment is one of the biggest challenges. Reducing the cost of existing technologies or finding other cheaper approaches are essential to ensure safe, adequate water supplies. Agriculture is another major source of pollution in much of the Third World. Non-point source runoff is a serious issue everywhere. Engineering solutions alone do not work: the answer will depend on technologies and practices that combine ecological know-how with engineering capabilities.

The technology needs that have been outlined are illustrative, for the real needs are many and varied. Many of them are required for the problems of the industrialized, as well as the developing, world. All will require technology transfer and verification. We must increasingly be mindful of directing our efforts to developing technologies to address the world's, as well as our own, most serious problems. Technology alone cannot solve today's and tomorrow's problems. A whole range of other factors must be addressed simultaneously. Everywhere, and especially in the developing world, barriers to transferring appropriate technologies abound. Among them are the lack of knowledge about the existence of commercially available technologies and the benefits they bring. Other factors include lack of skills and finance, as well as inadequate policy environments.

It is the private sector, not the public sector, which is the principal developer, purveyor, financier and distributor of technology; the governments and international organizations must work in partnership with business and industry to ensure that technology is developed and distributed. Increasingly, public and private partnerships are becoming a vehicle to promote use of technologies. They bring industry's technology, finance, managerial efficiency, entrepreneurial experience and engineering expertise together with governments' capacity to generate the political will, and create a policy environment conducive to investment and long-term sustainable development.

The various development organizations in the United Nations (U.N.) system over the years have sought to play a constructive role in promoting technology transfer to countries in economic transition and to developing countries. Additionally, they have tried to institutionalize technology transfer in many of the environmental agreements and treaties negotiated under their auspices. Concern about technology and technology transfer was given priority at the United Nations Conference on Environment and Development in 1992 and again at the Johannesburg Conference on Sustainable Development in 2002. They signaled the need for favorable access to and transfer of environmentally sound technologies, in particular for developing countries, through technology cooperation and transfer of technological know-how, as well as building capabilities for efficient use and further development of transferable technology.

A number of U.N. agencies have important technology programs to promote the use of appropriate technologies. The World Bank, the U.N. Development Programme, the regional development banks, the U.N. Industrial Development Organization, and the Global Environment Facility have active programs to

promote the use of new, safe technologies. Many governments also have international programs fostering technology development and transfer.

A number of international agreements encourage the use of new technologies and benefit from technology verification. Among them are:

- ✧ The Montreal Protocol on Substances that Deplete the Ozone Layer, which calls for the phase-out of fully halogenated chemical emissions by converting to alternative technologies. The treaty's Multilateral Fund provides funding for development and employment of new technologies.

- ✧ The Climate Change Convention, which aims to reduce greenhouse gas emissions and encourage the use of alternative energy technologies to cut such emissions. Its Joint Implementation Program promotes technology transfer.

- ✧ The Persistent Organic Pollutants (POPs) Convention, which seeks to regulate the production and use of 12 persistent toxic substances and find alternatives to them.

- ✧ The Bio-Safety Protocol to the Biodiversity Convention, which seeks to regulate the trade in genetically modified agricultural commodities and find safe technologies for them.

- ✧ The Basel Convention on Hazardous Wastes, the Desertification Convention and others, which promote development and use of appropriate and new, more sustainable technologies.

The UN organizations and treaties can all benefit from technology verification.

UNEP has a number of technology programs. The Environmental Technology Assessment Programme aims to create awareness of the need and value of environmental technology assessment among key decision makers, such as government agencies, industries and trade associations, nongovernmental organizations (NGOs), research institutions and funding organizations. They see technology assessment as an essential support to developing and applying environmentally sound technologies. UNEP seeks to include environmental considerations in technology assessment. They give priority to developing countries and stress their needs for awareness raising and capacity building. In awareness, they stress showing the linkages between economic and environmental benefits, and illustrate both good and bad technology choices from an environmental standpoint. Capacity-building focuses on helping developing countries carry out and apply assessment, by providing information on methodologies and the ways to apply them.

UNEP provide directories of technology assessment institutions and sources of information and training resources. UNEP's Environmentally Sound Technologies Information System (ESTIS) provides for the creation and management of information on the Internet and for decentralized dissemination of technology assessment information (http://www.estis.net).

These programs are carried out by the Division of Technology, Industry, and Economics, headquartered in Paris, France, and the International Environmental Technology Centre (IETC) in Osaka and Shiga, Japan (http://www.uneptie.org). The Centre focuses on water and sanitation; implementation of

sustainable reduction and consumption in Asia, with special attention to waste management; and disaster prevention and management.

Given what has been said about the global environmental issues we face, UNEP is convinced that the U.S. EPA ETV Program is making an important and vital contribution to technology development and transfer. UNEP believes it is essential to provide third-party, quality-assured testing to speed implementation and use of innovative environmental technologies. Given the mounting pressures and needs of a mushrooming developing world, they believe an important effort must be devoted to bringing the benefits of the U.S. EPA ETV Program and other technology verification programs to the poorer countries and countries in economic transition. This calls for, perhaps, a less sophisticated program than the U.S. EPA ETV Program, one that requires a somewhat less technical infrastructure of skilled professionals, measurement and analytical facilities and well-defined testing protocols, which are more likely to be available in developing countries. Developing countries' immediate need is assessment for technology selection and implementation. Given their resource and skill constraints, the assessment process for them should be fast, simple and inexpensive. They are not looking for 99.99 percent accuracy; rather, a much broader level of 90 percent accuracy. They are looking for robust, low-tech and easy maintenance operational programs that do not require specialists to operate and maintain.

For the verification to really yield results in the developing world, part of the program must build in capacity building so that nationally tailor-made programs can be developed and put in place. With financial support, UNEP could undertake to carry out such capacity building within the framework of their Bali Strategic Plan on Technology Transfer and Capacity Building. UNEP thinks that they should increasingly incorporate the environment focus of the verification program into a Sustainable Technology Verification Program where increasingly development and social factors also are assessed (e.g., the impact on jobs and on poverty reduction). This, of course, is more difficult but increasingly in keeping with the direction of world thinking.

As the biggest need for selecting the right and environmentally sound technology in the developing world is in the Small and Medium Sized Enterprises (SMEs), the program could very usefully be evolved to address more specifically the technologies they use, keeping in mind their resource constraints.

It is clear that the technology verification program should reach out for acceptance by a wider international audience. Broader international acceptance would help to ensure that verification would achieve greater use and would not contribute to the potential of trade barriers. Ideally, the verification process should be adaptable and implementable by as many technology suppliers and users as possible around the world.

In the past, the international community has undertaken to adapt these specialized and often nationally based programs (e.g., hazardous wastes) first within the framework of the Organization for Economic Cooperation and Development (OECD) for developed countries. That accomplished, the baton has been passed to UNEP to work with developing countries to adapt the approach and program to their needs.

Through the IETC, UNEP is ready to participate in technical discussions on how to move forward on a technology verification program that takes into consideration the wider set of information and other needs of developing countries, to assist them in their choice of suitable technologies with parameters that help them.

As decision makers in government, industry and other areas focus more on introducing environmentally sound technologies into their policies, programs and practices for managing environmental issues, environmental technology verification will become an even more essential tool for protecting the global environment. UNEP commends the U.S. EPA on its program, and urges them to consider with others in the field ways to expand its current reach to the wider international community.

Attaining sustainable development is a great challenge facing the community of nations; it is a challenge that can be met by developing and deploying technologies that will protect the environment while sustaining economic growth. That makes technology verification an essential tool for achieving sustainable development in the 21st century.

U.S. Department of Commerce Perspective

Carlos Montoulieu is the Director of the Office of Energy and Environmental Industries (OEEI) in the International Trade Administration of the U.S. Department of Commerce (U.S. DOC). In that capacity, he oversees the Department's programs and initiatives to develop greater commercial opportunities in, and exports to, foreign markets for U.S. energy and environmental companies. Prior to his current position, Carlos Montoulieu was Deputy Director of the Office of Latin America in the DOC, where he was responsible for economic relations and trade and investment policies with the region, with particular emphasis on the Southern Cone countries—Argentina, Brazil, Chile, Paraguay and Uruguay. In this role, he was actively involved in the development and implementation of the Enterprise for the Americas Initiative, the precursor to the Free Trade Area of the Americas (FTAA). In previous assignments in the U.S. DOC, he was Director for Andean Countries, and served in the Secretary of Commerce's Office of Economic Policy. He is co-author of the "Economic Report on Puerto Rico"—a Presidentially-mandated study conducted by the U.S. DOC that is the most comprehensive report ever done on the subject—and was staff advisor to the first White House Task Force on Puerto Rico.

Carlos Montoulieu stated that for policy, technical and commercial reasons, environmental technology verification is critical. It is something that we have to have, and we have to have more of it. He provided background information on the link between verification and the commercial work that is done in the U.S. DOC. The mandate of OEEI is relatively straightforward: to enhance the international competitiveness of U.S. environmental and energy companies and to help them increase their exports to the world. One way that this is done is through trade policy development. For example, they are very actively involved in work in the World Trade Organization (WTO) to liberalize trade in environmental goods and services. This is a new focus of opportunity for industry and a unique focus on a particular sector that the WTO has decided to embark on in a new round of negotiations. The U.S. DOC has been actively involved in all of the Free Trade Agreements that the United States is negotiating bilaterally or multilaterally to ensure that

there is adequate attention paid and opportunities provided to the environmental and energy industries of the United States.

Another area that the U.S. DOC actively works in is the commercial arena and outreach to U.S. industry. It is a two-way flow. The U.S. DOC needs to know what their industry's needs are, their interests, and their concerns, and also learn about developments in the industry. Industry needs to know about the many ways in which the U.S. DOC can help them target and succeed in international markets. The U.S. DOC provides information on specific project opportunities, the faster growing markets, and the faster growing areas of opportunity within subsectors of the environmental industry.

Another major area that the U.S. DOC works in is research, providing in-depth research about markets of opportunity. They address such areas as: where is the growth, what are the particular barriers to trade, what are the project opportunities, who are the key contacts, and what are the ways of doing business in those markets globally that offer the greatest opportunity for growth for exports for the U.S. environmental and energy industries. A good amount of the work that the U.S. DOC does in this area is focused on big emerging markets and economies, such as Brazil, India, China, Thailand and Mexico. This is where the major environmental market growth is taking place, now and in the foreseeable future.

The U.S. DOC also does advocacy for individual U.S. companies that are pursuing specific projects overseas. Many of the projects that take place in the environmental sector are government-led projects, such as water and wastewater treatment plants, and major plans and initiatives to clean up the air or reduce solid and hazardous wastes. The U.S. DOC is competing head-to-head with its counterparts in some of the other major exporting countries, such as the United Kingdom, Germany, France and Japan. The U.S. DOC and these countries all do advocacy on behalf of their companies that are competing for the major procurement projects overseas.

A large amount of the work that the U.S. DOC does is in the area of matchmaking, which is the area most closely related to verification. The U.S. DOC works to figure out how to more effectively bring together the U.S. suppliers of environmental goods and services and the foreign buyers of those goods and services, whether the buyers are in the private or public sector. As mentioned before, many of the potential overseas buyers are governments or government agencies. These decision makers and potential buyers are often high-level officials in ministries of environment, ministries of public works, energy departments, etc. The U.S. DOC works closely with these individuals/organizations to bring U.S. companies to their attention and provide information on how these technologies or services can help them solve the environmental problems they are trying to address. The U.S. DOC consistently runs into the issue of verification. The process goes like this. First, the environmental problem is defined. Second, they identify what kinds of technologies or services are available to deal with that problem. Third, they identify who supplies those goods and services. Afterwards, the logical next questions that the U.S. DOC gets from the overseas buyers are: Does this technology do what it says it does? Will this technology or process help them meet the environmental goal or standard that they have to meet for regulatory or economic reasons? Related to this is the issue of clean energy and energy efficiency that is becoming increasingly important as the price of oil and related products continues to surge.

The U.S. DOC is continually asked: Can you verify that this technology works? This question is most frequently asked by two types of buyers or groups of buyers. One group consists of buyers in the less-developed countries who have less experience in environmental investment and in environmental applications. They need greater certification or assurance that this technology does what it says it does. The second group consists of buyers who are looking at state-of-the-art technologies (i.e., newer emerging technologies that everyone has some questions about). For example, they have heard about tremendous advancements and improvements in the area of ultrafiltration in water. There is a tremendous movement toward membranes, ultraviolet (UV), and other treatment mechanisms. Will a technology really work in the application that a buyer wants to use the technology for? It may work in an application in a developed market that can invest more money and has more resources to buy state-of-the-art technologies. Will it work as well, and is it needed as much, in a lesser application where that state-of-the-art technology may or may not be required?

Competition in the global market for environmental technologies is fierce, because everyone is involved in it. There are some great competitors from the other countries mentioned previously. The ability to guarantee the delivery of a service and the efficiency of a product that is being sold is a necessity. Reducing the risk of a particular project becomes increasing important in the environmental sector. It is also increasingly important for social reasons. Many of these projects have economic or environmental benefits, as well as major social and health benefits. The demand from the public sector in all of these developing countries is increasingly to show results, to deliver what you said you would as you embark on investing perhaps hundreds of millions of dollars or billions of dollars to clean air, treat water, or reduce waste. Those who are supplying goods and services to government officials or private sector companies are very well armed when they have had verification conducted on their product or process.

In summary, Carlos Montoulieu stated that he is a big fan of verification programs. He completely supports the work that the U.S. EPA has been doing through the U.S. EPA ETV Program. He endorses greater international complementary programs. He believes that U.S. companies that manufacture these products and deliver these services would be extremely supportive of this and would be active users of the program. He commended the U.S. EPA and the other countries at the meeting for their work on verification and he will endorse expanded use of any of those programs for the benefit of commercial applications of U.S. industry.

Questions

Sally Gutierrez thanked Carlos Montoulieu for his presentation and asked if there were any questions. Mehboob Sumar (Bodycote Materials Testing Canada Inc.) stated that the U.S. EPA ETV Program was supported by the government. Is it the same in all of the other countries that their ETV programs are supported by the government? Teresa Harten responded that the U.S. EPA ETV Program is receiving increasing support from the private sector to sustain the program. She stated that the next session would be presentations on the ETV programs in the other countries and they would be addressing how their programs are funded.

Market Analysis, International Opportunities

Andrew Paterson has been working with technology enterprises and engineering firms for 20 years, primarily in market, financial and technical analysis of innovative technologies and commercial issues in bringing them to market. He has worked with Environmental Business International (EBI) for more than 10 years on projects with engineering firms and large manufacturing companies. EBI is a leading publisher and research group for market intelligence and strategic information related to environmental and energy markets. During the last 5 years, he has conducted market and technical reviews of nuclear waste, energy and environmental markets for a number of commercial clients. Andrew Paterson is a graduate of Stanford University with a Bachelor of Arts in human biology, with an emphasis in economics and environmental policy. He also attended the Cornell Graduate School of Business, and completed the Professional Accounting and Finance Program with Price Waterhouse. He began his business career with Price Waterhouse and worked with a variety of engineering and technology companies in the Emerging Businesses Practice Group of the firm based in Los Angeles, California, where he served as a regional director for the Technology Executives Network.

Andrew Paterson complimented William Mansfield and Carlos Montoulieu on their presentations, which set the stage for a many of the issues and trends that will be discussed throughout the forum. Andrew Paterson stated that his presentation would focus on the environmental market outlook to 2010. Environmental technology is unfolding in a local political context, not just a national context. Markets do not buy technologies—customers do. Often, they are buying not a technology, but a solution. Environmental legislation in the 1970s and 1980s helped drive the growth of the U.S. environmental market, but economic recovery and manufacturing excellence in the 1980s became larger drivers as cleanup markets topped out. Exports comprise about 10 percent of the total market and are concentrated in air and water equipment. The U.S. environmental market growth trends from 1970 to 2010 show that the market is beginning to crest. The market is composed of three broad categories: (1) services, which is populated with engineering firms; (2) equipment, which is populated by technology providers; and (3) resources such as water and recycled goods. These categories were developed in part with the U.S. EPA and with the DOC. Success has been part of the story behind the cresting of some markets. On the one hand, it is bad news that the markets are cresting if you are in environmental sales. On the other hand, there has been success in the reduction of lead emissions in air and the reduction of some pollutants in the wake of the onset of technologies in the energy sector. There still are global challenges such as clean air, safe water and land restoration.

There are several service sectors that are declining in the United States, while the water and energy sectors are growing. The backend treatment services (e.g., remediation, hazardous waste management, analytical laboratories, and related consulting) peaked in the 1980s and will continue to decline. In the remediation and hazardous waste sector in the United States, particularly with the huge success by the U.S. EPA in cleaning up underground storage tanks, much of the work has been done. Therefore, there is a cresting in those markets. Water and their process and prevention technologies are growing, however, as we move from end-of-pipe treatment in the manufacturing sector to the use of catalysts and material substitution. In the last five years, a segment called environmental energy sources (i.e., alternative energy

sources, wind, solar) has been added, and it will be a big trend globally. Some sectors are growing and some sectors are cresting.

Andrew Paterson provided a chart on 2003 environmental markets by media (i.e., air, water/wastewater, hazardous waste, remediation, solid waste, multimedia). The U.S. EPA tends to organize itself by media, and some of the technologies that are verified are grouped by media. The U.S. EPA's budget tends to follow the market; the spending that the U.S. EPA has done in air and water tracks with the activity that is going on in the overall environmental economy. Water and solid waste are huge chunks of the environmental marketplace, both globally and in the United States.

Andrew Paterson discussed the 2010 forecast for the U.S. environmental markets in terms of growth versus size. There are three groups of environmental markets where spending and selling is occurring. There are smaller markets, such as the prevention process technologies and the environmental energy technologies, which are growing fast. There are some large markets, such as infrastructure, hazardous waste and wastewater treatment services segments, which tend to grow with the economy and population. The third group is the shrinking or cresting markets that include the traditional backend cleanup and consulting sectors. In developing countries, the backend services (e.g., remediation, land restoration) are often tied to finance and development projects, rather than a stand-alone program. The different market traits (growth rate, competitive dominance, the nature of purchasing decisions) call for different export development approaches and affect the issues related to technology verification. Clean energy and process technologies offer much higher growth rates (>20 percent per year) to allow for the recovery of equity investments. The larger markets, such as water treatment and resource recovery, have steadier growth rates that match the economy and demographic trends, and also allow for some debt funding and project finance (often with some public finance). Municipal ownership is high in these sectors, thus precluding venture capital; tax-exempt bonds and international lending are more typical. Declining markets, such as remediation and consulting, must rely on asset conversion (e.g., brownfield development or facility turnaround) to generate returns because losses on operations are common. For international markets, project debt financing is a paramount factor driving purchasing decisions because markets and enforcement mechanisms are not well developed.

Andrew Paterson discussed revenue generation based on public versus private ownership. In the United States, there is a much higher public sector ownership of water utilities and water treatment works; this is not the case in the United Kingdom and France. Public versus private ownership is another factor in how purchasing decisions are made on technology systems.

In looking at the global market by geographic region, developing countries offer higher growth markets, but environmental spending is still dominated by industrialized, high per capita income countries. The United States is almost 40 percent of the global market, with Western Europe at 30 percent, and Japan at 17 percent. The lack of enforcement, funding problems and economic instability are major issues. The global markets are driven by demographics and energy needs. Energy and water niches will grow worldwide to meet the demands of surging populations. More than 25 "mega-cities" (>10 million people) will appear by 2020, up from 12 now. The percentage of environmental exports in some segments is highly variable. Instrumentation and air and water equipment are the leading sectors for export from the

United States, and these sectors also are top priorities for the U.S. EPA. The export of services poses more difficulties and is more often connected with specific projects.

In the United States, there are regional differences that make it difficult to frame national solutions. The energy use patterns, the levels of urbanization and air pollution, the availability of renewable resources, and water and land usage are all issues that differ markedly by region and have an impact on technology purchasing decisions. Some states tend to be concentrated around common themes, such as transportation, energy exploration, clean coal, water and drought management. Other states are concentrated around other themes, such as mass transit, transportation planning, water infrastructure makeovers (rather than expanding a water treatment plant for a suburb) and restoration. The regional differences are important in terms of the market opportunities.

Different market segments see different growth rates and demographic drivers. Economics is a key driver (versus enforcement). The regional political differences lead to different environmental and energy policies, which have a direct bearing on market opportunities for innovative products and technologies. Financing is paramount for exports because some of the growing overseas environmental markets are less developed. The U.S. EPA should consider focusing on some of the missing links for technology implementation, such as validation with stronger links to real projects, resolving policy conflicts, and mechanisms for international regulatory acceptance. Verification of technology must involve training of regulators.

Questions

Sally Gutierrez thanked Andrew Paterson for his presentation and asked if there were any questions. Donna Perla, U.S. EPA, stated that many countries have carbon constraining policies. Germany and Japan are strong manufacturers of renewable energy technologies. Do countries with carbon constraining policies and manufacturing capabilities present an advantage or a barrier to United States exports of renewable energy technologies? Carlos Montoulieu responded that it would be both. The discourse on climate change and carbon sequestration is continuing and there may be room for growth in these areas. From a commercial perspective, many U.S. environmental companies will be disadvantaged. The counterpoint is that if you are an American multinational company operating in any of the markets that subscribe to Kyoto and other mechanisms, you will have to abide by those requirements and standards. It may put U.S. industry at a disadvantage, depending on how it develops. Exactly how aggressively and successfully Kyoto will be enforced and implemented is not yet clear. The European Union (EU) is having considerable problems in getting its program started. Andrew Paterson stated that the carbon-constrained market is going to be an interesting market, much more than Kyoto. The focus needs to move away from Kyoto, in part because it is not going to get signed by 2012 no matter what happens politically in the United States. It boils down to one issue—the United States generates 50 percent of its electricity from coal. U.S. companies are not waiting for the United States to make a decision. Many aggressive companies such as Toyota are already operating in the United States. The globalization issue is a two-way street. There is a bell curve of leaders and laggards in the U.S. industry, with many of the multinational companies ahead of where the political will is in Washington. Broad statements cannot be made about American industry relative to carbon constraint. Companies are not waiting for carbon constraints to be

enforced. The signatories to Kyoto have enforcement and political problems, as the recent EU vote indicated. There should be a good global market for carbon capture, monitoring and verification technologies because commercial decisions are going to be made in that direction, not because government regulations enforce it on people. Andrew Paterson suggested watching for multinational blocks to develop. The best illustration is the International Partnership for the Hydrogen Economy, which includes 16 countries. Those 16 countries have 85 percent of the global gross domestic product (GDP); 75 percent of all energy use; and two-thirds of all carbon emissions. What is interesting in terms of an environmental and energy policy in a carbon constraint perspective is the blocks within the 16 countries. The United States, Russia, Canada and France are pro-nuclear; Germany and Italy are anti-nuclear. This is not stopping forward movement on the hydrogen economy; it will evolve on a multilateral basis. It will be worth watching the blocks that are organized within international efforts; they will affect policy development and commercial decisions.

NATIONAL AND INTERNATIONAL ETV PROGRAMS

Teresa Harten, Director, U.S. EPA ETV Program, served as the session chair and introduced each of the presenters. She stated that this session would provide snapshots of each of the national and international ETV programs. The focus of the presentations is to provide information on the history of the program, a summary of their accomplishments, and how they are operating. The technical details of the results of technology verifications and the technology categories of importance will be presented in a later session.

United States

Teresa Harten is Director of the U.S. EPA ETV Program, U.S. EPA ORD, NRMRL. She has been with the U.S. EPA for 16 years. Before becoming Director of the U.S. EPA ETV Program, she served in various capacities in management of pollution prevention and clean technology research. Prior to joining the U.S. EPA, from 1982 through 1989, Teresa Harten worked as an environmental engineer with the State of Ohio EPA in wastewater programs, including as a pretreatment coordinator, with responsibilities in permitting, compliance and enforcement. She has a master's degree from the Department of Civil and Environmental Engineering, University of Cincinnati, Ohio, and an undergraduate degree in biology, also from the University of Cincinnati.

The U.S. EPA ETV Program was started in 1995. The objectives of the EPA ETV Program are to provide credible performance information for commercial-ready technology that can be used to solve high-risk environmental problems. This information also can aid policymakers and regulators in making policymaking and permitting decisions for innovative technologies; purchasers in making decisions to purchase innovative technologies; and vendors/developers in selling and further innovating technologies.

The early stages of the technology research and development continuum involve research, proof of concept and development. Verification comes in towards the tail end of this continuum, after the technology is commercially ready. All of the ETV programs discussed at this forum only work with commercial-ready technologies. As identified in the definition of verification, verification establishes or proves the truth of the performance of a technology under specific, predetermined criteria or protocols

and adequate quality assurance (QA) procedures. The U.S. EPA ETV Program does not pass/fail, approve or certify technologies.

Since 1995, the U.S. EPA ETV Program has completed 318 verifications and 82 protocols. The program has been involved in solving a wide range of environmental problems in air, land and water. Over the years, there has been increasing funding from vendors and other partners. The original premise for the program was that it would become totally self-sufficient and totally privatized. However, both vendors and the EPA Science Advisory Board (SAB) did not think it was a good idea to have the program totally privatized, so there will continue to be some involvement by EPA. The program is trying to obtain increasing funds from others. Currently, 50 percent of the program funding comes from others, which includes 30 percent cash and 20 percent in-kind contributions. There are 805 stakeholders in 21 groups. The stakeholders groups, which include representatives from regulators, potential users and trade associations, help to identify the important technologies to verify and develop the test plans used for the verifications. There has been increasing Web interest; there are more than 1 million hits per year to the ETV Web Site. Because of the program's previous successes, the U.S. EPA ETV Program was recruited in 2002 to begin homeland security verifications. More than 50 homeland security technology verifications have been completed. Recently, the homeland security portion of the U.S. EPA ETV Program has been moved to another research program because it has unique information security needs and there was a desire to provide more guidance and to compare technology performance, which the U.S. EPA ETV Program does not do. The U.S. EPA ETV Program presents the verification results and lets the users make the technology comparisons.

The U.S. EPA ETV Program has six centers. Two centers receive continued partial EPA funding and full quality assurance and technical support. The two centers are the U.S. EPA ETV APCT Center, managed by RTI International, and the U.S. EPA ETV Advanced Monitoring Systems (AMS) Center, managed by Battelle. Four other centers have moved to a status whereby they will no longer receive EPA funding, but EPA will provide full QA and technical support. These centers will seek full funding from vendors and other sources. The four centers are: U.S. EPA ETV DWS Center, managed by NSF International; U.S. EPA ETV Greenhouse Gas Technology (GHG) Center, managed by Southern Research Institute; U.S. EPA ETV Water Quality Protection (WQP) Center, managed by NSF International; and U.S. EPA ETV P2 Coatings and Coating Equipment Pilot (CCEP), managed by Concurrent Technologies Corporation.

The U.S. EPA ETV Program has completed 142 verifications of monitoring devices, including 36 for water, 49 for air, and 57 for soil/surface; 75 verifications for air technologies; 58 verifications for water technologies, including 37 for drinking water and 21 for water quality; 21 verifications for pollution prevention; and three verifications for building decontamination, which were done under homeland security.

In 2005, the ETV Environmental and Sustainable Technology Evaluations (ESTE) program was created. The program is targeted to high-risk Agency needs. Under the regular U.S. EPA ETV Program, stakeholder groups choose the technology categories. Under ESTE, EPA will choose the technology categories to verify. A competition within the Agency has recently been completed to select the projects to be verified. EPA will initiate and directly manage these projects. The scope includes all environmental

technologies except remediation, which is covered under the U.S. EPA's Superfund Innovative Technology Evaluation (SITE) Program.

Teresa Harten described the ETV verification process. EPA, verification organizations and stakeholders identify the technology categories to be verified; under ESTE, only EPA identifies the technology categories. Stakeholders provide assistance in developing test protocols and QA test plans. They also help to identify vendors and collaborators (i.e., other federal agencies, trade associations, local governments). The technology testing is conducted and a verification report is written. The ETV Web Site (http://www.epa.gov/etv) is the major outreach mechanism for the program and contains the stakeholder meeting minutes, vendor solicitations, test protocols, QA test plans, verification reports, and other documents generated by the program.

The U.S. EPA ETV Program has four values: (1) quality, which includes a strong QA system; (2) transparency, which includes the publication of all test plans and results; (3) fairness, which involves invitations to all vendors to participate in the program; and (4) credibility, which is the result of the first three values.

The U.S. EPA ETV Program follows ANSI E4 standards for environmental technology evaluation. The program includes quality planning and implementation. There is an overarching program Quality Management Plan (QMP) and each center has its own center-specific QMP. Test-specific QA project plans (test plans) are developed for each test. Reviews and audits are conducted by EPA QA staff and Center QA staff. In 2000, the SAB reviewed the U.S. EPA ETV Program and commended ETV on its QA procedures and their implementation.

The number of hits to the ETV Web Site has increased 50 percent per year on average over the last few years. Approximately 10 percent of the total hits are from international visitors.

The U.S. EPA ETV Program has moved from emphasizing the number of protocols and verifications completed to measuring outcomes that show improved health and environmental quality because of ETV (e.g., what are we achieving in the environment, how many technologies are being sold, what influence does verification have on permitting actions). The focus is now on demonstrating the program's outcomes rather than the outputs. The program has successfully met all of the commitments to Congress in terms of achieving a certain number of protocols and verifications each year. There is now a new Office of Management and Budget (OMB) rating system for programs that requires the demonstration of outcomes. The U.S. EPA ETV Program is using a number of different mechanisms to measure outcomes. A vendor survey conducted in 2001 showed that the vendors are using ETV verification results in their marketing; they think that ETV is a good program; they are returning to the program for additional verifications; and they are willing to pay more of the costs for verifications. Since 2004, there has been an ongoing survey of ETV Web Site users, who have provided positive feedback on the program. Fifteen case studies for different technology categories are being developed to show that these verifications are having an impact on sales, permitting and purchasing of technologies; the case studies should be published in September 2005. In addition, purchaser, permitter and vendor surveys are planned for 2006-2007. The purpose of the purchaser and permitter surveys is to find out how these groups are using verification results. There is

already evidence from the drinking water community, specifically the Association of State Drinking Water Administrators (ASDWA), that their members are increasingly using ETV results to help in permitting and to reduce pilot testing. Finally, outcomes planning is being included in the new center agreements.

Teresa Harten described a case study for diesel retrofit technologies. From 2003 to 2005, seven technologies were verified. Six of the technologies reduced particulate matter (PM) in the range of 21 percent to 95 percent. ETV data can also be submitted by the vendor to the Voluntary Diesel Retrofit Program (VDRP). As a result of verification (by ETV and VDRP) and grants, 1,230 technologies have been installed. At a 10 percent market penetration and assuming seven years of use, ETV calculates that PM could be reduced by 9,000 to 31,000 tons. This reduction could result in the avoidance of 683 to 2,380 instances of premature mortality and associated monetary benefits of between $5 billion to $18 billion. ETV has also become a participant in a new pilot in a new EPA Accountability Initiative to show actual health outcomes. Under this pilot, the health of school bus drivers will be tested before and after the installation of diesel retrofit devices.

From 1999 to 2001, ETV-sponsored training workshops were held in the United States, Thailand and India for Central and Southeast Asian countries interested in starting their own ETV programs. In 2003, the U.S. EPA ETV Program was represented at Japan's ETV kick-off meeting. In 2004, a letter of intent was signed to cooperate with Singapore on the development of ETV protocols. An ETV Stakeholder/Team meeting was held on May 11-13, 2004, which included an international session with presentations from Singapore, the EU and Korea. In 2005, Teresa Harten presented at a European Commission verification meeting. These international activities have culminated in this International Forum to discuss potential collaborations and to identify the next steps for moving forward.

Canada

John Neate is President of ETV Canada, the not-for-profit organization that manages the Canadian Environmental Technology Verification Program. He has more than 25 years of experience in the assessment, evaluation and verification of technology and in the provision of strategic resource planning and decision support services to private and public sector organizations, both in Canada and internationally. Much of his management and project experience has focused on issues in the energy and water sectors, including: options for the long-term management of used nuclear fuel; technologies for climate change mitigation; and integrated approaches for the development and deployment of environmentally sound water, wastewater and site remediation solutions.

John Neate stated that it was a pleasure to be at this International Forum. He commented that in 1999, there was considerable effort on the part of the U.S. EPA and other organizations, including Environment Canada, to stimulate dialogue in this area because it is important to ensure that environmental performance information is reported clearly and in a transparent manner. There are large differences between the U.S. EPA ETV Program and Environment Canada's ETV Program, but a lot has been learned from the U.S. EPA ETV Program. It is that type of information sharing that is going to allow everyone to find common ground going forward.

John Neate stated that third-party verification is a proven assessment mechanism for determining technology performance with a high level of reliability and it is based on scientific and statistically valid protocols for verifying performance claims. The Canadian program was established by Environment Canada and Industry Canada in 1997. The two departments funded the development of the initial verification program's intellectual and assessment protocols. ETV Canada is the sole licensee of the Government of Canada Environmental Technology Verification Program. It is strategically positioned to manage the preparation of credible performance guidelines, screening methods and verification protocols for technologies, projects and programs. ETV Canada supports the development and promotion of new environmentally sound technologies. It provides technology purchasers with independently verified data to augment purchasing decisions. ETV Canada also provides regulatory agencies and industry sectors with a process and data to help qualify available technologies for solving environmental problems. ETV Canada is part of a national process in Canada and is recognized by all Provinces, with sector-specific technology performance standards and independent verification.

To make ETV Canada more relevant to stakeholders, a 3-Part Strategy for ETV Canada is being implemented, consisting of: (1) technology verification, which is focused on the supply side; (2) performance benchmarking, which focuses more on the users of the technology; and (3) harmonization and cooperation, which focuses on the adoption and use of environmentally sound technologies in the global marketplace.

The scope of the technology verification program includes the environmental performance verification of a broad range of production and consumption technologies, not just "environmental" technologies. Technologies are characterized in terms of their contaminant sources, contaminant characteristics, and the receptors of the contaminants. A range of technologies is considered, including prevention, control, remediation, and measurement and monitoring technologies. This involves working closely with technology innovators and qualified testing organizations. The focus is on third-party independent verification of performance to reduce subjectivity and conflict of interest. It incorporates test methods relevant to the specific features and performance characteristics of the technology being verified. The focus on the particular performance claims of the vendor, some of which go well beyond regulation, is what separates verification from certification.

A distributed network of 26 Verification Entities (VEs) is used; the VEs are selected on the basis of their technology expertise and independence. In selecting VEs, ETV Canada first looks at laboratories accredited by the Standards Council of Canada. National laboratories and universities, and sometimes experts, also are used if the performance claim requires it. The program is very flexible and adaptable to meet the needs of the performance claims of the technology vendor/developer.

The verification process starts with a company submitting a pre-screening application, followed by a formal application. The company must provide testing data that have been developed independently by an accredited laboratory. There must be full confidentiality, chain-of-custody, and no conflict of interest. The test data are submitted and ETV Canada enters into a contract with an appropriate VE. The verification is performed against the ETV Canada generic verification protocol, which results in a report and award. Typically, the verification costs are approximately $15,000 to $20,000 Canadian dollars.

All verifications require sufficiently complete and representative baseline operational data, they must comply with the ETV Canada generic verification protocol, demonstrate environmental benefits, conform with health and safety standards, and reflect operational realities.

ETV Canada also has a complementary Environmental Technology Development Assessment Program (ETDAP), which helps companies develop and implement an effective test plan and provides an assessment of the market for their technology, including a critique of the company's performance claim.

There are five types of verification clients: (1) clients with complete data sets; (2) clients with data sets needing clarification/augmentation; (3) clients needing to modify their performance claims; (4) clients requiring technology/market assessment (such as that which can be provided through ETDAP); and (5) clients requiring new testing protocol development.

The Government of Canada owns the Canadian ETV license. ETV Canada is the licensee for Canada and operates the program. The key to the program is that ETV Canada draws upon existing institutions and capability within Canada. This includes institutions and capability either on the research and support side for protocol development, or on the marketing side in conjunction with the three Canadian Environmental Technology Advancement Centres (CETACs), which have the responsibility for providing mentorship to the SMEs that are generating the technologies. The VEs are the technical verification specialists in the program. Independent testing agents and laboratories produce the test data and are sometimes used to perform the verification, provided they were not the generator of the performance test data. The program results are the development and promotion of new environmentally sound technologies and independently verified data to augment technology purchasing decisions.

Performance benchmarking is a new area. Its scope includes the development of environmental and sustainability performance benchmarks in support of sector and program initiatives. It involves working closely with technology users, associations and regulatory agencies. It also involves the use of specific decision-support tools (e.g., Environmentally Sound Technology Performance Assessment [EST-PA], Multi-Attribute Utility Analysis [MUA]) to facilitate a stakeholder process for the development of performance criteria. Performance benchmarking incorporates ETV Canada's expertise and track record arising from the following initiatives: ETV arsenic mitigation, mercury removal, manure management, greenhouse gas technology actions, water quality, green infrastructure, and contaminated site remediation.

The performance benchmarking process includes stakeholder engagement, development of draft performance objectives, preliminary screening of the performance objectives, and development of draft performance benchmarks that go through a stakeholder validation and acceptance process. These performance benchmarks can be used to provide a more credible verification of the technology beyond what would be simply defined by a single vendor. One of the key aspects is the linking of performance benchmarking and verification, which includes engagement with key sectors to identify priority pollutants and performance objectives; the development of implementation options, including technologies and process modifications; verification against performance objectives; and facilitation of informed decisions for both government and industry. Performance benchmarking helps technology users to focus on the

identification and qualification of relevant performance criteria, and allows technology and service providers to focus their development efforts in response to market realities.

Harmonization and cooperation provides a mechanism for inter-jurisdictional reciprocity, facilitates mutual recognition and accreditation of VEs, enables sharing of protocols and test methods, and provides better information and knowledge management. In the inter-jurisdictional reciprocity area, there are Federal-Provincial Agreements (through an Inter-Provincial Working Group) to streamline permitting and approvals. There also are international agreements to facilitate technology cooperation and capacity building. ETV Canada already has worked with China and South Korea and would like to cooperate with other countries.

Mutual recognition and accreditation of VEs involve the further development and nurturing of an effective network of credible VEs. Some VEs already are accredited under other programs, such as those that are recognized by NSF International. The sharing of protocols and test methods involves cooperation to further develop and apply effective protocols and test methods, and the promotion of standardized methodologies for demonstration, testing and evaluation of performance claims. This area is a good starting point for international cooperation. Information and knowledge management involves cooperation among verification organizations to improve the quality of environmental performance reporting. It is a basic requirement for effective technology cooperation. It is important for improving access to information and encouraging the adoption and use of environmentally sound technologies.

John Neate stated that, as a result of this meeting, he would like to see the acceleration of environmentally sound technology implementation and deployment through credible environmental performance verification of technologies. This meeting is a great opportunity to build a dialogue, develop and implement agreements and cooperative initiatives, and establish an international platform. There are many opportunities for synergy, including performance verification of technologies of national and international importance, development of relevant performance benchmarks and verification protocols, and establishment of mechanisms for fostering international cooperation and harmonization of performance verification and reporting.

All components of ETV Canada's strategy are supportive of Agenda 21, adopted at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, and the Canadian Environmental Protection Act (CEPA). Certain aspects are directly linked to various Multi-Lateral Environmental Agreements. ETV Canada would like to strengthen its working relationships with all partners in areas of mutual interest to promote global access to environmentally sound technologies. ETV Canada has a Web site at http://www.etvcanada.ca.

Korea

Yeom Sang-Ug is a Chief Manager of a Technology Verification Team at Environmental Management Corporation (EMC) in Korea. He oversees day-to-day teamwork and previously worked on the Technical Consultation Team, analyzing problems from environmental facilities (e.g., sewage and wastewater treatment plants and night soil and livestock wastewater treatment plants), and worked towards

establishing solutions. He also supports government policy for water quality treatment. He has a Master of Science in environmental engineering from Dong-A University in Korea.

Ryu Nam Yong gave the presentation for Yeom Sang-Ug. He stated that Korea's ETV Program is intended to expand the environmental technology choices for public and private decision makers who usually prefer existing technologies to new ones. This allows the consumers to have confidence in the verified technology and in the developers to rapidly apply the verified technologies in the field. To meet its ultimate goal to promote new technology development, the government has let EMC perform the ETV Program, which provides validation and independent verification of environmental technology performance claims.

He provided a brief description of the verification process. When an environmental technology developer, which can be an individual or a company, wants to validate their performance claims, they apply to the ETV Program, through EMC, for verification of the technology. ETV verifies the developer's performance claims using predetermined protocols. If the claim is verified, the applicant is issued three documents: a certificate, a fact sheet and a final report. They also are entitled to use the ETV logo. This program provides the users or buyers with an assurance that the developer's performance claims for their environmental technology are valid and credible and helps the users or buyers to select the best technology for their needs. The developer can then receive reimbursement for their development costs; this reimbursement is usually reinvested in new technology.

Ryu Nam Yong presented a brief history of Korea's ETV Program. In October 1997, EMC investigated ETV programs throughout the world. In December 1997, they developed their first protocols for sewage treatment and incineration. The ETV Program began in January 1998. In August 2000, the first revised regulations for the ETV Program were completed. In August 2001, protocols for drinking water, landfills and recycling were developed. In May 2003, the regulations were revised again for the ETV Program. When a certificate and fact sheet are issued for the first time, they are valid for three years. Under the revised regulation, the developer can apply to the program for an extension if it is done before the expiration date of the certificate.

Ryu Nam Yong stated that EMC was established as a nonprofit public organization in 1987 under the Korea MOE. The Technology Verification Team in the EMC is funded by the MOE. The framework of the ETV Program includes the MOE, EMC (which includes a verification committee), and six verification entities, which are the third-party accredited testing organizations. These six verification entities, which are nonprofit research institutions, include:

- ✧ Korea Institute of Energy Research (KIER) (incineration, recycling, gas treatment from automobiles)
- ✧ Korea Institute of Machinery and Materials (KIMM) (incineration, treatment of dust and hazardous gas, prevention of noise and vibration fields)
- ✧ Korea Testing Laboratory (KTL) (environmental measurement, prevention of noise and vibration fields)

- ✧ Korea Testing and Research Institute for Chemical Industry (KOTRIC) (recycling, treatment of drinking water fields)

- ✧ Korea Institute of Science and Technology (KIST) (recycling fields)

- ✧ Korea Environment and Water Works Institute (KEWWI) (treatment of drinking water fields)

The verification committee includes 1,200 experts, who are mostly university professors and a few public organization staff from different fields. This committee evaluates the developers' claims and whether they have presented credible data based on sound scientific and engineering principles. The experts decide to accept or reject the developer's technology as a new environmental technology during a committee meeting.

Ryu Nam Yong provided an overview of the ETV Program verification procedures. All applications are prescreened to see if the technology applies to the ETV Program. The technology must offer an environmental benefit or address an environmental problem. It also must meet minimum Korean standards and national guidelines for the specific technology. If the technology meets these criteria, the applicant submits an application to the MOE. The application is reviewed by EMC, which determines if it can be accepted for the verification process. If the application is not acceptable, EMC sends the document to the applicant for modification, which must be completed within 60 days. If the application is accepted, the applicant pays a registration fee and the verification committee meeting is held. Each committee meeting contains 12-14 committee members who have been selected to evaluate one applicant's technology. If the committee accepts the technology and its credibility, a contract is signed between the EMC and the applicant for site verification. EMC then contacts verification entities for the verification process and assessment. The cost for verification totally depends on the technology that is submitted and includes the management of the application process by EMC and the validation by the verification entities. Two EMC members decide the verification process and the verification entities conduct the validation of the performance claims using verification protocols. If the analyzed and assessed data substantiate the applicant's claim, an EMC member prepares a report on the results of the verification. Before issuing a certificate, a fact sheet and a final report, another verification committee meeting is held for a final evaluation of the data contained in the report.

The benefits to the developer for verifying a technology include:

- ✧ The vendor receives a fact sheet and certificate issued by the MOE. Verification results are reported in the official gazette and announced to local governments.

- ✧ Verified technologies are advertised in numerous publications and technical journals.

- ✧ Verified technologies usually are prioritized for use in public facilities. These technologies receive an extra score during pre-qualification (PQ) reviews in both the application of appropriate technology for public facilities and in bids for turnkey projects. There also is recognition of the actual track records

of new technology. In addition, one-half of the total cost of the site verification is subsidized by the government.

- ✧ Verified technologies receive publicity on the Internet. Verified technologies are published on the Web sites of the National Environmental Technology Information Center (http://www.konetic.or.kr) and EMC (http://www.emc.or.kr) and announced to the public. Also, the technologies are promoted at Environmental New Technology Seminars.

In addition to the verification report, the vendor receives a certificate and fact sheet from the MOE. There are two types of certificates—Designation of New Environmental Technology and Verification of Environmental Technology. The Designation of New Environmental Technology certificate is awarded based on the successful validation of an applicant's performance claim through the application review only. The newness and excellence of technology are used as the criteria for awarding this certificate, and both of these factors are evaluated by the committee. The certificate contains: the title, scope and description of the technology; the developer's name; the expiration date; the government seal; and the statement of the regulation. The Verification of Environmental Technology certificate includes the information found in the first certificate, but must also contain information about the site verification process. The fact sheet is a two-page information sheet that contains: a detailed description of the technology; a detailed description of the performance claim, including the scientific parameters, operating conditions and applications; the expiration date; and a statement that the applicant has successfully completed the ETV Program verification process. Originally, the certificate was valid for three years from the issued date. However, before the expiration date of a certificate, the developer can apply to the program for an extension. A committee meeting is held and an extension of zero to three years is provided based on the developer's efforts to upgrade the technology and records of real site applications. The validated period can last a maximum of six years.

The protocols that have been developed for site verifications include:

- ✧ Wastewater Treatment (nitrogen and phosphorus removal technologies)
- ✧ Incineration (stoker, gasification and melting, rotary kiln, etc.)
- ✧ Treatment of Dust and Acidify Gas (SCR, SNCR, dioxin control, deodorization)
- ✧ Environmental Measurement, Prevention of Noise and Vibration
- ✧ Treatment of Leachate, Landfill
- ✧ Recycling, Treatment of Drinking Water
- ✧ Treatment of Night Soil and Livestock Waste Water
- ✧ Composting, Operation and Monitoring Software

The verification period varies depending on the technology category. For sewage treatment, the verification period for biological treatment lasts more than six months and includes winter months. The verification period lasts more than three months for physical chemical treatment. For incineration technologies, the verification period lasts more than three months and includes the summer months; waste dry technologies also last more than three months. The verification period for landfill technologies lasts

more than three months and includes both winter and the rainy season; recycling technologies also last more than three months.

The cost of verification includes $2,000 for registration and an average cost of $40,000 for site verification. After certification, the government reimburses the developer for 50 percent of their expenses. Between 1999 and 2004, 1,068 technologies were applied at sites. The total cost of these applied technologies was approximately $1 billion.

As of the end of June 2005, 51 verifications have been completed in the wastewater area for nitrogen and phosphorus removal. It is by far the highest number of technologies verified in one technology category and accounts for more than 40 percent of the 128 total verifications. The government has set nitrogen and phosphorus reduction as a priority to improve water quality. As a result, vendors are motivated to develop this type of technology.

Ryu Nam Yong stated that cooperation is needed to apply the ETV framework to other nations. By extending the ETV network and the performance of technology, the demand for verified environmental technologies should increase. These verified environmental technologies will be applied on-site to enhance the efficiency and economics. The profits gained from the ETV Program will be reinvested in environmental related industries, allowing new environmental technologies to be developed. If more excellent environmental technologies are developed, industries will advance, our quality of life will be promoted, and industry competitiveness will be strengthened.

Questions

Teresa Harten asked if there were any questions. Philip Koga, U.S. Army, asked how many of the applicants were actually verified and how many were rejected. Ryu Nam Yong responded that about 20 percent to 30 percent of the applicants are rejected. Philip Koga asked what recourse was available if they were rejected; could they appeal? Ryu Nam Yong responded that once an application has been rejected by the committee, then the applicant can apply again. However, if the applicant applied for the stage of newness and was rejected by the committee, they cannot apply for the same technology.

Japan

Kenji Kamita is Deputy Director of the Office of Environmental Research and Technology at the MOE, Japan. In this role, he oversees the Japanese Environmental Technology Verification program (J-ETV). At the MOE, he has been involved with chemicals management, and air and water pollution prevention. He also has been involved in national research and development projects at the Ministry of Economy, Trade and Industry. Kenji Kamita has a Bachelor of Engineering in chemistry and biotechnology from the University of Tokyo.

Kenji Kamita stated that the J-ETV is not as established as the other programs being presented. He provided a brief discussion on the background of the J-ETV program. The first time the government acknowledged the importance of environmental technology was in a Cabinet Decision in the *2002 Basic Policy on Economic and Financial Management and Structural Reforms*, which stated, "One challenge is the need to create frameworks to obtain proper market assessments of innovative environmental and

energy-related technologies." In April 2002, the Central Environment Council, which is the advisory board to the MOE, also addressed environmental technology in its *Report on Promotion Measures for Environmental Research and Technology Development*. It stated, "It is necessary to significantly improve technology assessment methodologies, to establish institutional arrangements for implementation, and to consider ways to widely utilize the assessment findings."

Kenji Kamita stated that the J-ETV program is not a certification program. The program is for advanced environmental technologies for which no objective performance data exist. The objective is to promote the spread of technology by having independent parties verify the performance of the technologies. This will promote both environmental protection and environmental business. Under the J-ETV program, technologies are not judged as good or bad according to some standard. Evaluation of data is left up to the users.

The pilot period to establish a verification system is from 2003 to 2007. Verification will initially be conducted on a trial basis in representative technological categories. This will lead to Phase 2, at which time vendors will be expected to pay for verification services. Starting in FY08, the technology categories will be expanded, and the verification program will enter into full operation.

The J-ETV program is run by the MOE. There are three advisory groups: the ETV Pilot Program Advisory Committee, Working Groups in each category, and the Technology Verification Committee. The Verification Organizations, which are almost all local governments, report to the MOE. The National Institute for Environmental Studies is a support body, and there is a database management group that maintains the Web site.

A brief description of their approach for the selection of technology categories was provided. During the pilot period, representative environmental technology categories will be selected for: (1) technologies related to major environmental challenges in Japan, and for which the need exists to find ways to encourage the diffusion of those technologies; and (2) technologies for which many companies are requesting verification. At present, this program does not cover the following areas, which are covered under other programs: (1) technologies related to global warming countermeasures, (2) equipment to reduce vehicle emissions, (3) technologies related to waste countermeasures, and (4) installation of greenery on walls and roofs.

In FY03 and FY04, the budget was approximately $2.3 million; in FY05, the budget is approximately $1.8 million. Eight technology categories have been selected related to: (1) water quality and chemical substances, and (2) the atmosphere and energy. The five technology categories under water quality and chemical substances are: (1) organic wastewater treatment for small establishments, (2) toilets for mountain areas, (3) simplified monitoring of chemical substances, (4) wastewater treatment technologies for nonmetallic elements (e.g., boron), and (5) water quality improvement of lakes/reservoirs. The three technology categories under the atmosphere and energy area are: (1) ethylene oxide treatment, (2) mitigation of the urban heat-island effect, and (3) volatile organic compounds (VOC) treatment.

Once the technologies have been selected by the MOE, the protocol for verification testing is formulated by the MOE and working groups for each technology category. After verification organizations are

invited and selected, target technologies are invited and selected. Verification testing is conducted by Verification Organizations and a report is prepared and published on their Web site.

In September to October 2004, J-ETV conducted a questionnaire survey of five participating Verification Organizations for FY03 projects to determine the impact of verification. They were asked the question: What were the specific outcomes of your organization becoming a Verification Organization? The responses included the following:

- ✧ We were able to obtain knowledge/know-how for providing guidance and information on procurement of environmental technologies to users of these technologies (60 percent of respondents).

- ✧ We were able to obtain knowledge/know-how regarding criteria and methods of technology assessment in procuring environmental technologies for ourselves (60 percent of respondents).

- ✧ Developers were able to learn about features and improvements in technology, and this stimulated technology improvements, thanks to publicity from the ETV (40 percent of respondents).

- ✧ Verification technologies were promoted and purchased, thanks to publicity of ETV pilot projects (20 percent of respondents).

Other comments provided by the respondents included:

- ✧ "We were able to obtain data useful for us to provide governmental guidance to industry."

- ✧ "By dialogue with developers on issues such as analytical results and equipment maintenance, both sides were able to gain new knowledge."

- ✧ "This activity provided us useful experience for considering conducting an independent verification project in the future."

Vendors also were surveyed. The questionnaire was sent to 16 companies and 14 companies responded. They were asked the question: What was the impact on your company's overall activities (e.g., sales, technology development, etc.) by conducting verification in the project? In response to this question, 10 of the 14 respondents indicated either "a large impact" or "somewhat of an impact." Other comments provided by the respondents included:

- ✧ "This project helped our sales development."

- ✧ "We experienced an increase in inquiries from customers and various facilities."

Kenji Kamita stated that their next step would be to enhance the benefits of verification. A verification logo will be introduced. Use of the logo will be permitted for verified technologies under conditions similar to those used in the United States (i.e., the logo does not imply certification or approval; unauthorized use is prohibited). After completion of the verification process, the verification results will

be published on their program Web sites. In FY06, symposiums will be held to raise awareness of the verification program. For each technology category, other ways, such as using verification data in government procurements, will be sought to stimulate demand for utilization of verified technologies.

During Phase 2, J-ETV will implement fee-based verifications. After the pilot period, technology categories that have established verification methodologies will shift to a vendor-pay, fee-based system. In principle, fees will cover the actual costs of verification testing. The cost of equipment installation and removal will be covered by the applicant. In some cases, the cost may be too high for small and medium enterprises. For example, the cost of installation and removal of toilets in mountain areas could be prohibitive at high elevations. For organic wastewater treatment, testing costs themselves are relatively high, approximately $40,000. Some support for small and medium enterprises is being considered.

In summer 2005, the corporate and vendor demand for verification will be studied. The next technology categories will be based on the results from this study. Additional technology categories will be added in FY06.

The five-year pilot period will end in FY08, followed by full program implementation. J-ETV is addressing two issues. Do they expand the target technologies for verification in the future? (If so, it will be even more important to streamline the overall operations.) How do they address the problem of disparities between regions in verification activity? (If small Verification Organizations are unevenly distributed, it will be difficult for companies in other regions to apply for verification.)

Kenji Kamita stated that the English version of their Web site is at: http://etv-j.eic.or.jp/en/index.html.

Singapore

Tay Joo Hwa is the Director and Chief Executive Officer of the Institute for Environmental Science and Engineering (IESE) in Singapore. He stated that Singapore does not have an ETV program, but they do have an ETV-like initiative. Singapore is an island, a state and a city. The land mass is only about 646 square kilometers and houses a population of 4 million people. Singapore is not even one-half the size of New York City. Singapore is facing many challenges, particularly environmental challenges. All of their food is imported. Singapore receives 2.4 meters of rainfall each year; 80 percent of the rain is concentrated in the last three months of the year. However, 50 percent of their drinking water is imported from Malaysia. There are 24,000 births each year. They produce 7,000 tons of solid waste per day, and 1 million tons of wastewater per day. They are ranked number two from the bottom in the generation of carbon dioxide. All of their landfill sites are exhausted. They have four incinerators that burn 80 percent of their solid waste. Their beaches cannot be used for bathing because of the pollution from ships. Every year there are two to three oil spills. There are 145,000 vessels that come into their port each year. As a result, they are the second busiest port in the world. With these challenges, Singapore has a lot of initiative to fight for survival.

Singapore's focus is to develop environmental technology; they hope to become the environmental technology hub in Asia. They have several funding programs to encourage new environmental technologies, including:

- ✧ The Enterprise Challenge (TEC) from the Prime Minister Office (PMO), which has a budget of $30 million (Singapore dollars).

- ✧ Innovation for Environmental Sustainability (IES) from the National Environmental Agency, which has a budget of $25 million (Singapore dollars).

- ✧ The MPA Trident funding administered by the Marine Port Authority, which has a budget of $30 million (Singapore dollars). This funding supports the verification of marine technologies.

All of these funding sources are for pre-commercial verification/test bedding programs. Because the government wants Singapore to become the environmental technology hub in the region, approximately 40 percent to 50 percent of the technology verifications are from the environmental technology area.

The objective of the IES Fund is to encourage and assist Singapore-registered companies to undertake innovative environmental projects that can help the government to meet the goal of environmental sustainability. All Singapore registered companies are eligible if the project meets the following criteria:

- ✧ It must be "innovative" and "early adoption." It is not yet a commercial product.

- ✧ It must meet the government's environmental sustainability goals to: (1) enhance the Ministry's capability to handle the environmental issue, (2) develop environmental technology for commercialization, and (3) improve the environmental performance of a company.

- ✧ Funding can be applied for throughout the year.

- ✧ The maximum project duration is three years.

Funding is a maximum of $2 million (Singapore dollars) per project. Full funding is available if the technology can be employed directly by the Ministry, including ownership of the intellectual property rights. The funding can support manpower, equipment and materials, and professional services. This funding is a grant and the following reports are required: report and audited statements every six months, an annual project review, and a final report within six months after the project's completion.

A number of ETV-like projects are being conducted—such as a food processing waste treatment technology for an integrated food processing waste factory, which has 200 food factories located in the same building. This project was funded by TEC. Other projects include a wetland treatment technology and another food waste technology to convert the waste into energy as well as fertilizer. The Singapore Ballast Water Programme will be presented later in the meeting. The project is co-funded in the amount of $1 million (Singapore dollars) by the TEC and the Marine Port Authority. The technology will be developed in the laboratory and then moved to a small-scale dockside pilot plant study. Monitoring protocols are developed. The technology will be developed into a prototype system, which includes technology from Singapore and the United States, and then it will be tested. Ultimately, it will be installed on a ship for evaluation and demonstration. The ship is one of Singapore's cargo ships and the test will be run while the ship sails from Singapore to the United States, back to Singapore and then on to Europe, back to Singapore and then to Hong Kong. If the technology is successful, it will be commercialized.

The TEC has $29 million (Singapore dollars) in funding to support innovative proposals that have the potential to create new value or significant improvements to the delivery of public service in the areas of national economic development, education, environment, health, safety, security and social welfare. It was established to encourage the public sector to work with the private sector and to pave the way toward commercialization of new technology.

In closing, Tay Joo Hwa stated that Singapore aims to be the environmental hub for Asia. IESE is the environmental technology receptacle for Singapore. They wish to develop more collaborations with other countries. Singapore is the gateway to Asia, which will be one of the biggest markets in the future.

European Union

Ian Clark is head of the Research, Science & Innovation Unit in the Environment Directorate General of the European Commission. One of the unit's key tasks is to coordinate implementation of the European Union's Action Plan for Environmental Technology. He has been working for the European Commission since 1984, originally for the Regional Policy Directorate General, and has spent 11 years in the Environment Directorate General. Here, he has worked on the integration of environment policy into transport policy and, recently, the environmental aspects of the recent European Union enlargement. This included the accession negotiations with the ten countries that joined in May 2004. Ian Clark studied geography and regional planning.

Ian Clark began by responding to some comments made during the first session about problems in the EU to conduct environment policy following the negative referenda results in France and the Netherlands. He clarified the issue by pointing out that the negative votes concerned the future draft constitutional treaty that would have entered into force in 2009, and that these unfortunate negative votes do not affect the existence of the EU or the solidity of its institutions. The existing EU treaties remain in force and still provide a strong legal base for environment policy making.

A brief overview of the political and technical issues that need to be addressed in developing an ETV system was provided. The aim of the EU Environmental Technologies Action Plan (ETAP) is to improve the use and wider development of environmental technologies, particularly by removing the obstacles to development. ETAP has strong political support in the EU and it is closely related to their economic policy and competitiveness strategy. ETAP has three fields of action: (1) getting from research to markets, (2) improving market conditions, and (3) acting globally. The action plan includes a request that the EU develop a verification system that should be based on existing European centers and structures. The assessments should verify environmental technology performance claims from an economic and environmental viewpoint and take into account the life cycle of the technology; therefore, the sustainability dimension has been included. Commonly agreed protocols would be developed and common certificates may be developed at a later stage.

There is no EU ETV program, but there are a number of voluntary initiatives in the environmental field that include third-party verification. The Eco-label has been in existence for 10 years and is designed to encourage the marketing of environmentally friendly products. Energy labeling has been in existence since 1992. This is a system whereby member states can include labels showing the energy performance of a range of electrical appliances. If they include these labels, they must be based on harmonized

standards and methods to measure the energy consumption, and the verification takes place at the marketing stage. This labeling has been successful in the refrigerator area, where a large reduction in energy consumption for refrigerators has been seen in the EU. The Eco-Management and Audit Scheme (EMAS) has been in place for 10 years. It is a tool for companies to evaluate, report and improve their environmental performance. The environmental management system is based on the International Standard ISO 14,001. A company must provide the review, the environmental system and environmental audit, and a statement of performance, which are approved by an accredited verifier. There are 305 accredited verifiers in 25 countries of the EU. A total of 4,200 organizations have taken part in EMAS. Another voluntary initiative is product declarations, also known as ISO Type 3. It is a means of presenting quantified life cycle-based information in a standardized way. No judgments are made; this is left up to the consumers and purchasers. There are discussions under way as to whether international standards should be established for product declarations.

The European Eco-label is being used by 28 countries, and it is open to third-country producers. The Eco-label uses a set of simple environmental criteria. The license holders are certified by an independent third-party. The testing is conducted by national and regional Eco-label competent bodies. The focus is on environmental performance and fitness for use. There are 23 product groups, with three more to be added. The product groups include such items as paper, home and garden products, paints, electrical products, personal computers, washing machines, cleaning products and textiles. As of the end of 2004, 226 companies have registered. Italy, Denmark and France are the leaders, and the majority of the licenses are in the area of textiles. A challenge is to move the Eco-label into the mainstream. A key question is how the Eco-label could be expanded to award creativity and innovation. At present, the criteria are based on existing technologies and their limitations. Further information on the Eco-label can be obtained at http://www.europa.eu.int/ecolabel.

Verification of environmental technologies could contribute to other ETAP priorities. A key priority in the action plan is to develop performance targets for key products, services and processes. This could be based on a comparison of the environmental performance of products available on the market and taking the best on the market as being the target. A second key priority is checking environmental criteria in green public procurement initiatives. Public procurement in the EU represents about 16 percent of the gross domestic product. The rules on public procurement for contracts over a certain size are set at the EU level for reasons of the single market. These rules have been revised recently to allow environmental criteria to be taken into account and also, potentially, for technology to be taken into account, and thus challenge companies to go beyond available technologies. There are enormous differences in the ways that EU countries integrate the environment into public procurements. Norway and Sweden lead the way with 40 percent or 50 percent of contracts taking the environment into account, whereas the EU average is only 19 percent. A key challenge in the coming years is to push the EU average up to a higher level. A handbook on green public procurement has been drafted for local authorities to explain ways to take the environment into account. A verification system could be of great assistance in developing this initiative. A third key priority is attracting investors to environmental technologies. The Commission is developing an instrument to encourage risk capital and venture capital for environmental technologies. This would provide a specific financial envelope for eco-innovation related to risk capital along with the traditional support that is available.

More information on ETAP can be found at http://www.europa.eu.int/comm/environment/etap.

Andrea Tilche obtained his Doctorate degree in agricultural sciences at the University of Milano in 1978. His scientific career was mainly carried out at ENEA (the Italian National Board for New Technologies, Energy and the Environment), where he set up and directed the wastewater treatment laboratories in Bologna. In 1998, he moved to the Joint Research Centre of the European Commission in Ispra, where he was appointed Head of the Water Research and Monitoring Unit. One year later, he was called by the European Commission in Brussels to become Head of the Water Key Action of the 5th Framework Programme. He is now Head of the Environmental Technologies and Pollution Prevention Unit within the Environment Directorate of DG Research.

Andrea Tilche provided a presentation on their first ideas for building an EU ETV system. The scope of an EU ETV system includes the development and promotion of new and innovative (product and process related) environmentally sound technologies (EsT) through an European verification and testing programme that would give confidence to buyers, attract vendors, and facilitate the access of the technology to the market. The Institute for Prospective Technological Studies (IPTS), a Research Institute of the European Commission, conducted a study to identify the characteristics of the EU-ETV system. The system should be:

- ✧ Defined by clear definitions of the scope
- ✧ Interesting for the vendors
- ✧ A tool to ease market access
- ✧ A tool to promote innovation
- ✧ A tool that provides confidence to the buyers
- ✧ Close to the vendors and national, local and regional industries
- ✧ A simple process (simple and quick procedures)
- ✧ A single European-wide programme
- ✧ The programme should benefit from a broad recognition

The system should not be:

- ✧ Expensive
- ✧ Time consuming
- ✧ Lengthy
- ✧ Built without consensus on its scope and on its objectives
- ✧ A network of programmes implemented at a national level
- ✧ Complicated in terms of application procedures, testing process, etc.

The basic elements of the system have been identified. Any EsT will be accepted for verification. The eligibility criteria provide that the technology should be ready for commercial use. Test and verification entities must be independent, accredited and subjected to QA procedures. The testing laboratories should be accredited and based on existing accreditation systems, not new ones. Common EU-wide general guidelines and protocols will be developed. Funding will be a mix of public and private, with special considerations for SMEs. The system will be open to non-EU technologies.

The EU ETV outcomes include:

- ✧ A successfully verified EsT that could enter the market displaying an ETV logo.
- ✧ A summary report focusing on performance, without unveiling technical specificities, which would be made public.
- ✧ A detailed report that the vendor would decide whether it is made public.
- ✧ A database compiling information on all evaluated technologies.

The organizational structure of the ETV system has been discussed. The first hypotheses are that the EC/ETAP coordinators will designate the EU ETV Team and together they will lay the foundation of the verification programme (programme scope, objectives, strategies and general guidelines/generic protocols). The EU ETV Team will design and supervise the programme, and entrust verification entities with the task of operating the programme. Stakeholder groups will review protocols and test plans, and define minimum performance requirements.

The pilot phase for the system started with a round table brainstorming session with the U.S. EPA ETV Program and ETV Canada in February 2005. The IPTS study on the overall concept and structure of an EU-ETV system was completed in May 2005, and a feasibility study will be completed in March 2006. The Directorate General for Environment and the Directorate General for Research are preparing a discussion document, outlining the scope, objectives, possible organizational structure, costs and funding, which is to be completed in summer 2005. A series of pilot projects have been set up. They include: EURODEMO (soil and groundwater remediation technologies), PROMOTE (soil and groundwater protection and rehabilitation), and TESTNET (clean products, water and environmental monitoring). Two new projects are being started on air emission reduction technologies and solid wastes and sludge treatment. Short descriptions of the pilot projects are provided in the meeting notebook.

Andrea Tilche stated that he had presented the first ideas of the Commission services for starting the discussion on a possible future EU ETV system. These ideas were presented to the representatives of the EU Member States in June 2005, and comments have been received that still need to be incorporated into the proposal. He would welcome any critical remarks from the meeting participants to help them better shape their proposal.

Teresa Harten thanked all of the presenters and commented that their presentations have provided a good basis for understanding other international ETV programs.

TECHNICAL PRESENTATIONS

Water and Water Security

Karen Riggs, the Battelle Manager for the U.S. EPA ETV AMS Center, and Tay Joo Hwa, IESE, served as the session co-chairs. Karen Riggs welcomed the meeting participants to this session on water and water security technical presentations. Earlier, William Mansfield, UNEP, discussed how water and

climate change were the two most critical global environmental issues facing the world today. The presentations in this session will describe some of the environmental initiatives that may help to ensure that there is clean, potable water available for human consumption and agricultural purposes. She stated that there would be a panel discussion after the technical presentations.

U.S. EPA ETV Advanced Monitoring Systems (AMS) Center

Amy Dindal is a Project Manager at Battelle. She earned a Bachelor of Science in chemistry from Pennsylvania State University in 1992. She currently serves as a Verification Testing Leader in the U.S. EPA ETV AMS Center.

Amy Dindal introduced Robert Fuerst, who is the EPA Center Manager for the U.S. EPA ETV AMS Center. She provided an overview of the ETV AMS Center, which was initiated in October 1997. The center has verified 92 monitoring technologies, which includes 48 air monitoring technologies and 44 water and water security monitoring technologies. Outreach, stakeholder groups and partnerships are an integral part of the ETV AMS Center.

The focus of the ETV AMS Center is on monitoring technologies. Priority water and water security technology categories that were discussed include: atrazine test kits, multi-parameter water quality probes and on-line monitors, beach monitors, immunoassay test kits for biotoxins, and rapid polymerase chain reaction (PCR) instruments.

The ETV AMS Center has verified immunoassay-based atrazine test kits. Atrazine is the most widely used herbicide in the United States. Approximately 76 million pounds are applied in both agricultural and non-agricultural applications in the United States each year. This includes applications to crops such as corn and sugarcane, as well as on golf courses and residential lawns. Although atrazine is not likely to be carcinogenic, it appears to cause hormonal imbalances. The U.S. EPA announced a program in 2003 to protect vulnerable drinking water systems from contamination by atrazine. The program involves intensive, targeted monitoring of raw water in areas of high atrazine use.

There are a number of potential outcomes from testing of atrazine test kits. There are approximately 940,000 private water wells, 3,800 surface water community water systems, and 10,000 watersheds located in areas where atrazine may be used. The technologies that were tested could be applied to these systems. They also could be applied for compliance monitoring to ensure that the atrazine levels in community water systems are below the maximum contaminant level that has been set by the U.S. EPA as 3 parts per billion (ppb). The test kits can result in significant costs savings because immunoassay analyses cost approximately five times less than laboratory analyses. They also can provide timely information on atrazine levels in water to identify if the level is above or below applicable standards, or identify the need for mitigation to decrease atrazine levels in drinking water or watersheds. These test kits can provide data in minutes or hours, as opposed to days or weeks.

The four atrazine test kits that were tested are: Silver Lake Research Corporation's Watersafe® Pesticide Test; Abraxis, LLC's Atrazine ELISA Kit; Beacon Analytical Systems, Inc.'s Atrazine Tube Kit; and Strategic Diagnostic, Inc.'s RaPID Assay® Kit. These test kits are all immunoassay-based technologies. The Silver Lake Research Corporation's Watersafe® Pesticide Test is a test strip that produces a semi-

quantitative result that can tell you whether the water sample is above or below the maximum contaminant level for atrazine. The other three technologies are all enzyme-linked immunosorbent assays, which are quantitative technologies.

The verified test parameters included: accuracy, linearity, matrix interference, rate of false positives/negatives, precision, method detection limit and cross-reactivity. The ETV AMS Center partnered with a number of organizations on these tests. The Texas Commission on Environmental Quality provided a test operator who ran the analyses during the test. The standard analytical laboratory method for atrazine is a gas chromatography/mass spectrometry method that was performed by a laboratory within the U.S. EPA's Office of Pesticide Programs. Test samples were provided by the National Oceanic and Atmospheric Administration (NOAA) and the University of Missouri-Rolla.

Amy Dindal provided some general observations from the testing. The Method Detection Limits (MDLs) for the quantitative technologies were considerably below the 3 ppb maximum contaminant level. They ranged from 0.06 to 0.10 ppb. Battelle found that some previous experience in performing immunoassays is important when using quantitative tests, due to the repetitive nature of the sample preparation process. All of the quantitative test kits had a positive cross reactivity to certain compounds that are similar to atrazine. Several technologies showed apparent evidence of interference from the brackish water matrix.

The ETV AMS Center has conducted tests for monitoring parameters for water quality. There are two separate verification categories under this general category—water quality probes and on-line monitors. Water quality probes were tested in an environmental setting. These probes are inserted into an open water source such as an ocean, river or a lake. The on-line monitors are tested in water distribution systems. Both technologies are similar in that they are testing for parameters continuously to monitor the quality of the water. The difference between the two technology categories is the configuration of the technologies, which is necessitated by the application of the technology. There also are some differences in the type of parameters that are monitored by the two technology types. There are a number of uses for continuous water quality monitors. Continuous monitoring to observe changes to water quality parameters has application to both routine environmental and water security applications. There are 160,000 U.S. public drinking water systems. In a water security application, these technologies can serve as an early warning system to detect signs of intentional or unintentional contamination. These technologies also could be used for ocean, lake, river or stream water quality monitoring to monitor for indications of changing environmental conditions and potential impacts to animals and plants.

The performance of four multi-parameter water quality probes has been verified. These included two technologies from YSI Incorporated; one from AANDERAA Instruments, Inc.; and one from General Oceanics, Inc. These systems are designed to continuously monitor various water quality parameters in open waters. The tests were conducted in partnership with NOAA, which provided a test site and test operators, and conducted the reference analyses. The technologies were verified under three scenarios (saltwater, freshwater, and mesocosm, a laboratory-controlled environment) for up to 30 days. The technologies monitored one or more of the following analytes: dissolved oxygen, temperature, turbidity, pH, conductivity and chlorophyll. The verification parameters that were evaluated included: pre- and post-calibration results, relative bias, a visual record of fouling, precision, linearity and inter-unit reproducibility. Some general observations from the testing are that the technologies were set up and deployed with minimal difficulty, and the level of maintenance varied among the technologies. There was

a visual inspection of biofouling to see how the physical condition of the technology changed as it was deployed in a saltwater and freshwater environment.

Multi-parameter on-line monitors for water distribution systems were tested for water security applications in partnership with the U.S. EPA's Testing and Evaluation Facility in Cincinnati, Ohio. The verification test experimental design was composed of four stages. Stage 1 used controlled solutions to test the following parameters: pH, chlorine, conductivity, turbidity, temperature and alkalinity. During Stage 2, contaminants were intentionally injected. The range of contaminants included: aldicarb, nicotine, arsenic trioxide and *Escherichia coli*. Stage 3 consisted of extended deployment (52 days) to evaluate maintenance and reliability. Stage 4 (only one technology participated) consisted of identification of the following contaminants: aldicarb, nicotine, arsenic trioxide, *E. coli*, glyphosate, sodium fluoroacetate, potassium ferricyanide, dichlorvos, dicamba, lead nitrate, mercuric chloride, colchicine and methanol. The participating vendors included: Analytical Technology, Inc.; Rosemount Analytical; Clarion Sensing Systems; Hach Company; and Mantech, Inc. Testing has been completed and the verification reports are under preparation. The verification reports will be posted to the ETV Web Site as soon as they are completed.

The next technology category discussed was beach monitoring. The application focus for this test is identified as rapid detection (less than eight hours) technologies for quantification of enterococci and *E. coli* in estuarine and marine waters. The current approved standard requires 24 hours for results to be reported. This type of monitoring is designed to detect pathogen indicating organisms in recreational waters that are used for swimming. The current scenario (which requires 24 hours for results) means that beach closures are based on yesterday's data. There is a great need for monitoring technologies to detect beach pathogens in a more rapid manner. There are 910 million trips to coastal areas each year in the United States and $44 billion is spent annually at beaches. In 2004, 1,000 of 3,400 beaches monitored were closed (or carried warnings) for one to two days due to high bacterial indicator readings. The availability of rapid and reliable monitoring technologies will improve the safety of recreational waters and minimize tourist impacts.

Up to this point, the only reason these types of technologies were not verified by the ETV AMS Center was that the technologies with the required sensitivity and speed were not commercially available. Vendor detection capabilities for enterococci have been on the order of 100 to 1,000 times higher than the regulatory level of 104 *Enterococcus* colonies per 100 mL for ambient marine water. Additionally, most vendors had not worked with real matrices and had interference issues. However, vendor interest and readiness are increasing. Beach monitoring technology types include: immunological devices, transcription-mediated amplification, particle imaging, portable incubation/spectrophotometry, enzymatic techniques and PCR. Vendor agreements have been sent to five vendors who expressed interest in participating in testing. The ETV AMS Center has been in active communication with potential partners who are interested in providing test sites and reference analyses, including the Southern California Coastal Water Research Program (SCCWRP), the Alabama Department of Environmental Management (ADEM), and the Barnstable County (Cape Cod) Department of Public Health. As soon as the vendor and partner commitments are finalized, the ETV AMS Center will move forward with this verification test.

Another test in the area of water security is immunoassay test kits for biotoxins. This is similar to the atrazine monitoring technology category, where there is quantitative Enzyme-Linked Immunosorbent

Assay (ELISA) technologies as well as test strips. The four technology vendors that completed verification testing are: Tetracore, Inc. (ELISA); Tetracore, Inc. (test strips); Response Biomedical Corp. (RAMP test cartridges); and ADVNT Biotechnologies (BADD test strips). The verification reports are completed and posted on the ETV Web Site. Testing of three additional kits is underway. The three vendors are BioVeris, QTL BioSystems and Pharmaleads.

It is important that these types of technologies have been verified. These are test kits that can and are being used by first responders. It is important that there is performance information that can be provided to buyers and users of these test kits. There is a potential that verification testing will spur development of new technologies (e.g., field-portable concentration techniques).

The technologies work by an antigen/antibody reaction that triggers a color change when the analyte is present. The two types of test kits verified were test strips and an ELISA. For the test strips, a few drops of the sample are placed on the strip. "Positive" is indicated by the appearance of a red line within approximately 20 minutes. For the ELISA, samples are placed in a 96-well plate containing the antibodies. "Positive" is indicated by a solution color change within approximately four hours. The analytes tested were anthrax, botulinum toxin and ricin.

Amy Dindal provided a few general observations on the test results for the immunoassay test kits. The sensitivity of the immunoassay test kits for biotoxins was higher than expected based on what was reported by the vendors. This was particularly true for anthrax, which had a detection capability of 10 to 10,000 times higher than expected. Botulinum toxin was up to 10 times higher and had a type-specific dependency for two of the technologies. Ricin was up to 50 times higher than expected. The technologies were easy to use in or outside a laboratory setting, and a non-technical operator was able to perform testing for test-strips. In general, cross-reactivity, metals and concentrated drinking water did not cause matrix interferences.

The last technology category is rapid PCR technologies. The three technologies that were tested by the ETV AMS Center included: Applied Biosystems' TaqMan® *E. coli* O157:H7 Detection System; Idaho Technology, Inc.'s R.A.P.I.D® System; and Invitrogen Corporation's PathAlert™ Detection Kit. Rapid PCR is a technique used to detect and measure deoxyribonucleic acid (DNA), thereby making it a bacteria/contaminant selective technology. However, this technique cannot distinguish between live or dead bacteria. For this verification test, the rapid PCR technologies provided qualitative detection/non-detection results. Rapid PCR is gaining popularity for security applications, including: U.S. Post Office mail screening, post-sampling decontamination confirmation, and battlefield air monitoring for biological agents. The technologies were tested using one or more of the following five contaminants: *Bacillus anthracis*, *Yersinia pestis*, *Francisella tularensis*, *Brucella suis*, and *E. coli*. Idaho Technology's system was the only technology that was tested for all five of these contaminants. The matrices used were: (1) drinking water, which included chlorinated surface water (filtered and unfiltered), filtered ground water, and filtered chloraminated surface water (all were concentrated to 400 times through ultrafiltration); and (2) ASTM Type II DI water—water spiked with contaminants at various levels and with interferents (humic and fulvic acids). The concentration levels ranged from 0.20 to 5×10^4 cfu/mL.

Amy Dindal provided some summary results from the testing. All of the lethal/infective dose levels, except for those of *F. tularensis*, were below the vendor-claimed system limit of detection (LOD) for each

technology. The accuracy of the systems was 98 percent on average across PCR technologies and bacteria. The false positive and negative rates were low. This indicated that the systems were very effective for indicating the presence and absence of the bacteria of interest. The precision (i.e., reproducibility of results) ranged from 76 percent to 100 percent. There was little or no effect from humic/fulvic acids across the systems and that also is true for most of the drinking water samples.

The other ETV AMS Center water and water security technology categories include: nutrient monitors, arsenic analyzers, on-line turbidimeters, nitrate analyzers, mobile mass spectrometers, enzymatic test kits, rapid toxicity monitors and cyanide monitors. Testing results for these water and water security technology categories are posted on the ETV Web Site at http://www.epa.gov/etv.

Over the next six months, the ETV AMS Center will complete the five reports for the on-line multi-parameter water monitors for distribution systems. Recently, verification testing of continuous nutrient monitors was completed at an industrial wastewater treatment plant in Richmond, Virginia. Those verification reports will be available at the end of September 2005. Testing will begin in the next few months for enzymatic test kits, mobile mass spectrometers, rapid toxicity technologies, and immunoassay test kits for biotoxins. It is hoped that the verification test for beach monitors will begin soon. Also, an environmental test for nutrient monitors may be conducted.

In conclusion, Amy Dindal stated that the ETV AMS Center is looking at a variety of water and water security monitoring technologies. Reductions of risk and environmental improvements are potentially significant outcomes from verification testing and are strong considerations in technology prioritization. Multiple water monitoring technologies are in the queue to be verified. The ETV AMS Center has had very successful partnerships with the U.S. EPA Test and Evaluation Facility, U.S. EPA Office of Pesticides, NOAA, Texas Commission on Environmental Quality, DuPont Company, and the SCCWRP. These organizations have been invaluable in helping the center to leverage EPA funding and lending technical credibility to the verification tests. The ETV AMS Center looks forward to establishing international partnerships as a result of this meeting.

J-ETV

Kenji Kamita, Deputy Director of the Office of Environmental Research and Technology at the MOE, Japan, provided a presentation on organic wastewater treatment technologies for small-scale establishments, human waste treatment technologies in mountain districts, simplified monitoring technologies for chemical substances, wastewater treatment technologies for nonmetallic elements (e.g., boron), and technologies for improving the water quality of lakes and reservoirs.

Kenji Kamita began his presentation by discussing organic wastewater treatment technologies for small-scale establishments such as kitchens/restaurants and food manufacturing plants. There is a need for these technologies because water quality has not been adequately improved. Biochemical oxygen demand (BOD)/chemical oxygen demand (COD) concentrations have been improving, but in FY03, the achievement rate for the Water Quality Standard was still at 87.4 percent for rivers, 55.3 percent for lakes/reservoirs, and 76.2 percent for seawater. There is a similar problem with total nitrogen and total phosphorus. In addition, there are many unregulated emissions sources. Small establishments (effluent less than 50 m^3/day) are not subject to effluent standards for organic pollutants. These small-scale

establishments account for approximately 87 percent of all establishments. To reduce the organic pollutant load, there is a need to promote organic wastewater treatment technologies that are low-cost, compact and low-maintenance.

J-ETV defines the small-scale organic wastewater treatment technology category as technologies that treat organic wastewater from the kitchens of small establishments (wastewater discharge up to 50 m^3/day). In FY03, three verification organizations participated in the verification of eight technologies; these verifications and reports have been completed. In FY04, five verifications organizations participated in the verification of 10 technologies; these verifications and reports are completed. In FY05, the program is shifting to the vendor-pays stage (Phase 2) as the two-year pilot period has ended.

In FY03, the eight technologies that were verified were tested for removal of the following pollutants: BOD, COD, suspended solids (SS), and normal hexane (n-hex). For each technology, the actual pollutant removal was confirmed to generally match the technology's stated specifications, although some technologies failed to achieve their stated specifications. In some cases, the technology also was confirmed to remove some pollutants that were not being targeted (even total nitrogen or total phosphorus in some technologies).

The summary version of the verification report is four pages per technology. The first page contains the technology name, a technology flowchart, the locations of the test, and technical specifications. The second page provides the verification results for the technology's performance in pollutant removal. The third page contains verification results relating to the environmental impact, resources used, and maintenance features. The last page contains applicant information such as product data and contact information.

The next technology category discussed was treatment technologies for human waste in mountain districts. The cold atmosphere and absence of electrical and water supply infrastructure make it difficult to use conventional sanitation equipment in Japan's mountain areas; thus, the availability of proper toilet facilities is inadequate in these areas. The boom in recent decades of middle-aged hikers has increased the number of visitors to mountain areas, giving cause for concern about the impacts of human waste on the surrounding environment. In recent years, there has been progress in the private sector with the development and commercialization of human waste treatment technologies that can be used in mountain areas. However, performance data on these technologies are limited to what the companies have released. In the absence of clear standards, users such as local governments question whether or not the technologies have the proper treatment capabilities. Thus, there is a need for objective information and verification regarding human waste treatment technologies that can be used in mountain areas.

J-ETV defines this technology category as technologies for the treatment of human waste from public toilets in areas such as mountain districts that lack adequate infrastructure (sewerage/drain pipes, electricity, etc.). In FY03, one verification organization participated in the verification of two technologies. In FY04, four verifications organizations participated in the verification of four technologies. In many cases, verification testing cannot be completed in one year, due to the need for post-winter testing. Of the six projects that started the verification process over the past two years, reports have been completed for only two technologies. In FY05, the program is shifting to the vendor-pays stage (Phase 2) as the two-year pilot period has ended.

The verification testing included: operating conditions, maintenance functions, indoor environment, impact on surrounding environment, and treatment performance. For the two technologies for which verifications have been completed, no troubles arose during the testing period, and both functioned well, even at times of peak use. For both toilets, 70 percent to 80 percent of respondents to a user survey on the indoor conditions during the testing period responded that "the odor and other inside conditions were acceptable."

The next technology category discussed was simplified monitoring technologies for chemical substances. As the importance of risk communication relating to chemicals increases, there is a rising need to have a good grasp of the situation of chemical substances in the environment for the public and other stakeholders. Because there are many kinds of chemicals and many of them are in the environment at low concentrations, conventional analytical methods are mostly complex. As a result, there is a need to develop and apply simple analytical technologies. There are many simple, yet sensitive, analytical technologies being placed in the market that could answer these analytical needs. However, these technologies often lack credibility, as little performance data are available based on actual sample testing, and there have not been enough comparisons with existing measurement methods. As a result, there is a need for objective verification of these simple analytical methods.

J-ETV defines this technology category as technologies that can be implemented more easily than conventional methods, particularly to analyze chemical substances in the environment that are not yet covered by officially sanctioned methods. An example of this type of technology is simple analytical methods such as enzyme immunoassays or fluoroimmunoassays that use antigen-antibody reactions for substances subject to Japan's Pollutant Release and Transfer Registers (PRTR) Law, as well as suspected endocrine-disrupting chemicals. In FY04, three verifications organizations participated in the verification of eight technologies (three companies, eight substances, eight kits); these verifications and reports are completed. In FY05, invitation and selection of verification organizations is in progress.

In FY04, the eight technologies that were verified were tested for removal of five agricultural chemicals (atrazine, fenitrothion, linear alkylbenzene sulfonate [LAS], alkylphenol and isoxathion), polychlorinated biphenyl (PCB), and two surfactants (malathion and isoprothiolane). All of the technologies were based on the ELISA method. The findings illustrated the convenience of the new technologies compared to conventional technologies (detection time ranged from three to five hours for the new technologies versus three days for the conventional technologies). The results showed that for some technologies, the measurable range was not broader than the company's stated product data.

The next technology category discussed was wastewater treatment technologies for nonmetallic elements (e.g., boron). Because of evidence of the human health impacts of boron and fluorine, Japan introduced effluent standards in 2001 (i.e., across-the-board standards of 10 mg/L for boron and 8 mg/L for fluorine, with the exception of seawater). In 2001, provisional standards were established for some industries as a concession for small-scale factories. In 2004, a study found that efforts to introduce treatment equipment were lagging, particularly in service industries such as hotels and inns that use the water from hot springs. In recent years, space-saving, low-cost technologies to treat boron and other substances have been developed, but facilities such as inns with hot springs still lack the knowledge and experience with introducing such technologies. Even though excellent technologies may be available that do not require

the installation of expensive equipment, they are not being used. To promote and further develop these technologies, it is important to verify the environmental protection effectiveness of these technologies and obtain objective data about them.

J-ETV defines this technology category as technologies for treatment of wastewater containing nonmetallic elements, such as boron, applying to operating establishments such as hotels and inns where only organic pollutants in wastewater have been considered to date. In FY05, one verification organization was selected. The process of inviting and selecting technologies for verification is under way. Initially, the target will be boron-removal technologies.

The last technology category discussed was technologies for improving water quality in lakes and reservoirs. Lakes and reservoirs are enclosed water bodies, and once organic pollutants accumulate in them, it is difficult to return them to a clean state. Only 40 percent to 50 percent of lakes and reservoirs in Japan meet environmental water quality standards for COD. Also, pollution from nutrients such as phosphorus cause frequent occurrences of algal blooms of phytoplankton (water bloom). Despite steps taken by the MOE (e.g., strengthening effluent standards) to enhance efforts to reduce pollutant loads flowing into these water bodies, water quality has failed to improve. In recent years, many technologies have been developed to directly improve water quality in lakes and reservoirs. It is important to promote the development and application of these technologies, along with strategies to reduce pollutant load inflows.

J-ETV defines this technology category as technologies for directly removing pollutants that have accumulated in water, benthic mud, etc., or preventing internal production of pollutants within enclosed lakes and reservoirs, where it is difficult to improve the water quality merely by reducing pollutant load inflows. In FY05, five verification organizations were selected, and invitation and selection of verification organizations is in progress.

Institute of Environmental Science and Engineering (IESE)

David Liang is Vice President, IESE, Nanyang Technological University (NTU). He has a bachelor's degree and a master's degree in chemical engineering from Queens University, Canada. He provided a presentation on ballast water treatment technologies, including land-based application issues.

Why is Singapore so interested in ballast water? The whole issue with ballast water is bioinvasion (i.e., ships discharging foreign species into waters that have benign indigenous species). In the United States and Canada, the most familiar foreign species is the zebra mussel; in Asia, it is the red tide, which is caused by microbes and results in significant damage to aquaculture and economics in the region. The Singapore Government is investing a lot of money in verification testing projects because they hope to obtain some economic benefit by commercializing the technologies in the future.

David Liang presented statistics on the maritime market, based on information provided in 2001 by Douglas-Westwood Associates. The global maritime market for all oceangoing activities is $1.3 trillion (Singapore dollars). Of the total market, North America represents 25 percent, Europe 26 percent, and Asia 34 percent. For shipping, shipbuilding and ship repairing, the total market value is $500 billion (Singapore dollars) per year and Asia accounts for 45 percent of the total. Shipbuilding is a very

important part of the economy in Asia. Approximately $35 billion (Singapore dollars) per year is spent on maritime technology research and development; Europe accounts for 24 percent, Asia 29 percent, and North America 39 percent. They looked at the research and development market and at where in the future (2003-2013) the maritime technology development is needed, and where they expect money to be spent. Globally, they estimated that $20 billion would be invested in the ballast water technology area. Of this total, Singapore's ballast water market is expected to equal approximately $275 million. Singapore is a trans-shipping center in Asia; a significant number of ships come to Singapore each year for repairs and service, and Singapore operates 14 ports worldwide. In addition to ballast water, the whole maritime area covers other environmental areas/markets, such as wastewater discharge ($90 million), anti-fouling tanks ($32 million), and oily water separation ($20 million). Each one of these areas/markets could be quite substantial. The total Singapore market could be more than $500 million (Singapore dollars) for the emerging needs in the environmental sector.

Singapore is hoping to have an ETV-like program. Last year, a letter of intent was signed with the U.S. EPA for joint collaborative work on test protocols for the verification of environmental technologies, starting with ballast water. They hope to extend the collaboration in other areas such as water and wastewater treatment, air pollution, greenhouse gas and energy. IESE is taking the lead as a major research and development player in ballast water treatment technologies, membrane technologies and emission control technologies. They also are playing a significant role in new standards and protocol development for ballast water. They hope to form strategic international partnerships, such as with the U.S. Coast Guard, as well as local partnerships with the Maritime Port Authority (a local port authority in charge of all of the port management in Singapore), and Neptune Orient Lines (NOL) (a local Singapore shipping line).

The three objectives for the ballast water verification project are to: (1) provide objective, independent performance data to users and developers, (2) facilitate market penetration and acceptance of new marine environmental technologies, and (3) facilitate distribution and exportation of technologies within and outside of the Singapore/Asia region.

Singapore is one of the busiest ports in the world. Each year, about 150,000 ships come to port in Singapore, with close to 100 vessels coming into port daily. The majority of the ships sailing out of Singapore are going to ports in South and Southeast Asia. The rest go to Hong Kong, China, Taiwan, Japan, Europe and the United States. These ships are sailing worldwide. The concern is that the ships will carry some of the water as ballast from Singapore to their other destinations. Some of the countries have decided to impose unilateral standards for ballast water control. Singapore has to careful so that it is not cut out of these markets. The bioinvasive species of concern that are carried in ballast water include: phytoplankton (dinoflagellates, diatoms), zooplankton (copepod larvae, bivalve larvae, crab zoea), and microorganisms (bacteria, viruses, protozoa).

In the Singapore Ballast Water Programme, they have completed lab-scale research and development and process development, monitoring protocols development, a dockside pilot plant study, and prototype system fabrication and testing. They are ready to do the shipboard installation, evaluation and demonstration, which will lead to commercialization of the technology.

The project objectives for the shipboard treatment system are to: (1) demonstrate an innovative treatment concept; (2) allow Singapore-flagged ships and the Port of Singapore to adopt safe and efficient ballast water management options; (3) generate data on ballast water treatment effectiveness, reliability, and life cycle costs; and (4) determine the engineering requirements needed to commercialize the technology. IESE is leading the project. Project funding is coming from The Enterprise Challenge Program and the Maritime Port Authority; in-kind contributions are being provided by the IESE, the Tropical Marine Science Institute, Ngee Ann Polytechnic (a local college), Neptune Orient Lines, and the American Bureau of Shipping (a ship classification society).

The system was installed onboard a ship early in 2005, and three trial sailings (Asia, Europe, United States) have been completed. The primary treatment system uses filtration and can easily remove big particles. Also, the system has less sedimentation problems, requires a smaller footprint for the secondary treatment process, and has negligible operation and maintenance costs. The system is also flexible for seawater and port-to-port variations. The secondary treatment system is a ferrate-based system. Ferrate is a very powerful oxidant. The costs to commercialize ferrate were very high until recently, when a company developed an on-site liquid ferrate synthesis utilizing commodity feedstocks. Ferrate has a very short shelf life, so it must be generated just before it is used. Ferrate produces non-toxic residuals and requires relatively small capital investments. It also requires a small footprint and is easy for retrofitting.

The shipboard system was installed on the APL PEARL, a container ship that has a dead weight of 63,693 tons, a total ballast water capacity of 17,688 cubic meters (m^3), and a ballast pump capacity of 1,200 tons per hour.

The most recent International Maritime Organization (IMO) regulations state that particles greater than or equal to 50 μm must have less than 10 viable organisms per 1 m^3 of ballast water. Particles between 10 to 50 μm must have less than 10 viable organisms per 1 mL of ballast water. The following standards have been set for indicator microbes: (1) toxicogenic *Vibrio cholerae* with less than one colony forming unit (cfu) per 100 mL or less than 1 cfu per 1 gram (wet weight) zooplankton samples, (2) *E. coli* less than 250 cfu per 100 mL, and (3) intestinal *Enterococci* less than 100 cfu per 100 mL.

Three trials of the shipboard system have been completed. Preliminary results from two of the trials indicate that, using the ferrate, the shipboard system can comply with the IMO standards for the three indicator microbes. For the two trials, the total coliform was 323 and 345 before treatment, and both were less than 1 after treatment. There was a significant reduction in the phytoplankton and zooplankton after treatment, due to the 60 micron-sized filtration screen that was used before the ferrate addition. However, a larger decrease was expected. The technology developer has suggested that the ferrate dose should be increased from 4 ppm to 20 ppm to have an effective kill for the larger species. The cost of ferrate disinfection compared to other technologies is very low, approximately 1.3 cents per m^3 using a dose of 3 ppm.

U.S. EPA ETV Water Quality Protection (WQP) Center

Tom Stevens is the NSF International Manager for the U.S. EPA ETV WQP Center. He has 29 years of experience in environmental engineering; the last 20 years have been at NSF. Prior to NSF, he worked for several consulting engineering firms and the U.S. Army Corps of Engineers. He holds bachelor and

master degrees in civil and sanitary engineering from the University of Michigan, and is a registered professional engineer in the State of Michigan.

After introducing Ray Frederick, the EPA Manager for the U.S. EPA ETV WQP Center, Tom Stevens noted that the current technology areas of interest in the ETV WQP Center are: decentralized wastewater treatment technologies (six verified, three in progress), watershed protection technologies (eight verified, one in progress), urban infrastructure rehabilitation technologies, ship ballast water treatment technologies, wet weather flow technologies (nine verified, 10 in progress), and technologies with water security applications (one verified). All told, the ETV WQP Center has completed 13 generic protocols and test plans (two are in progress); 35 test plans (three additional test plans are in progress); and 24 verifications (14 additional verifications are in progress). Tom Stevens focused the remainder of the presentation on three technology categories: stormwater treatment, infrastructure rehabilitation, and ship ballast water treatment.

Tom Stevens provided a brief discussion on stormwater treatment activities. The types of systems that are being evaluated by the ETV WQP Center range from single catch basins to larger systems that treat multiple catch basins or whole systems. The complexity of these systems ranges from the very simple to the very complex, and includes gravity settling, adsorption or filtration. The test period for this technology category is long (more than 16 months) mainly because it includes 15 qualified storm events. The primary focus of the testing is to determine the reduction of total suspended solids (TSS) and suspended solids concentrations (SSC). Nutrient and metals reductions are considered if these measures are part of the vendor's performance claims. Installation, operation and maintenance requirements also are evaluated, including the ease or difficulty of these activities.

Although TSS and SSC were the primary focus, total phosphorus, Kjeldahl nitrogen (TKN), nitrate-N, copper, lead and zinc also were tested. TSS and SSC are important because the U.S. EPA is considering guidance on these types of systems and one of the targets they are looking at is 80 percent removal for TSS. Based on the verification testing results, this may be difficult for the technologies to achieve. Test results were presented, including the best and worst event mean concentration (EMC) ranges. EMCs are used to report the percent reductions achieved by the technologies tested. For TSS, the EMC ranged from 47 percent to 97 percent under the best conditions, and from –620 percent to 56 percent under the worst conditions. Because only storm events with 0.2 inch or greater of rain are included in the verification, there are likely to be accumulations of solids in the units between the sampled events that wash out of the units when there is a big storm. Higher percent removals were seen with the SSC results, from 3 percent to 99 percent under the EMC best conditions, and from –870 percent to 56 percent under the worst conditions. The sum of loads (SOL) results were presented. The SOL calculation takes into account the total contaminant load that goes into and out of the unit over the course of 15 storm events. The median removals based on SOL for TSS and SSC are 26 percent and 44 percent, respectively. The range of the SOL removals are 19 percent to 82 percent for TSS and –67 percent to 92 percent for SSC.

The ETV WQP Center is also working in the infrastructure rehabilitation area. Infrastructure rehabilitation is a significant issue in the United States because an expenditure of many billions of dollars is being projected to bring the country's infrastructure up to a state of good repair. Europe is ahead of the United States in this technology category. Sewer problems include roots, open joints, cracked pipes, broken and missing pipe, and leaks that allow infiltration to enter the collection systems. These problems

can cause operational problems at treatment plants and reduce the capacity of the wastewater treatment systems, potentially resulting in the need to expand the systems. The technologies under consideration include grout for infiltration control, and coatings, liner materials and pipe bursting for structural repair. The ETV WQP Center is working with the University of Houston on coatings, with a draft protocol having been completed. There has not been a lot of interest from vendors of pipe liner materials and pipe bursting products. Many engineering firms and municipalities are not requesting that vendors have verification data, so vendors have not seen a need to participate in testing. In the grout area, the vendors are very interested.

Verification of grouts will focus on nonstructural characteristics, since grouts are not meant to strengthen pipes, but to prevent water intrusion. The grout material will be characterized so that users of the technology can determine if the grout is the same grout that was verified by ETV. The grout will be evaluated for its ability to be applied and withstand a variety of environments. Other evaluation factors will include the working properties, mechanical characteristics and durability of the grouts and grouted soils, and the performance of grouted joints and repaired concrete cracks.

Ship ballast water treatment, which addresses issues related to aquatic nuisance species, such as zebra mussels, European green crabs and mitten crabs, is the most challenging area that the ETV WQP Center has faced and has worldwide implications. A Memorandum of Understanding (MOU) between the U.S. EPA ETV Program and the U.S. Coast Guard (USCG) was signed in June 2001. This MOU defines the roles of each organization under the cooperative effort leading to the verification of ballast water treatment technologies. A technical panel has been established and the development of a land-based protocol, which allows for an equal and consistent evaluation of all technologies, is being pursued. The USCG has provided additional funds to research and identify two to three surrogate organisms that will be the hardest and most difficult to remove. As part of the verification testing, operation and maintenance will be evaluated because ship owners and operators have indicated that this issue is very important to them. Talks have also been held with the IESE about setting up a testing facility in Singapore. The USCG is funding a pilot test of the protocol at the Naval Research Laboratory in Key West, Florida, to identify problems with the proposed approach for conducting testing. This test will provide significant input for the next revision of the draft protocol.

Tom Stevens provided target dates for the ballast water treatment technology verification activities. An initial draft of the protocol was completed in April 2002; a second draft protocol was completed in August 2004. The Naval Research Laboratory pilot testing is anticipated to occur in fall 2005/winter 2006. It is hoped that additional information will result from the pilot test that will aid in finalizing the protocol. It is expected that the final draft protocol, which is funded by the USCG, will be completed by the end of September 2006.

ETV Canada

Andrew Houlson is Assistant Technical Director for ETV Canada, responsible for the technical evaluation of innovative environmental technologies. His protocol development and technology assessment experience includes the preparation of technology-specific test plans for a variety of technologies. He has played a major role in the testing and verification of technologies for the removal of arsenic from drinking water in Bangladesh and removal of mercury amalgam from wastewater. He has a Higher National

Diploma in environmental analysis and monitoring, a Bachelor of Science in environmental studies, a master's degree in environmental pollution science, and an engineering doctorate in environmental technology.

Andrew Houlson provided a presentation on mercury wastewater treatment, stormwater treatment and arsenic drinking water treatment. For a vendor claim to be verified under ETV Canada: (1) the technology must provide environmental benefit and comply with health and safety requirements; (2) the technology must be based on sound scientific and engineering principles; and (3) the claim must be fully supported by independently generated, peer-reviewed quality data. The data used for verification are generated primarily by laboratories accredited by the Standards Council of Canada, or its equivalent, and through independent test agents. The verification process includes the submission of a prescreening application that provides proof that the technology is commercially available and meets Canadian standards. The next step is the formal application that includes the performance claim to be verified and independent third-party data to support the claim. The selection of an ETV Canada approved VE must be impartial and the VE must be specialized in the topic of the verification. A successful verification results in the award of the verification report and certificate.

ETV Canada has four types of VEs: (1) laboratories accredited by the Standards Council of Canada, (2) national laboratories, (3) universities, and (4) experts. Three case studies on water-based treatment systems were presented. The VEs for each of the case studies were independent experts with professional qualifications.

The first case study addressed Hygenitek's dental wastewater amalgam removal unit, which was verified in 2005. The main contaminant of concern in dental amalgam is mercury; the main source of the mercury is the dental amalgam that ends up in sewers and subsequently contaminates aquatic ecosystems. This technology uses sedimentation, filtration and mercury absorbing media to prevent mercury from releasing into the sewer. A new test plan was developed for this verification. It was designed to test conformance with ISO 11,143 Dental Equipment – amalgam separators (a method of determining removal of amalgam particles greater than 1 μm). The test plan also included the Canada-wide standard on mercury from dental amalgam waste; the standard is 95 percent reduction.

Testing was performed at the Faculty of Dentistry, University of Toronto. The tooth amalgam sample and influent preparation were performed by the dentists. To ensure quality control, the following procedures were followed: (1) all samples were collected and forwarded under chain-of-custody by the analytical laboratory; (2) samples were preserved at pH 2 and kept at 4°C; (3) all sampling equipment was acid rinsed, cleaned and proofed by the independent laboratory; (4) blind mercury standards and blanks were sent with the samples; and (5) all samples were sent to a mercury accredited test laboratory.

Three replicate units were tested. Testing results showed that the Hygenitek Amalgam Removal Units met the Canada-wide standard on mercury for dental amalgam waste and ISO 11,143, with 95 percent removal of mercury. The vendor provided the following comment: "ETV Canada verification provides authority and authenticity for sales."

The second case study addressed Stormceptor Canada, Inc.'s Stormceptor®, a technology designed to treat stormwater runoff from small-sized catchments for the reduction in TSS and TKN, which have the

potential to impact streams and lakes. This technology removes sediment and oil by separation and sedimentation. Andrew Houlson noted that Stormceptor had their data sets, but they needed to modify their performance claims. He further clarified that the TSS measurements were performed at three sites in the United States, and that the TKN measurements were performed at two sites, also in the United States. To provide more information on the site, water flow monitoring and rainfall data were collected at each of the sites. The independent test agent used for this verification was Associated Earth Sciences, Inc., Kirkland, Washington.

Verification test results showed that Stormceptor is capable of removing TSS and TKN from stormwater runoff when designed in accordance with the Expert Sizing System version 2.0, as developed by the Stormceptor group of companies. The vendor claims verified were: (1) TSS overall loading removal ranged from 76 percent to 94 percent, and (2) TKN overall loading removal ranged from 43 percent to 65 percent. The vendor provided the following comment: "ETV Canada verification is an excellent marketing tool." The company would like to see mandatory Canadian use of verification and more reciprocity with the U.S. EPA ETV Program.

The third case study presented addressed ADI International, Inc.'s Arsenic Removal Unit system, which is an adsorption-based technology for the removal of arsenic in drinking water. Testing was conducted at a drinking water treatment plant in Michigan. The VE was Geomatrix Consultants, Inc., based in Canada. The technology is focused on arsenic, which is a naturally occurring contaminant in drinking water.

The verification results showed that influent pentavalent arsenic was reduced from 41 ppb on average to less than 5 ppb (95 percent confidence). The system produced $5x10^6$ gallons of treated water without regeneration of the media. The vendor provided the following comment: "ETV Canada verification … will be useful for future Canadian sales, and has helped with approval by regulators in the United States." After ETV Canada verification, ADI "had the confidence to … be successfully verified under the EPA/NSF ETV Program in 2005."

In summary, ETV Canada has verified technologies for drinking water cleanup, stormwater cleanup and dental office wastewater treatment. All of the companies see value in the independent performance verification of their technologies. All of these verified technologies have relevance in addressing environmental issues both in Canada and internationally. The potential exists to build on this work and to promote the development and implementation of internationally relevant verification protocols. ETV Canada has worked with Environment Canada to develop the mercury amalgam removal unit testing and verification protocol.

U.S. EPA ETV Drinking Water Systems (DWS) Center

Bruce Bartley has more than 25 years of experience in water quality research, testing, and protocol development. He has a Bachelor of Science and a Master of Science degree in water resources from the University of Michigan. For 20 years, he has worked with NSF's environmental research department, and he is very familiar with the consensus-building process and the development of standards and protocols. He has been the Manager of the U.S. EPA ETV DWS Center since 1995.

Bruce Bartley provided a presentation on pathogen and arsenic treatment technologies for drinking water.

The ETV DWS Center was established in October 1995, with a focus on small-system technology needs. The center's protocols provide uniform testing and quality control procedures. Testing is primarily performed in the field. In the United States, the states are responsible for ensuring that the drinking water is safe. The U.S. EPA sets the standards, but they are implemented by the states.

Bruce Bartley described four of the ETV DWS Center technology categories for verification: filtration technologies (microorganism reduction), ultraviolet (UV) and other disinfection technologies, water security (including residential protection systems), and arsenic treatment technologies.

Pathogen reduction technologies include a number of technology categories, including disinfection and filtration processes. Disinfection processes (inactivation) include: UV (three verifications completed), on-site chlorine generation (three verifications completed) and ozone generator (one verification completed). Filtration by low-pressure membranes includes microfiltration and ultrafiltration (MF/UF) (13 verifications completed). Alternative filtration systems include: bag and cartridge filters (two verifications completed); back-washable depth filter (one verification completed); chemical coagulation, flocculation and filtration (two verifications completed); and pre-coat, or diatomaceous, earth filtration (one verification completed).

Verification results were reported for UV radiation technologies. The first UV radiation verification test conducted by the center showed a 3.9 $\log_{10}$ inactivation for *Cryptosporidium parvum*, using animal infectivity methods, with two lamps and a UV dose of 20 mw-s/cm^2 at 215 gpm. The second verification test results showed a 2.1 to 3 $\log_{10}$ inactivation of MS2 virus with lamps at 80 percent power; the UV dose was 43 mJ/cm^2 at 695 gpm. The third verification test results showed a 1.7 to 2.1 $\log_{10}$ inactivation of MS2 virus with lamps at 100 percent power; the UV dose was 40 mJ/cm^2 at 350 gpm. All of the units experienced operation and maintenance issues (e.g., irradiance sensor failures, quartz sleeve wiper failures).

Verification results were reported for bag and cartridge filters. One verification test for a bag and cartridge filter system had a flow rate of 10 gpm. The results showed a 1.1 to 2.1 $\log_{10}$ removal of 2.5 to 7 μm microspheres. A verification test for a prefilter and bag filter combination had a flow rate of 20 gpm. The results showed a 1.9 to 3.2 $\log_{10}$ removal of 3.7 μm microspheres.

One membrane filtration (microfiltration and ultrafiltration) test was conducted in which four technology vendors participated. The test results showed differences between technologies for removal of *Giardia* and *Cryptosporidium*. Originally, people thought that all MF membranes would perform the same. A difference of one log is critical if the utility that installs the membranes needs certain *Cryptosporidium* credits. One log could make a difference in whether the utility would have to add additional treatment. The test results showed that even if the same types of membrane systems are being used, how they are put together can impact the results.

A verification test was conducted for on-site chlorine generators, which produce a hypochlorite solution using brine. The products were tested for average hyprochlorite production and average DC current usage. Only one vendor wanted their product to be tested for inactivation of *Pseudomonas aeruginosa*; there was a 4 to 6 $\log_{10}$ inactivation of this common bacterium. The differences in product performance varied in terms of the hypochlorite produced and the amount of sodium chloride that was consumed.

Under the water security technology area, the ETV DWS Center technical panel recommended residential point-of-use (POU) reverse osmosis (RO) systems using two phases of testing: microbiological and chemical removal. The microbiological test plan includes surrogates based on size and physical properties similar to the actual agents. Verification testing of three technologies was completed and the verification reports were issued in 2004. Testing for chemical agent removal has started, and it is anticipated that the verification reports will be completed in spring/summer 2005. The test results for microbiological agents for viruses and bacteria showed reductions from 2.3 to 2.9 log for viruses and 1.6 to 8.4 log for bacteria. One system was designed, not as a typical RO unit for homeowners, but with a bacteria/virus filter added for homeland security applications. It performed as well as or better than the other systems tested.

The ETV DWS Center has completed eight verification reports for arsenic treatment technologies: three chemical coagulation, flocculation and filtration systems (CCFF); two adsorption technologies (disposable or regeneration); and three RO systems. There are an additional three tests in progress (two CCFF, and one adsorption). All but one verified technology reduced arsenic consistently below the maximum contaminant level of 10 ppb, and many of them reduced arsenic to the minimum detection limit of 2 ppb. Preliminary test results of technologies in progress have shown similar trends. Performance is greatly influenced by water quality and process parameters; pH is a critical parameter in arsenic removal. The following operational parameters were measured with varying results: chemical consumption, electrical power, labor and estimated ease of use.

Bruce Bartley discussed the potential impacts and outcomes of ETV verification. ETV provides information to help states, utilities and other organizations select appropriate water treatment technologies to meet the 10 ppb arsenic regulatory standards. This provides several available alternatives for off-the-shelf technology products to U.S. drinking water systems required to meet the new arsenic standard. Arsenic in drinking water is a known carcinogen with additional adverse human health impacts. The U.S. EPA estimated health benefits of arsenic reduction in its EA 2000 report (EPA-815-R-00-026). As the arsenic concentration is reduced, mortality cases are reduced and cancer cases are avoided.

Many of the ETV-verified technologies could potentially be used by the 4,100 water systems that EPA estimates may need to employ additional treatment processes to meet the new standard. These systems serve approximately 12.7 million people. A more conservative estimate of the potential market could be developed by narrowing this market to the 3,900 smaller drinking water systems, which serve approximately 4.4 million people. The economic benefits of lung and bladder cancer prevention that could be realized by using ETV-verified arsenic treatment technologies were estimated using the more conservative estimate of the potential market and different market penetration scenarios. At a 10 percent market penetration, the estimated economic benefit is $4.8 million to $6.8 million; at a 25 percent market penetration, the estimated economic benefit is $12.1 million to $17.1 million. The estimated economic benefits do not include other combined health benefits, such as reductions in liver, kidney, skin and prostate cancers; and cardiovascular, immunological, neurological and endocrine effects.

State agencies have indicated that ETV data may help minimize pilot testing requirements and help expedite the approval and implementation of arsenic treatment technologies at sites. To calculate potential savings, it was assumed that pilot testing costs $20,000, and that there would be a 10 percent to 75 percent reduction in required pilot studies for ETV technologies. For a 10 percent market penetration of ETV-verified systems, the estimated pilot testing savings may range from $800,000 to $5 million.

Another added benefit is that ETV results help provide technology vendors with valuable data on product weaknesses that may be addressed by vendors in subsequent product modifications.

Questions

Karen Riggs thanked all of the presenters for this technical session and asked if there were any questions from the audience.

John Neate, ETV Canada, commented that Tom Stevens had mentioned that the ETV WQP Center was not getting vendor interest in trenchless technologies. He asked if Tom Stevens has contacted the International Society for Trenchless Technology. They are very interested in promoting that technology area as being environmentally sound, rather than digging everything up. Tom Stevens responded that the Society has not been contacted, but he appreciated receiving the information and would follow up with them.

Jafrul Hasan, U.S. EPA, asked Amy Dindal if biofouling has compromised the test efficiency. If so, is there any advice for the vendors? Amy Dindal responded that his question was a general one and could be better answered on a specific basis because each of the technologies had some impacts to their verification data; however, it may not be directly attributable to the biofouling. When they looked at the biofouling, it was just a physical assessment and capturing of what the technology looked like before it went into the deployed situation and when it came out of it. The individual verification reports contain information on what was reported for each technology.

Michael Deane, Monteco Corporation, asked how protocols are amended for lessons learned. Tom Stevens responded that in the U.S. EPA ETV Program, protocols are developed through a technical panel that has representatives from state regulators, industry, consulting engineers and other interested parties. The panel had indicated that 30 storm events should be done; however, it was finally agreed that 15 storm events would be done. It takes 18 months to get 15 storm events. There have been some lessons learned in regard to TSS versus SSC, and some changes to the protocol have been proposed. Andrew Houlson commented that writing a test plan would involve standard methods and other peer-reviewed documents such as journals. An attempt is made to try to control as many variables as possible, but some technologies are left in the open air and all of the factors cannot be controlled. Karen Riggs commented that the U.S. EPA ETV AMS Center goes through a similar process and has a technical panel help to develop the test plans. Despite all of the input, sometimes there are reasons why the test plan cannot be implemented, and they will revise the test plan. In the next round of testing, they use the lessons learned from round one and formally revise the test plan.

Jafrul Hasan, U.S. EPA, commented that the U.S. EPA has been mandated by the government to ensure the safety and security of water, and it is a huge issue. They are struggling to come up with an early warning system. The system should be fast, reliable, effective, easy to handle, easy to operate, durable, on-line and moderately priced. Are there any existing or planned systems of this type? Bruce Bartley responded that in his experience working with water utilities, he has heard them talk about residual chlorine monitors as being good and useful for normal system operations, and it might prove to be something that is quick. On the other hand, it would not address a chemical or another agent that did not exert a chlorine demand. Amy Dindal commented that this was an issue for the U.S. EPA ETV AMS

Center, and they had discussed it with their water security stakeholder panel. They tried to address this on multiple levels. In terms of an early warning system, the technology category for multi-parameter on-line monitors includes a parameter to monitor residual chlorine. They have also looked at a number of quick monitoring systems for various contaminants such as chemical and biological agents. The challenge is making existing systems for environmental monitoring cross over to homeland security and water quality protection at the same time (i.e., What can they do with the existing systems to augment them and to be able to provide an early warning system?). Andrew Houlson commented that it is a complex issue because 100,000 new chemicals are produced each year. Having an instrument able to monitor a new chemical that could be toxic would require that the instrument be updated regularly for the new toxic chemicals. There also are bacteria and parasites that would need to be monitored.

Water and Water Security Panel/Open Discussion

Karen Riggs stated that one of the goals of this International Forum was to look at ways the different programs from the different countries can collaborate on technology verifications. She suggested that the panel address the following questions: What are the areas that might be considered for collaboration? How would we go about doing it?

As William Mansfield stated in his earlier presentation, water is one of the most pressing environmental issues from his perspective and from a global perspective. Karen Riggs asked the panelists to address their single most important problem that they have seen in terms of buyers and users coming to their program and asking for a technology in a specific area. What are the most immediate needs that might identify some technology areas that the group could consider for collaboration?

Tom Stevens stated that one obvious issue is ballast water because it has global environmental and economic impacts. Another area is confined animal feeding operations (CAFOs) and their impacts on local streams and groundwater supplies.

David Liang commented that developing countries need technologies that are very simple and cost effective. For example, when the tsunami hit areas in Asia, the victims were looking for very simple water treatment systems because they had no electrical power. The IESE came up with a hand pumped membrane unit for them to treat groundwater together with chlorine tablets so that the water would be drinkable.

Andrew Houlson stated that a problem that affects Canada and the global world is global warming with glacial melting. Alberta relies on all of its drinking water from glaciers, and they are receding quite rapidly. Worldwide, India and Kilimanjaro are also losing their glaciers.

Tay Joo Hwa stated that 1 percent of Singapore's drinking water is from reclaimed wastewater. They are able to identify close to 400 chemicals. The ones they cannot measure are a big concern. They do not have a good way to measure estrogen in drinking water. It is also an issue in California, where the groundwater contains high levels of estrogens.

Amy Dindal stated that the most critical problem facing our nation's water supply is implementation of a comprehensive early warning system.

Kenji Kamita stated that in Japan the environmental quality standards are not being achieved, but he thinks this is not the most important technological problem. He thinks that low-level chemicals, such as endocrine disruptors in the environment, will be Japan's next problem within the area of water.

Bruce Bartley commented that affordability of technologies to solve drinking water issues is an overarching issue. In the United States, we can afford more and that means that the technologies are more sophisticated and easier to operate. They will cost a lot more than someone who wants to remove arsenic in Bangladesh can afford to spend. The developing countries are not going to be able to afford the ETV-verified arsenic technologies. In the future, the issue will be affordability for all technologies, nationally and internationally. The information on operation and maintenance costs contained in verifications is critical for equipment buyers.

Karen Riggs asked if the audience had any comments on the most critical environmental needs that technology verification might be able to help.

Phyllis Posy, Atlantium, commented that creating technologies that operate and maintain at verified levels over time is the biggest challenge. It is also a real challenge for the verifiers because there is limited time to verify a technology. The challenge is that you need to look at the total cost of ownership over the lifetime of the technology in a marketplace that is looking at current capital investment. One of the things that verifiers can do by focusing on operation and maintenance costs is to help decision makers move from their current capital investment mode to a more total cost of ownership mode.

John Classen, North Carolina State University, stated that he agreed with William Mansfield's comments on the overall worldwide availability and distribution of water. The counter to that on the local side is conservation. Are there ways to encourage local, low-cost technologies that will allow Singapore to keep the 2.5 meters of rainfall every year? On the other side, can we use less water in everything that we do?

Andrea Tilche, European Commission, commented that on a worldwide basis, water problems basically are not technology problems; they are more problems of use and management. There is a lack of technologies in many fields. The European Commission has established a technology platform on water supply and sanitation. There is a forum where stakeholders from industry, technology suppliers, service companies, various downstream industries, farmers, researchers and regulators have developed this technology platform, and the forum is tasked with designing a vision for 2030, a strategic research agenda and an implementation plan. They are at the stage of designing the strategic research agenda. The stakeholders all have different views of the priorities because the water service companies look at the asset management as the main problem. This is not the point of view of many of the stakeholders.

Danny Epstein, Environment Canada, thanked the organizers of the forum. ETV means different things to different people. To some, ETV is a verification process. Others see ETV as just looking at whether certain performance claims of vendors are true. There are some language issues that need to be addressed to see what you want ETV to be. There definitely are opportunities to share best practices. There are opportunities to look at the issue of reciprocity (e.g., if a technology is verified in Europe, how does it influence a company that wants to take it into the marketplace in Canada or the United States). How do we in North America want to use ETV as a mechanism that opens the market or is supportive of free

trade? There is a huge opportunity for collaboration, but there also needs to be the acceptance that if ETV is going to be meaningful globally, we need to have some uniformity and integration. In addition, we need to start looking at the whole sustainability issue. Thought needs to be given to the incentives that ETV can apply in the marketplace so that ETV is seen as either a verification system or a system that identifies which product is better. The linkage to the SMEs has not yet been made. They have an issue with respect to a lack of capitalization to go through the ETV process; SMEs are also huge marketplace. Getting the message to the SME community in terms of the technologies that are available for their applications is a large issue and a major challenge. In Canada, a new department has been formed with respect to infrastructure in communities. One of the tasks of the department is to redistribute gas tax dollars back the municipalities and provinces. One of the reasons for this is to provide some longer term sustainable funding to communities for infrastructure renewal. It is not just infrastructure, it is green infrastructure. There are communities in Canada that are dependent on groundwater. They will run out of water if they do not start looking at their water programs. We need to start thinking in terms of using less water and using the infrastructure better. We need to design communities that are denser, but use fewer resources.

Karen Riggs asked the panel members to identify a first step for moving toward collaboration, where we can work together to have reciprocity or to develop test protocols.

Tom Stevens commented that the U.S. EPA ETV Program has done similar work to the verifications discussed in Andrew Houlson's presentation on the mercury amalgam separator and the Stormceptor testing. It is important to try to be sure that protocols are as comparable as possible. If there are differences in protocols, there could be differences in how the technology performance is evaluated. For example, the Stormceptor data showed 76 percent to 94 percent removal for TSS. Similar technologies verified under the U.S. EPA ETV Program did not perform that well. Were the storms comparable? Was the way samples were collected comparable? Because it is becoming a global market, there could be situations where verifications that are performed in Japan, Korea, or the United States are taken to other countries, and the way the verification was conducted and the performance results could raise issues of comparability.

David Liang stated that sharing best practices and protocols is essential. Singapore signed a letter of intent to work with the U.S. EPA ETV Program to collaborate on developing the protocol for ballast water.

Andrew Houlson agreed with Tom Steven's comment that the ETV Canada data for Stormceptor might not look the same as the data resulting from verifications by the U.S. EPA ETV Program. The issue is that we can write the same test protocol, but we cannot control the weather or the suspended solids influence. He suggested that the verification reports contain a disclaimer to explain that the verification is just one test and the user will have to judge whether the technology is appropriate for any other type of influent or weather conditions.

Tay Joo Hwa commented that sharing test protocols and having comparable test protocols are important.

Amy Dindal stated that the first step is to identify the technology categories that could be mutually beneficial and then move forward and collaborate on a test. These mutually beneficial technology categories have been identified at this forum. Based on the presentation by Kenji Kamita, she thinks that Japan has verified an atrazine monitoring technology for a vendor that also was verified under the U.S.

EPA ETV AMS Center. She suggested that they compare the two protocols to see if they are similar or have major differences.

Kenji Kamita suggested that periodic (at least once per year) information exchange should be considered. He agreed with Amy Dindal that there should be an exchange of the protocols for the atrazine monitoring technology that was verified by both programs.

Bruce Bartley agreed with the need to harmonize and share protocols. Early in the U.S. EPA ETV DWS Center program, they tried to get agreement from representatives from all of the 50 states on their test protocols for drinking water technologies. In the end, the protocol that was agreed to represented a majority of the states. However, there were eight large states that took the minimum that was included in the ETV protocol and added to it. We have to be able to accept that fact that agreement may only be achieved at some minimum level and that each country is going to need something a little different. If we are willing to do that, then there is a real opportunity for success.

Teresa Harten, U.S. EPA ETV Program, commented that there were at least four of the same technology categories being verified by the different ETV programs. She thought that ETV Canada uses the U.S. EPA ETV Program protocol as the basis for their protocol for mercury amalgam separators. If we could offer vendors co-verification (i.e., the verification would count for both programs), that would be attractive to them. If the protocols from the two programs are slightly different, then we would have to make sure that the requirements from both protocols were met, which could result in a bigger test.

Amy Dindal asked if an action item could be established to schedule a monthly conference call with one representative from each of the ETV programs to continue the dialogue.

John Neate stated that it was a great idea, and ETV Canada would be happy to do co-verifications with the U.S. EPA ETV Program.

Charles Wilde, BioGenesis Enterprises, Inc., stated that his goal as a vendor and technology developer is not to sell to the United States, Canada, Singapore or Korea. His goal is to sell to the world. You need to think bigger—think about world collaboration, not just collaboration between Canada and the United States.

Teresa Harten commented that the U.S. EPA ETV Program prioritizes its technologies based on input from the stakeholder groups. They have done testing for UV treatment of wastewater for purposes of reuse, but have not done anything in the area of conservation. The U.S. EPA Office of Water is starting a program to look at technologies that conserve water. There is a push in the Agency for these types of reuse and conservation technologies for water sustainability. ETV would like to help out with these programs and do verifications of those types of technologies. ETV is looking at adding sustainability metrics into all of their verifications, especially the verifications that will be done under the new part of the U.S. EPA ETV Program, the Environmental and Sustainable Technology Evaluation program.

Bill Sellerberg, Pall Corporation, stated that his company supplies microfiltration and ultrafiltration systems for drinking water applications, wastewater applications and industrial water applications. They have participated in three U.S. EPA ETV Program verifications, which have been extremely helpful to

them. They have systems in approximately 20 states. Every time they go to a state they have found that having the ETV report is a credential that helps them in their certification process. Sometimes the regulators are not familiar with ETV, and they have to educate them. Is there a program or effort that ETV supports to educate the state regulators? Karen Riggs commented from the perspective of the U.S. EPA ETV AMS Center. They have two stakeholder committees and their meetings are held around the United States deliberately to reach out to the different states. Prior to the meeting, they invite representatives from state regulatory offices, EPA Regional Offices and municipalities to attend the meeting. Teresa Harten stated that the U.S. EPA ETV Program has an outreach program, which includes exhibiting the ETV booth at 30 conferences each year, publishing articles in journals, newsletters, working with professional and technical associations, and providing information on the ETV Web Site and though e-mails.

Penh Tov, Stormceptor Group, stated that Stormceptor was involved in a number of verification programs in the United States, including programs in the state of Washington and the city of Portland. Also, they are involved in a New Jersey Department of Environmental Protection program called Technology Acceptance Reciprocity Program (TARP), which involves eight states. There are many other verification programs in addition to ETV. Why are they not all working together to develop one protocol, one testing area so that you can expedite implementation of these technologies? Tom Stevens responded that there are different stakeholder groups, and the technology panels that are involved in each of the groups are a little bit different. Each one has a test protocol that is a little bit different and there has not been a willingness to accept protocols between these groups. From an ETV standpoint, our requirements as far as rainfall events are probably the most stringent of all. The approaches taken in the state of Washington program and the New Jersey TARP program are different from ETV. It is a good question, particularly in the spirit of trying to establish collaborations between different verification programs, nationally and internationally. Karen Riggs stated that Penh Tov's point was well taken. As they are looking globally, they should be looking nationally and talking to other verification programs.

Thursday, July 14, 2005

TECHNICAL PRESENTATIONS (CONTINUED)

Air and Energy

Andrew Trenholm, Director, U.S. EPA ETV APCT Center, and Tim Hansen, Director, U.S. EPA ETV GHG Center, served as the session co-chairs. Tim Hansen welcomed the meeting participants to the second day of the ETV International Forum.

U.S. EPA Air Pollution Control Technology (APCT) Center

Andrew Trenholm is a chemical engineer with RTI International and is the Director of the U.S. EPA ETV APCT Center. He has more than 35 years of environmental experience that spans government, industry, and research organizations. He has worked for a local agency, developed environmental regulations at the U.S. EPA, and conducted research and consulting related to air pollutant monitoring, air pollution control technology and waste combustion. He has a Bachelor of Science in chemical engineering from Clemson

University and a Master of Science in chemical engineering from Georgia Institute of Technology. He provided a presentation on fabric filter fine particulate control, diesel engine retrofits, and indoor air pollution products.

The ETV APCT Center operates similarly to the other ETV centers. The ETV APCT Center was established in 1997. They have an overall stakeholder advisory committee, which provides advice on priorities and direction for center activities. The ETV APCT Center has completed nine verification test protocols and 36 verifications, and seven verifications are in progress. The verification test protocols and verification reports are on the U.S. EPA ETV Web Site. The center also does extensive outreach.

The primary focus of the ETV APCT Center is on PM, nitrogen oxides (NO_x), VOCs and hazardous air pollutants (HAPs). Test protocols have been completed for paint overspray arrestors, baghouse filtration products, NO_x control technologies, dust suppressants for unpaved roads, mobile source retrofit controls (three protocols), and biofiltration systems for VOC control. A protocol for indoor air products is being developed.

He briefly described the baghouse filtration products (BFP) verifications conducted by the ETV APCT Center. The protocol covers the performance of all BFPs, but the original focus was to verify the removal efficiency $PM_{2.5}$ of fabrics and materials used for bags and baghouses. There is a detailed protocol and equipment setup to do the testing, which takes the filter material and conditions it before running the test. The testing procedures were incorporated into ASTM D6830 "Characterizing the Pressure Drop and Filtration Performance of Cleanable Filter Media." He presented a chart depicting the BFP verification test results for membrane fabrics and non-membrane fabrics, including pressure drop, total mass and fine PM penetration. He stated that the pressure drop needs to be looked at in combination with penetration. The test results distinguished between membrane versus non-membrane fabrics. The ETV testing procedures are being reviewed as part of ongoing ISO effort to develop an ISO standard in this area. Fifteen verifications have been completed. Three vendors (who have had previous verifications) are being tested or are in discussions for future testing.

The ETV APCT Center is considering reconvening the technical panel to expand the coverage of the verification protocol. The potential product areas for expansion include: reverse air cleaning, woven fabrics with a membrane, bonded (versus sewn) bags, pleated (cartridge) filters, high-temperature ceramics and metals, and coated media (i.e., activated carbon). They will also be looking at whether they can run verifications on more than just the standard dust, and at different gas temperatures, so that they match up to user needs better.

Andrew Trenholm provided a brief discussion on the mobile sources technology category. There is increasing recognition of the environmental significance of diesel engine emissions, and innovative technologies are needed and are being developed. Heavy-duty diesel engine emissions are significant sources of NO_x and fine PM emissions, which contribute to public health problems in the United States. The U.S. EPA is setting stringent emission standards for new engines. The existing fleets may remain in operation for another 20 or 30 years. Retrofit technologies will be especially important in the early years of standards implementation. The U.S. EPA OTAQ has a program called the VDRP that verifies the performance of diesel retrofit technologies. Vendors have submitted ETV test results to OTAQ for posting on the OTAQ Verified Technology List, thus making their technologies available for State

Implementation Plan (SIP) credits and for use by stakeholders interested in engaging in retrofit projects. When the ETV APCT Center decided to verify mobile source technologies, they established a technical panel and developed test protocols with OTAQ as a major stakeholder. The three ETV APCT mobile source protocols that have been completed are: devices (retrofit hardware), which includes diesel exhaust catalysts (DECs), PM filters and engine modification units; fuel and lubricant modifications, which includes alternative fuels (emulsions, biodiesel), reformulations, fuel additives, and lubricants and lubricant additives; and selective catalytic reduction (SCR). Technologies are tested by the ETV APCT Center when they are de-greened (new) and aged (used). Seven verifications have been completed by the ETV APCT Center and one verification is in progress.

Andrew Trenholm discussed the impacts of the U.S. EPA ETV/VDRP collaboration. Three well-accepted protocols were developed for demonstrating emission-reduction performance. The protocols are posted on both the ETV and OTAQ VDRP Web sites. The protocols have helped to advance efforts to standardize testing. Performance data were generated that have been used to post ETV-verified technologies on the VDRP Verified Technology List. ETV verifications have enabled vendors to "participate in many national voluntary retrofit programs" (in addition to VDRP). Ultimately, the verifications should help to reduce state- or program-specific testing requirements.

There are potential environmental, health and monetary impacts of use of these verified technologies. Assuming a 10 percent market penetration (e.g., 10 percent of the current fleet of heavy-duty trucks and buses use an ETV-verified retrofit technology), ETV estimates that PM emissions potentially could be reduced by 8,980 to 31,300 tons after seven years of use, 683 to 2,380 instances of premature mortality (via a comparison to PM-related impacts in the 2007 Heavy-Duty Highway Rule) could be avoided, and $5,150 to $17,900 (millions 1999$) in associated monetary benefits could be realized.

Andrew Trenholm provided quotes from two vendors on their experiences with the ETV Program. One was from Clean Diesel Technologies, Inc.: "Verification under the ETV Program has generated considerable commercial interest in our technology from end users, as well as regulators and potential distribution partners." Clean Diesel Technologies recently announced the first commercial orders for its ETV-verified Platinum Plus purifier system from Coca-Cola Enterprises, Inc. (a participant in EPA's SmartWay Transport Program) to retrofit the system to beverage delivery vehicle fleets in several locations. They commented: "A small company would never be able to access Coca-Cola if they did not go through the ETV process."

The second quote was from Donaldson Company, Inc.: "Obtaining EPA's ETV Verification has enabled Donaldson to participate in many national voluntary retrofit programs." They have retrofitted 100 New York school buses with EPA-verified emission control devices under a grant from Clean School Bus USA to the New York State Energy Research and Development Authority (NYSERDA).

In addition, Lubrizol's verification resulted in a partnership with the Pennsylvania Department of Environmental Protection, Sunoco, and the Philadelphia Diesel Difference to retrofit 29 city of Philadelphia diesel vehicles.

A new area that the ETV APCT Center is looking at is indoor air products. People spend up to 90 percent of their time indoors. Studies show that indoor air can be more polluted than outdoor air. The U.S. EPA

recognizes the importance of health effects from indoor air pollutants. Many products are sold to clean air, using a wide variety of technologies of varying performance. ETV can provide quality data to help effective technologies enter the market and help building owners and consumers with buying decisions.

The technologies for ducted ventilation systems include: general ventilation media filters, electronic air cleaners, ultraviolet radiation, carbon and other sorbers, atmospheric plasma and other energy devices, and photocatalytics. There are also appliance air cleaners with self-contained fans (room air cleaners). In addition, there are newer, innovative concepts that include in-duct sprays and system approaches.

The ETV APCT Center is considering offering three test options for devices that work in ducts. The basic test would be the American Society of Heating and Refrigeration and Air-Conditioning Engineers (ASHRAE) 52.2 test. It measures a full particle size range from 0.3 to 10 µm diameter. When pertinent to a technology, the RTI/ETV-HS test can be used to measure smaller particle size, from 0.03 to 10 µm diameter. The third test option is the RTI/ETV-HS bioaerosol test, which also measures the smaller particle size, ranging from 0.03 to 10 µm diameter.

The ASHRAE 52.2 test is based on RTI research conducted in the early 1990s under projects funded by the U.S. EPA and ASHRAE. It is a fractional efficiency test method. Potassium chloride particulate is used to condition the filter. The filter is then loaded with dust. The ASHRAE test dust contains 5 percent cotton linters, 23 percent carbon black, and 72 percent SAE standard J726 test dust (also called Arizona road dust). Efficiency tests are run for the clean filters and for five different levels of dust loading. The results are reported as a minimum efficiency reporting value (MERV). MERV ratings are now widely used in filter marketing.

The bioaerosal test is based on the ASHRAE 52.2 test, including dust loading. The organisms that have been selected for the test include: *Bacillus antracis* Sterne, yersina *rohdei*, MS2 bacteria virus, and fungi.

J-ETV

Kenji Kamita, Deputy Director of the Office of Environmental Research and Technology at the MOE, Japan, provided a presentation on ethylene oxide treatment technologies, technologies for mitigation of the urban heat-island effect (for removing the heat emitted from air conditioner heat exchangers), and VOC treatment technologies (for decomposing organochlorine degreasing agents such as dichloromethane).

According to data collected under Japan's (PRTR) Law for FY03, ethylene oxide, a carcinogenic substance, is emitted in large quantities into the environment, making it a high priority for countermeasures. Ethylene oxide is often used in sterilization equipment in hospitals. According to the PRTR data for FY03, its emissions from hospitals are estimated at about 210 tons, while national emissions are about 510 tons. However, there currently are no regulations in Japan that cover ethylene oxide emissions from sterilization equipment in hospitals. At present, any actions are left up to the voluntary efforts of businesses. The emissions from sterilization equipment may be huge. According to research by the Tokyo metropolitan government, only a small number of hospitals have equipment installed to treat emissions from sterilization equipment using ethylene oxide.

J-ETV defines this technology category as technologies for cleaning ethylene oxide gases used for sterilization in manufacturing, medical institutions, etc. In FY03, one verification organization participated in the verification of six technologies; these verifications and reports have been completed. In FY04, one verification organization participated in the verification of two technologies; these verifications and reports are completed. In FY05, the program is shifting to the vendor-pays stage (Phase 2) as the two-year pilot period has ended. The number of applications under this technology category has been decreasing. If no applications are received, the technology category will be terminated.

For the eight verified technologies, almost all of the equipment showed that 99.9 percent of the gas was removed (the lowest rate was 99.4 percent).

The next technology category discussed was technologies for the mitigation of the urban heat-island effect. Steps must be taken in the long term to counter the heat-island effect. It is important to start by promoting feasible measures to address the problem. According to estimates by Japan's MOE, about 50 percent of the heat (sensible heat) that is raising air temperatures in the Tokyo core comes from waste heat from artificial sources, and about one-half of this is waste heat from buildings, including their air conditioning systems. Local governments put a lot of effort into promoting energy efficiency in buildings, but very little effort is being made to suppress waste heat from existing air conditioners. In particular, because a very large number of outdoor heat exchangers of air conditioners are already installed, efforts to suppress waste heat from these sources can be expected to be very effective.

J-ETV defines this technology category as technologies to counter the urban heat-island effect by suppressing the heat emitted from outdoor heat exchangers of air conditioners. In FY04, one verification organization verified four technologies; these verifications and reports have been completed. In FY05, one verification organization is inviting and selecting target technologies.

The verification included two test conditions. Pattern 1 used outdoor temperatures of 35°C for dry bulb and 24°C for wet bulb. Pattern 2 used outdoor temperatures of 30°C for dry bulb and 25°C for wet bulb. Indoor temperatures were common in both patterns (dry 27°C, wet 19°C). The sensible heat suppression rate ranged from 14.6 percent to 80.1 percent for Pattern 1, and 8.1 percent to 37.7 percent for Pattern 2. The reduction in electrical consumption ranged from 3.0 percent to 15.8 percent for Pattern 1, and 2.2 percent to 10.0 percent for Pattern 2. Operating costs and cost reductions were estimated based on the average values of both test conditions, and were based on an assumed 0.022 yen/Wh for electricity and 0.228 yen/L for water. The operating costs ranged from zero to 9.72 per hour. The cost reduction (due to lower electrical consumption) ranged from 2.55 per hour to 9.15 per hour. Kenji Kamita noted that these cost reduction data are certainly based on many assumptions.

The last technology category discussed was VOC treatment technologies. Photochemical oxidants and suspended particulate matter (SPM) are the main air pollutants in urban areas. VOCs become sources of these pollutants through atmospheric chemical reactions. According to PRTR data, emissions of organochlorine hydrocarbons, such as dichloromethane, are particularly high. VOC emissions from large establishments will be regulated under Japan's Air Pollution Control Law (amended in 2004, entry into force in 2006), but small- and medium-sized establishments will not be regulated for the time being. Therefore, it is important to encourage voluntary initiatives. There has been progress in recent years with the development and application of technologies to treat organochlorine degreasing agents, such as

dichloromethane, and compact equipment has been coming onto the market that can be retrofitted at small- and medium-sized establishments. However, many businesses are not yet aware of this equipment, so its use is spreading very slowly. It is necessary to promote emissions reductions by conducting technology verification.

J-ETV defines this technology category as technologies for removing the emission gases from dichloromethane (a type of VOC) and other organochlorine degreasing agents that are used for metal degreasing and cleaning in metal plating and processing factories. In FY04, one verification organization verified two technologies; these verifications and reports have been completed. In FY05, invitation and selection of verification organizations is in progress.

Verification was conducted with a focus on the performance of the equipment in removing solvent gas injected into the treatment system. These verification tests do not cover the solvent gas directly emitted from the degreasing equipment without being aspirated. The substance targeted for testing was dichloromethane in one test and trichloroethylene in the second test. The removal rate was 99.9 percent for both technologies.

ETV Canada

Mona El Hallak is a Technical Analyst with ETV Canada, responsible for the commercial and technical evaluation of innovative environmental and energy technologies. Her responsibilities include: assessments of chemical, electrical and biological processes; reviews of compliance with policies and legislation; and interpretation of potential environmental impacts and related technology implications. Through her work, she plays a key role in helping to advance the commercialization of innovative technologies. She holds a Master of Science in forestry/environmental studies from University of Toronto. She provided a presentation on a diesel engine retrofit device, a liquid manure composting system, and a lighting and control system for commercial office space.

Mona El Hallak briefly reviewed ETV Canada's program requirements for a claim to be verified and the technology verification process, as was previously presented by Andrew Houlson under the water and water security session. All three of the case studies she presented used laboratories accredited by the Standards Council of Canada as their VE.

The first case study addressed Environmental Solution Worldwide's Quiet Cat™ Particulate Reactor™, which was verified in September 2003. Small compression ignition engines emit PM_{10}, which is a probable human carcinogen. This technology is specifically designed for use on small compression ignition engines such as lawn mowers, small generators and other small construction vehicles. The company submitted a complete data set to support the performance claim to be verified. The technology was installed and tested on a Yanmar diesel engine. Three individual runs were done using the U.S. EPA 5-mode test for small non-road engines. Test results showed that the Quiet Cat™ Catalyst/Muffler utilizing the Particulate Reactor™ can reduce carbon particulate (PM_{10}) mass emissions by at least 60 percent by weighted average, when installed and operated in accordance with the manufacturer's specifications on diesel-fueled compression ignition engines operating at constant speed. The vendor provided the following comment: "Verification has created opportunities in the national and global market." As a result of this verification, the company is interested in verifying other technologies.

The second case study was on Global Earth Products, Inc.'s Marvel® Liquid Manure Management system, which was verified in March 2003. Liquid manure emits significant amounts of greenhouse gases to the atmosphere. This technology is a farm-scale liquid manure composting system that uses an aerobic in-vessel channeled batch system. The system features mechanical turning and forced aeration, and it uses liquid animal manure combined with carbon source material (straw, corn, paper sludge). The company submitted two data sets from different testing sites for their performance claim. One data set was accepted based on the testing approach and the quality of the data generated. The testing used to demonstrate their performance claim was conducted with a research and development experimental design on liquid swine manure, in a statistically defensible format by independent researchers at Ridgetown College. The data were collected under conditions that were typical of farm operations. Greenhouse gases, methane and nitrous oxide emissions during composting and curing were monitored using chamber techniques. The greenhouse gas emissions were confirmed with emissions estimates from a conventional system of liquid/slurry manure management, as defined by the International Panel on Climate Change. The test results showed that the technology, when operated according to the vendor specifications (temperatures between 55 °C and 70 °C, moisture content of 50 percent, mixed with straw in a ratio of 5:1 by volume), reduced greenhouse gas emissions by 64 percent as compared to a conventional liquid manure system as defined by the International Panel on Climate Change. The technology produced solid compost with low odor and low metal concentrations. The compost was free of pathogens and can serve as a nutrient source. The intent of the verification was to prove that the system could reduce greenhouse gas and produce solid compost. The system has been expanded to include a thermal energy recapture system that can provide a heat source to be used in electricity production, downstream processing or space heating. As yet, the expanded system has not been verified.

The third case study presented was on Encelium Technologies, Inc.'s Encelium Energy Control System, which was verified in March 2004. The main source of contaminants is wasted energy in commercial buildings, which results in emissions from power plants during energy generation. The technology can be used for the following applications: individual and building light control, energy management, task tuning, fluorescent dimming, occupancy control, time scheduling, daylight harvesting and load shedding. This verification required the development of a new protocol because the performance claims were related to energy consumption reduction through the application of the lighting system. Because energy consumption varies each day (based on the occupancy and the weather conditions), data were collected on alternate days over 34 days of *in-situ* testing. The energy consumption was measured remotely (via telephone links) in 15-minute intervals using an electronic energy meter. The test results showed that in a commercial building where lighting-related energy conservation means have not been implemented, the Encelium energy system can reduce lighting-related energy consumption (kWh) by at least 70 percent. In a commercial building where basic lighting-related energy conservation means have been implemented, the Encelium energy control system can reduce lighting-related energy consumption by at least 55 percent. By means of load shedding, the energy control system can reduce power demand by at least 25 percent. The vendor provided the following comments: "The verification provided authenticity to the system." "Projects implemented after verification are playing a great role in marketing the system."

All of the vendors in these three case studies reported that the verification proved the viability of their technology and that the verification provided credibility in the competitive market. Fact sheets on these case studies are available at http://www.etvcanada.ca.

U.S. EPA ETV Greenhouse Gas (GHG) Technology Center

Tim Hansen is an environmental engineer with nine years of experience in multimedia environmental engineering. He currently serves as a Senior Chemical Engineer in the Environment and Energy Department of Southern Research Institute, and works primarily as the Director of the U.S. EPA ETV GHG Center, a public-private partnership between the U.S. EPA ETV Program and private industry. The ETV GHG Center conducts independent third-party performance verification of greenhouse gas mitigation and monitoring technologies. Tim Hansen is responsible for the day-to-day operations of the ETV GHG Center, technology vendor and partner solicitations, management of test programs, and Center outreach activities. He earned a Bachelor of Science in chemical engineering and a Master of Science in engineering science. He is also a registered professional engineer. He provided a presentation on distributed generation and combined heat and power (DG-CHP) applications, renewable fuels and waste to energy, fuel-efficient vehicle technologies and energy efficient technologies.

The mission of the ETV GHG Center is to locate promising greenhouse gas mitigation and monitoring technologies, subject them to comprehensive performance testing, and report the results to the public, in hopes that this information will accelerate the use of good environmental technologies. The ETV GHG Center was established in 1997.

Tim Hansen presented a chart showing greenhouse gas emissions in the United States for 1990 through 2000. Electricity generation, transportation and the industrial sector had the largest GHG emissions and the highest growth. The ETV GHG Center works mainly in these three areas. In the electricity sector, the focus is on distributed generation (DG). DG applications produce power using small power production devices located at the point-of-use. In the transportation area, the focus is on light-duty and heavy-duty vehicles, including gasoline and diesel-fired trucks, which are responsible for a fair fraction of the total GHG emissions in the entire transportation sector. In industry, the focus is on the oil and gas sector. The kinds of technologies that reduce greenhouse gases in this sector also make money for the people who use them, making it easier for the ETV GHG Center to work in this nonregulated area. They have started to focus on fuel economy improvement technologies. In the agricultural area, the focus is on animal waste, primarily animal waste-to-energy conversion. Animal waste is a renewable source of energy with a number of issues. The ETV GHG Center is just beginning work in this area. In the residential and commercial sector, the focus is on combined heat and power (CHP). This area is similar to DG except that CHP technologies convert the heat value of the exhaust stack from the small units into usable energy at the point-of-use in a commercial or residential building.

Under the advanced and sustainable energy technology category, the focus is on biogas production, treatment and use. Testing for this technology category was conducted at a dairy farm, a swine farm, a wastewater treatment plant (WWTP), and a landfill. Most of the verifications have been associated with distributed energy sources operating on fossil and renewable fuels, with a focus on microturbines and fuel cells.

The ETV GHG Center evaluated the NATCO Group, Inc.'s Paques THIOPAQ Gas Purification Technology, a gas conditioning system. This system uses a caustic scrubber to remove hydrogen sulfide (H_2S) while also digesting waste into a sulfur product to reduce hazardous effluent and regenerating and recycling sodium hydroxide (NaOH) into the scrubber. Testing of the biogas system was conducted at a

WWTP in Cedar Rapids, Iowa. In 2006, testing will be conducted on the sour gas treatment system (high pressure). Selected test results for the biogas system include: H_2S removal efficiency of 99.8 percent; bioreactor H_2S vent concentration of 9.29 ppb in volume (ppbv); 0.12 gallons NaOH/1,000 cubic feet (cf) biogas; and 59.2 percent solids product produced.

Another technology verified was the United Technologies Corporation (UTC) PC25C Phosphoric Acid Fuel Cell. This system uses biogas from anaerobic digesters at a Brooklyn, New York, WWTP to fuel a 200 kW phosphoric acid fuel cell to provide power to the site and heat for digester temperature maintenance. Selected test results for the system include: electrical efficiency of 37.5 percent; potential total efficiency of 93.8 percent; NO_x emissions of 0.013 ppm; and estimated emissions reductions of 1346 tpy for CO_2 and 1.82 tpy for NO_x. The power quality met or exceeded IEEE standards.

The ETV GHG Center also evaluated a Capstone 30 kW Microturbine DG-CHP and a Martin Machinery 100 kW reciprocating engine at a 5,000-head swine farm in Lamar, Colorado. These generating units are fueled by biogas produced by the digestion of swine waste in an anaerobic digester at the site. The power was used on-site at the farm and for grid sales. Waste heat was recovered from the systems to maintain the digester. Selected test results for the Capstone's microturbine include: electrical efficiency of 20.4 percent; power output of 19.9 kW; system efficiency of 53.7 percent; and emissions of 3.45 pounds per kilowatt hour (lb/kWh) for CO_2, 8.21E-5 lb/kWh for NO_x, and 0.0027 lb/kWh for total hydrocarbon (THC). Selected test results for the Martin Machinery's reciprocating engine include: electrical efficiency of 19.7 percent; power output of 44.7 kW; system efficiency of 52.1 percent; and emissions of 1.97 lb/kWh for CO_2, 0.012 lb/kWh for NO_x, and above detection limits (ADL) (greater than 10,000 ppm) for THC. The findings for both of these technologies were: high sulfur, NO_x and CO emissions from the engine; and low microturbine generator (MTG) electrical efficiency (due to altitude and compressor load).

A technology verification test is being conducted for the Aisin-Seiki 6kW Natural Gas Fired Engine-CHP. It is a lean burn natural gas engine. The recovered waste heat is being used to heat water at a sports bar in Syracuse, New York. The system preheats water for dishwashing to 140°F. The vendor's claim is an estimated efficiency of 85 percent. Testing is scheduled to be completed on July 21, 2005, and the verification report is expected to be completed by September 30, 2005. This project is being completed in collaboration with NYSERDA and the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).

The Microturbine and Engine CHP Generic Verification Protocol was developed by the Southern Research Institute for ASERTTI. The verification is using a draft Generic Field Testing Protocol for Microturbine and Engine CHP applications developed by ASERTTI, which provides procedures for evaluating electrical, thermal and emissions performance. The protocol is being adopted by ASERTTI, the U.S. Department of Energy (DOE), and state energy offices as a national standard protocol for field testing. The ETV GHG Center will be adopting and publishing it as an ETV generic verification protocol. Also under this project, protocols were developed for laboratory testing/certification (to be adopted by Underwriters Laboratory, Inc., including reference to the field testing), long-term monitoring and case studies. In addition, a national distributed generation testing database is being developed.

A case study of the potential impacts identified from the microturbine-CHP verification tests was presented. In the United States, electrical generation is the largest single source of CO_2 emissions (31

percent) and 21 percent of NO_x emissions. The ETV GHG Center has evaluated six microturbine CHP applications. Assuming an estimated 50 MTG installation per year for the next five years, these technologies could potentially result in a 41,000 tpy CO_2 offset and a 167 tpy NO_x offset. (These potential results are dependant on the unit type, application, fuel and current power source.) These reductions would help to conserve our limited fossil fuel resources and help our energy security. Several state energy agencies, the U.S. Combined Heat and Power Association, the U.S. EPA CHP Partnership, and others are utilizing the ETV microturbine verification reports in developing guidance and demonstration programs.

Mariah Energy, one of the verified vendors, provided the following comment: "It may be years before we know the impact ETV had on sales, but it is already an important factor in discussions with our new customers. ETV has opened doors we didn't anticipate it would. For example, new partnering organizations are using ETV data to make decisions on investing in our technology."

Tim Hansen briefly discussed the transportation technology category. The primary verification parameter for all of the tests is on fuel economy improvements. Two fuel additive verifications are in progress. One advanced lubricant verification was completed two years ago. One engine modification was looked at this year and there have been discussions on additional technologies (e.g., idle reduction technologies, diesel hybrids) to add in the future. He presented information on two transportation verifications.

EnviroFuels' Diesel Fuel Catalyzer is a diesel fuel additive for locomotive and other heavy-duty equipment. Testing was completed in October 2004 at a site hosted by Genesee and Wyoming Rail, using an actual locomotive with an EMD 645 3000 HP engine. The treated fuel was compared to a standard diesel fuel for fuel economy and emissions. The preliminary results showed that there was a 5 percent to 10 percent weighted fuel economy improvement, depending on which duty cycle was used. The U.S. EPA has two cycles: one is a line haul and one is a switchyard. There was up to a 15 percent fuel economy improvement, depending on notch. The following weighted emission improvements were observed: less than 9 percent NO_x, 39 percent to 44 percent CO, and 22 percent to 27 percent HC. There was a 46 percent to 100 percent weighted total particulate matter (TPM) increase (although it remained below the standard), which was an unexpected test result. The verification report will be completed by the end of July 2005.

The verification for the White Sands CleanBoost Combustion Catalyst is in progress. It is a fuel additive (Fe-based) for heavy-duty diesel equipment. The vendor is claiming a 3 percent to 5 percent fuel economy improvement and reductions in THC, NO_x and CO. The fuel additive will be tested on a 1991 Detroit Diesel engine. The treated fuel will be compared to a standard diesel fuel for fuel economy and emissions. Testing is scheduled to take place on July 20, 2005, and the verification report should be completed by September 30, 2005.

Tim Hansen stated that the oil and natural gas industries account for about 2 percent of total greenhouse gases in the United States and 13 percent of total industry greenhouse gases, and that a substantial amount of air toxic emissions are produced in these industries. The focus in both of these industries has been on production and processing (i.e., wellhead operations) and transmission (i.e., getting refined products from one end of the country to the other). The ETV GHG Center has verified eight technologies in this technology category. Strong interest is developing again in this area, possibly due to the U.S. EPA's Methane to Markets Partnership program and climate change issues.

Tim Hansen presented a case study on a vapor recovery unit. Currently in the United States, there are 94,000 oil and gas tank batteries, 12,670 of these generate significant vent gases on the order of 33 billion standard cubic feet (bscf) per year methane and 7,000 tpy hazardous air pollutants. In 2002, the ETV GHG Center verified the Environmental Vapor Recovery Unit (EVRU) developed by COMM Engineering, USA. This technology is used to recover waste gases vented from large crude oil and other storage tanks that exist in both the oil and natural gas industries. Previously, these gases, which are mostly methane and hydrocarbons, were vented directly to the atmosphere or were flared. This device allows for the gases to be recovered and used. It is a double benefit—emissions are being reduced and money is going back to the purchasers of the technology. Since 2002, COMM has installed the EVRU in 13 facilities and they have projected that 1,000 units will be installed within three to five years. Current installations of the unit have an estimated methane emission reduction of 65 million standard cubic feet (mmscf) per year. If the 1,000 units are installed, there could be an estimated methane reduction of 2,629 mmscf per year. There could be significant emission reductions for HAPs (182 to 714 tpy) and VOCs (2,222 to 3,780 tpy) as well. There are significant economic incentives associated with this technology. For the 13 units that have been installed, there is a savings of $23 million per year. For 1,000 units installed, it is estimated that the savings could be $1.8 billion per year. The President of COMM Engineering provided the following comment: "We present ETV performance data at every sales call, and we direct potential customers to EPA's Web site so they can see for themselves the detailed Verification Report. The technical performance data are good, but it's ETV's independent verification of our system's economic payback period that gets the most attention by our customers. ETV verification, and the outreach conducted by ETV, has been a major factor in the success of this technology. The technology has been an economic success for COMM, but it also provides new revenue streams for our customers and big benefits to the environment."

Tim Hansen briefly described two energy efficiency technologies; one is undergoing verification testing and the second is scheduled to begin verification testing in 2006. These are technologies that result in improved energy efficiency and reduced energy consumption in the areas of electric power, water heating/HVAC, appliances and building materials. ECR Technologies' Earthlinked Geothermal Water Heating System is a commercial-scale ground source hot water system that uses refrigerant loops in the ground as the heat source for commercial water heating. The vendor claims increased efficiency and significantly reduced (70 percent) power consumption. The technology was installed at an elder care facility in Florida. Testing consists of a direct comparison between two installed systems—Earthlinked versus an electric hot water heating system. The testing parameters include: electric power consumed, efficiency/coefficient of performance (COP) and emissions reductions. Testing is in progress and the verification reported is expected to be completed in late fall 2005.

The second technology (to be verified in 2006) is Legend Power's Electrical Harmonizer, which is a passive device (transformer type) that reduces overvoltages and provides cleaner power. Although it is new to the U.S. market, nearly 3,000 of these devices have been installed in Japan. The benefits claimed by the vendor are: reduced energy costs (typically in the range of 7 percent to 12 percent); improved power quality in the facility, through power quality management and conservation voltage regulation; reduced electricity (kilowatt) demand and KWh consumption; improved power factor; reduced KVAR demand charges; reduced incoming harmonic levels; and reduced phase voltage imbalance. Testing will begin as soon as an appropriate host site has been identified and selected.

Tim Hansen provided a brief overview of future activities for the ETV GHG Center. As a result of reductions in EPA's funding, they are looking to privatize the Center and obtain funding from partnerships with outside sources (i.e., state agencies, vendors, etc.). There has been an increase in the number of transportation technology verifications and there may be opportunities for additional verifications for idle reduction technologies and diesel truck fuel saving technologies (e.g., hybrids). The ETV GHG Center expects more applications for combined heat and power, especially in renewable fuels and newer technologies. There is also a renewed interest in oil and gas technologies.

U.S. EPA ETV Advanced Monitoring Systems (AMS) Center

Karen Riggs currently serves as Deputy Product Line Manager in Battelle's Measurement and Data Analysis Systems Product Line. In this position, she is responsible for acquisition and deployment of laboratory equipment, facilities and staff resources within her product line. Her technical experience has recently been focused on technology verification and evaluation. She has managed programs to verify environmental and indoor monitoring technologies, verify building decontamination technologies, evaluate air pollution control technologies, and demonstrate emission measurement methods. She serves as Battelle's manager for three of seven technology centers/efforts under the U.S. EPA ETV Program. In this role, she helped develop and currently manages processes and procedures for ETV stakeholder involvement, verification testing, reporting, outreach and quality assurance. Under her management, the U.S. EPA ETV AMS Center has verified 92 technologies in the past six years. She has a Bachelor of Science in chemistry from the University of Illinois. She provided a presentation on rapid and/or continuous emission monitors for ammonia, hydrogen sulfide, dioxin, and mercury and personal impactors for PM.

Karen introduced Bob Fuerst, the EPA Project Manager for the U.S. EPA ETV AMS Center. The ETV AMS Center, which was initiated in 1997, has verified 92 monitoring technologies (48 air monitoring technologies and 44 water and water security technologies). She stated that her presentation would address the air monitoring and detection technologies verified by the ETV AMS Center. The scope of the ETV AMS Center includes verification of air monitoring technologies for source, ambient and indoor environments. The ETV AMS Center has an extensive outreach program, which includes a bimonthly newsletter. They also hold technology field days where the test site is open to the public. Representatives from state and local government are invited to attend to provide them with information on the ETV Program and the performance data for the verified technologies. There are three active stakeholder committees (i.e., water monitoring, water security, air monitoring). The ETV AMS Center uses the stakeholder committees to prioritize technologies to be verified, design the verification test, provide peer review of test plans and verification reports, and conduct outreach to their respective organizations. Stakeholder committee meetings are held in different areas of the United States to promote ETV-verified technologies in different regions of the country. The ETV AMS Center has a strong emphasis on partnerships to try to leverage their EPA funding so that they can do more work. They look for two types of partnerships: other funding organizations that have an interest in a particular type of technology that will be verified, and organizations willing to provide in-kind support.

A total of 48 air monitoring technologies have been verified, including: eight portable NO/NO_2 monitors, six open-path optical monitors, 13 ambient $PM_{2.5}$ monitors, nine mercury continuous emission monitors (CEMs), one XRF multi-metals CEM, one portable multigas emission analyzer, one onboard vehicle

emission monitor, two ammonia CEMs and seven ambient ammonia monitors. The verification reports, protocols and test plans are posted on the ETV Web Site.

Karen Riggs discussed a recently completed verification test of ambient ammonia (NH_3) monitors. This test was done in partnership with the U.S. Department of Agriculture (USDA) for field-testing of continuous NH_3 monitoring instruments at CAFOs. The ETV AMS Center worked closely with the USDA National Soil Tilth Laboratory in Ames, Iowa. The USDA provided significant in-kind contributions. USDA staff arranged for field sites for testing, supported test planning, and collaborated in the field test activities, including providing the reference sampling and analysis. The USDA also helped to support the technology field day.

Animal feeding operations are estimated to be the largest single source of NH_3 emissions in the United States. Approximately 65 percent of the NH_3 emissions in the United States are from livestock agriculture. CAFOs in the United States emit approximately 2.2 million metric tons of NH_3 each year. NH_3 contributes to the formation of fine particles with the associated human health effects from inhalation, nitrogen deposition/eutrophication of coastal waters and visibility reduction ("regional haze"). Ammonia emissions occur across the United States and are concentrated in high-population areas.

The ambient ammonia monitor tests were conducted in two phases. Four technologies participated in the Phase I test, which was conducted September to October 2003 at a swine finishing farm (20,000 swine) in Ames, Iowa. Seven technologies participated in the Phase II test, which was conducted October to November 2003 at a cattle feedlot (3,000 cattle) in Carroll, Iowa. The test involved comparisons to a reference method and challenges with NH_3 standards during continuous monitoring.

The seven vendors who participated in the ambient ammonia monitors test included: Aerodyne Research, Inc. (tunable diode laser absorption spectroscopy); Bruker Daltonics, Inc. (open-path Fourier transform infrared absorption spectroscopy) (Phase II only); Molecular Analytics (ion-mobility spectrometry) (Phase II only); Omnisens SA (photoacoustic infrared absorption spectroscopy) (Phase II only); Pranalytica, Inc. (photoacoustic infrared absorption spectroscopy); Mechatronics Instruments BV (selective membrane permeation with conductivity detection); and Thermo Electron Corporation (catalytic oxidation and chemiluminescence).

The range of results for the seven ambient ammonia monitors tested included: relative accuracy of 2 percent to 44 percent; relative precision of 0.2 percent to 2.5 percent; and response times of less than one second to one hour. The approximate price of the monitors ranged from $30,000 to $100,000.

Karen Riggs provided the following outcomes from the ambient ammonia test: (1) ETV results will aid in the selection of NH_3 monitoring methods for the two-year/28-location CAFO study under the U.S. EPA's Air Compliance Agreement with animal producers; (2) up to 15,000 large and medium CAFOs may need NH_3 monitors to address state and federal regulations; and (3) use of NH_3 monitors at CAFOs can improve emission estimates; establish effectiveness of emission reduction measures; and lead to decreased emissions, particle formation and depositions. She provided the following quote on health outcomes from an *Environmental Science & Technology* article: "…a 10% reduction in livestock ammonia emissions can lead to over $4 billion annually in particulate-related health benefits."

A verification test of hydrogen sulfide (H_2S) monitors is in progress. The test is being conducted at a swine finishing farm near Ames, Iowa (same site as the Phase I ambient NH_3 monitor test). Worker exposure is an issue, as well as facility emissions and odor complaints. The test is being conducted in collaboration with USDA; they are supporting the test in similar ways as they did for the ambient ammonia monitors verification test. The two vendors participating in the test are Horiba Instruments (APSA-360A H_2S) and Teledyne Instruments API (Model 101E).

There are significant health risks for CAFO workers. H_2S emissions at CAFOs can exceed 100 ppb. There are regulations in California and Iowa that set a one-hour H_2S standard at 30 ppb. In addition, H_2S is a severe odor problem for CAFO workers and neighboring residents.

Karen Riggs described the measurement principle of H_2S technologies. The ambient air (less than 1 L/minute) is passed through a scrubber to remove ambient SO_2. H_2S is oxidized to SO_2 (using a heated converter at approximately 300°C). The SO_2 is detected by UV fluorescence.

The test was conducted over a six-week period from April 25 to June 2, 2005. The verification procedures included: zero air and H_2S standard challenges for zero/span drift and response-time checks; linearity, accuracy, bias and precision checks (0 to 300 ppb); routine operation with concurrent reference sampling/analyses; interference checks (sulfur dioxide, carbonyl sulfide, carbon disulfide, methyl mercaptan, dimethyl sulfide, hydrocarbon blend, ammonia); and recorded observations on the ease of use, maintenance, downtime, etc.

The outcomes for the H_2S monitor test, which are similar to the outcomes for the ambient ammonia test, include: (1) ETV results will aid in the selection of H_2S monitoring methods for the two-year/28-location CAFO study under the U.S. EPA's Air Compliance Agreement with animal producers; (2) up to 15,000 large and medium CAFOs may need NH_3 monitors to address state and federal regulations; and (3) use of H_2S monitors at CAFOs can improve emission estimates; establish effectiveness of emission reduction measures; and lead to decreased emissions, reduced exposures and reduced odor problems.

Another verification that is in progress is dioxin emission monitoring systems. Polychlorinated dibenzo-p-dioxins and –furans (PCDD/Fs) include the most toxic compounds known. Emission measurements currently require complex, costly and slow methods. Improved monitoring is needed for improved understanding of dioxin sources, emission rates and human exposures. The draft test and QA plan for this verification has been completed. Two categories of dioxin emission monitoring system technologies will be evaluated. The first technology category is automated sampling systems for subsequent laboratory analysis. The two vendors and their technologies that will be tested are: Becker-Messtechnik, GmbH (AMESA) from Germany and MonitoringSystems, GmbH (Dioxin Monitoring System) from Australia. The other technology category is semi-continuous sampling with *in-situ* laser ionization and mass spectrometric detection. The two vendors and their technologies that will be tested are: IDX Technologies, Inc. (RIMMPA-TOFMS) from Japan and SRI (JET-REMPI) from the United States.

The ETV AMS Center is collaborating with U.S. EPA ORD researchers under these verifications, with co-funding from the EPA OAQPS, EPA ORD, EPA Office of Solid Waste (OSW), and the Chlorine Chemistry Council. Testing will be conducted at EPA's pilot-scale boiler in Research Triangle Park, North Carolina, co-firing #2 oil and 1,2-dichlorobenzene. They hope to be able to vary boiler conditions

so that they can vary the dioxin concentrations. The test will use EPA Method 23 reference samples over intervals from one hour to 24 hours, during a two-week test period. The performance parameters to be evaluated include: accuracy, linearity, precision and ease of use.

The potential outcomes of the dioxin emission monitoring systems test include: more continuous monitoring of dioxin emissions, improved emission inventories, better estimates of human exposures, and improved regulation of dioxin sources. A technology field day will be held the first week in September 2005 at the EPA facility in Research Triangle Park, North Carolina. Karen Riggs asked that anyone interested in attending the technology field day give her their contact information and she will send them an invitation.

Karen Riggs reported that another verification in progress is for personal cascade impactor samplers (PCIS), which are designed to be worn to collect contaminants for exposure assessment. The ETV AMS Center was approached by the National Urban Air Toxics Research Center (NUATRC) in Houston, Texas, to collaborate on a verification test. The test is for a personal particle impactor and sampling pump developed under NUATRC support, and now being sold by SKC, Inc. (Sioutas Personal Cascade Impactor with Leland Legacy Personal Sampling Pump). The verification test is co-funded by NUATRC and the ETV AMS Center.

Personal particle sampling is important for a number of reasons. Long-term mortality is 17 percent to 26 prcent higher in communities with higher ambient fine PM (Harvard Six Cities and American Cancer Societies studies). There is a 0.5 percent increase in mortality per 10 $\mu g/m^3$ increase in ambient PM_{10} (HEI National Morbidity, Mortality, and Air Pollution Study). Personal exposures can by higher as they are driven by indoor activities and personal habits.

The general PCIS test design includes: (1) comparison to a reference impactor at a fixed site, (2) operational testing while worn by several people in work and residential settings (under review) to look at the ease of operation, and (3) analysis of collected samples (e.g., for metals) to assess the adequacy of sample mass as a function of particle size ranges and sampling conditions.

The potential outcomes of the PCIS test include: increased use of personal particle impactors to assess personal exposures to fine particles, improved identification of sources and personal activities contributing to personal particle exposures, and reductions in personal particle exposures, with consequent health benefits.

Karen Riggs reported that a Phase 3 verification test is in progress for mercury continuous emission monitors (CEMs). The objective is to test mercury CEMs in operation on a challenging flue gas matrix at a full-scale coal-fired power plant. Phase 1 testing was conducted at an EPA pilot-scale facility. Phase 2 testing was conducted at the U.S. DOE Toxic Substances Control Act (TSCA) hazardous waste incinerator in Oak Ridge, Tennessee. The Phase 3 test will be conducted from September to October 2005 at the Coffeen Power Station of Ameren Services in Illinois. Co-funding is being provided by the Illinois Clean Coal Institute (ICCI), and they required that the test be conducted at a facility that burns Illinois coal. The test will include bracket shutdown of SCR. Coal mix and SCR operation will provide two different test conditions.

Coal- and oil-fired power plants are the largest man-made mercury source in the United States, with about 48 tons of mercury emitted each year—about 1 percent of the global total. Mercury is a global pollutant that bioaccumulates in the food chain. On March 15, 2005, the U.S. EPA issued the Clean Air Mercury Rule (CAMR), which aims for a 70 percent reduction in utility mercury emissions and establishes a cap-and-trade system for mercury reduction. The cap-and-trade approach requires accurate mercury measurements for allowance trading. CAMR accepts sorbent-based mercury samplers, as well as true CEMs.

The mercury CEM test will include both CEMs and sorbent-based mercury samplers. The mercury CEM test procedures will include: continuous operation of CEMs/sorbent samplers for six weeks in routine operational mode, comparison to reference mercury measurements in the first and last week of the field period, and repeated challenges with Hg^0 standards and zero gas throughout the field period.

The potential vendors for the mercury CEMs are: Tekran, Horiba, and Lumex (MiniCEM). The potential vendors for the mercury sorbent systems are: Apex Instruments (XC6000D MercSampler), Environmental Supply Company (Hg Sampler) and EPRIsolution (QuickSEM).

The potential outcomes of the mercury CEM test include: recognition of sorbent-based mercury samplers (not previously tested) with consequent cost savings; application of mercury CEMs and sorbent samplers to achieve an effective cap-and-trade program for mercury; and environmental benefits from reduced mercury emissions.

Karen Riggs stated that technology areas for future testing may include leak-detection monitors and portable UV systems. Other technology areas under consideration include: PM monitors, including ambient coarse PM ($PM_{10} - PM_{2.5}$) and portable direct PM mass monitors (not surrogates); VOC monitors for landfills, municipal waste facilities and wastewater treatment plans; VOC monitors for vapor intrusion in buildings; and on-board diesel emission monitors.

Karen Riggs stated that the ETV AMS Center has performance results on numerous air monitoring technologies available on the ETV Web Site. The strong partnerships established by the ETV AMS Center have enhanced the verification tests by lending them scientific credibility because the partners are using the technologies in the field. There is a continued need for verification of air monitoring technologies that address critical environmental problems. Verified technologies have considerable potential to help to improve the environment and minimize human risk.

Air and Energy Panel/Open Discussion

Andrew Trenholm asked if there were any questions for the panel.

Max Diaz, U.S. EPA, asked Kenji Kamita if Japan was trying to phase out chlorinated solvents. Kenji Kamita responded that some of the substances were carcinogenic. If there are sufficient data to prove that they are of high risk, then they would be banned.

One participant asked if the operating costs of technology were verified or only provided for information purposes. Karen Riggs responded that the ETV AMS Center does not include operating costs of the

technology in the verification report. They provide a cost to purchase the technology and comment on the requirements for maintenance, downtime, time to repair equipment, and materials consumed, but no costs are provided. Andrew Trenholm stated that the ETV APCT Center does not include specific operating costs in their reports. They try to measure all of the major cost factors and document the amount of energy or water that is needed, if it is pertinent, so that someone else could take that data to calculate their own costs. Tim Hansen stated that in some cases, mainly in the oil and gas sector, the ETV GHG Center has provided a very simple payback calculation that was included in the verification reports. Mona El Hallak stated that ETV Canada does not verify operating costs.

Mark Lay, EnviroFuel, L.P., commented that his company would fall into the SME category. With the exception of the U.S. EPA ETV AMS Center, the customer list is populated by small technology companies trying to get to the next level through a verification process. Based on their experience, flexibility is very important in the testing process. If the true purpose is to identify new technologies, there needs to be a recognition that those new technologies are not going to operate in the same manner as older technologies, and that requires a certain amount of flexibility. They found the U.S. EPA ETV GHG Center to be a tremendous resource in terms of providing an objective third-party evaluation of the test data that were collected during the testing process. There is a significant resource that could be provided in an advisory capacity to smaller companies to help them understand what the requirements are for their particular product with respect to regulatory implications, as well as alternatives for testing. How much consideration has any of the ETV programs given to providing the overview aspects, as well as the protocol preparation, for smaller companies? For example, for a small fee, the ETV program could provide assistance by reviewing the technology in a little more detail, providing the vendor with testing alternatives or other testing resources, and making sure that the vendor knows that there are other smaller scale tests that they should make sure they have gone through prior to committing to a fully public disclosure of test results, which is required under the U.S. EPA ETV Program. Andrew Trenholm responded that the ETV APCT Center identifies the technology areas and then a stakeholder panel is formed to develop the protocols. The protocols vary in how detailed they are, which is driven by the stakeholders. If a vendor is interested in a verification under one of these protocols, then the center enters into discussions with the vendor and tries to advise them as to how they fit in and what needs to happen, and how sure they need to be of their performance evaluation before they sign up for the test. Tim Hansen stated that the ETV GHG Center typically only has one or two vendors participating in one technology category. As a result, they have more flexibility to do more technology-specific or test-specific test plan development than generic verification protocol development. Karen Riggs commented that the ETV AMS Center tells vendors that they should be ready for testing. The center hopes and expects that the vendors have already participated in some previous testing and have some test data that they can share in development of the test plan. Vendors with no prior testing experience are strongly discouraged from applying, and they also are told that their performance results will be publicly available. Mona El Hallak stated that ETV Canada has a program that is helpful for SMEs. They do market research for the technology to identify the performance claim they need to verify to market their product. They also recommend the tests that the vendor should complete before going through the verification process.

Mike Kosusko, U.S. EPA, asked the panel to address whether testing data are reported as is or if some interpretation is provided in their reports. Andrew Trenholm commented that the ETV APCT Center tries not to interpret the data. They try to quantitatively describe the performance of the technology. Karen Riggs commented that the ETV AMS Center reports the performance data and lets buyers and users

interpret the data. Tim Hansen stated that the ETV GHG Center operates the same way as the other ETV centers. If something was observed during testing or if a technology did not perform well, an explanation is included in the verification report. Mona El Hallak and Kenji Kamita stated that their ETV programs report the performance data and they do not interpret the data.

Paul Groff, U.S. EPA, asked Karen Riggs if the dioxin technologies were commercially ready or prototypes. She responded that the technology should be commercially ready. The vendors are told that by the time they complete the verification process, they must be able to produce the technology for sale.

Mehboob Sumar, Bodycote Materials Testing Canada, Inc., asked Andrew Trenholm whether the test results or vendor claims were compared to U.S. EPA standards. Andrew Trenholm responded that no comparisons are made when the test results are presented. They try to present the data in a format and units that are useful to people, who might want to look at the performance relative to existing standards or the performance of other technologies.

Bob Bessette, Council of Industrial Boiler Owners, asked if all of the ETV programs had stakeholder groups. Andrew Trenholm responded that all of the U.S. EPA ETV Centers have stakeholder groups. Mona El Hallak stated that ETV Canada does not require the use of stakeholder groups. John Neate stated that ETV Canada was initiating performance benchmarking. This involves working with user groups and stakeholders to identify their performance expectations, which are then built into the process as specifications or criteria for verification. Kenji Kamita stated that Japan has very few members from industry on their committees or working groups under their guidance and advisory structure; however, they may need to include them in the future.

Andrew Trenholm stated that he wanted to pose questions on the international cooperation theme of the meeting to the panel. The baghouse test method that the ETV APCT Center is using was developed in Germany, and was adapted for the U.S. EPA ETV Program. It then became an ASTM method and it may become an ISO method, which would make it an international method for verifying baghouse fabrics. Are there other areas where there might be similar opportunities to try to move toward more international standards, methods and testing protocols? Tim Hansen stated that the ETV GHG Center developed a protocol for the microturbine CHP; a separate laboratory field testing protocol and monitoring protocols were developed, which are being submitted for adoption by the Underwriters Laboratory as a standard. It is mainly for the laboratory certification part, but field-testing will be included as a reference in the laboratory certification. The one problem is that it will take years to get approved as an ISO standard and timing is very important to vendors, regulators and other stakeholders. Karen Riggs commented that a representative from ASTM was invited to one of the ETV AMS Center stakeholder committee meeting to explore whether the center wanted to take their test and QA plans and move to more of an ASTM method. The stakeholders want the verifications completed as quickly as possible and do not want to do the ASTM or ISO process if it will slow the completion of the tests. The stakeholders want the center to focus on doing verification testing and are concerned that the effort and time to go through the ASTM or ISO process will impact the testing.

John McKenna, ETS, Inc., stated that the ISO process is a multiyear process; however, the ASTM process can be done with a minimum effort. Within one year, the ETV baghouse protocol was adopted as the ASTM method. It was a method that was needed in the industry, as there was no common test method.

The fabric vendors are coming to their laboratory and asking for the ASTM test to be done as they are developing fabrics. It provides vendors with the screening technique that gives them a high level of assurance before they go to the U.S. EPA ETV Program. As a result, the contribution from the U.S. EPA ETV Program is significant.

Mike Kosusko, U.S. EPA, commented that there are a lot of methods and protocols that are available overseas that could apply to the ETV programs. The U.S. EPA ETV Program developed a protocol for liquid coatings, and it is in the process of being adopted as an ASTM standard. It did not take a significant amount of ETV time. The key is to have a strong protocol and worldwide industry interest in it.

Mona El Hallak stated that if there is to be international collaboration, there needs to be QA/QC standards that everyone will follow.

Teresa Harten, U.S. EPA, asked Kenji Kamita if the benefit was accruing to the user of the heat-island mitigation technology or was the objective to lower the temperature of Tokyo. Kenji Kamita responded that use of the technology could have some effect on cooling the temperatures of Toyko and other large cities, if they are installed in many buildings. The managers of the commercial building will install the technology if the cost reductions (due to lower electrical consumption) are larger than the operating costs of the technology. If this incentive is not enough to encourage installation of the technology, then Japan may consider providing some type of subsidy. Tim Hansen asked if J-ETV plans to do a case study or impact analysis of these technologies on the temperature of the cities. Kenji Kamita responded that the study would be useful if they are thinking of some type of subsidy, but as yet they have no plans to do a study. Tim Hansen stated that this technology is very interesting and he would propose it as a technology category to the ETV GHG Center stakeholders, especially in light of the rising energy costs.

Mehboob Sumar, Bodycote Materials Testing Canada, Inc., asked if ETV verification data, from any of the programs, are accepted by regulators. Andrew Trenholm responded that the U.S. EPA ETV Program generates data that are publicly available to anyone who wants to use it, including regulatory bodies. Tim Hansen stated that the U.S. EPA ETV Program has representatives of regulatory agencies and state and local government on their stakeholder groups to get their input on what they need from verification testing. Raymond Klicius, Environment Canada, stated that they have tried to educate their provinces, which is the jurisdiction that issues permits, that if a company has an ETV certificate, it should be taken into account to facilitate the permitting process for the company. Many of the provinces have signed a Statement of Recognition acknowledging that this certificate is going to facilitate the process. Part of the problem is communicating this down to the people who are analyzing the applications and making sure they understand that they should give special consideration to these companies. Danny Epstein, Environment Canada, added that if a new substance was to be evaluated, the ETV program would not be expected to evaluate it. Karen Riggs stated that in addition to the Illinois Clean Coal Institute, the state of Connecticut is also co-funding the mercury CEM verification test so that they can be assured the mercury CEMs can generate continuous data of appropriate quality. They are considering establishing regulations to require the use of mercury CEMs for power plants in the state of Connecticut. In this case, the U.S. EPA ETV Program will have an impact on regulations that are going to be developed. John Neate, ETV Canada, stated that they have been asked by Environment Canada to look at the treatability of a particular contaminant, such as mercury amalgam. There was concern as to what level the regulation should be set.

Ray Frederick, U.S. EPA, commented that in the U.S. EPA ETV Program, if something happens that makes the technology not perform as expected, there is a place within the verification report where the vendor can explain why it happened. Is there anything in the reports of the other ETV programs that allows the vendor to explain what has happened during a verification test if the technology does not perform as expected? Mona El Hallak responded that ETV Canada documents everything that happens during the testing.

Waste and Other

John Neate, President, ETV Canada, and Randy Parker, Acting Associate Director for Technology, U.S. EPA ORD NRMRL, served as the session co-chairs. Randy Parker welcomed the participants to this session, which includes waste treatment, remediation, pollution prevention and recycling, and other environmental verification categories.

ETV Canada

Tammy Lomas-Jylha is the Managing Director of the Canadian Brownfields Network (CBN)—Canada's voice for brownfields redevelopment. The CBN implements recommendations made by the National Roundtable on the Environment and Economy for the development of a national brownfields strategy; delivers outreach and capacity building initiatives; creates linkages between private and public sectors; and works with strategic organizations to consolidate issues on urban sustainability. She is also the General Manager for aboutREMEDIATION, Canada's resource for brownfields redevelopment and site remediation. She has specialized expertise in designing programs, policies, guidelines and protocols for the Ontario Centre for Environmental Technology Advancement and Ontario MOE. She provided a presentation on PCB extraction technology for contaminated electrical equipment, thermal desorption technology for soil remediation, and aerobic digestion technology for biodegradable organic waste (food and beverage waste, municipal solid waste, sewage sludge and animal manure).

Tammy Lomas-Jylha briefly reviewed ETV Canada's program requirements for a claim to be verified and the technology verification process, as was previously presented by Andrew Houlson under the water and water security session. She presented three case studies, all of which used an independent expert with professional qualifications as the VE. The first case study addressed Sanexen Environmental Services, Inc.'s Decontaksolv®, which was verified in 2001. This is a solvent extraction process to remove PCBs from electrical equipment such as transformers and circuit breakers. The decontamination system is a mobile unit attached to a flatbed trailer made up of a distiller, autoclave, heat exchangers, and air ventilation and filtration systems. A thermal unit and a drying unit for recovery of residual fluids following the extraction also are part of the system. The extraction fluid that has been used for decontamination is regenerated by distillation for reuse in the process. The PCB fluid is reduced to a minimum volume and sent for proper disposal. The technology has been used in both mobile and fixed installations in Canada. A schematic of the technology process was presented that showed the material distribution and the various stages in the process: degreasing, dismantling, separation of the carcass, core and windings that will be decontaminated. It also displayed the final decontamination step, the constant solvent recycling system and the metal recovery process. The main wastes from the process are the residual fluid containing the removed PCBs, the porous material (i.e., wood, cardboard), and the activated carbon that is saturated with the PCB residual fluid. All of these wastes are sent for destruction to a proper

facility and the solvent is recycled and removed through the distillation process. The company submitted a complete data set to support the performance claim to be verified.

Test results showed that Sanexen's Decontaksolv technology will reduce PCB contamination from Askarel and mineral oil transformers to levels less than or equal to the Canadian and U.S. Standards of: less than 50 mg PCBs/kg for the windings and insulation materials, and less than 10 µg PCBs/100 cm^2 for metal surfaces. The vendor provided the following comments: "Provided authenticity." "Not currently promoting the technology in Canada although have sold licenses for technology in Japan and Mexico." "Will be pursuing verification for other technologies that the company is developing."

The second case study presented was on Trans-Cycle Industries, Inc.'s Continuous Thermal Desorption (CTD) Technology, which was verified in 2004. The technology is a continuous thermal desorption process for treating organic-contaminated soils, including VOCs and SVOCs from contaminated sites. CTD is an on-site soil remediation technology for contaminated sites in Canada. CTD is a non-incineration alternative to fixed incineration facilities. Because it is mobile, CTD eliminates the risk and cost of transporting large volumes of contaminated soil over land and water. Clean solids from the process are returned to the site, avoiding the cost of replacement fill. CTD is a multi-purpose technology that is capable of treating different organic contaminated soils. It is designed to remove organics from soil by transferring it into the water phase, where it is treated with conventional water treatment technologies. The company needed to modify their performance claims to account for the data provided and market needs.

Test results showed that Trans-Cycle Industries, Inc.'s Continuous Thermal Desorption Process was capable of: reducing polycyclic aromatic hydrocarbons (PAH) by at least 97 percent; reducing pentachlorophenol concentration by at least 93 percent; reducing VOCs by at least 97 percent; and capturing 97 percent (on average) of the mass loading of desorbed VOC and SVOC compounds in the vapor-recovery system, leaving only 3 percent (on average) for thermal oxidation. The vendor provided the following comments: "Verification assisted in the development of a joint venture with another company." "Technology is positioned to capture a niche market—treating remote contaminated sites."

The third case study was International Bio-Recovery Corporation's Enhanced Auto-Thermal Thermophilic Aerobic Digestion, which was verified in 2000. The technology processes biodegradable organic wastes into pathogen free organic solid and liquid fertilizers. The contaminant is waste organic matter from waste produce and restaurant waste that ends up in landfill sites. The technology is used for processing biodegradable organic wastes such as: food and vegetable waste, municipal solid waste, sewage sludge and animal manure. The company submitted a complete data set.

Test results showed that International Bio-Recovery Corporation's Enhanced Auto-Thermal Thermophilic Aerobic Digestion uses waste produce/restaurant waste as feedstock and conserves nutrients in the digestion process. Secondary digester samples showed no mean difference for TKN, phosphorus and potassium at a 99 percent confidence level. The end product of the process is a solid organic fertilizer that contains: (1) TKN, phosphorus and potassium concentrations greater than 29,400 mg/kg, 7,050 mg/kg, and 6,250 mg/kg, respectively, and the N:P:K: grade is approximately a 3:2:1 ratio; (2) concentrations of metals that do not exceed the existing standards under Agriculture and Agri-Food Canada's Fertilizer Act (1991); (3) no detectable levels of fecal coliforms and fecal streptococci; and (4) less than 10 percent

moisture by weight. The vendor provided the following comments: “Verification gives end users the assurance that the technology can perform.” “Fertilizer product has been sold in Canada, United States, Mexico, Philippines, Singapore and Indonesia.” “Sold licenses for processing plants internationally.” “Testing new applications for the technology.”

Tammy Lomas-Jylha stated that independent verifications have assisted these technology companies with effective market penetrations and business growth opportunities. It is important to recognize that performance claims need to reflect the current market need. ETV Canada works with clients to assess the market need for their technology. The next step to helping these companies achieve market success is performance benchmarking. Performance benchmarking addresses the need to develop acceptable performance criteria that are used to establish credible third-party verification of reported performance claims. Users in key sectors should participate in this benchmarking process to help identify contaminants of concern, and develop implementation options (including technology and process modifications) to obtain performance objectives through verification. They also need to be able to guide the benchmarking process to ensure that relevant and achievable criteria or objectives are established.

It is apparent that the Canadian redevelopment sector would benefit from a benchmarking process. Redevelopment is a challenging process and Canada is just beginning to enter into a much more active brownfields market. It can be a daunting process for stakeholders to understand the steps of redevelopment. Municipalities and property owners need to have a good assurance or comfort level regarding the technologies that have been reviewed and selected for site cleanup and brownfields redevelopment. Performance benchmarking or the establishment of acceptable performance criteria would enable brownfields owners and managers to identify and select proven technologies and, in turn, be able to give a comfort level to the general public.

U.S. EPA Superfund Innovative Technology Evaluation (SITE) Program

Randy Parker is the Acting Associate Director for Technology at the U.S. EPA ORD NRMRL, Land Remediation and Pollution Control Division, located in Cincinnati, Ohio. He leads the planning and implementation of the Superfund Innovative Technology Evaluation (SITE) Program. SITE supports the research, development and deployment of innovative hazardous waste treatment technologies. For the past 15 years, he has been involved in federal programs providing information to decision makers in EPA regions and states to address hazardous waste technology needs. He also coordinates other programmatic efforts with federal, state and private sector organizations. He provided a presentation on remediation and monitoring technologies.

Randy Parker stated that the purpose of the U.S. EPA SITE Program is to promote the demonstration, development and use of innovative technologies for cleanup of Superfund and other hazardous waste sites. NRMRL is under the U.S. EPA’s ORD. NRMRL’s research areas include: drinking water protection, watershed management and restoration, air pollution control, pollution prevention and sustainability, and contaminated media remediation (where the SITE Program is housed).

The SITE Program is composed of three components. The first component is a demonstration program that evaluates full-scale commercial-ready or near commercial-ready innovative environmental remediation technologies. The second component is the characterization and monitoring program that

evaluates field portable real-time devices for characterization and monitoring of contaminants at Superfund and other sites. The third component is a technology transfer component that disseminates information on the technologies evaluated under the SITE Program.

The Superfund Program was established by Congressional mandate in 1986 for treatment of the most contaminated sites in the United States. Along with the law that established the Superfund Program, Congress mandated the initiation of a development and demonstration program for innovative technologies to treat those sites. At the time that Superfund was established, there were very few remedial options for the clean up of Superfund sites. The conventional treatments were pump and treat for groundwater, and excavation and incineration for soils. The demonstration program includes third-party evaluation of environmental technologies, evaluation of treatment performance, estimation of treatment costs and publication of the results.

The purpose of the SITE Program is the evaluation of innovative technology performance and cost. The SITE Program is important because it provides relevant innovative technology performance data to regions and other decision makers. It also provides cost data for the evaluation of remediation and monitoring options. The SITE Program focuses on *in-situ* treatment and hard-to-treat wastes; 58 percent of all Superfund site source control treatment is an *in-situ* treatment. Twice as much Superfund site contaminated soil (28M yd^3) is being treated *in-situ* than *ex-situ* (14M yd^3). There is a demonstrated need for on-site, real-time characterization and monitoring technologies.

The types of research activities that SITE is currently involved in include: evaluation of innovative treatment approaches and their associated costs; dense non-aqueous phase liquid (DNAPL) remediation processes; evaluation of sediment capping or treatment technologies; investigation of mine waste remediation options; evaluation of innovative measuring, monitoring and characterization technologies; and containment technology research.

When the SITE Program started, the initial focus was on innovative technologies. In 1996, the focus of the program changed to looking at the most pressing problems at sites, and then looking for innovative technologies for use at those sites. The SITE Program priority site areas are: sites with mine drainage, manufactured gas plants, Superfund, RCRA and other federal facilities. The priority areas for soils and groundwater are: DNAPL, chlorinated solvents, PCBs, and arsenic, mercury and other heavy metals (e.g., cadmium, chromium, lead). The priorities for sediments (both freshwater and marine) are: pesticides, PCBs, PAHs, and arsenic, mercury and other heavy metals.

Randy Parker discussed how projects are brought into the SITE Program. Their first approach is to solicit the involvement of stakeholders who have an interest in the site and site owners. Those priority sites are matched with technology solutions. Some sites come into the program with an interest in a particular type of technology. Other sites enter into the program with a specific technology and vendor already identified. The most challenging scenario is when the program acts in a consulting role. Many sites will come to them without having a good handle on what type of technology might be appropriate for their site. The program will provide advice on the technologies that might be useful. Treatability studies may be conducted to look at a couple of technologies and compare them in an effort to find the best technology for use at that particular site. Once those tasks are completed, then the technology evaluation proceeds

and the information on performance and cost of the technology is transferred to the remediation community.

A chart was presented on the relationships that form a SITE demonstration and the cost share of the different parties. No funding changes hands between the SITE Program and the vendor or the site owner. Each party in the demonstration is responsible for a certain number of tasks associated with the demonstration. The SITE Program is responsible for: the test plan, which includes a health and safety plan, sampling and analysis plan, and a quality assurance plan; sampling the site prior to the demonstration and establishing the baseline contamination; sampling during the demonstration to determine the performance of the technology; sampling after the demonstration to determine the efficacy of the technology; analyzing samples and data reduction; and reporting of the results. The vendor is responsible for mobilizing personnel and equipment to the site, operating the equipment during the demonstration, and demolition or demobilization of the technology at the end of the demonstration. The site owner is responsible for preparing the site for demonstration, which may include any type of infrastructure needs (i.e., roads, concrete pads, security fencing), and disposal of the waste after the demonstration is completed. Sometimes, the vendor and site owner will enter into a financial arrangement whereby the site owner might pay or defray some of the vendor's cost in doing the demonstration.

A number of programs and agencies are involved in the SITE project team. One of the members of the project team is the Interstate Technology and Regulatory Commission (ITRC), which is a consortium of 48 states. These state representatives are responsible for permitting and furthering the use of innovative technologies in their member states. Other members of the project team include: U.S. DOE's Strategic Environmental Research and Development Program (SERDP), state agencies, EPA ORD, EPA regional staff and EPA program offices.

A brief overview of the SITE Program planned activities for FY05/06 was presented. An *in-situ* chemical oxidation technology is being demonstrated at Roosevelt Mills, Connecticut. (This is one of three *in-situ* chemical oxidation technologies that are being evaluated.) In the sediments area, a demonstration is being conducted at the Anacostia River, Washington, DC, where three different types of caps are deployed in the river. They are evaluating the stability of the cap, weathering of the cap, and the cap's resistance to storms and navigational waves. They also are measuring any flux from the cap into the water column. A steam injection project was completed recently at the Port of Ridgefield, Washington; the demonstration looked at creosote and DNAPL. One of the partners on this project is the EPA Brownsfield Program. After the port is cleaned up, the area close to the waterfront will be revitalized as a shopping district. The SITE Program is working with the U.S. EPA ETV Program on their mercury in soils and sediments demonstration. There is another sediments project in Venice, Italy, working with the port authority of Venice. The follow-up to this demonstration will be performed in the New York/New Jersey harbor in the fall of 2005. Bioremediation processes also are being demonstrated at Pearl Harbor, Hawaii.

In FY04, a number of different mercury in soils and sediments test kits were evaluated in the measurement and monitoring technologies program. A field test was completed recently for test kits for dioxin in soils and sediments. In FY05, there are 11 field portable XRF instruments that will be deployed to the same site and evaluated.

A case study was presented on the development of biological tools and methods for evaluating monitored natural recovery of PCB-contaminated sediments at the Twelvemile Creek/Lake Hartwell Superfund Site. This is a multi-phased study to develop a fully integrated assessment of PCB uptake through all levels of the ecosystem. They are looking at biological tools that serve a dual purpose of assessing the condition and gauging the efficacy of mitigation efforts for contaminated sediments.

A second case study was presented on remediation of *in-situ* DNAPL in fractured rock at Loring Air Force Base, Maine. Based on the results of the SITE demonstration performance and cost data, the technology was implemented by the Army Corps in Rhode Island. Two additional implementations are planned for Maine.

A third case study was presented on a revitalization project at Roosevelt Mills in Vernon, Connecticut. An *in-situ* chemical oxidation treatment for chlorinated solvent contaminated media was demonstrated at a dry cleaning building. The SITE treatability study results will be used as a decision tool for remediation of the site. If the technology is successful, it will be used for clean up of the site. The Roosevelt Mills revitalization plan calls for a mixed-use retail and residential facility.

One of the future directions of the program is to not only conduct evaluations and demonstrations for the sake of determining the performance and cost of the technologies, but also to take it one step further and use the technology at the site as one of the cleanup options if the technology is successful. The program will continue its partnerships and resource leveraging (e.g., working with the Port of Venice). They also are looking for SITE demonstrations in Germany.

Approximately 180 demonstration and evaluation reports and SITE annual reports are available on the SITE Program Web Site at: http://www.epa.gov/ord/SITE.

Institute of Environmental Science and Engineering (IESE) - Singapore

Tay Joo Hwa, Director and Chief Executive Officer of the IESE in Singapore, provided a presentation on dioxin destruction and used oil lubricant recovery.

Singapore has formidable environmental challenges including the disposal of municipal solid waste. There are no landfill facilities on the main island of Singapore. All of the solid waste generated must be disposed of efficiently. Given the tropical weather, the domestic waste could turn into a real nuisance if it is not disposed of quickly. About 80 percent of the 7,000 tons of waste generated annually is incinerated in four large incinerators, which range from about 1,800 to 3,000 tons per day. Several types of technologies have been implemented worldwide to control and destroy dioxin from municipal waste incinerator plants. In Singapore, two of the incinerator plants have been installed with baghouses that use catalytic filter bags. The second alternative is to have a baghouse with a catalyst bed. The third option is to use a baghouse with an activated carbon adsorption bed. The fourth option is gray lime injection and a baghouse. More recent methods that have been introduced include: an electron beam and a high-energy source, an ion beam and a high-energy source, and a hydroxyl flame and a low-energy source.

Tay Joo Hwa discussed a proposed project to demonstrate a hydrocarbon oxidation and hydroxyl flame technology. In all destruction-based technologies, either ions, electrons or free radicals perform the actual

degradation of the hydrocarbon (HC) molecules. The key species for any oxidation reaction are: •OH, •H and •O in a highly activated state**,** as charged, ionized atoms, or dissociated free radicals. Carbon oxidation requires the presence of hydrogen atoms.

The theory of hydrogen combustion is: $H_2 + ½\ O_2 \rightarrow H_2O$

There are 27 reaction steps, all with free radicals. Only 5 percent to 7 percent of these reaction steps are conversions to water. The rest of the reaction steps are involved in the generation, propagation, and recombination of the radicals. During the combustion reaction, a lot of free radicals are generated. Hydroxyl radicals are powerful reducing agents. Contaminants can be degraded easily by these radicals.

Hydroxyl flame technologies are capable of oxidizing most hydrocarbons including halogenated organics (PCB and dioxin/furan) and VOCs and PAH. Additional reactions include CO oxidation, odorous compound destruction, soot oxidation and degradation of halogens (Cl_2, Br_2, etc.).

Tay Joo Hwa discussed the application of hydroxyl flame technology in a municipal solid waste incinerator. Typically, dioxin present in a flue gas in a municipal solid waste incinerator is measured at a parts per trillion (ppt) level or a sub-ppt level. Because the level is small, it does not require large amounts of hydrogen gas. The gas phase reaction is characterized by fast kinetics and easy mixing. The technology can serve as a final "polishing" step prior to stack release, be used as a safeguard against sudden releases due to plant upsets, and be installed as multiple burners with an independent hydrogen supply as a backup.

There is interest in installing this system in Singapore. There are four incinerator plants, three of which were built when the requirement for air pollution control was not quite as strict as the current standards. The three plants have electrostatic precipitators (ESP), which are the only dust-control mechanism. Some of the plants have been retrofitted to include a lime reaction chamber to scrub out hydrochloride (HCl). Typically, they do not have a baghouse built into the system. The availability of space is limited in Singapore. In many cases, there is not enough space left in the plant to retrofit a baghouse, which would be needed with catalyst bed and carbon adsorption retrofits. The hydroxyl system does not require a baghouse.

The advantages of the in-line hydroxyl system include: virtually no additional pressure drop is introduced; minimal retrofitting; a minimal footprint; continuous or on-demand operation; significantly lower capital and operating costs; can be designed to remove other pollutants; and provides additional draft for the stack.

The test platform for the hydroxyl system will be installed at an existing municipal solid waste plant in Ulu Pandan, Singapore. The objectives are to: (1) design and test the performance of the hydrogen flame based technology to destruct dioxin and/or other air pollutants, (2) identify possible problems and modify the system to optimize the process and maintenance, and (3) fine-tune the operational and maintenance costs to achieve the most cost-effective treatment process.

The proposed budget for this project is $1.1 million (U.S. dollars). Tay Joo Hwa stated that if there were other potential vendors that wanted to demonstrate their technology, their participation would be

welcomed. The U.S. EPA has a dioxin CEM system that is being tested. The demonstration of a dioxin CEM system in Singapore would be a good project for collaboration between the United States and Singapore under the U.S. EPA ETV program. The current methods for measuring and sampling of dioxin are very time consuming due to the small concentrations. Samples have to be collected over a period of time, which could be weeks, before there is a sample that can be sent to the laboratory for analysis. Having a continuous emission monitor, such as the one being tested under the U.S. EPA ETV Program, would benefit this program a great deal. They would like to explore this in more detail with the U.S. EPA ETV Program.

The possible sources for the proposed project funding are: The Entreprise Challenge (TEC) from the PMO, IES from the National Environment Agency, and private investors. They hope to have the budget approved within two months.

U.S. EPA ETV Coatings and Coating Equipment Pilot (CCEP)

For 20 years, Michael Kosusko has worked for the U.S. EPA's Air Pollution Prevention and Control Division in Research Triangle Park, North Carolina. He received his Master of Science in chemical engineering from the University of Virginia in Charlottesville, Virginia, and his Bachelor of Engineering from Stevens Institute of Technology in Hoboken, New Jersey. He leads three ETV projects. These are the CCEP, the APCT Center and the new Environmental Science and Technology Evaluation (ESTE) project on Pesticide Spray Drift Reduction Technology. He is responsible for three Internet-based pollution prevention expert systems that assist small businesses to identify low-emitting alternatives for their existing operations. He provided a presentation on laser targeting devices and high-transfer efficiency (TE), non-high-volume, low-pressure (HVLP) spray guns.

Michael Kosusko stated that the U.S. EPA ETV CCEP Pilot was established in 1996. EPA's verification organization for this pilot is the U.S. DOD's National Defense Center for Environmental Excellence (NDCEE) in Johnstown, Pennsylvania. The pilot is operated by Concurrent Technologies Corporation (CTC), which has managed the pilot since its inception. The pilot is focused on verifying technologies for control of VOCs, HAPs and waste generation. They have completed four test protocols, which reflect the technical areas of the pilot. The test protocols include: HVLP paint spray guns; UV-curable coatings; innovative liquid coatings; and powder coatings. There is a draft protocol for high TE paint spray guns, which should be completed in 2005.

One laser-targeted paint application device was tested in 2000. The product was developed by a startup company, Laser Touch and Technologies, LLC (Laser Touch Model LT-B512). The verification factors included painter TE and finish quality. This device helps the painter to paint at the right distance with a higher TE. The testing results showed that painter TE improved by 11.1 percent and that there was improved appearance of the painted products.

The device is attached to the side of a paint spray gun. The device projects two beams of laser light, which can be aimed so that they come to a single point at the proper distance from the surface to be painted. When the painter is at the proper distance from the surface to be painted, the highest TE is achieved.

A case study was presented on the use of this device for manual spray painting in the auto-refinishing industry. The potential impacts from the use of the laser-targeted paint application device include: VOC emission reductions of up to 11,000 tons per year, solid waste reductions of up to 31,000 tons per year, and paint usage savings of up to $500 million per year.

Michael Kosusko provided a brief overview of the verifications completed for HVLP paint spray guns, which included verification of improved TE while maintaining product quality. Four verifications were completed in 1999, and one product was verified in 2003. One product (EXEL Kremlin Airmix) is currently in testing. This product is not an HVLP paint spray gun, but it has high TE characteristics. The Kremlin Airmix product will be tested against a conventional air paint spray gun baseline. The generic verification protocol for HVLP paint spray guns is available on the ETV Web Site.

In 2003, the ETV CCEP Pilot verified an HVLP automotive refinishing spray gun developed by ANEST IWATA Corporation (LPH400-LV) that provided a relative TE improvement of 64 percent over a conventional air spray gun baseline. Increased TE reduces paint usage, volatile emissions and waste generation. This results in material savings and reduced waste disposal costs. The spray guns provide a comparable finish quality at a higher TE.

The ETV CCEP Pilot developed a test protocol for high TE paint spray guns to verify TE at levels comparable to, or above, HVLP paint spray gun levels. The test included a three-part California-compliant coating system, including primer, topcoat and a clear coat on a metal substrate; and the TE was measured for all three coats. They also coordinated with California's South Coast Air Quality Management District's (SCAQMD) Coating, Printing, and Aerospace Operations personnel to facilitate equivalency determinations. Two verifications were completed in 2004 and these reports are on the ETV Web Site. One report (ITW Automotive Refinishing DeVibiss GFG-670 'Plus' Spray Gun) is in review. The generic verification protocol has been drafted and is in review.

Michael Kosusko closed by noting that to date 10 technologies have been verified by the ETV CCEP Pilot and three more are in progress. Four generic verification protocols have been completed and one more is expected to be completed in 2005.

Waste and Other Panel/Open Discussion

John Neate asked Michael Kosusko what other projects the NDCEE worked on in addition to the ETV CCEP Pilot. Michael Kosusko responded that the NDCEE has a large pilot-scale, small demonstration-scale factory set up for coatings. They have a good powder spray booth that has been used for production trials for some new applications for powder coating. There also is an E-coat system that has been set up. The facility is used to provide technology demonstrations for the U.S. DOD.

Teresa Harten, U.S. EPA, commented that under the ETV Canada program, the cost of testing is paid by the vendors and they supply the data sets to the program. Are the verification entities supported by the government of Canada? John Neate responded that the vendor pays $15,000 to $20,000, of which 25 percent to 35 percent remains with ETV Canada to cover administrative costs and overhead. Sometimes, Environment Canada will assist in underwriting some of the verification costs at a modest level (up to $5,000). In the manure management area, there is a stakeholder group that has a defined interest in seeing

manure management technologies demonstrated. A program was set up with the Agricultural Adaptation Council where they were going to pay $10,000 toward the verification. The problem was that none of the vendors had enough money to get the data sets together. The big cost to the vendor is the initial data set, and that is an area where they need help. Teresa Harten commented that in the U.S. EPA ETV Program, there is a policy for existing data where a vendor can supply their data and ETV will review it. Vendor-supplied data can be used for verification as long as it meets ETV's quality assurance standards. This policy is contained in Appendix C of the ETV Quality Management Plan. The use of existing data for a verification test could be as expensive as conducting a new verification test. How do you make sure that ETV Canada is getting all of the data? John Neate responded that ETDAP is used for new vendors to review their marketing plans, potential performance claims, and the requirements to assemble data sets. There is a modest cost of less than $10,000, but many times it is done at a cost of $3,000 to the vendor. In some cases, this review is provided before the vendor submits a preliminary application to the program. The understanding is that the data sets must be defensible; they must have been developed by an independent third-party laboratory. A chain-of-custody for the sampling and testing procedure is required. ETV Canada ensures that the test methods being cited are for test methods for which that laboratory is accredited. The VE reviews the analytical assumptions.

Teresa Harten commented that she was interested in the presentation by Tammy Lomas-Jylha on municipal solid waste treatment that might be applied to sewage. In the new ETV ESTE program, a proposal was received for biosolids treatment. If the test is done, it would be good to follow up with the vendor from the ETV Canada program. Tammy Lomas-Jylha responded that the vendor was very interested in looking at other technology applications. Teresa Harten suggested that this might be an opportunity for a co-verification. John Neate agreed and identified the vendor as International Bio-Recovery Corporation (IBR) located in Vancouver, Canada. Their Enhanced Auto-Thermal Thermophilic Aerobic Digestion is a fairly conventional technology, but it has a number of applications. ETV Canada approached the vendor on the animal manure application. The vendor asked what ETV Canada's relationship was with the U.S. EPA ETV Program. There is a huge market in the United States and the vendor would probably be enthusiastic to work with the U.S. EPA ETV Program. NSF has an accredited laboratory in Vancouver, which was involved in the IBR verification done by ETV Canada. John Neate offered to discuss the possibility of a co-verification with IBR and Environment Canada. Teresa Harten asked if the technology used land disposal for the end product. John Neate responded that they use it as a fertilizer, and there is an energy recovery component from it as well.

PANEL/ROUNDTABLE SESSION

Dennis Cunningham, Southeast Asia Program Manager, U.S. EPA OIA, served as the session chair for this panel/roundtable session. He has had a long history with the U.S. EPA ETV Program. He used to manage EPA's International Technology Transfer Program, and he attended the first ETV International Workshop in 2000.

Before coming to the forum today, he attended a meeting with a group from Indonesia, who commented that they were testing a number of new air monitors. They found that the vendors, who were mainly from Europe and North America, made certain claims about their technologies but they had never accounted for the use of these technologies in a consistently hot, humid and rather corrosive climate. In the initial tests, the technologies did not live up to the vendors' claims. They had not heard of the U.S. EPA ETV

Program, and he provided them with information and literature on the program. It is a good reminder that technology suppliers should take into account the needs of developing countries and the circumstances under which the technologies might be operated outside of the countries where they were developed.

Dennis Cunningham introduced the following panel members:

- ✧ United States – Joseph Ayoub, Team Leader, U.S. DOC (substituting for Carlos Montoulieu)
- ✧ Canada – Abe Finkelstein, Chief, Innovation Solutions Division, Environment Canada
- ✧ Korea – Yeom Sang-Ug, Chief Manager, EMC, Korea MOE
- ✧ Japan – Kenji Kamita, Deputy Director, Office of Environmental Research and Technology, Environmental Policy Bureau, Japan MOE
- ✧ Singapore – Tay Joo Hwa, Head of the Unit, IESE
- ✧ Teresa Harten – Director, U.S. EPA ETV Program
- ✧ European Union – Andrea Tilche, Head of the Environmental Technologies and Pollution Prevention Unit, European Commission, Directorate General for Research

The three topics for discussion are:

- ✧ Topic 1: Identifying technologies of mutual interest and international relevance.
- ✧ Topic 2: Developing internationally relevant verification protocols.
- ✧ Topic 3: Other mechanisms for fostering international verification efforts.

Dennis Cunningham asked each of the panel members to make a few introductory remarks.

Andrea Tilche stated that he was very pleased to participate in this conference. The European Commission is studying the possibility of launching an ETV system in Europe. His participation at the conference was to learn about the different ETV programs and their best practices to possibility apply to a scheme for the European ETV program. There were many positive aspects of the programs presented, but he would have liked to hear about the problems. His presentation included a slide on what the system should and should not be. After hearing all of the presentations, it is evident that the ETV systems are complex. To achieve credibility of a system, a certain level of complexity must be introduced. If the system is too complex, it may discourage the participation in the program or raise the costs and make the system unsustainable in the long term.

Kenji Kamita suggested that atrazine monitoring could be a good place to start in comparing testing protocols with other ETV programs as the beginning of information exchange. There were no other technology categories that were close enough to the technology categories used by J-ETV. Although the

greenhouse gas effect is one of the largest environmental issues in Japan, greenhouse gas technologies are somehow verified in many other projects that have a larger budget than J-ETV. Vehicle emission reduction retrofits are under the Ministry of Land, Infrastructure, and Transport (MLIT), which has a certification program. There is no government funding for waste technology verification, for there is a private verification program for these technologies. Dioxin had been a big problem in Japan, but it is no longer a problem because they achieved the target of 90 percent reduction of national dioxin emissions. Mutual participation in each other's stakeholder meetings would promote collaborations among the different ETV programs; however, for Japan, it would be very difficult because of the language barrier. Kenji Kamita introduced Professor Koji Arizono of the University of Kumamoto, who is the Chair of the Working Group that developed the protocol for simplified chemicals monitoring technologies, including atrazine. Professor Koji Arizono stated that the Society of Environmental Toxicology and Chemistry (SETAC) North America 26th Annual Meeting will be held on November 13-17, 2005, in Baltimore, Maryland. If there will be booths or opportunities for presentations at this meeting, he would be happy to discuss Japan's activities and exchange information.

Abe Finkelstein thanked Teresa Harten and Evelyn Hartzell (U.S. EPA ETV Program) for inviting Environment Canada and ETV Canada to the forum. The Canadian team has found the discussions and presentations to be very informative, and they anticipate that there will be opportunities for future collaborations. Environment Canada is responsible for a number of government support programs. They also support the Canadian Environmental Technology Advancement Centres (CETAC), which are incubator organizations. ETV Canada is part of one of the incubator organizations.

Abe Finkelstein addressed Topic 1: Identifying technologies of mutual interest and international relevance. They look at it in terms of where the money flows. It is easy to see where Canada looks at technology innovation and where the money should be going. One recently announced area is greenhouse gas capture and reduction technologies including renewables, which has about $800 million budgeted for the next few years and tax incentives of $1 billion for renewables. Another area is water and wastewater technologies. In two of their key programs, Sustainable Development Technology Canada and the Green Municipal Fund, $250 million is allocated to support technology innovation. Over the next three years, $250 million is allocated for research, technology demonstration, and commercialization for clean soils technology for contaminated sites and brownfields remediation. Another important area is clean air technologies, including transboundary area issues between Canada, the United States and globally, looking at mercury, and acid rain. They have allocated $100 million to support technology demonstrations in this area.

Abe Finkelstein addressed Topic 2: Developing internationally relevant verification protocols. He stated that it was important to come up with a common term for a generic verification protocol. They would like to develop a road map to verification of all technology categories. They want to identify the key criteria for all technology categories. Some of the criteria could include: demonstrate environmental benefits, be based on sound scientific and technical principles, be supported by peer review, be independent and third-party witnessed, conform to all health and safety standards, use chain-of-custody and reflect operational realities. This forms the foundation for all verifications in Canada. Technology-specific protocols could be stakeholder-based in areas of priority interest. For Canada, it is water, energy and soil using benchmarking. Another key area in Canada is to look at environmental issues not so much from a media-specific basis, but from a multi-media approach to look at environmental impacts. For example, in dealing

with the automotive sector, what is the complexity of environmental issues dealing with air, discharges, etc.? They are looking at multi-sector communities to address this area. Clean coal is also a priority area for Canada.

Abe Finkelstein addressed Topic 3: Other mechanisms for fostering international verification efforts. The discussions at this forum have indicated a lot of interest in moving in this direction. He suggested establishing an international working group made up of ETV program organizations to share protocols, test methods and data. This working group could be used to explore criteria for establishing an international network of mutually recognized, accredited verification entities and reciprocal agreements. It might be possible to establish, through a recognized world body such as UNEP or the World Bank, a Web site of ETV-verified technologies to facilitate the transfer of technology solutions to address global and environmental priorities, especially for use by developing countries. The U.S. ETV International Forum initiative can be built upon by organizing annual information exchanges.

Abe Finkelstein stated that Canada developed a reciprocal agreement with California EPA. They conducted pilot verifications whereby ETV Canada verified some of the technologies verified by California EPA, and California EPA verified some of the technologies verified by ETV Canada. Each government had specific criteria important to their jurisdiction. Through the process, they determined that approximately 80 percent of the evaluations were useful to both jurisdictions. A technology going from Canada to California would not require a 100 percent reassessment of all of the data—only a portion of the information had to be reassessed. That reduced the cost and time for a company to go reciprocally between Canada and California.

Teresa Harten stated that the forum has been very valuable and far exceeded her expectations. She thanked all of the panel members, speakers and participants for their contributions to the forum. In each of the ETV program's presentations, there were areas of potential collaboration for the U.S. EPA ETV Program. For each of the EPA ETV Program's centers there were potential collaborations in the areas of air, water and greenhouse gas. The presentation from UNEP on water conservation, and what developing countries needed, linked up with what they have been hearing from the U.S. EPA Program Offices as directions that the U.S. EPA ETV Program should pursue. The U.S. EPA ETV Program is linking more closely with the high-priority Agency needs, such as the new ESTE Program that is starting in 2005. Hopefully, the ESTE areas will intersect with what the other countries are interested in. A number of the items on the list that Abe Finkelstein mentioned would be of interest to the U.S. EPA ETV Program. The question on protocols is very closely related to the question on the technologies of interest, and the protocols for those technologies of interest would be prioritized by the U.S. EPA ETV Program. The program is thinking about the ISO process and will be getting more information from EPA personnel involved in ISO. They would like to get feedback from vendors about how valuable the ISO process might be to them, given that it might take a long time. Is it valuable to have an internationally recognized verification if it would come through an ISO-like process? One of the barriers of the U.S. EPA ETV Program is accreditation for laboratories. One of things that has been limiting in the number of verifications that can be completed, at least according to vendors in the diesel retrofit area, is that there is only one test laboratory that is used.[1] It is very expensive for the program to qualify other testing

[1] ETV APCT later clarified after the forum that they have not reached capacity at the current qualified testing laboratory.

laboratories. Having an external body accrediting the laboratories is something that would help the U.S. EPA ETV Program and its ability to work with programs in other countries. Teresa Harten stated that she agreed with many of the ideas that Abe Finkelstein presented.

Joseph Ayoub stated that the discussions at the forum have been on how the technologies are verified, the ways in which the different programs can learn from each other, and how an international standard might be developed and adopted in the future. From a trade standpoint, this is important because of competitiveness. It is the focus that the DOC takes when they look at the U.S. trade relationships with their trading partners. When U.S. environmental technology companies have their technology verified, those companies will be more competitive in the international markets than the companies that are not having their technologies verified. That is why it is critical that there is a U.S. ETV program and why this forum is useful to the extent that other countries are able to show how they have verification programs and why their technology can be seen as more competitive when they are also looking abroad to other markets. Another important issue when it comes to trade relationships is that of standards. To the extent that standards can be agreed upon internationally and they are understood by our trading partners, it enables technologies that are of high quality to be appreciated by other trading partners. From a U.S. market perspective, 55 percent of environmental technologies go to markets in the European Union, Canada and Mexico. If Japan is added, then it is 62 percent of all U.S. environmental technology exports. These countries continue to be the primary trading partners of the United States in this sector because there are developed markets and there is a strong emphasis on the need to address environmental issues. There are many growing markets, particularly in Asia (China, Singapore, Taiwan, India, Korea), that recognize the need to address environmental issues and compare their development to the ability to remediate or reduce the environmental impact that the development is going to entail.

Joseph Ayoub commented on the technologies that would be important to link to verifications. In terms of ranking the technologies, water and wastewater treatment technologies are at the top of the list because 40 percent of the global market is for water and wastewater treatment. There is a strong link between being able to provide clean water and health and social development. The second area is air pollution, which is an important issue as a country develops and industrializes. Many countries are recognizing that air pollution has a negative economic impact if it is not addressed. To the extent that workers are suffering health problems related to poor air quality, it reduces a country's ability to grow their economy and bring prosperity to more of their people. The next area is the issue of clean energy, energy efficiency and renewable energy. This has to be addressed in order for the world to continue to grow at the rate it is growing without negative consequences for human health. Efficiency is staggering when you think about how much is wasted and what can be done to address it. As we use energy more efficiently, the more we get out of the energy for less pollution or less emissions. In fact, a U.S. DOE study showed that if all Americans had their automobile tires inflated at the proper air pressure, approximately 1 million gallons of gas per day could be saved. U.S. companies are looking to become more involved in renewable energy in the future. Some of the larger companies have been exploring getting into these areas (e.g., General Electric just acquired a wind company and a water company). Lastly, there is waste minimization and ways to use the byproduct of one production process as an input to another production process. For example, flyash can be captured from a coal-burning power plant and it can be used to make drywall, which results in a greatly reduced impact on the environment.

Yeom Sang-Ug stated that it is very important for the international verification organizations to cooperate with each other, not only for enhancement of each individual ETV program, but also for promotion of the effectiveness of international verification systems. This will require time-consuming efforts to establish an international verification system. Before work is begun to develop this system, some conditions should be met. An exploration of each ETV program should be conducted, including the intention of the program, because the protocols are developed in response to the purpose of each ETV program. For example, the ETV program in Korea has been established to propagate environmental technologies and promote environment-related industry by the government. There is a need to induce the active participation of many interested countries or parties to develop international verification protocols. There should be incentives or benefits to the member countries for participation.

Tay Joo Hwa stated that the interest in environmental technology should be generated from the needs of a particular country, as well as the economic situation of the country. It is very difficult to generalize what the environmental technology requirements are worldwide. The United States and Canada have different requirements than China and India. We cannot generalize and say that there is one specific technology that we can generate that is of interest worldwide. Countries with similar situations, economically and culturally, and needs can generate their own interests. The one technology that can generate interest worldwide is water security technology. There has been a lot of discussion about international collaboration. If there is a wish and a will, then it should be done. The development of an ISO process might be a good place to begin. Some years ago, some countries started ISO systems for environmental management systems. At that time, no one agreed that we should have the system internationally. Now, it has become the most important ISO standard (ISO 14,000) that every country must follow. The ISO procedure is lengthy, and it will take much time and effort to develop it. The U.S. EPA started their ETV program 10 years ago, and now we have this meeting with participants from 14 different countries. It may take 20 years to develop and implement the ISO procedure for the verification system, but if we do not make the first step toward the main goal we will never reach it. He suggested that they start small, possibly with establishing an international working group to keep the forward momentum, and to begin working on the ISO system. Having representatives from 14 different countries attending this meeting is not a coincidence; there is great interest in developing an international ETV verification system.

Dennis Cunningham thanked the panel members and opened the session to questions from the audience. He stated that he works with developing countries and asked what would be the best way to involve these countries in the development of test protocols and testing priorities, and incorporate their opinions.

Tom Wagner, U.S. EPA, complimented Tay Joo Hwa on his comments on the ISO system and what needed to be done to develop an international ISO standard. It can be a long, slow process, but part of it is being done in the baghouse area. There is a specification for the ISO already under way in the U.S. EPA ETV GHG Center. The ISO system may not be appropriate for every protocol or verification that is conducted. The EPA person responsible for the Agency's ISO efforts is Gary Johnson; he has been contacted and he is willing to work with any group that is formed on this issue.

Andrea Tilche, European Commission, commented that they are convinced of the need to go toward with some type of standardization mechanism. That may involve the development of a generic guideline, which could define the framework conditions under which any protocol or testing has to be carried out. The ISO 14,025 for product declarations already contains something similar as it describes how vendors

have to produce data for environmental performance of products. This is seen under a life cycle framework. Once you have something like this as a starting point, this makes it easy for any verification organization to verify data that are produced by a vendor following a certain agreed standard. This is the direction that we should follow. We also need to obtain an international mutual recognition of the system. There are other existing ISO standard systems that could be used.

John Neate, ETV Canada, commented that he supports the suggestions that have been made. However, much of what they are doing in the verification area is "pushing the envelope." There are some very complex issues that require a stakeholder process and that are not yet ready for an international standard. In some cases, the methodologies and test methods used are already derived from ISO standards, or in many cases could be derived from ISO standards. There also are cases where the technology is innovative and we do not have a full comprehensive understanding of it. On the other hand, there are developing countries that may not want to go as far for what they need. There may be user groups who want to treat 80 percent of the problem at 20 percent of the cost versus 99 percent of the problem at 100+ percent of the cost. One the attractions of the verification concept is that it is "pushing the envelope" in a variety of ways, but we eventually have to incrementally move toward uploading those things that become established and well-known and are better managed in the realm of an international standard. We could then focus attention back on to the things where we need to be more innovative.

Teresa Harten, U.S. EPA ETV Program, asked whether the group wanted to establish a working group to develop a generic verification protocol. Abe Finkelstein suggested starting small. The elements of a working group are at this meeting in the representatives of the 14 countries that are here. There are probably other countries that might be interested in participating. He suggested that the first step should be to start putting together the working group through e-mail and other mechanisms. The ultimate end of the activities of this working group could be to generate a new ISO standard or use some of the existing ISO standards. Teresa Harten asked if there was a volunteer for a lead organization. As no one volunteered, she suggested that one alternative would be to alternate the lead country every couple of meetings. Joseph Ayoub, U.S. DOC, offered to work with Teresa Harten on setting up the working group.

John Neate, ETV Canada, asked whether the outcome of this meeting would be a report. From what he has heard at the meeting, there is going to be a concerted effort to sustain some sort of a working group. He stated that Canada might be able to host the next meeting, possibly in Vancouver. Teresa Harten stated that a report of the minutes and action items will be prepared and finalized within a few months. An ETV outreach workshop was held in May 2005, and the report from that meeting is one of the ten most popular documents on the ETV Web Site.

Abe Finkelstein stated that Canada hosts a biannual conference, the Globe Series, which will be held in Vancouver on March 29-31, 2006. ETV Canada and the U.S. EPA ETV Program will be attending, along with a large attendance from Asia. This may be an excellent forum to organize a pre-forum event to look at some of the issues discussed at this meeting.

Max Diaz, U.S. EPA, asked what was being done to engage large companies such as Exxon and General Electric. Teresa Harten responded that different groups are contacted in the private sector on a case-by-case basis for each environmental category that is undertaken for verification. Sometimes they participate on stakeholder groups. There is no programmatic strategy for engaging these large companies.

Teresa Harten thanked everyone for their participation in the meeting. She also thanked Evelyn Hartzell for organizing the forum and the members of the planning committee.

The meeting was adjourned at 4:30 p.m.

POTENTIAL ACTION ITEMS AND SUGGESTIONS

- ✧ Teresa Harten (U.S. EPA ETV Program) will follow up with William Mansfield (UNEP) on this offer to have UNEP, through its International Environmental Technology Centre (IETC) participate in technical discussions on how to move forward on a technology verification program.

- ✧ Consider scheduling a monthly conference call with one representative from each of the ETV programs to continue the dialogue.

- ✧ Tom Stevens (U.S. EPA ETV WQP Center) will contact the International Society for Trenchless Technology.

- ✧ Amy Dindal (U.S. EPA ETV AMS Center) and Kenji Kamita (J-ETV) will explore the possibility of exchanging and comparing protocols for the atrazine monitoring technology that was verified by both of the programs.

- ✧ Teresa Harten and Professor Tay Joo Hwa (IESE) will explore the possibility of a collaboration between the United States and Singapore under the U.S. EPA ETV Program to demonstrate a dioxin CEM system in Singapore. (Update: IESE's proposed dioxin destruction demonstration did not receive final approval and this action item has been put on hold.)

- ✧ Teresa Harten and John Neate (ETV Canada) will explore the possibility of a co-verification on biosolids treatment.

- ✧ Consider atrazine monitoring as a place to start in comparing testing protocols with other ETV programs as the beginning of information exchange.

- ✧ Teresa Harten and Joseph Ayoub (U.S. DOC) will begin the work to establish an international working group made up of ETV program organizations to share protocols, test methods and data, and to develop ISO standards in the future. (Update: DOC budget and staffing limitations will prevent further action on this item in FY 2006.)

- ✧ Consider the possibility of establishing, through a recognized world body such as UNEP or the World Bank, a Web site of ETV-verified technologies to facilitate the transfer of technology solutions to address global and environmental priorities, especially for use by developing countries.

- ✧ Teresa Harten will distribute the draft report of the minutes and action items resulting from the ETV International Forum. The final report will be posted on the U.S. EPA ETV Web Site.

- ✧ John Neate will take the lead in planning the next ETV International Forum in Vancouver, Canada, in March 2006.

U.S. Environmental Protection Agency (EPA)
Environmental Technology Verification (ETV) Program
ETV International Forum

July 13-14, 2005
Washington, DC

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Environmental Technology Verification (ETV) Program
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