



U. S. Department of Energy



Clean Cities International
India Reverse Trade Mission
Trip Report

Prepared by:
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Washington, D.C.
October 6-11, 2002

The U.S. Department of Energy (DOE) Clean Cities International Program, with funding and organizational support from the Gas Technology Institute (GTI) and the U.S. Asian Environmental Partnership (USAEP), brought a delegation of four (4) Indians to Washington, DC to attend the Indian Reverse Trade Mission in conjunction with the 8th International and 20th National Conference and Exhibition of Natural Gas Vehicles (World NGV2002), October 6-11, 2002. This delegation was augmented by five (5) representatives from India and three (3) representatives from Bangladesh, sponsored by the U.S. Agency for International Development (USAID) South Asian Regional Initiative (SARI); four (4) representatives from Thailand sponsored by USAEP; and seven (7) representatives from the Philippines, sponsored by USAID and the USAID Mission in Manila.¹ This group was coordinated by Clean Cities International Director, Marcy Rood; Rebecca Dyer, U.S. Department of Energy; Clean Cities' consultants Julie P. Doherty and Nancy Checklick of Science Applications International Corporation (SAIC); Ira Dorfman, eMobility International; and Mark Perry, Gas Technology Institute. Additional support came from Maria Reidpath, James Ekmann, and Eric Bell of the National Energy Technology Laboratory.

All delegates were invited to attend a natural gas vehicle (NGV) training session sponsored by DOE and USAID and held at the offices of the Natural Gas Vehicle Association and American Gas Association. Those who were able to attend the class included some of the representatives from India, the Philippines, Bangladesh, and Bolivia.² Leo Thomason, President of the NGV Institute, taught a class, "Natural Gas Vehicle Fueling Facility and Safety Training." This one and one-half day course was designed with modules to cover 1) natural gas as a vehicle fuel; 2) properties and characteristics of natural gas; 3) NGV technology; 4) NGV fueling equipment; 5) NGV facility safety equipment and practices; 6) indoor vehicle maintenance; 7) indoor vehicle fueling; and 8) starting a NGV program.

The first full day of training covered the first four modules. Much of this information was introductory for the more advanced delegates from India, but very useful for the delegates from the Philippines as they begin to develop a NGV program. The Indian delegates dominated much of the first day with specific

¹ For a complete list of delegates' names and contact information, please see Appendix A. Delegate Contact Information.

² For a complete list of class participants, please see Appendix B. USDOE/USAID NGVI Class Participants.

technical questions pertaining to problems they have been experiencing (see conclusions section for Indian Concerns). This provided a forum for representatives from many sectors to flesh out their differing opinions on technology choices.

The second half-day long class was only attended by the Philippine delegates and provided them an opportunity to focus on learning technology options and designing a program to fit their needs.

Mr. Thomason volunteered to add a third supplemental session to address concerns that had arisen from the Indian participants during the first day of training and to compensate for their inability to attend the second half-day session due to other commitments. This supplemental session gave the Indian participants a more open forum to ask the instructor to address problems specific to the NGV Indian experience. All parties recognize and affirm the need for additional NGV training in India. Mr. Thomason expressed his interest in responding to requests for in-country training from representatives from India to Clean Cities International representatives.

All delegates were invited to a welcoming dinner held at the Heritage India restaurant, organized by Clean Cities International and sponsored by Cummins Westport and GTI. The director of Clean Cities International, Marcy Rood, introduced the delegations and welcomed them. Representative Charlie Kerr from Cummins Westport, joined by Ian Scott and Patric Oullette, spoke with delegates about products and opportunities with Cummins Westport.

Of the USAID-sponsored delegation from Manila, Philippines, six (6) representatives attended the technical tour of the Washington Metropolitan Area Transit Authority (WMATA) CNG refueling and maintenance facility. This group rode to the WMATA facility in two Honda Civic GX NGVs, lent courtesy of American Honda. The tour included a CNG bus, the fueling bay (almost completed), compression system, and maintenance facility.



WMATA has 170 CNG buses with New Flyer chassis powered by Cummins OEM dedicated CNG engines and an order for 250 more. Five buses are being built, powered by John Deere engines, donated by John Deere in an effort to increase market share. The fueling bay is designed to accommodate five buses and holds the CNG spherical storage system on its roof. The compression system has three compressors and a fourth is planned, and two dryers. The facility receives gas at 70-80 psi from a 12-inch pipeline extension off the Washington Gas pipeline and compresses the gas to 4600 psi. The maintenance facility has been retrofitted to meet standards for natural gas, including the addition of methane detection systems, explosive-proof lighting, skylights, and emergency shutdown systems.

WMATA quotes the cost of the CNG buses at \$325,000 versus \$275,000 for a diesel bus, and overall operating and fuel costs for compressed natural gas (CNG) buses at 20-30% higher than prior costs for diesel. However, the fueling costs for this facility also include a payment to Washington Gas for the new pipeline that delivers gas to the facility. Some Philippine representatives commented that the price (\$325,000) is cost prohibitive for fleet owners in Manila. A representative from California Bus Lines suggested that the horsepower (HP) of these WMATA buses (250 HP) was too large for Manila's needs and that perhaps something smaller (near 200 HP) would be more suitable and affordable.

Some of the Indian delegates participated in other tours, including a full day tour of Mack Trucks Macungie Assembly Operations where the company assembles six on/off road models, including CNG versions. There are over one million square feet at the Macungie plant, yet nothing looks so massive as the frame rails laid down to form the chassis of each new truck; and a half-day tour of Mack Trucks Hagerstown Powertrain Operations where Mack has over 150 engineers conducting engine testing and assembling engines, including CNG models.



All of the delegates attended the World NGV2002 held at the Omni Shoreham Hotel in Washington, DC. This conference and exhibition included technical tours of a manufacturing plant, an assembly plant, and a mass transit refueling facility; presentations on the U.S. and global NGV market and opportunities; and sessions focused on country reports, technology, and policy & commercialization.³ There was also a “Ride-n-Drive” program that offered conference participants test drives of various NGVs.

Highlights from the presentations included updates from Takeo Fukui, President of Honda R&D, on the new lineup of PZEV-rated vehicles from Honda (Civic GX and Civic Hybrid) and the FCX -- the first fuel cell vehicle certified by the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) that will be delivered to Los Angeles by the end of the year. Linda Fisher, EPA Deputy Administrator, showed examples of how NGVs have been the key to meeting emissions regulations in non-attainment areas by allowing new industry construction (and additional emissions) to be offset by the emission reduction benefits of NGVs, and thus fostering continued economic growth without increased pollutant emissions. Norma Glover, Chairman of the South Coast Air Quality Management District, announced a new program, the California Natural Vehicle Partnership, which pulls together stakeholders from federal, state, and local governments, manufacturers, fleet managers, fuel providers, and environmental organizations to develop strategies that will be transferable to the rest of the U.S. in R&D, awareness for policymakers, incentives, technical assistance, and public outreach for purchasing programs.

Highlights from the sessions included presentations given in the “Country Reports” sessions. Mr. Gandhi of the Society of Indian Automotive Manufacturers (SIAM) presented on the status of NGVs in India and gave statistics of vehicles in Delhi. He talked about future automotive designs that would move mounting of cylinders from the lower chassis to the rooftop. Mr. Bhanot of Automotive Research Association of India (ARAI), as a developer of certifications and standards, added comments about India by stating that the levels of particulate matter caused by the low quality of diesel fuel need to be lowered and NGVs can assist in that end. Mr. Kakar of Indraprastha Gas Ltd. (IGL) gave a breakout of refueling stations in India (see chart) and by March 2003, this total number will increase to 110.

	Mother	Online	Daughter Booster	Daughter	Total
<i>As of June 13, 2002</i>					
IGL	18	05	24	06	53
OMC	0	10	06	16	32

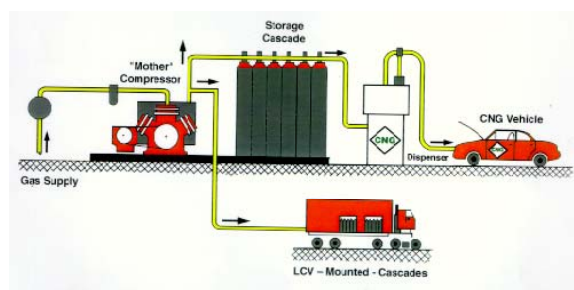
³ For a complete agenda of World NGV2002, please see Appendix C. Also see the website <http://www.ngvc.com/ngv/ngvc.nsf/bytitle/ngv2002.html>.

DTC	9	0	0	0	9
Total	27	15	30	22	94
<i>Planned for March 2003</i>					
IGL	35	07	19	0	61
OMC	0	12	19	0	31
DTC	18	0	0	0	18
Total	50	19	38	0	110

IGL - Indraprastha Gas Ltd.; OMC – Oil Marketing Companies; DTC – Delhi Transport Commission

To understand the difference between the stations, see diagram. Mother stations are connected to the pipeline and have high compression capacity. These stations supply CNG to both vehicles and daughter stations (through mobile cascades). The “Daughter Stations” dispense CNG using mobile cascades. Installing a booster compressor can eliminate drawbacks of daughter stations. Daughter booster (compressor) is designed to take variable suction pressure and discharge at constant pressure to the vehicle being filled with CNG. “On-line Stations” are equipped with a compressor with relatively small capacity.

CNG MOTHER STATION



Mr. Kakar also gave statistics of NGVs in India: more than 100,000 vehicles, 70,000 CNG vehicles alone in Delhi. IGL plans to invest additional USD 70 million in the next year to increase the compression capacity from the present level of 650,000 kg/day to 161,000 kg/day by June 2003. The cumulative expenditure on CNG will stand around USD 120 million. All 10,000 buses are supposed to run on CNG by Dec 2002. The chart below outlines the activities of 2002-03:

	CNG Buses	Other Vehicles	Total Vehicles	CNG Compression Capacity*(1000 kg/day)
Apr-02	4341	47000	51341	604
Oct-02	6141	53000	59141	899
Mar-03	7641	59000	66641	1351

*Compression capacity has been worked out with 18 hrs of operations of compressors in a day

Mr. Kakar also discussed plans for a national pipeline grid and natural gas imports by December 2003.

Another important session was on Policy & Commercialization with speakers from international aid and support programs, including Marcy Rood, U.S. Department of Energy Clean Cities; Gordon Weynand, USAID; Craig O'Connor, Export-Import Bank of the United States (Ex-Im Bank); Cornelius Huizenga, Clean Air Initiative for Asian Cities (Asian Development Bank); and Jitu Shah, World Bank. These presentations discussed what each organization can do to assist clean transportation development, through direct funding mechanisms, loans, and insurance; training; technical analysis and advisement, etc.

Of particular importance to our delegates, the interactive Ex-Im Bank presentation invited developing country conference participants to discuss project ideas with the speaker after the presentation. They informed that their programs provide the most attractive financing option for foreign small- and medium-sized firms to purchase of U.S. goods and services. The Ex-Im Bank also has project experience, for

example, with a direct loan of \$49.7 million to the sponsor Ormat Leyte Co. Ltd., to build, own and operate four geothermal plants 530km from Manila; and in China, they enabled Daisibi Environmental Corp. to win a \$5.2MM contract for air quality monitoring stations in 11 Chinese cities and provided a guarantee to the Bank of America who made the loan to the China Construction Bank who financed the deal for China's State Environmental Protection Agency.

The delegations from India and the Philippines each held meetings with Mr. Al Ebron of the National Alternative Fuel Training Consortium (NAFTC). These meetings discussed the potential for training on AFVs, and examples of classes and curriculum offered by NAFTC. NAFTC and SIAM currently have a training partnership in place and plans for a "train-the-trainer" program in January 2003. The delegates from the Philippines were interested in maintaining a relationship with NAFTC for possible future collaboration.

Conclusions

India

Indian Concerns that were voiced at the Natural Gas Vehicle Institute (NGVI) Training, in sessions and presentations, and conversations are summarized as follows:

- **Gas Pressure:** Often at Indian stations, the pressure is only up to 2400 psi and not the 3600 psi that the vehicles are designed to fill at, causing long fueling times.
- **Vehicle Inspections:** The U.S. requires annual emission tests. The program in India is not vigorous enough, possibly due to too few inspectors, less stringent monitoring, or poor scheduling of inspections.
- **Correct Conversions**
 - **Diesel to NG:** In the early 1990s, conversions on transit buses used Italian bi-fuel kits, but the CNG fuel caused high RPMs but not when idling which is when it is needed the most for buses. Now, new Caterpillar engines with fuel injectors use diesel to ignite the NG; and most others are spark-ignited OEMs derived from diesel engine designs. However, the addition of cylinders (and their weight) has affected other parts of the vehicle, e.g. increased brake wear and clutch wear. A solution would be found in the transmission system - different shift points are found on NG engines. Overall, re-powering the engine requires addressing the entire powertrain.
 - **Emissions:** In India, some conversions have been incorrectly done with an open loop system and an oxidation catalyst that releases more NOx emissions. Conversions need to have a closed loop system with feedback and a catalytic converter, and proper maintenance to accurate conversions are required to keep from burning through the catalytic converter.
 - **Cylinders:** Indians made requests for information on cylinder mounting standards. They also expressed frustration with mounting brackets sold separately from the tanks.
 - **Temperature:** Some conversions complain of a hotter driver compartment due to the higher combustion temperature of NG. These conversions were done incorrectly and note the requirement of adjustments to the cooling system as well.
 - **Vehicle Selection:** General complaints related to converted vehicles point to the importance to match the use of the vehicle to the use of the fuel because there are changes in fuel efficiency, power, emissions, and range.
- **Fuel Quality:** The percentage of methane in natural gas in the U.S. is usually 89% or more. The percentage of methane in natural gas in India is more variable and there are concerns that these other components can affect combustion temperature and air mix ratios. Also, questions about the proper amount of oil in NG to lubricate the injectors were raised (70 ppm suggested).

- **Gas Odorants:** Odorants need to be added to NG. In the U.S., mercaptan is added twice, once by the producers and again by the utilities. India adds mercaptan to LNG and is looking to determine an odorant for CNG and have in place by the end of the year.
- **Power:** Indian concerns question sacrificing power with NG conversions. The trainer informed about a study by Baytech that documented an OEM gasoline engine converted to NG that recorded higher horsepower with the NG fuel.
- **Fueling Pumps:** Indian fuel pumps do not all have breakaways as safety devices on pump hoses (fueling and recapture hoses). They also find higher rates of o-ring deterioration, reasons debated as due to a dustier environment, NG contaminants, or lack of proper refueling training to vehicle operators.
- **Fueling Times:** Indian refueling stations find that the receptacle size(s) does not change/improve refueling times. Informed that different refueling systems required for different vehicles (light duty vs. transit).
- **Station Systems:** India still has a “mother-daughter” station system because of lack of pipelines and infrastructure. These stations use 60-70% of storage and experience pressure drops and causes long lines, because use should be closer to 40%. Suggestions for improvement included: tube trailers with small compressors that can be replaced by stations when a fleet grows and gas arrives into that area served. Poorly designed stations can be fixed. Overall, a full assessment is required to design the compressors, pumps, and storage needed for the number and type of vehicles that require servicing at specific intervals.
- **CNG Demand:** Many project plans are based on the demand of the product and could become unviable if the predicted demand does not materialize.
- **Station Location:** Land acquisition for stations requires multi-stage approvals from multiple agencies. There is no single land-allotting agency in Delhi to direct this infrastructure development and procedures for station location needs to be standardized, centralized, streamlined, and with expert technical advice.
- **Safety Guidelines:** The Central Committee on Explosives is the approving agency for developing safety guidelines. This is a top priority in AFV program development.

Clean Cities International will use these concerns to develop ways in which it can assist India in program development. For example,

1. Clean Cities International will communicate these concerns with NAFTC to support the training partnership with SIAM;
2. Clean Cities International will coordinate between NGVI and parties in India to assess potential for training collaboration;
3. Clean Cities International will continue to share information with parties in India, such as technical analyses, U.S. NGV product guides, etc.

Thailand

1. Clean Cities International representatives will follow-up with representatives in Thailand regarding the potential collaboration on information sharing efforts.

Bangladesh

1. Clean Cities International will work with USAID and ASG Renaissance to provide training support for NGVs in Bangladesh.

Philippines

1. Clean Cities International will continue to explore the development of a Clean Cities program in Manila.
2. Clean Cities International will investigate coordinating training programs in support of Philippines NGV development.

Appendix A. Delegate Contact Information

India Delegation

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Based in Pune, ARAI was a research organization formed by the Indian Automotive Industry, affiliated to the Ministry of Industry, Government of India. Serves as a key testing and certifying agency, under the Union Ministry of Industries. Has approval authority for Indian emission and safety standards. Developed the "CNG Code of Practice" and "LPG Code of Practice" for India.

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One of India's leading manufacturers of commercial vehicles. In June 1999, DTC launched first CNG bus by Ashok Leyland. Following a trial batch of ten CNG buses, another 100 will join the DTC fleet soon.

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SIAM is the apex national body representing the leading vehicles and vehicular engine manufacturers in India. SIAM plays a proactive role on all issues promoting the sustainable development of the Industry. It is an important channel of communication for the automobile industry with the Government, national and international organizations. It disseminates information concerning automobile industry through publications, reports, seminars and conferences.

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The Central Institute of Road Transport (CIRT) was established in 1967 as the joint initiative of the then Ministry of Shipping and Transport, Government of India, and the Association of State Road Transport Undertakings (ASTRU). ASTRU represents State Transport Undertakings, which operate about 110,000 buses all over the country and employ nearly

800,000 workers. The main aim of CIRT is to help in improving the quality of public transport through management development, research, testing and consultancy activities.

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Bajaj is currently India's largest two and three-wheeler manufacturer and one of the biggest in the world. Bajaj developed CNG and LPG 4-stroke 3-wheelers in the last two years and over 15,000 vehicles are already on road. Bajaj Auto has an ongoing demonstration program for electric vehicles involving USAID.

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Hindustan Motors Limited manufactures and sells passenger cars, commercial vehicles and earthmoving equipment. On-road automobiles accounted for 70% of fiscal 2000 gross revenues.

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Tata Engineering is India's premier and the only fully integrated automobile manufacturer. It is among the world's top ten commercial vehicle producers. It has manufactured CNG version of buses and followed it up with a CNG version of its passenger car, the Indica.

Philippines Delegation

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An operating bus transport company in Manila with interest in natural gas buses.

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An operating bus transport company in Manila with interest in natural gas buses.

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At present three companies transmit and distribute gas in their respective operating areas, including Titas Gas Transmission and Distribution (T&D) Company Pvt. Ltd., a subsidiary of the Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), a semi-government body. This is the oldest gas marketing company of the country. The company currently operates a network of 7391 km pipeline, which includes 735 km transmission, 356 km distribution and rest feeder mains and service lines.

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A subsidiary of Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), RPGCL was organized as a company to convert vehicles to compressed natural gas (CNG) and to popularize the use of CNG. Later, the company was also given the responsibility of extracting LPG from the wet gas stream, and refining for bottling and marketing.

South Africa Delegates

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PTT is Thailand's only fully-integrated gas company while having a leading position in the marketing and trading of various crude oil, refined petroleum products. In addition, through interests in associated companies, PTT has invested in Thailand's petrochemicals and refining industries.

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Kasetsart University was established on 2 February 1943, has established 7 campuses distributed to cover all regions of Thailand, and at present the number of enrolled students at all levels of study is 23,000.

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Operating under the jurisdiction of the Ministry of Transport and Communications, the Bangkok Mass Transit Authority (BMTA) is charged with providing bus service to people living and working in Bangkok and the nearby provinces

Bolivian Delegation

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Bolivia's hydrocarbon pipeline transport company

Clean Cities Representatives

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Modeled after the U.S. Department of Energy's Clean Cities Program, Clean Cities International is using its experience in North America to help international communities realize the benefits of alternative fuel vehicles. Clean Cities International works with governments, organizations, and individuals to help them establish foundations for viable alternative fuel markets.

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GTI provides energy and environmental products and services with a focus on natural gas. Programs of this kind allow organizations to out-source all or part of their technology function and implement technology solutions to gain competitive advantage.

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GTI provides energy and environmental products and services with a focus on natural gas. Programs of this kind allow organizations to out-source all or part of their technology function and implement technology solutions to gain competitive advantage.

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Blue Energy & Technologies LLC is an independent, clean transportation fuels and technologies company providing economically and environmentally compelling natural gas vehicle (NGV) fuels and related alternative motor fuel products and services.

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The South Asia Regional Initiative for Energy Cooperation and Development (SARI/Energy) promotes mutually beneficial energy linkages among the nations of South Asia to help unlock the energy potential of South Asia, focusing on Regional Energy Trade and Exchange; Regulatory and Tariff Policy Reform; Private Sector Involvement; Rural Energy Supply; and Energy Efficiency. Participating nations are: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka.

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ANGI International is a world leader in the compressed natural gas (CNG) refueling industry. A specialized team of sales and engineering experts work with each customer to analyze and define specific conversion and refueling needs, prepare station sites, and coordinate compliance to standards and codes.

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Helios International Inc. is an engineering consulting and marketing firm specializing in the advancement of clean alternative fuel technologies in the transportation sector.

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Cummins Westport Inc. is a joint venture between leading diesel engine manufacturer Cummins Inc. and alternative fuels engine technology company Westport Innovations Inc.

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The Natural Gas Vehicle Institute (NGVI) is North America's leading provider of training and consulting services on subjects related to natural gas as an alternative vehicle fuel. NGVI's services and programs address the full range of alternative vehicle fuel issues - from building and maintaining a fueling station to adding NGVs to your fleet to mapping a Clean Cities Program.

Appendix B. USDOE/USAID NGVI Class Participants

Day 1: Full-day Training

Indian Delegation

Mr. Balraj Bhanot, Automotive Research Association of India (ARAI)
Mr. M.K. Chaudari, Automotive Research Association of India (ARAI)
Mr. Ramasami Devarajan, Ashok Leyland, Ltd.
Mr. K. K. Gandhi, Society for Indian Automobile Manufacturers (SIAM)
Mr. A.S. Lakra, Central Institute of Road Transport (CIRT)
Mr. Ashok Saxena, Bajaj Auto Ltd.
Ms. Deepti Singh, Society for Indian Automobile Manufacturers (SIAM)
Mr. S. Venkataraman, Hindustan Motors Limited
Mr. Shrawan K. Vikram, Tata Engineering & Locomotive Company, Ltd. (TELCO)

Philippines Delegation

Mr. Francisco Benito, Philippines Department of Energy
Ms. Teresita Borra, Philippines Department of Energy
Mr. Edwin C. Cutiongco, California Bus Lines
Ms. Cecilia Dalupan, USAID/Manila
Ms. Arlene Donaire-Paminutuan, Academy for Education and Development
Mr. Dionisio Llamas, California Bus Lines
Mr. Clovis Tupas, Philippines Department of Energy

Bangladesh Delegation

Mr. Ali Nurallah, Rupantarita Prakritik Gas Company Limited

Bolivian Delegation

Fernando Navarro, Transredes, S.A.

Clean Cities Representatives

Marcy Rood, U.S. Department of Energy
Rebecca Dyer, U.S. Department of Energy
Julie Doherty, Science Applications International Corporation (SAIC)
Nancy Checklick, Science Applications International Corporation (SAIC)

Other Private Sector Representatives

John Ingersol, Helios International, Inc.

Day 2: Half-Day Training

Philippines Delegation

Mr. Francisco Benito, Philippines Department of Energy
Ms. Teresita Borra, Philippines Department of Energy
Mr. Edwin C. Cutiongco, California Bus Lines
Ms. Cecilia Dalupan, USAID/Manila
Ms. Arlene Donaire-Paminutuan, Academy for Education and Development
Mr. Dionisio Llamas, California Bus Lines
Mr. Clovis Tupas, Philippines Department of Energy

Day 3: Supplemental Training

Indian Delegation

Mr. Balraj Bhanot, Automotive Research Association of India (ARAI)

Mr. M.K. Chaudari, Automotive Research Association of India (ARAI)

Mr. Ramasami Devarajan, Ashok Leyland, Ltd.

Mr. K. K. Gandhi, Society for Indian Automobile Manufacturers (SIAM)

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