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the cairo air improvement project
helping millions live healthier lives

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About this report

This report is about what works, and what does not, in addressing a tremendous threat to sustainable development, air pollution in one of the world's mega-cities. It is about what we accomplished and what we learned from this project, and it is an invitation to learn from our experience.

This report is about impact and how it was achieved. It seeks to answer the most important question of all: how has our work improved people's lives? We urge you to share the answers — with other practitioners, with counterparts, and with beneficiaries.

We hope you will want to read this report in its entirety. Those wanting to start with a short introduction to project impacts and activities can turn to "CAIP by the Numbers" and the "In Brief" summaries accompanying each chapter.

A complete copy of this report is also available on CD.

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Project Overview and Impact

Cairenes are well aware that there is an air pollution problem in their city of 16 million. Doctors report more frequent complaints during periods of higher pollution, especially among children and the aged. School teachers ask whether children should be kept inside on "bad air" days. Parliament presses the experts for explanations and solutions. Press coverage of the issue is sometimes a daily occurrence.

There is hard evidence demonstrating the seriousness of the problem. A USAID-funded comparative risk assessment, completed in 1994, estimated that as many as several thousand people could lose their lives to Cairo's air pollution each year. A 2002 World Bank analysis described the economic cost. According to that assessment, air pollution surpassed all other environmental problems in its severity, draining an estimated $2 billion annually from the economy.

Fortunately, the situation has begun to change. Tons of pollutants have been removed from Cairo's air in the last several years. Through the partnership of the US Agency for International Development and the Egyptian Government, Cairo has put in place reforms that will support healthier lives without curtailing economic growth.

Cairo's Air — a powerful driver

As early as the 11th century, Cairo was subject to periods of serious air pollution[1]. Its location in the Nile river valley and local weather patterns compound an already dusty environment at the edge of the desert. In recent decades, rapid population growth and economic development have loaded the air with a range of pollutants. Vehicles, industry,

[1] Ibn Ridwan, an 11th century physician, reported that "In the evening….a troubled, blackish vapor hangs over the city. The dust, which is irritating to the throat, is particularly thick when there is no wind in the air". From: *Cairo, The City Victorious*, Max Rodenbeck, 1998.

and the open burning of wastes are the main causes. Lead and fine particulate matter have been tagged as the most dangerous pollutants. During the mid-1990s, levels of lead in Cairo's air were more than 30 times international limits, while some workers were exposed to levels 500 times occupational norms. At the same time, residents of the city were exposed to particulate matter levels up to 10 times the legal standard. World Health Organization information showed Cairo among the worst of developing country cities.

If the environmental challenges facing Egypt resemble those in the rest of the world, Egyptian officials have not been daunted. Rather than neglect them, the Government of Egypt decided to tackle the risks of air pollution head-on. Their policy imperative: improving health. With USAID, Egypt developed a program that would be the first donor assisted effort to directly address the Cairo air pollution problem.

The Cairo Air Improvement Project — an ambitious scope

From the beginning, officials acknowledged that the Cairo Air Improvement Project would only begin to address Cairo's air quality problems. Those who know the history of environmental health programs in other major cities understand that with close attention, the problems take decades to resolve. Still, the project's scope was ambitious: "CAIP is designed to include activities that have some immediate impacts on reducing vehicular emissions and lead while setting the stage for a long term effort through demonstrations and pilot tests of alternative technologies and increased public awareness."

Targets for interventions were the 1.5 million vehicles that ply the streets of the capital, and industrial sources of lead, namely factories smelting lead scrap. Lead smelters became the top source of this toxic metal following the government's aggressive move to eliminate lead from gasoline beginning in 1997.

While CAIP was designed and began before Egyptians started noticing serious air pollution episodes (labeled "the black cloud") in the fall of 1999, its activities were completely consistent with a strategy to address this more recent priority. In addition, specific tasks supporting episode management and reduction were added as the project progressed.

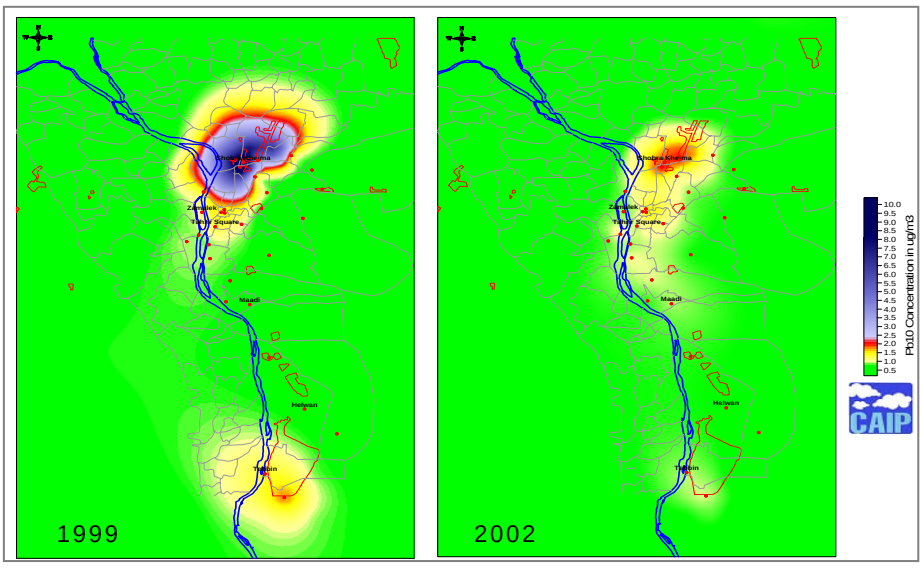
The project's approach, while fostering measurable improvements in the short-term, served as a catalyst for longer-term progress toward improved health and economic conditions. Technical, institutional, and policy interventions created the foundation for

sustained and expanded action after the project ended. A comprehensive program of air monitoring and analysis now makes crucial, factual information available for the first time in Egypt. Increased awareness among decision-makers, the news media, and the general public supports a constituency for change.

An unqualified success

CAIP's nearly seven years of operation (May 1997 to March 2004) have been an unqualified success. By creating a critical mass of environmental progress — from a robust emissions testing program to cleaner technologies in industry and transportation — the project has helped push measurable change in a sector that so often hangs in the uneasy balance between business and government regulation. And even as CAIP comes to a close, its impact, though considerable to date, is only just beginning to be felt. Two examples: A vehicle emissions testing program that now serves two Cairo governorates will eventually serve the entire greater Cairo area; and Cairo's fleet of 50 compressed natural gas (CNG) buses is set to expand within a year — all thanks to CAIP engineering, procurement, and training procedures that exemplify sustainability.

A summary of CAIP's accomplishments and impacts is provided on the following page. The approach to reach these achievements is described in the next sections.



Pollution maps show reductions in airborne lead levels around Cairo, with a reduction of 75 percent in Shoubra El Kheima to the north.

CAIP by the Numbers

Impacts

1. Lead levels in the air in Shoubra El Kheima dropped 75 percent. Over the lifetimes of the current generation, this could translate into 500 fewer cancer cases, 4,500 fewer premature deaths caused by cardiovascular disease, and more than $30 million saved in health costs. Given the amount invested to achieve the reduction, this represents a 10-fold return to the economy.

2. Fall air pollution episodes went from 31 to 4 between 1999 and 2003.

3. Egypt's largest lead smelter owner reduced his air emissions by 99 percent.

4. Lead emitted by all sources in greater Cairo fell 65 percent.

5. Natural gas buses released 91 percent fewer particulates than diesel buses. The pilot fleet alone will remove 64 metric tons of particulates from the air over its lifetime.

6. Pollution from Cairo's diesel transit buses, subjected to inspection and maintenance, dropped an average of 50 percent. This means 300 fewer tons of particulates could enter Cairo's air annually from the fleet of 5,000 buses. An estimated 4 million Egyptian pounds (about $650,000) in fuel costs can be saved each year as a result of the program.

Key Accomplishments

1. After nearly four years of operation, Egypt's first compressed natural gas transit bus fleet has traveled more than 10 million kilometers, carried 8.5 million passengers or half the population of Cairo, and generated 17 million Egyptian pounds (about $3 million) in revenue.

2. A national vehicle emissions testing program was launched. Testing is now mandatory for 500,000 vehicles in Cairo, and equipment and training are in place to test 50 percent of all vehicles in Egypt.

3. Egypt's first environmentally sound smelter, representing two-thirds of the nation's lead production capacity, is now operational. Pollution control technology for other smelters can now be manufactured locally based on CAIP designs.

4. Nearly $20 million in US environmental technology and related commodities were transferred to Egypt, covering buses and their maintenance, air and industrial monitoring, vehicle laboratories, and vehicle emissions testing. More than 10 private Egyptian companies were strengthened to provide sustainable operations and service.

5. A comprehensive air monitoring system for greater Cairo has been fully operational for five years. The Egyptian government has run this system on its own for the past two years.

6. Computerized management systems and enhanced maintenance procedures were introduced, transforming the way Cairo's 5,000 bus transit companies operate.

7. A state-of-the-art vehicle emissions testing laboratory was established. As one of 9 of its kind in the world, it allows Egypt to be a leader in research and development, certification, and commercial applications for the government, universities, and the private sector.

Clean Alternative Fuels in Transportation

In any urban setting, vehicles are among the top contributors to air pollution health risks. Diesel vehicle emissions cause special concern, as science now shows that the fine particles and associated toxins can represent nearly three-quarters of the health risks from air pollution in urban areas.

CAIP's work to introduce clean, natural gas into Cairo's mass transit system represents one pillar in a comprehensive vehicle emissions control program — complementary to CAIP's tune-up programs for gasoline and diesel vehicles already in use. Other programs to make traditional gasoline and diesel fuels cleaner, and improve transportation planning, have been initiated outside of CAIP. The government's rapid elimination of lead from gasoline is just one example of success to date. Various government agencies are now taking steps to introduce cleaner vehicle technologies, the final element in a comprehensive program.

Buses provide a catalyst for broader change. An estimated 5,000 diesel-fueled public transit buses travel the streets of greater Cairo. The numbers climb each year as residents and visitors seek inexpensive forms of transportation. The duty cycle for the buses is around the clock and intense, with drivers maximizing revenue by maximizing time on the road.

While diesel vehicles pose a great health concern, they also pose challenges in attempting to reduce impact on the environment. Conversion of large diesel vehicles to clean fuels is technically difficult — more so than for gasoline vehicles — and CNG technology is more complex and costly to operate. At the same time, Egypt's inexpensive diesel is more attractive at the pump. Yet with large natural gas reserves, the government is committed to expand the use of natural gas. And officials understand that the buses are

In Brief: The CNG Program

The foundation of the program was a demonstration fleet of natural gas transit buses, a model of US technology transfer to Egypt. Fifty buses were procured under the project, with chassis manufactured in the United States and shipped to a local factory in Egypt for final assembly. Tremendous coordination between Egyptian and US engineers led to the right specifications and sound assembly. The first bus began rolling on Cairo's streets in April of 2000, and the fleet has now been in daily transit operation for nearly 4 years, traveling more than 10 million kilometers.

Buses were just the beginning. Two garages were constructed, Al Moustakbal at the Cairo Transit Authority (CTA) and Al Amal at the Greater Cairo Bus Company (GCBC), to house a total of up to 400 CNG buses. Funding of $5 million from the Egyptian government made the garages possible. Each was designed and equipped for safe operation and maintenance of advanced CNG vehicles. The project provided an additional $1 million for maintenance equipment, and introduced computerized management systems and enhanced maintenance practices. Arrangements with local fuel suppliers created dedicated fueling stations at each garage.

Developing the human resources was key. Drivers, maintenance personnel, managers, and top executives all received training to ensure success of the new program. CAIP's US company partners built local private sector dealers to ensure long-lasting technology expertise and local service. Awareness and educational activities communicated the benefits of CNG to government officials as well as the public. Briefings for the Cairo governor kept him well informed of the program so that he could speak effectively about it at the national level.

The state-of-the-art heavy duty vehicle testing facility at Misr Lab, a division of Misr Petroleum Company, was created to serve a research and development and national certification function for buses and trucks. It is available to the government, universities, and the private sector.

Finally, CAIP addressed national policy. Three new national standards are legally in force to ensure that technology used in Egypt's entire program is safe and up to international practice.

only a piece of the overall investment in technology, various forms of infrastructure, and policy reform.

Aligning with national priorities. The government's move to use natural gas is part of a broader energy strategy to capitalize on an abundant natural resource. And the use of natural gas is not a new concept in Egypt. As far back as 1998, nearly all Cairenes surveyed knew about natural gas, and most knew it was a cleaner fuel than gasoline or

diesel. More than three-fourths of those interviewed said that if compressed natural gas were readily available for vehicular use, they would use it instead of gasoline or diesel.

By 2003, more than 50,000 natural gas vehicles were being served by a greatly expanded fuel distribution network. A favorable CNG versus gasoline fuel price as well as soft financing of the conversions have raised Egypt to seventh place worldwide in the number of CNG vehicles on the road.

Solutions

From the first day of the project, the CAIP team and its Egyptian and USAID counterparts realized that tackling an issue such as alternative fuels required an integrated approach. The project's natural gas component was part of a larger strategy by the Government of Egypt to change transportation in Cairo.

CAIP advisors knew from the start that they possessed neither the time nor resources to engage in an extensive policy reform effort. Instead, the project adopted a "build it and they will come" approach that used the power of demonstration on policy-makers and private business alike.

A pilot fleet of transit buses was used to demonstrate the value of natural gas in reducing vehicular air pollution in greater Cairo. Tackling public buses first had several advantages. First, it would visibly announce to the people of Cairo that the government was taking steps to provide relief from the city's chronic pollution. Second, it would help raise awareness of the causes of that pollution and the practical mitigation measures available to policy-makers. This awareness and the high visibility of the intervention would in turn generate momentum for the broader acceptance of natural gas as an alternative fuel.

On the technical side, alternative solutions for large, typically diesel vehicles, are more complex than for those operating on gasoline. Since diesel vehicles pose major health risks, devoting major resources to addressing them was paramount yet difficult for the government to do alone.

Creating a platform for sustainable operation and expansion of CNG buses was the overall objective. CAIP resources were able to get this program launched quickly, when it otherwise would have taken much longer, or would not have happened at all.

US-Egyptian partnership builds a better bus

The first and most important step was to build a fleet of new compressed natural gas buses and get them on the roads of Cairo. Without successful buses, there would be neither a CAIP nor a national program. The local bus companies of course knew what worked in transit operations in Cairo. Whatever solution was selected, it had to meet their specifications. At the same time, these specifications had to accommodate accepted practice in the global CNG vehicle industry.

Engineers on both sides of the ocean collaborated to first lay out the technical requirements and then engineer the proper bus configuration. The engine manufacturer needed to ensure greater cooling capacity for Cairo's hot climate. The chassis designer enhanced the suspension for more passengers and rough roads. The gas cylinder company furnished more fuel tanks to accommodate the realities of longer driving cycles.

A US-made CNG rolling chassis awaits body assembly at the Egyptian manufacturing plant.

Private sector production of CNG buses in Egypt was set as the long-term goal from the beginning. Partial assembly of the pilot fleet in Egypt was a step in this direction and required extensive planning. The body and other systems had to fit together perfectly without compromising warranties. Extensive reviews between the US and Cairo led to finished vehicles viewed by all parties as a remarkable achievement.

A framework beyond the buses

Even before the new CNG buses were ready, CAIP began the added interventions that would make the leap from simple vehicle procurement to an integrated program for alternative fuels. These activities created all necessary infrastructure and represented many of the up-front, one-time investments required to build a larger national program.

The project looked at the situation from a broad perspective and asked the following question: What measures are needed to make Egypt's investment in natural gas more

effective and sustainable? For every challenge that arose in response, CAIP was there to provide the necessary ideas, assistance, and technologies:

Challenge: Keep the new CNG bus fleet up and running
CAIP responses:

- Design dedicated, up-to-date CNG bus maintenance garages
- Procure spare parts for the garage and train engineers and technicians in enhanced maintenance and repair
- Involve original manufacturers in the program to enhance local private sector dealerships
- Design a CNG fuelling station on the site of the new garage
- Arrange for warranty coverage of the chassis, engines, and spare parts

Challenge: Secure a broad, long-term commitment to cleaner fuels in Egypt
CAIP responses:

- Develop comprehensive operating and safety standards for compressed natural gas
- Secure government agreement and formal issuance of natural gas standards
- Work out a detailed institutional development and implementation plan for new national standards, involving the government and the private sector
- Train public and private technicians in CNG standards and handling practices, ensuring certification of trainees to international protocols
- Build the Misr Laboratory for heavy vehicle testing, to monitor bus and truck emissions

Keeping things running

The physical infrastructure. The project's 50 new road-ready CNG buses represent the future of mass transit in Cairo. Since their demonstration power clearly depends on keeping them in operation, a separate set of initiatives was needed from CAIP.

Right off the mark, the bus companies needed two things: maintenance garages and fuelling stations. The Ministry of Petroleum felt that these two types of facilities should be combined. To gain government acceptance and financial contribution, CAIP agreed to the Ministry's request and set about creating two new facilities, one for CTA and one for GCBC.

Built at a combined cost of about $6 million, the two garages were designed by Egyptian engineers with US engineering assistance on specific natural gas issues. The facilities also included natural gas fueling stations valued at $2 million. CTA's Al Moustakbal garage, the larger of the two, spreads over 42,000 square meters within Cairo's green belt. Each facility and its computerized safety systems can accommodate 200 buses — a deliberate design element by the Egyptian government that allows for the expected expansion of Cairo's CNG fleet in coming years.

The human infrastructure. CAIP took the additional step of training the transit authority staff and managers in both Egypt and the United States. Central to this training was teaching the mechanics how to maintain and repair the electronic engines and drive trains of CNG buses. GCBC and CTA mechanics are expert engineers with decades of experience working on diesel engines. Even so, CAIP recognized that new buses require new skills and new tools. Preventative maintenance concepts were especially important for advanced technology CNG.

Dedicated CNG fueling stations were established within the bus garage properties.

The organizational infrastructure. Bearing in mind the importance of the bus companies' bottom lines, CAIP took extra steps to ensure that improved environmental management went hand-in-hand with more efficient and ultimately profitable operations. One such step was to transform CNG bus operations through a Computerized Maintenance Management System (CMMS). This new system allows the companies to manage everything from spare parts stocks to employee training. CMMS has further increased the efficiencies enjoyed by GCBC and CTA by providing managers clear and up-to-date reporting on key cost and resource parameters of their operations. CTA Chairman Nabil El Mazny now sees the benefits of expanding CMMS from his CNG unit to his entire organization of 22 facilities.

The private sector infrastructure and business opportunities. At the same time that CAIP worked to introduce bus companies to CNG, local support capability had to be added. CAIP's initial bus tendering created a business model in which US manufacturers would be supported by private dealers, already proficient in some segment of the vehicle industry. Throughout the project, local dealer capacity was fostered by training their staff as trainers, ensuring that they coordinated all fleet-wide campaigns and upgrades in

conjunction with the original equipment manufacturer (OEM), and defining practical, local spare parts sources for the bus companies. Defining multiple sources for parts ensured that local dealers still could be supported by dependable income streams from sales on certain parts, while giving the cash-strapped bus companies other cost-effective parts options when possible.

The "critical mass" of technology sales for the CNG OEMs in the US also meant that they were willing to invest significantly in local dealer capacity. Cummins, the engine supplier, stationed an expatriate in Cairo for one year to enhance local dealer capability. Successful products and business relationships created additional opportunities for the US companies. Both the US chassis and engine manufacturers are now working with local companies to develop the next generation of CNG buses for the local market.

Turning the problems into a success. As with any pilot, the 50-bus fleet met with unforeseen challenges. Each of these was an opportunity to learn and plan for longer-term sustainability.

During the bus specification stage, CAIP worked with the Cairo transit companies to ensure that the local gas supply met the specifications of the engine manufacturer. Laboratory tests confirmed acceptable quality of the gas. However, several months into the operation of GCBC's CNG fleet, engine problems led CAIP to again investigate the fuel. It was found that in the interim, the pipeline supplying the bus companies had changed, introducing off-spec fuel to one company, which in the worst case caused engine component failures. CAIP responded by negotiating with the bus company to use an alternate gas source. At the same time the bus engine manufacturer responded with special engine components more tolerant to fuel quality variations.

Other problems arose due to poor maintenance of the fueling facility compressors, which led to compressor oil entering the bus fuel and ultimately damaging the CNG engine. However, the fueling stations were operated by independent companies with no direct financial interest in the CNG transit bus program. Appealing to the companies' desire to sell more gas to a successful, expanding market, CAIP was able to convince them to apply more rigorous procedures to their fuel compressor maintenance program.

These problems have in turn created a high level of scrutiny of all elements affecting engine performance. This has uncovered specific maintenance lapses at the bus garages that could negatively affect the bus fleet, and have significant revenue and cost implications. In each case, CAIP and bus company management have used this as leverage to progressively enhance maintenance practices.

Securing a broader commitment

The policy infrastructure. The development from scratch of a full set of natural gas operational and safety standards in Egypt required nothing short of a separate subproject under CAIP. The project's experts worked in tandem with the Egyptian Organization for Standards — part of the Ministry of Industry — to smooth interagency cooperation, negotiate roles and responsibilities, and create a collective understanding of what was needed from the Egyptian government to make CNG use safe for transit company workers and the general public. The CNG standards adopted by the government will apply to all natural gas initiatives and will help grow Egypt's clean fuel sector safely and efficiently.

Three sets of standards were required: natural gas tanks and cylinders, fuelling components such as pipes and nozzles, and the fuelling stations themselves. For each, CAIP engineers and safety experts drafted regulations, shared them with all the relevant agencies and the EOS Board, and succeeded in getting the standards issued. Each final standard specifically referenced the corresponding standards of international bodies in the United States and Europe.

Before these standards could be applied and enforced, they had to be endorsed by the Ministry of Industry via formal decree. In a matter of months, CAIP and EOS worked with the Minister of Industry to issue the decree and promulgate the necessary regulations. This was a remarkably quick turnaround for such a significant policy decision and was attributable to the critical mass created by the visibility of CNG buses.

The final step was to make them work. Implementation of the standards will take the active involvement of multiple government ministries as well as public and private sector vehicle manufacturers, operators, and service providers. CAIP created a comprehensive plan detailing the authorities and responsibilities of each entity in carrying out the standards.

World class certification and research capability. As a complement to the CNG bus program and other CAIP emissions testing and tune-up programs, CAIP worked with the Ministry of Petroleum to design and build the Vehicle Emissions and Performance Testing Center (known as Misr Lab). Inaugurated on February 28, 2002 at Misr Petroleum Company's existing testing facility in Cairo, the $4 million Misr Lab puts Egypt at the leading edge of emissions and performance research and control. As one of nine such labs in the world, it represents the most sophisticated facility of its kind in the Middle East and Africa.

Misr Lab is a high-technology tool for demonstrating the benefits of advanced vehicle technologies and ensuring that standards are being met by Cairo's buses and trucks. The lab will help set national standards to control exhaust and generate critical data on sources of air pollutants and the trends over time. To create the lab, USAID provided $3 million in equipment and training, while the Misr Petroleum Company contributed an additional $1 million for construction.

State-of-the-art Misr Lab provides Egypt with unique capability to evaluate vehicle emissions and performance.

The equipment and newly trained staff at Misr Lab comprise yet another tool to build the critical mass for the national transition to cleaner fuels and technologies. Anticipated customers at the new laboratory include transit and tourist bus companies, truck companies, technology manufacturers, environmental regulatory agencies, and university or other research institutions. One tourist company using the lab sees the value not just of emissions measurements, but also meaningful data on vehicle performance and safety. A European manufacturer wants to use the lab to check the performance of new pollution control devices prior to taking them to market.

In a highly publicized inauguration ceremony, Egyptian Prime Minister Dr. Atef Ebeid described the facility as "a major step forward in fighting pollution and improving public health." US Ambassador David Welch echoed this sentiment, praising the Egyptian leadership for its commitment to sound environmental management. "Egypt is now the proud owner of one of the world's most advanced vehicle emissions testing facilities," he said.

The Future

CAIP put the buses on the street and filled them with passengers. The value to Cairo's population is clear, and the policy implications even more so. In the end, the changes came about because they were demand driven.

CAIP's introduction of CNG buses built on the initial successes of natural gas in the Cairo marketplace. At the end of 1999, when CAIP's fleet was being manufactured, government initiatives resulted in 20,000 taxis converting to CNG and 17 CNG fueling

operating stations throughout greater Cairo. Today, with a fleet of CNG buses, dedicated maintenance and fuelling stations, national safety standards, and a state-of-the-art emissions laboratory, the stage is set for a more fundamental shift to alternative fuels for a cleaner environment.

Already other actions are following. CTA is planning to purchase 25 additional buses in the next year. EEAA, with support from CAIP experts, has also designed and activated a plan to convert Egyptian government vehicles to CNG. With an initial budget of more than $2 million, they are now well on their way, having converted more than 200 vehicles to date.

The local market is also starting to respond. The first CNG bus to be fully assembled in Egypt is now under production using CAIP-procured components, and will reach Cairo's streets by mid-2004.

Air pollution is now on the national agenda in Egypt. Egyptian President Hosni Mubarak has seen the CNG buses in action and stated he wants the program to be expanded. This fact alone offers hope of a future in Egypt driven by alternative fuels.

Many challenges remain. The main impediment — and indeed, the main opportunity — to significantly expanding the city's CNG fleet can be found in the marketplace. Government subsidies for diesel fuel keep the street price of this commodity at about one-half of its true cost, and well below the equivalent price of CNG. For their part, CNG buses cost 25 percent more to build than diesel buses — the difference coming primarily from the engines and fuel systems. These numbers mean that removal of even a portion of the diesel subsidy would make compressed natural gas technology for buses highly competitive with diesel technology. When factored in with CNG's advantage in emissions, such a policy action would have far-reaching consequences for Egypt's transportation and environmental sectors.

The operation of new CNG buses proves that natural gas is a viable alternative fuel. It is an abundant resource in Egypt and can save millions of dollars in imported diesel fuel. Introducing natural gas for city buses and taxis has had the added positive impact of enhancing the skills of local mechanics and environmental managers.

Making the arguments in favor of such sweeping changes is far easier now than when CAIP began. The benefits from clean fuel demonstrated by the project's activities have provided policy-makers with the tangible evidence to support reform, and the people of Cairo with the understanding to demand such changes from their government.

Vehicle Emissions Testing

Motor vehicles are perhaps the most challenging sources of pollution in any setting. Responsibility is spread among a daunting number of vehicle owners, some government or commercial businesses, but the vast majority being private individuals. Recognizing collective responsibility for the problem is a significant first step. However, convincing the public of the need to pay for vehicle emissions testing and tune-up can pose a colossal challenge. For this reason, programs throughout the world often face substantial political resistance. Programs unpopular with the public have been known to be cancelled at the final moment after years of planning and investment.

The concept for Egypt's vehicle testing and tune-up program predated CAIP, with a pilot project in the early 1990s shedding light on the benefits as well as pitfalls of such programs. Making vehicle testing a reality for the 1.5 million vehicles in Cairo and ultimately the three million in Egypt proved to be no less of a challenge than other countries have faced.

CAIP recognized early in the planning stages that this element of the project posed the greatest risks to success. Technical and logistical challenges were significant. Political constraints could halt the effort at any point.

Solutions

Introducing a new program using advanced technology and requiring understanding, acceptance, and involvement of many stakeholders demanded investment in several crucial areas:

In Brief: Vehicle Emissions Testing

Recognizing the significance of more than a million vehicles to Cairo's air pollution, the activity's objective was to put in place a legally mandated program to test and tune them up during the vehicle licensing process.

Like similar programs elsewhere, Cairo's program was complex. Initial planning and design work focused on a "centralized" program with all testing done by the private sector at dedicated test-only facilities across the city. Tune-ups would be done elsewhere in private garages.

Several phases were completed. The first "Quick Start" program, put testing and diagnostic equipment in private fueling stations for a non-mandatory pilot period, developing public awareness and technical capacity in low emissions tune up.

In the second phase CAIP designed, equipped and operationalized an on-road testing program for more than 50,000 cars, light trucks, and motorcycles. This provided data, training, awareness raising, and institutional arrangements that would support the design and launch of a full program.

At the same time, a "model" testing center was designed, constructed, and equipped to serve as a blueprint for future testing facilities throughout Egypt. This facility is now the National Technical Center operated by the Egyptian Environmental Affairs Agency (EEAA), with coordination functions for the national program.

Through extensive policy dialogue — including periods when it appeared the political climate would not allow such a program — CAIP supported creation of the national program. Following a legal decree issued in December 2002, CAIP furnished equipment, training, and communications support for the program beginning in two of the three Cairo-area governorates: Giza and Qalyubia on June 1, 2003. CAIP also provided equipment and training for the Cairo governorate program, which will begin shortly.

Finally, and as a companion to CAIP's efforts with CNG buses, the project has supported an emissions testing and tune-up program for the thousands of diesel public transit buses in Cairo. CAIP furnished testing and tune-up equipment, training, and maintenance support.

These programs were all completely new to Egypt and represent substantial and successful technology transfer. At the same time, the established programs plus the expansions already planned translate to multi-million dollar opportunities for private companies.

- Technology transfer: defining, procuring, and operating equipment that measures up to international standards, yet is appropriate for the first program in Egypt and the country's economic constraints

- Stakeholder involvement: defining and navigating the key stakeholders based on perceived environmental responsibilities, legal mandate, and political dynamics
- Institutional development: not just training, but establishing new units and inter-agency partnerships from scratch
- Communications: awareness of the program and its benefits, leading to acceptance among the government, private sector, and the general public to allow the program to succeed
- Financial feasibility: from equipment purchase to fee collection and burden on the public, the numbers needed to work for a sustainable program

Programs in other countries have taken nearly a decade in some cases from initial design to launch. Modifications from that point go on for twice as long. CAIP's mandate: bring up a successful program in a fraction of that time, on a foundation of public perceptions much less prepared to accept it than in other countries.

Defining the right stakeholder mix

Identifying and working with stakeholders is a fundamental step in building such a program. Initial planning for CAIP targeted government partners: the Egyptian Environmental Affairs Agency (EEAA), with environmental responsibilities, and the three Cairo-area local governments, the governorates of Giza, Qalyubia, and Cairo. The picture quickly became more complex. Legal authority in Egypt for enforcing vehicle emissions norms lies with the governorate Traffic Departments. These units are under the dual — and hence sometimes confusing — authority of the governorate and the Ministry of Interior. Early on, it became clear that no testing program would proceed without the active engagement and acceptance of all three government entities.

Another initial plan tied the testing program in greater Cairo together. It was to be operated by the private sector under contract with the government. Coordination and oversight functions would be provided by a government "technical center". Planning dialogue quickly demonstrated differences between governorates. Qalyubia was especially active in environmental health issues and early on made commitments to the program. Cairo, the largest of the three, had to balance hundreds of obligations. Each governorate also had different working relationships with the two key ministries. In the end, CAIP de-coupled the three governorates, allowing them to proceed with their own pace and design.

Building to the "critical mass"

Education and capacity for tune-up. Despite the relatively short timeline of CAIP, no sustainable program could be created over night. The public, the private sector suppliers and service agents, and the technicians up to the managers at the key implementing agencies all required development from the ground up. Pushing policy change for its own sake would have no impact. CAIP had to demonstrate to the government of Egypt that emissions testing could work — and work on a large scale.

CAIP's response was to develop all requisite program elements through stepwise demonstrations. First came the Quick Start program. Tuning up vehicles for low emissions was new to Egypt, despite a tremendous pool of well-trained mechanics. Diagnostic equipment to jump-start this effort was lacking. Through direct collaboration with the Minister of State for Environmental Affairs, proper equipment — unused following a previous donor project — was refurbished and mobilized for use at private service stations around the city. Training efforts selected capable mechanics and worked with them to interact with the public.

Quick-Start's voluntary approach introduced service technicians to criteria and techniques for reducing vehicle pollution, while maintaining the engine performance their customers demand. The public began their education on the merits of the process, including the potential for fuel savings.

Creating integrated testing capacity. Much was still required prior to approval of a final program. As it became clear that traffic department and environmental agency officials would jointly carry out program functions, means of collaboration had to be developed. The public needed greater exposure to requirements of the law and how it would be implemented. Data was required for final program design and to address concerns of some government officials on sensitive issues such as expected failure rates of the vehicles tested.

The on-road testing program used teams from the traffic department and environmental agency to check vehicles under existing laws before the national program started.

CAIP's response was an on-road testing program for automobiles, small trucks, and motorcycles. With CAIP-furnished equipment and training, dedicated, inter-agency teams operating under

existing traffic law prohibiting polluting vehicles, tested more than 50,000 vehicles at random locations around Cairo. Vehicle owners were given educational materials, including locations for low emissions tune-ups (the nearly 30 Quick Start participants).

Results of on-road testing demonstrated to decision-makers that high volume testing was practical, that the public could accept such a program, and that emissions could be reduced without failing an unacceptable number of cars.

Model center guides the design. The initial design for the national program called for centralized emissions testing — large centers run by the private sector to test a high volume of vehicles daily. Centers would be on government-supplied parcels of land.

Since this type of program was new to Egypt, CAIP was asked to design and construct a model center that would serve as the first high volume test location and create as a blueprint to be replicated elsewhere. The approach proved invaluable, as the major issue of land availability quickly became apparent. What followed were months and months of discussions, site visits to many potential properties in different governorates, and even land assignments that had to be reversed due to conflicting use expectations within the government. Nonetheless, the Qalyubia governor, especially supportive of CAIP's initiatives, found suitable land for the first center in Shoubra El Kheima. CAIP used a joint US-Egyptian engineering team to design, construct, and equip the center, inaugurating it with the first vehicles in April 2000.

The testing center itself reflected the primary partners in the national program. The governorate owned the land and building. CAIP facilitated a memorandum of understanding between the traffic department and EEAA, one with the overall responsibility for vehicle licensing including enforcement of safety and environmental statutes, and the other with responsibility for emissions testing. Both agencies were to furnish staff to the effort.

The testing center in Shoubra El Kheima was constructed as a model for subsequent facilities. It is now EEAA's Technical Center, supporting the national program.

The center in Shoubra El Kheima has seen many uses independent of a mandated national program. The Minister of Environment and EEAA have launched several special projects there. One tested more than 900 tourist buses under a new program by

the Ministry of Tourism to ensure safe and environmentally sound operation of fleets under their control. Another initiative gathered data for ministerial discussions of the growing diesel microbus population in the city. In the context of the national program, the Shoubra El Kheima center has been turned over to EEAA as a coordination, calibration, and training center.

Persistence leads to results

By 2001, most of the elements for the national program were in place. Yet the key piece was missing — final commitment by policy-makers. The desire for cleaner air was not fully reconciled with other factors such as perceived program cost and complexity of a program with direct impact on the public. Other issues on the national agenda took priority, and at the traffic departments, safety inspections were seen as more critical than emissions checks. Despite a great deal of high level dialogue, the programmed appeared stalled.

Enhancing financial feasibility. By 2002, CAIP was working with newly appointed government officials to take a fresh look at the program. A special working group determined that the best solution was to use existing traffic department licensing stations for emissions testing. Tests would be performed by specially equipped and trained technicians employed by the traffic departments in each governorate. Answering to the tremendous challenges to date in obtaining land for the model center, and the anticipated expense of acquiring land and building centers, no new land or buildings would be required. Management costs would be kept to a minimum by integrating the test with existing safety checks. Equipment would need to be small and highly portable to serve the huge variety of conditions at traffic departments throughout the governorates. With all of this, the projected cost of the program dropped dramatically.

The Egyptian prime minister and environment minister attended the launch of the vehicle emissions testing program at a station in Giza.

The role of public opinion. Also by 2002, public awareness about air pollution and its causes and solutions had progressed tremendously. Noticeable "black cloud" episodes had occurred for three years during the fall season. CAIP's analyses identifying vehicles as one of the causes were featured in the press. General news

articles on air pollution topics were increasingly commonplace, many tied to CAIP interventions. In more than one instance, journalists wrote of the program design in place through CAIP and challenged the government to start the national testing program.

Launching the national program. In December 2002, governmental officials made a bold move, legally mandating the start of the program through a ministerial decree. As of June 1, 2003, owners of the 500,000 vehicles in the Cairo governorates of Giza and Qalyubia would need emissions inspection certificates from one of 19 traffic departments before they could register their cars.

With the program launch merely six months away, CAIP's pace accelerated. Final equipment specifications were drafted, an international tender was issued, equipment was shipped and operators were trained all in the span of four months. A trial period prior to the June 1 launch date ensured all players, from top managers to technicians, were ready.

Today in Giza and Qalyubia, car owners pay five Egyptian pounds — roughly 80 cents — to have their cars tested. If they exceed emissions standards set by the Egyptian Environmental Law, owners have 30 days to tune their engines or risk permanent cancellation of their vehicle licenses.

A poster was distributed throughout Cairo to announce the start of mandatory vehicle emissions testing.

Fostering knowledge and public acceptance of the national program. The foundation of public awareness was laid over several years. Once the start date for the national program was announced, the focus shifted. Preparing the maintenance sector began first. A CAIP field team, carrying fact sheets outlining basic, low-cost repairs and testing equipment, went door-to-door to more than 800 neighborhood garages. These workshops were otherwise unreachable, yet critical for the many vehicle owners with older cars. Formal

meetings, also with maintenance and testing demonstrations, were arranged for larger repair workshops. At each one CAIP arranged equipment vendor displays, helping maintenance centers find low-cost testing equipment for their shops.

Government stakeholders, the media, and the general public were parallel targets. Press conferences, TV spots, posters, and other coverage in newspapers, radio, and television emphasized multiple benefits of the program: cost savings from reduced maintenance and increased fuel efficiency, as well as health benefits from pollution reduction. Brochures and plaques created for the traffic departments provided simple instructions for the motorist, including where they could get inexpensive tests prior to the start of the mandatory program.

Targets of opportunity for greater impact

Early in the project, the CAIP team identified a clear opportunity to achieve substantial short-term impact as well as the potential for a long-term program. While CNG buses provided a clean alternative, the rate of changeover in public transit fleets would in all cases leave several thousand diesel buses on the road for the foreseeable future. CAIP laid out a simple scheme to ensure optimal environmental performance of the diesel fleet while enhancing maintenance and saving money — this was branded the Inspection and Maintenance of Transit Buses (IMTB) program.

Conceptually, this program is simple. The fuel system of a diesel engine is responsible for the majority of engine failures and malfunctions. By measuring the opacity of smoke emitted by these engines, bus technicians can gauge the efficiency of the engine and at the same time identify those vehicles that are the most polluting. Using 30 portable meters procured from the US and delivered to each of the bus companies' garages, workshops and training centers, IMTB-trained technicians measured the smoke emitted by every operating bus and minibus.

After grouping the resulting data by bus age and opacity, IMTB's analysis revealed that 65 percent of the worst polluting buses required only a simple tune-up, while the remaining 35 percent were due for more significant maintenance, including even engine overhaul or replacement. The data further showed that 10-15 percent of the buses produce 30-40 percent of the pollution, and thus targeting those highly-polluting buses for repairs would achieve noticeable reduction in emissions.

For maintenance, the IMTB team set a standard of 20 percent opacity for emissions, thereby ensuring that the worst buses were taken in for repairs but keeping sufficient

numbers of vehicles on the road to maintain company routes and revenues. Those failing to meet this standard undergo diagnosis and necessary repairs.

The immediate result of the IMTB program is substantial — an average reduction in harmful vehicle emissions across the diesel fleet, in many cases by more than 50 percent. The more significant longer-term result is the clear demonstration to greater Cairo's public bus companies that greater fuel efficiency — and thus lower operating costs — goes hand-in-hand with reduced emissions.

Equipment purchased for more than 20 garages allows better diagnosis of diesel bus problems, reducing pollution while saving on fuel and repair costs.

This simple business equation holds in it the potential to revolutionize not only the city's bus system, but the air Cairo residents breathe every day. The advantage of this program is that it requires no additional staff. With additional equipment and training, existing maintenance personnel have incorporated emissions testing in the normal bi-weekly bus maintenance schedule.

The Future

As of this writing, two Cairo governorates require vehicle emissions testing for vehicle licensing and license renewal. For the Cairo governorate, institutional agreements are in place, equipment is ready, and training of the several hundred anticipated technicians and engineers is underway. The program is expected to launch this year.

Already, detailed planning by the Egyptian government is underway to expand the program to the rest of the country. Four governorates outside of Cairo are in the process of preparing specifications for testing equipment and are sending participates to on-going training in Cairo.

The impact of the program is impossible to quantify at this early stage. While it will likely be significant, there will also be areas requiring change, as in all settings around the world. Loopholes allowing polluting vehicles on the road will be discovered and will need to be closed. Emissions limits, while now providing a failure rate acceptable to the public, will need to be re-examined over time. Progressively declining failure rates will allow Egypt to tighten the emissions limits to achieve greater benefits.

Vehicle emissions testing is now a reality in Egypt. It is arguably more far-reaching than any other of CAIP's components. The reason: emissions testing empowers the people of Cairo in the fight against pollution. It provides all with an inexpensive, equitable system for the fight against pollution.

Lead Pollution Abatement

Ten years ago, analyses leading to the design of CAIP concluded that none of the pollutants in Cairo's environment was more damaging than lead. A USAID-funded risk analysis estimated that the average child in Cairo lost more than four IQ points as a result of lead in the environment. Other studies gave statistics about lead factory workers dying prematurely and lead levels in blood 20 times higher than adults in the United States. The World Bank found airborne lead levels around one smelter in southern Cairo to be 50 times greater than those recommended by the World Health Organization.

To make matters worse, the largest lead smelters in Egypt were located in the densely populated Shoubra El Kheima residential area, an area that is to the north and upwind of the rest of the city. It was in Shoubra El Kheima, an area with some 3 million people, that child and maternal health had grown most worrisome and there that the most sobering data was drawn by health officials and international development agencies. If the lead smelters in that area could be relocated, using cleaner technologies and business incentives, air quality could be dramatically improved, positively affecting the health of all residents.

For these reasons, the Government of Egypt and USAID made lead pollution reduction a priority under the Cairo Air Improvement Project. Much progress had already been made since the government introduced unleaded gasoline. A Lead Smelter Action Plan was then developed with USAID support and incorporated into the CAIP design. Under CAIP, the action plan was to become reality, with demonstrable results created in partnership with industry leaders and local officials.

In Brief: Lead Pollution Abatement

CAIP implemented the Lead Smelter Action Plan, developed in the mid 1990s based on the recognition that lead smelters were the primary source of lead pollution to the environment following the removal of lead in gasoline.

Activities focused on short-term reductions of lead entering the environment as well as longer-term activities to evaluate contaminated sites and ultimately reduce demand for lead-bearing products. The primary activity focused on upgrading and relocating smelters, many of which were located in the downtown area of Shoubra El Kheima.

An initial survey defined the extent of the problem in terms of numbers and approximate capacity of smelters operating. CAIP prioritized activities based on smelter size, focusing on the largest, a smelter owner controlling about 65 percent of the national production.

For the large smelter owner, the project provided extensive engineering design support, leading to the eventual construction of a new facility at Abu Zaabal, outside of the densely populated downtown areas. Economic analysis ensured the profitability of the new facility. Planning for a local landfill ensured sound waste disposal.

The project provided analogous design and financial feasibility support to small and medium smelters. All smelters received training to allow more environmentally sound, yet profitable performance.

In tandem with the relocation effort, contamination at old smelter sites was assessed. CAIP developed preliminary plans to clean up lead from the primarily residential areas that were the most affected.

The final step was providing support to the policy agenda. CAIP evaluated the supply and demand framework for the lead manufacturing sector in Egypt with recommendations to reduce demand for lead in the future.

Solutions

CAIP undertook a comprehensive plan that first characterized and then laid out steps to enhance Egypt's lead manufacturing sector. The overall goal, provide long-term protection for workers and the general public while creating a more efficient and profitable industrial sector. The basic elements were clear:

- Define the lead smelting sector from large to small enterprises
- Upgrade the operations of the enterprises and relocate them to appropriate industrial zones
- Characterize the health problem left behind by the relocated factories
- Support policy dialogue to enhance the business sector in the future

Rapid assessment to define priorities

Some data existed on the structure of the lead processing sector in Egypt. However, defining priorities for interventions quickly emerged as a challenge. The sector had both legal and illegal, unlicensed operators. Some operations were quite mobile and could be relocated if the local community or government threatened enforcement action. Acting through local contacts and close-to-the-ground surveys, CAIP was able to draw up a comprehensive inventory of the sector. It was quickly decided that illegal operators would not be eligible for support. The government instead used CAIP's research to line up compliance actions against this group.

Carrot and stick approach. One very successful businessman with several lead production facilities stood out among the owners. Mr. Awadallah, who controls 65 percent of the market, quickly saw reasons to participate in CAIP's plan. At the same time that CAIP's survey had raised his visibility with environmental inspectors from the government, assistance from CAIP offered not only bringing his operation into compliance with environmental standards, but also greater efficiency and productivity. Other owners saw similar reasons to participate in the program.

Old lead smelting operations posed significant health risk to workers and the public.

Upgrading the sector

Relocation became a multi-pronged effort. Changes to the operations required expertise with modern technologies and procedures from the United States, modified by Egyptian engineers and manufacturers to factor in local requirements and financial realities. Relocation itself demanded an integrated approach for facility siting and waste disposal. Education provided owners and the workers with clear, factual information to grasp all

elements that would make the project a reality. Active involvement of all stakeholders — EEAA, the governorate, and the private owners — was essential for any meaningful progress.

Appropriate technology — reconciling environmental and market factors. The lead manufacturing sector in the United States has undergone substantial transition for environmental protection and therefore US engineers and facility operators were tapped to present the clean technology options now available internationally. Developing a conceptual, yet integrated design for a new facility, US engineers presented Egyptian engineers with options to select and as necessary adapt locally. From this, a more detailed design effort could be performed for owners in Egypt. Many design elements came into play: automated versus manual operations balancing efficiency with the availability of a large labor pool; high maintenance, high recovery pollution control devices versus simpler, more forgiving designs; and imported versus locally manufactured components.

Cost was of course paramount. CAIP worked with smelter owners to conduct financial feasibility analyses ensuring all designs could be operated profitably. In the end, Mr. Awadallah had large enough operations to support consolidating them in a single new facility. Other small and medium smelters could retain profitability with a locally-manufactured "baghouse" filter technology to capture their air emissions.

Comprehensive site planning for a new Awadallah facility. Overshadowing the relocation effort, the Egyptian government wanted to ensure that it was not simply moving a problem to another location. To gain cooperation of the Governor of Qalyubia to build a new smelter, CAIP offered a comprehensive urban plan for the selected site and completed the first Environmental Impact Assessment for an Egyptian smelter. One element of the impact assessment addressed waste disposal options. At the time, Egypt had no dedicated industrial waste landfill. Seizing the fact that rudimentary landfill existed next to the new site, USAID agreed to have CAIP draft a plan to upgrade that site as well. The outcome from implementing CAIP's plan was secure operations that would contain smelter waste and prevent exposure to the surrounding population.

Education. Part of the education process for Awadallah company officers concerned the nature of lead pollution itself. Because lead is heavy, airborne particulates tend to fall quickly and thus the pollution stays relatively close to the source. As a result, significant gains can be made by reducing the number of lead production centers and focusing clean-up efforts on the relatively small areas of former operations.

CAIP experts held training sessions with Awadallah and other facility owners and operators to familiarize them with the requirements of Egypt's environmental regulations. Separate sessions discussed worker health — specifically how lead poisoning and productivity losses from illness can arise from poor technology and lack of safety protocols for employees. Finally, CAIP prepared a manual for the smelter owners on types and sources of financing for facility upgrades.

Convincing the company. A central tenet of urban environmental management around the world is that pollution caused by private industry cannot be reined in solely by government fiat. Private operating costs and competitiveness, government ability to monitor and enforce compliance, land and demographic issues — all of these were important factors in the effort to tighten pollution controls in greater Cairo.

Because lead production in Cairo is a private endeavor, the bottom line for success by CAIP was convincing the Awadallah company of the benefits of introducing cleaner technologies for its smelter operations, and showing Awadallah and others how to improve their environmental performance while remaining competitive.

Gaining the support of Awadallah owners involved a two-step process. First, the CAIP team educated the company about the environmental and health impacts of its existing smelter technologies. Second, CAIP engineers described the changes and technologies they could introduce to mitigate these impacts while lowering costs and improving worker productivity.

Public-private partnership. Securing the agreement of Awadallah owners to relocate and rebuild their smelters was perhaps the most difficult step in CAIP's lead component. It was not, however, the only step. Focus now shifted to convincing the local governorate to support and help fund the relocation.

Initially, Awadallah purchased land to relocate the smelter. However the local community at the new location, not surprisingly, refused to accept even the new, clean smelter due to concerns about negative health impacts. It was a useful reminder of the public and political sides of air pollution management.

What followed was a concerted effort by CAIP to convince the governorate to allocate an appropriate parcel of land for the Awadallah smelter. CAIP addressed the governor's concerns about health and environmental impacts by developing contractual language committing Awadallah to strict guidelines for decommissioning and cleaning up the old smelter sites, monitoring emissions and ambient concentrations of pollutants for the

new smelter, and properly managing and disposing of smelter waste. This was a ground-breaking contract, never before seen in Egypt.

After extensive negotiations with the Governor of Qalyubia, a deal was reached: the Qalyubia Governorate would provide the land and help pay for certain supporting infrastructure if Awadallah agreed to meet strict environmental standards and help upgrade Qalyubia's landfill. The agreement was signed and the governor of Qalyubia allocated 63 hectares in Abu Zaabal to relocate all of Awadallah's smelters and foundries from Shoubra El Kheima.

An efficient and new manufacturing facility. With a green light to proceed, CAIP developed engineering specifications and the layout for the Awadallah plant — the nation's and the Middle East's first clean lead smelter. Mr. Awadallah then made the capital investment and constructed the facility according to CAIP's design. Not only is the smelter fully compliant with Egyptian law and international standards, Mr. Awadallah believes using this modern technology enhances the quality of his production, and this will increase his capability to export and increase his revenue. In spite of the difficulties he faced because of bureaucracy, and the large investments he made in new technologies, Mr. Awadallah is committed to becoming the first lead smelter owner who took steps to protect the environment.

Operations at the new Awadallah smelter reduce air emissions by 99 percent.

The new smelter's first phase was inaugurated in August 2002, producing 6,000 tons of lead ingots annually. The owner is now nearing completion of an expansion that will more than triple his output, to 20,000 tons per year. At the same time, in Shoubra El Kheima, levels of lead in the air have dropped more than 75 percent.

Supporting the community cleanup

The successful relocation effort removed the largest source of pollution in Shoubra El Kheima. Enforcement attention has caused other illegal operations to cease, further reducing lead releases to the environment. However, the legacy of smelting activity remains in the form of old smelter equipment and highly contaminated property. Worse

yet, the contamination has spread throughout the neighborhood over time. It is this remaining pollution that will affect local residents for years to come, continually endangering their lives.

CAIP addressed this on-going threat by conducting a comprehensive site investigation — determining lead and other contamination at a former Awadallah smelter, in the surrounding soil and ground water and at sensitive exposure points such as schools.

This investigation represents a pilot that will guide further work here and at other smelter properties. The US framework for hazardous waste investigation has been used as a benchmark, and this has been adapted and simplified to local conditions. For the first time, local specialists in EEAA and the governorate have been trained in not only the process, but the hands-on field techniques. They understand the significance of quality assurance to the integrity of the assessment and health and safety procedures to protect workers and the surrounding community. Factual information now exists to design realistic options for eliminating a hazardous situation, with the approach and costs required for each.

A comprehensive sampling effort determined the level of pollution at the old smelter site.

CAIP's work has now determined the nature and extent of the problem, created local capacity to continue at the current site and move on to others, and raised awareness that cleaning up former sites is essential. In other words, CAIP has put the analysis and options in place to design the final solution.

Furthering the policy agenda

The final element of the CAIP integrated lead abatement strategy supports planning for broader changes in the lead manufacturing sector. While there has been growing scrutiny on this sector in recent years for environmental reasons, no hard facts about the economics of the sector existed for long-term planning. As a result, CAIP prepared a detailed analysis for the lead processing industry. The work covered domestic and international supply and demand, pricing factors, trends over time and the reasons for changes in the sector, and recommendations for the future. One key area examined by the study is the market and other factors that will drive supply and demand for more

environmentally sound products. It is this work that will guide both the government and private sector as they examine how the market for lead-bearing products can and will change.

The Future

In Abu Zaabal, the new smelter is producing tons of lead each month with increased efficiency, and emission levels are less than one-tenth of what they were at the old facilities. At the same time, Mr. Awadallah is continuing to invest. Seeing the dual benefits of more efficient operations and reducing impacts to the environment, he is in the process of expanding his capacity, clear proof that the effort is successful from a business perspective.

In parallel, the remaining threat from old facilities is understood, and there is a legal obligation for Mr. Awadallah to remove the threat from his facilities. Work under the continuing Egyptian and US partnership — including work under the Egyptian Environmental Policy Program by many of the same CAIP specialists — will create specific cleanup implementation procedures for Awadallah. National cleanup guidelines will create the blueprint for replication elsewhere. Legal decrees will prohibit hazardous smelting in the future and obligate owners to clean up old sites prior to reuse. Some of these sites will actually be cleaned up under a subsequent USAID project.

Broader market forces and policy decisions will define this sector for the future. Undoubtedly the sector will continue, though with a more narrow suite of end products as more environmentally safe alternatives gain ground. CAIP has produced the technical analysis that will support sound decisions. Enforcement of the sector must continue, ensuring that un-licensed and non-compliant facilities cannot operate. With a combined "carrot and stick" approach, CAIP's successes in reducing lead in the environment and lead's adverse health effects will continue and grow.

Education and Raising Awareness

Environmental management practitioners worldwide understand the power and significance of education and awareness programs. Environmental education curricula have progressively developed populations that embrace sound environmental practices more often in their daily lives. Awareness raising activities have had wide ranging outcomes: more prepared policy-makers for decisions on environmental matters, a more accepting public for programs in which they may need to take part, a more pro-active public in pressing for positive change.

Environmental awareness programs in Egypt are relatively new. While the comprehensive environmental law of 1994 calls for information dissemination, much of the information to be distributed has only become available in the last few years. There are at present few means for regularly communicating environmental information to the general public.

At the same time, awareness is surprisingly high. A CAIP study conducted in 1998 demonstrated that a remarkable 99.5 percent of Cairenes interviewed said they were aware of the health effects of air pollution. More than 90 percent knew that pollution affects the national economy, and there was a similar level of knowledge about some of the main sources of air pollution.

Solutions

Independent of high levels of general awareness, CAIP's designers understood that there was a great deal to accomplish. First, the major project interventions would bring completely new programs and approaches to Egypt, requiring raising awareness, to be followed in most cases by acceptance. The vehicle emissions testing program is a prime

In Brief: Education and Raising Awareness

Two main objectives were set for CAIP's public awareness component. The first, to conduct selected activities that raise overall awareness of air pollution among Egyptians, including school children. Second, the component supported each of the specific CAIP interventions to raise awareness and ultimately modify attitudes and practices.

CAIP's first activity in 1997 was to support the government in a campaign publicizing the removal of lead from gasoline. Additional campaigns supported CNG as a safe alternative fuel, and vehicle tune-up as a way for citizens to protect the environment and save money. Numerous materials were also created to tailor technical information on CAIP interventions for technical and non-technical Egyptian audiences.

The most complex awareness activity focussed on gaining acceptance for the nationally mandated vehicle emissions testing program. Several years of progressive education transitioned to a full campaign for government officials, NGOs, the news media, the private sector, and the public in preparation for Giza and Qalyubia program launches in 2003. The campaign was designed to eventually serve all governorates in the country.

CAIP's broad air pollution awareness activities where wide ranging and generally supported the priorities of the Minister of State for Environmental Affairs. Through fall of 2001, significant work supported awareness in schools. Publications, outreach events, and puppet shows are example outputs of the project. After that time, focus shifted to communications within the government, providing technical information on priority issues within the government such as air pollution episodes (ominously labeled "the black cloud").

example — without acceptance from the owners of Cairo's 1.5 million vehicles, the program, even if it began under government mandate, could never be sustained. Second, general environmental awareness is the basis from which people build their awareness and acceptance of specific actions. CAIP was making a large volume of data and analysis available for the first time. This would be invaluable in raising the general level of knowledge. Finally, with CAIP's expertise and resources, there was a possibility to add to environmental education programs, just beginning in Egyptian schools.

Understanding the baseline

All parties understood the importance of raising knowledge of air pollution and its causes and solutions. With a knowledgeable population, it is then possible to convince people to adjust their practices to align with priorities of air pollution reduction.

The logical place to start at the project's outset was to assess the baseline conditions. Through a statistically designed approach, CAIP interviewed more than 1,000 people

across Cairo. Separate groups were included: the general public, end users such as bus riders, "influentials" such as NGOs and media leaders, supporters such as gasoline station staff who maintain vehicles, and policy-makers. The study assessed knowledge in a variety of general air quality areas, and specifically asked questions regarding vehicle emissions testing and compressed natural gas.

The findings were surprising. Over the relatively short history of formal environmental programs, the knowledge of air pollution, its sources, and its impacts was extremely high — more than 90 percent as mentioned previously. While this itself was excellent news, other findings showed areas for action. Less than one-fifth of the people believed that they could contribute to the solution by tuning their car. Only one-third viewed greater fuel economy as a reason to tune-up their vehicles. Clearly, some general knowledge was lacking, and that which existed needed to be channeled further toward sound practices.

Communication strategy tailored to varied stakeholders

What ultimately guided project communications activities for each technical intervention was a communications action plan. For vehicle emissions testing, compressed natural gas, lead abatement, and general awareness of air quality and CAIP, the planning effort targeted three levels of communications:

- Building understanding, consensus, and endorsement among stakeholders and policy-makers
- Supporting establishment of necessary technical infrastructure, such as testing centers
- Enlisting public support and participation

The plan was comprehensive yet flexible to evolve over time as program elements changed. For each of the four general technical areas, it defined the objectives of the communications, target audiences, messages, specific actions, timing, and resources needed. Like the training needs assessment (described below), this plan included an exhaustive assessment of partners and stakeholders, and their respective roles and responsibilities in each of the levels of communication. The plan was revisited after two years and updated to reflect changes such as the redesigned vehicle testing program and the emergence of air pollution episodes as a national priority.

Supporting decision-makers — good news can help

Decision-makers in the government are understandably reluctant to release certain information, especially on topics that have ramifications for health and the economy. In addition, the nature of air pollution is inherently complex. There are risks and uncertainties, and no individual can hope to grasp all of the elements of the problem. CAIP's approach included capitalizing on targets of opportunity to disseminate information and key messages. The targets were high priority issues that demanded attention and often could include a positive message. This approach ran in parallel with efforts to make decision-makers more comfortable with environmental information.

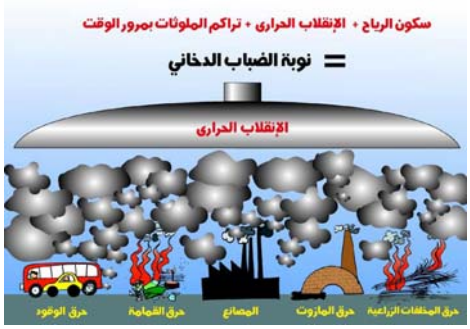
The unleaded gasoline campaign. During CAIP's start-up, one of Egypt's major environmental milestones was passing largely unnoticed. Through fast and decisive action, the Ministry of Petroleum had introduced unleaded gasoline in Cairo earlier in the year. With this, CAIP partners found an opportunity to highlight success and environmental progress by the government. In a matter of weeks, a campaign was devised to spread the news. The campaign targeted the point of sale. Banners, posters,

Gasoline stations in Cairo publicized the government's change to unleaded gasoline.

and brochures were created for gas stations around Cairo. Station owners were usually pleased to be able to feature the positive development for their customers, and over the next months, millions were informed of the government's positive action.

Air pollution episodes. Air pollution episodes arose as another priority. Regardless of actions by the government, the Egyptian media carried the issue extensively. This in part led to serious attention by Egypt's Prime Minister and the parliament. CAIP responded with integrated messages, working in various air monitoring and analysis findings to explain air pollution, its causes, what the government and others are doing, and what outcomes had been realized.

There are three reasons we believe the Minister of Environment and other policy-makers have picked up CAIP's messages. First, the issue required their attention. Second, many discussions on monitoring and other programs convinced them that the information they received was credible. Third, there was at least some good news they could show: simple yet scientific graphics demonstrating substantial and progressive reductions in airborne lead and the frequency and severity of air pollution episodes. At the same time, with CAIP and other policy planning, they could articulate a strategy for continuing the fight. CAIP's information removed some of the risk and uncertainty for them.



Technical data provides the basis for simple graphics explaining the contribution of weather to air pollution episodes.

Educating the media — clear facts and hands on experience

Project communications specialists quickly understood the perspective and needs of the primary partners, the news media in Egypt. It was clear there were frustrations and misperceptions, in part due to the lack of clear and consistent information coming from official sources. Compounding this were the different levels of knowledge of the media representatives. Although many were highly qualified with technical backgrounds, others were new to environmental reporting.

"CAIP in Print", a news clipping and analysis effort, was used within the project as a means to understand not only what was featured in the press, but what (right or wrong) was said, who said it, and what information and sources were being used. In some cases, CAIP consulted with more seasoned environmental reporters as a way of understanding what information was needed by the press.

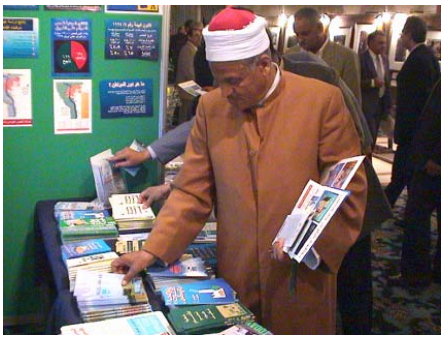
Throughout the project, CAIP paid special attention to producing tailored information based on the needs of different media staff. Press releases on project events were accompanied by background pieces to understand the context. Brochures, videos, and other materials featured highly simplified technical information, where appropriate adapted from established and extensively tested environmental communications programs elsewhere. Media briefings presented information and addressed questions,

but also gathered information on misperceptions or data gaps to address in future sessions.

Finally, the effectiveness of US study tours was substantial. Agricultural waste management, a factor in Cairo's air pollution episodes, became a very visible topic, with sometimes heated debates played out in the press. Yet there was also confusion in the press as to what Egypt was doing and should be doing about the problem. Following a media tour to the rice growing area of California, well documented, clear newspaper articles started appearing in Cairo, laying out effective programs in other settings and how they might be adapted to Egypt. The same group of media representatives met with the Minister of Environment after their tour and added to the knowledge of his office in moving forward with a waste management strategy.

Gaining acceptance for vehicle emissions testing

Communications activities related to vehicle emissions testing were among the most extensive on the project. Even so, they were highly abbreviated compared to similar programs in the United States. The effort was divided into two segments, one covering a voluntary period before the announced start date of the legally mandated program, and the other in the months preceding the launch of required programs in the governorates of Giza and Qalyubia. Please read the vehicle emissions testing section of this report to see how this activity was accomplished in the context of the technical program.



Outreach events allowed the public to learn about vehicle emissions testing.

Paying attention to the fundamentals — environmental education

In synergy with cross-cutting communication efforts to support the technical work, CAIP provided a unique ability to support educational programs. While priorities of top officials in the Egyptian government have changed over the course of the project, the benefit of CAIP resources has endured.

The educational focus has been on creative activities to raise environmental awareness in schools. The Friends of Environment festival, a government initiative to take messages to students, tapped CAIP's comprehensive technical expertise and information, mixed

with communications specialists and artists, to create an environmental puppet show carried to multiple schools. CAIP also designed and produced children's activity books with simple air pollution messages.

As word of CAIP and the significance of air pollution has spread, schools, clubs, business associations have used CAIP's expertise to educate their groups. A priority of the project has been educating NGOs — a recent NGO forum in the Qalyubia governorate had well over 100 attendees, learning about vehicle testing and other broad air pollution topics.

CAIP's environmental education activities included a puppet show for school children.

The Future

CAIP generated a large volume of technical data and analysis and fostered a great deal of awareness of general air quality issues, as well as specific interventions to reduce pollution. On the streets of Cairo and in meeting rooms, there is a remarkably accurate understanding of the issues and solutions.

There is clearly tremendous work still to be done however. Much of the information produced by monitoring and forecasting efforts is not available on a timely basis for either decision-makers or the public. Yet the need is even greater than when CAIP started. Along with population, vehicle numbers and industrial production continue to rise. With an educated population, there can be a more informed balancing of priorities and a more unified approach to action, sparing precious resources.

CAIP specialists working under USAID's environmental policy program are supporting the Ministry of Environment with a comprehensive information dissemination plan, part of an overall air quality strategy. The plan's design will acknowledge the abundance of credible, validated information now available; targets of opportunity for moving the agenda forward; and the realities of political will in communicating a complex issue requiring long-term commitments.

Monitoring and Analysis

Sound environmental decision-making and acceptance of the importance of interventions demands solid monitoring and analysis of environmental information. Building a constituency for change requires appropriate information in the hands of the government, private sector, and public at large.

In 1980s and early 1990s, government agencies, universities, and research facilities began producing air quality information for Egypt. However, different organizations had different priorities, and efforts for the most part were not coordinated. Much of the available data was for discrete research projects. It was this information that was available for health assessments and planning in the mid-1990s, including the design of the Cairo Air Improvement Project.

CAIP monitoring and analysis activities were designed in recognition of the need to increase the coverage of air quality information for greater Cairo. It was well recognized that the information available for the assessments of the mid-1990s was inadequate. What Egypt needed was a base of information that would guide short- and long-range planning in addition to supporting education and awareness activities. Priorities included:

- Establishing a monitoring network for target pollutants
- Characterizing sources of pollution
- Creating an inventory of lead pollution sources

In Brief: Air Quality Monitoring and Analysis

This component was launched in recognition of existing information limitations and the need to gather additional information over time.

The primary activity was establishing a network of 36 monitoring sites in greater Cairo to sample the air for CAIP's target pollutants, lead and fine particulate matter (in two size fractions, PM_{10} and $PM_{2.5}$). The network began operation in the fall of 1998 and continues to present, now operated by EEAA. Analysis of air quality data supports decision-making and communications activities.

The activity has done a variety of specialized analyses: two of the largest were a complete inventory of lead releases to the air in Cairo, and a source attribution study that defines contributions to air pollution from vehicles, industry, and open burning (garbage and agricultural waste).

Beginning in 1999 when Egyptians noticed air pollution episodes for the first time in Cairo, CAIP provided support to explain, forecast and mitigate these events.

Throughout the work, the project has provided Egyptian organizations, primarily EEAA, with the equipment, computerized analytical tools, and training to sustain the effort. This applies to emissions inventories, pollutant dispersion modeling, source attribution models, and general statistical analysis.

Solutions

CAIP activities created a framework to understand the status and trends of the target pollutants of the project — lead and particulate matter. For the first time, data could be packaged to show an objective and comprehensive picture of pollution across the city. Analysis of sources helped prioritize and guide CAIP interventions as well as separate but related initiatives of the government. Other activities gave EEAA tools to predict and manage air pollution episodes, which were first noticed in 1999.

Building sustainability into the monitoring effort

At the outset, CAIP was tasked with installing a network of monitoring stations that would determine baseline conditions and track pollutant trends resulting from interventions during the project's lifetime. Quickly however, it became clear that the Egyptian government wanted a sustainable program, one that they could manage on their own during and after the project.

The monitoring team developed criteria to ensure long-term success. Monitoring equipment was selected for ruggedness, battery operation for locations lacking a power

supply, technical simplicity, the ability to handle high pollution levels without overloading, low operation and maintenance costs, and a reliable supply of spare parts and dealer support. While a solid tendering process to purchase the equipment covered many of these bases, on-the-ground trials of some equipment were necessary. One device proved unable to handle the high dust levels found in Cairo during some times of the year. Sites throughout the city were needed to define pollution in different settings — residential, industrial, commercial, and heavy traffic locations. The monitoring team spent tremendous effort obtaining all approvals for long-term placement of monitoring stations at the 36 locations around the city.

Ensuring the financial sustainability of the effort was not easy. This was a new function for the environmental agency requiring both staff resources and capital expenditures. Existing staff in the environmental agency first had to be trained to be able to coordinate and oversee the program. While the design had most of the daily operations handled by a local university and outside laboratory, EEAA also had a quality control function and was responsible for all data analysis and reporting. CAIP provided extensive classroom and on-the-job training for staff who had never been exposed to substantial monitoring programs previously.

A local laboratory handles analysis and quality control for the 36-station air monitoring network.

The network transfer was accomplished with a phased approach. First, EEAA began paying costs for the network operations team. Next, laboratory services became part of their budget. Finally, the obligation for spare parts and new equipment purchases became theirs. Now, and since the summer of 2002, the network has been operated solely by the Egyptian government. Information from the network is used in routine reports from EEAA, the Egyptian government's State of the Environment Report, briefings for high level government officials, and various research activities. This network has clearly documented the reductions of airborne lead in greater Cairo during CAIP's tenure.

Sector assessment sets priorities for the greatest impact

Tackling such a serious problem as lead pollution demanded more solid data than existed previously. While lead smelting was a known concern, experts could not agree

whether other serious lead sources also existed. At the same time, more information on the lead smelting sector was needed since the players constantly changed and the project had limited resources to support the industry.

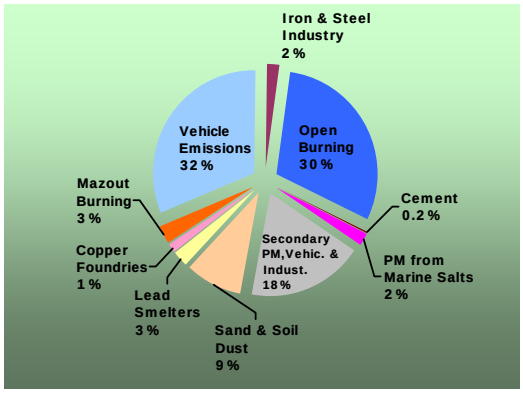
Local specialists conducted grass roots-level research to better identify what factories were operating — legally or illegally — and what hazardous pollutants were released to the air. Community interviews determined that significant illegal activity occurred and some owners had multiple facilities. This research was complemented by an emissions testing program to measure the actual pollution load to Cairo's air.

For the first time in Egypt, a comprehensive inventory of all contributors to airborne lead is in place. The environmental agency has the training, computer models, and equipment to update the inventory annually. Tracking changes due to activities of CAIP and others solely implemented by the Egyptian government, the most recent inventory update demonstrates that 65 percent less lead is entering the air in greater Cairo than when the project started.

Attribution study defines sources of human exposure

Developing a comprehensive inventory of each individual source of particulates was well beyond the scope and timeframe of CAIP, but this type of information was sorely lacking. Information on the contributions of different particulate sources to Cairo's air quality and human health, and how they vary at different times and locations is precisely what was needed for management purposes.

To fill these information gaps, the project performed a "source attribution study". This analysis used the unique "chemical fingerprints" of sources ranging from gasoline vehicles to cement factories to define the percentage contribution of these sources to the pollution levels measured at different locations around the city and at different times of the year. The results demonstrated that "base load" pollution of greatest concern to health comes mainly from a few industry types, vehicles, and garbage



CAIP's source attribution analysis clearly defined particulate contributors to support priority setting.

burning. During the fall period, agricultural burning can more than double the amount of pollution from garbage burning. The myth that most of Cairo's particulate matter comes from desert dust — and hence cannot be addressed — was dispelled.

The study led to more informed dialogue on the part of the government and a clearer picture in the news media of pollution sources. It also created a basis for defining sector-specific air quality strategies to tackle air pollution priorities in the years to come. This work is being conducted by many of CAIP's specialists under USAID's Egyptian Environmental Policy Project.

Flexible scope tackles new priorities — air pollution episodes

Air pollution changes on a daily basis. Around Cairo on any one day, pollution can be very different in different neighborhoods. Across the seasons, there are different sources of pollutants as well as natural factors that determine their impact on the urban area. Each of these factors needs to be considered for an integrated approach to the problem.

In 1999, residents of Cairo began noticing serious air pollution episodes — labeled the "black cloud" — during the fall. These peak levels were measured and reported by CAIP's air monitoring network. The Egyptian government requested CAIP's support to this new and politically charged priority. CAIP responded with the following plan:

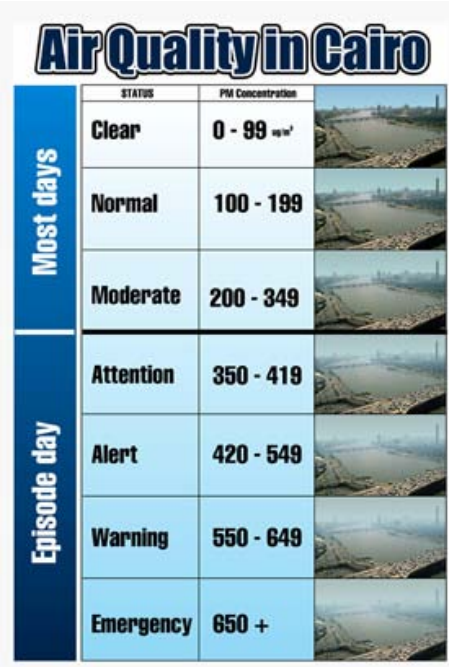
- Get the facts about episodes through sound data analysis
- Help the government anticipate episodes by developing an air quality forecasting program
- Identify short- and long-term mitigation options

Clear information as a prerequisite for sound decision-making. In the beginning, there was tremendous disagreement on the causes of the episodes. The local press was filled with wild speculation about sources of this serious health event. The CAIP source attribution study connected pollutant levels in the air with their contributing sources. For the first time, CAIP was able to show that the additional contributions from burning garbage and waste from the agricultural harvest could be drivers for these events. In addition, the analysis showed that serious episodes can occur with the normal load of pollution in the city if poor meteorological conditions exist.

With this information, the Ministry of Environment has helped raise waste management to the national agenda. Public pressure is contributing to the drive for solutions with

dozens of "black cloud"-related articles in the local press during the fall and winter, when episodes are anticipated.

Brokering interagency cooperation. When episodes first occurred, government officials were frustrated by their inability to anticipate them. CAIP was asked devise a program to forecast air quality. CAIP first formed a bi-national working group: Egyptian specialists in local air pollution and meteorology, US experts on technical tools for producing forecasts. The group met in late July 2000. In less than two months, all available data from CAIP, multiple Egyptian agencies, and other donor-funded efforts had been pooled and analyzed, and several predictive models were developed.



CAIP designed a simple scheme to classify air quality and air pollution episodes for communication to the public.

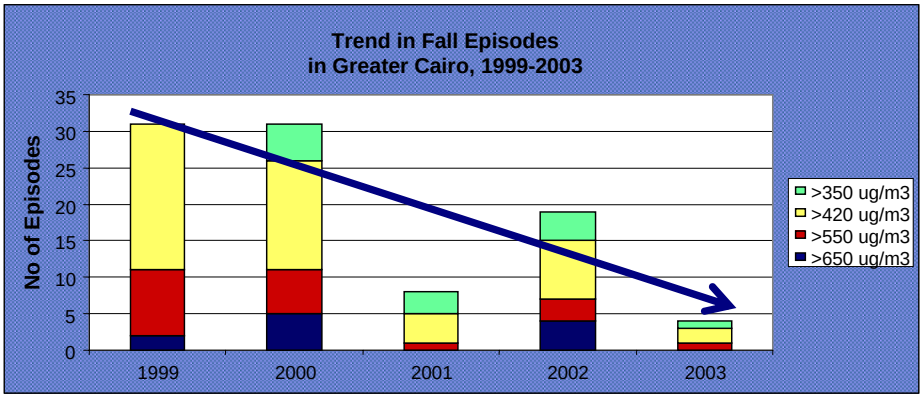
The next step was to create a new forecasting unit within the government. At CAIP's recommendation the national meteorological authority seconded two of its top meteorologists to the environmental agency, staffing a 24-hour, 7-day per week forecasting center. The center was equipped with special high capacity computers for the task. The meteorologists received special training in Egypt and the United States on advanced modeling techniques.

The forecasting center became operational in September 2000 and is now in its fourth year of continuous operation. There is daily reporting of the forecast through the environmental agency and to the desk of the minister, furnishing him with an invaluable tool to inform top officials in the government and the news media.

The bottom line: practical mitigation measures. While episode prediction became a political imperative, solving the problem was even more important. For the immediate term, CAIP provided the minister's office with an analysis of pollution reduction and exposure mitigation measures that had been applied successfully in other countries. At the same time, the project team began a communications effort to educate the

government and the public on the need for integrated strategies and long-term commitment to solve the problem. CAIP's alternative fuels, vehicle tune-up, and industrial control programs are part of that strategy. CAIP also supported refinement of Egypt's agricultural waste management program, drawing on program experience from rice growing areas of the United States.

While air pollution episodes continue, just as they do in other large cities around the world, Cairo has shown tremendous progress. From a high of 31 episodes in the fall of 1999, the city saw only 4 in 2003 — an 87 percent reduction.



Analysis of air monitoring network data demonstrated the government's progress in reducing both the number and severity of air pollution episodes.

The Future

Egypt for the first time has a comprehensive inventory of air pollution, its trends, and its sources, as well as a program to predict inevitable high pollution episodes. The program has proven its sustainability as it moves toward the third year of independent operation by the Egyptian government. Continued allocation of the right resources, including solid quality assurance efforts, will ensure the high standard of performance to date is retained.

The utility of the data and analysis generated from the program is clear. Already it has demonstrated the tremendous progress in reducing airborne lead levels and air pollution episodes. It has also guided the thinking for short-term interventions during the life of CAIP.

Ten years ago the need for better information was clear. Now, the enhanced data set is guiding updated assessments of the health and economic impacts of air pollution and is

being used to refine the government's pollution control strategy covering perhaps the next decade. In parallel, plans for regular dissemination of air quality information to the public are in the works. This would not be possible without a steady supply of high quality information with which the government managers can feel comfortable.

Training

Training programs were paramount under CAIP as the vast majority of programs implemented under the project were either completely new or represented substantial advancements over current practices. In some cases, expertise already existed in Egypt but needed to be brought to the implementing organizations. In many other cases, international expertise was required.

The complexity of interventions required both general and highly specialized skills enhancement. Programs would have to be tailored to different organizations, different units within those organizations, and different staff levels, from technicians to top management.

Solutions

The goal of the training program was simple: enhance the performance of individuals, leading to enhanced organizational performance and successful, sustained programs. Given the varied organizations and skill areas needed, different training approaches were required.

Comprehensive training needs assessment

The basis of the training program was a project-wide training needs assessment performed in the opening months of CAIP. The needs assessment put meaning behind the term "results oriented" by mapping out which different individuals and organizations supported specific CAIP technical objectives and how these in turn supported government environmental objectives, such as increased use of CNG and decreased airborne industrial lead. Extensive consultative sessions with CAIP partners identified all work units in the organizations that would be involved in CAIP activities.

In Brief: Training

CAIP's interventions were largely new to Egypt, and most of them were complex technically, requiring extensive training. The foundation of the program was a comprehensive, performance-based training needs assessment, refined and modified through the life of the project.

The result was extensive and varied training, ranging from basic skills training in computers to highly sophisticated classes in mathematical modeling and computer diagnostic techniques for electronically-controlled engines. Training targeted all levels within partner organizations, including hands on practical sessions for technicians and executive briefings for top managers. In-country sessions were complemented by carefully designed observational study tours to the United States, where Egyptian experts could see programs in their context.

CAIP's outputs are impressive: more than 2,800 participants trained through more than 220 sessions.

However, these lead to more impressive outcomes: teams, work units, and organizations that have been instrumental in achieving the impacts of CAIP and will sustain and expand the programs in the future.

The next task was to identify the structure of these work units and the roles and responsibilities of the units and their staff. Finally, the assessment defined the skills required for the individuals to allow the organization to ultimately fulfill its mandate.

Through the assessment process, organizations recognized the significance of defining position functions clearly and having people with the proper skills. The training needs assessment led to a recommended training plan for the first year, and this was updated for each subsequent year of the project.

Tailored programs achieve sustainability

A structure for each training program was developed to meet the needs of the trainees. The need for foundation ("prerequisite") training to develop skills in areas such as computers, language, or general management was first defined. For prerequisite or specialized activities, in-country training typically involved a combination of classroom and hands on sessions. Especially with technician-level trainees, the goal was to get them, as much as possible, out of the classroom and onto the workshop floor.

In most cases, CAIP used a training of trainers approach, identifying individuals who would be able to carry the work forward after the project concluded. Training was

institutionalized by using facilities and staff from training centers at the bus and petroleum companies as well as local universities. CAIP went a step further toward ensuring sustainability by working with these organizations to prepare their own training needs assessments and training plans. The plans were based on actual CAIP training programs as case studies rather than off-the-shelf programs.

Study tours to the United States were also fully tailored. In one case, bus company managers witnessed assembly and inspection operations at US manufacturing plants to educate them on the quality elements of US manufacturing, and to allow them to report more specifically within the government on the buses soon to be within their responsibility. In another instance, training for a local meteorologist on mathematical modeling used in air quality forecasting turned into productive technical dialogue and hands-on computer programming with US model developers. The end result of the study tour was a better skilled professional with a new model, modified for the Egyptian setting.

Hands-on training was extensive for new units of engineers and technicians learning advanced CNG technology.

Regardless of the structure, trainees attended an orientation briefing before each training. This session addressed logistical issues, but more importantly oriented them to the objectives and the context of the training. Afterward, they were obligated to complete a comprehensive evaluation. Evaluation material was included in CAIP's project database. This not only provided feedback for specific trainers, but also allowed the training manager to assess whether the training activities were meeting their objectives.

Optimizing technology supplier training

The technology-based programs under CAIP demanded extensive training by equipment suppliers and original manufacturers. These businesses were best qualified to perform training on their product yet understandably did not always offer all elements of a

comprehensive training program. Technology new to Egypt meant that Arabic trainers were not always available. Local dealers, while capable, did not have long experience with the product. In other cases, the US trainers most knowledgeable about the product had less experience with developing countries.

Each case was somewhat different, and CAIP adapted to ensure the overall program met the objectives. For vehicle emissions testing equipment that was completely new to Egypt, CAIP required US suppliers to travel to Cairo to conduct training in English to a core of bilingual Egyptian technical specialists, drawn from private companies, universities, and the government. These trainees became Egypt's knowledge base and trainers. In other cases, CAIP's long-term US and bi-lingual engineers facilitated training on CNG engines. They "translated" concepts related to preventative maintenance and problem trouble shooting to an Egyptian setting based on case studies drawn from the US.

Benefits from other umbrella training programs

Training was integrated in the CAIP scope and yet other funds were available through USAID's Development Training-2 (DT2) project. Initially, the highly technical nature of CAIP's training proved difficult to integrate with the more generalized training framework of DT2. CAIP eventually worked out an approach that involved the training manager as link between CAIP technical content specialists and the training organizers. Since technical training providers on specialized topics were usually limited, CAIP created a short list of qualified organizations that could conduct the sessions. The CAIP training manager then worked with the technical team to develop the training terms of reference. This package was forwarded to the training project for competitive bidding. CAIP then provided technical inputs during the trainer selection process. Through this mechanism, CAIP successfully leveraged more than $1 million in additional training funds.

Impressive outcomes as well as outputs

Many training programs tally the outputs of their efforts. In this regard alone the achievements of CAIP are impressive. The project held 224 formal training sessions, lasting more than 1,090 days, for 2,881 personnel from the Egyptian government, private sector, universities, and NGOs.

But the training accomplishments of CAIP are impressive for other reasons. EEAA monitoring staff know not just how to operate a monitoring network, but they have the

whole picture, including creating a network, defining a quality assurance program, and performing statistical analysis of the data to disseminate messages to government officials and the media. Traffic department engineers know how to purchase and troubleshoot emissions testing equipment in addition to operating it. The central traffic authority now has 20 of its own trainers to develop the skills of traffic department engineers further. Bus company managers know the merits of fuel quality analysis, computerized engine diagnosis, and gas cylinder inspection in addition to keeping buses on the road day to day. At the same time, more than 200 engineers and technicians know how to operate CNG buses for maximum performance. In other words, CAIP training has created new programs and enhanced the performance of the respective organizations.

The Future

Skills enhancement is a continual process, both for individuals and for organizations. First, the core capabilities must exist in Egypt and be available for those needing them. Training programs must be ongoing for new developments in technical areas, for new employees, or merely as a refresher.

CAIP has left behind the training materials and the capabilities for all types of training to continue in the future. Whenever possible, the project used existing trainers and organizations' training centers as the focal points to fully institutionalize the effort. The CAIP training team was careful to develop skills either within the implementing organization or with an outside group that would realistically be brought on as a training provider. This is one reason that university specialists were included in many project training sessions.

Core capability in CAIP's programs and the mechanism for sustaining it is now in place. The responsibility for doing so rests with each respective organization.

Lessons from the CAIP Design

Two realities affect the design of CAIP and future activities:

1. Protecting health is a well-known bottom line of environmental management. Health consequences of pollution translate into costs: health care expenditures, lost economic productivity, and lost tourism.

2. Environmental policy, while decades old in some settings, is still relatively new in developing countries. In Egypt, the first minister dedicated full-time to environmental affairs began in 1997, only three years after the nation's comprehensive environmental law was enacted. This is coupled with harsh economic realities that severely constrain funds and the climate for sweeping policy change.

At the beginning of a program design process, it is tempting to develop a substantial list of shortcomings in an environmental management framework. This is often done using well-developed, well-funded environmental programs of developed countries as the metric.

The Cairo Air Improvement Project was based on a different approach. The cornerstone was a desire to get to the bottom line: actual reductions in pollutants that cause adverse health and economic impacts. The 1994 comparative risk analysis defined the threat — lead and particulate matter as high-risk pollutants. A step-wise process then identified polluting sources. The final step defined interventions with short-term payback and feasible long-term expansion.

CAIP is about creating critical mass

The project worked from the ground up, driving meaningful change over both the short and long terms. It did this by making the up-front capital and other resource investments to initiate a series of programs. With these investments and the momentum from initial successes, programs are running and expanding:

- With 50 successful CNG buses and a cadre of trained personnel, local companies have invested in enhanced maintenance facilities, new fueling stations, and better local dealer support. The government has committed to purchase more CNG vehicles while investing in the policy shift to new national technology standards that guide the sector's growth.

- With cost-effective engineering designs, demonstrated economic feasibility, education on the severity of the problem and sound path forward, and increased visibility of environmental enforcement, Egypt's largest private sector lead smelter owner invested about $1 million in a more efficient and environmentally sound operation. Further investment in factory expansion is ongoing.
- With proven equipment for the first governorates, trained engineers, established local support, and extensive education and awareness programs, the national vehicle emissions testing program is already expanding outside Cairo.
- With comprehensive and factual monitoring data; stepwise analysis of the threats, sources, and interventions that can work; and education that makes planners and decision-makers comfortable with it all; the government is investing in refining its strategy to tackle the next set of air quality issues.

Monitoring performance helps define success

Defining quantifiable targets and measures of success is often difficult in technical assistance projects. It the case of CAIP, doing so helped define success. Better environmental performance means reducing the amount of pollutants entering the environment, their levels in air that people breathe, and when possible the resulting health and economic consequences. CAIP's ability to monitor key parameters, analyze their relevance, modify targets as new air pollution priorities arose, and evaluate outcomes gave the project clearer direction and better measures of success.

Flexibility accommodates environmental changes and complexity

Air pollution is complex and changeable. Environmental management programs mirror this complexity, demanding multi-disciplinary specialists and a huge number of stakeholders. CAIP was designed in the mid-1990s based on available information and expertise, but new situations arose. As discussed, air pollution episodes were first widely noticed by the public in the fall of 1999, prompting a request from the government for project support. In another instance, work planning discussions identified diesel buses, located at the same companies as the CNG pilot fleet, as prime targets for significant reductions through testing and tune-up. The structure of CAIP provided un-programmed funds to be dedicated to new initiatives agreed upon by the US and Egyptian governments. It was this flexibility that allowed CAIP to tackle some new and critical issues as they arose.

Including the private sector and the public

Donor assistance projects are usually structured to work between governments. With an issue as complex as air pollution, special attention is needed to involve the other elements of any environmental management program — the private sector and the public. Under CAIP, private sector partners entered as both polluters and as players in the market for environmental technologies. Market analysis, financial feasibility analysis, and private sector education and training contributed to both pollution reductions from industry (lead smelters) and private sector support to broader pollution reduction initiatives by others (government vehicle testing, and CNG buses). The public is also a major stakeholder, in CAIP's context primarily as the owners of private vehicles. Through the news media and NGOs CAIP was able to not just reach and educate the public but gain their acceptance for crucial interventions like vehicle testing and tune-up.

It may take a "bad" to make a "good"

Despite quality data, high levels of awareness, proper resources, and solid plans, some solutions are difficult to realize without the full attention of decision-makers. Acute problems at various levels (an air pollution episode or a bus out of service), may in some cases be what is needed to drive change. The CAIP design was flexible enough to react to changes in political will and tie initiatives to solving the priority problems. One example was raising the significance of vehicle tune-up by connecting it with the long-term battle against air pollution episodes. Another was being able to force better tracking of maintenance and fuel quality information in the context of eliminating serious engine failures and retaining valuable manufacturers' warranties.

Risk-based priority setting to stay on course for the future

CAIP was designed on a foundation of risk analysis, a procedure which prioritizes negative outcomes based on health risk. In the mid 1990s the health data was limited, yet this risk analysis, and the realization that more data was needed, created the basis for air pollution activities into 2004. Now, positive outcomes have been achieved, lessons have been learned, and much more is known about the problems facing greater Cairo. Ten years after the first risk analysis, the Egyptian and US governments — with many of CAIP's specialists — are partnering under the Egyptian Environmental Policy Program to update the risk analysis, add in economic outcomes, and define an air strategy for moving forward beyond CAIP.

Selected Reports

All reports are available on CD.

Clean Alternative Fuels in Transportation

Review of Existing CNG Standards and Regulations	April 1998
Project Design Report: Nasr City CNG Garage	November 1998
Institutional Support Plan for CNG Operations	January 1999
Natural Gas as an Alternative to Diesel Fuel, An Assessment of Pricing Alternatives	September 1999
Emissions Performance Testing of a Transit Bus Chassis with Cummins C8.3G Engine Using CNG	January 2000
Computerized Maintenance Management System (CMMS) Design Concept for CNG Bus Facilities	March 2002
Operations and Maintenance Manual for CTA and GCBC CNG Garages	September 2002
Recommended Implementation Strategy for CNG Safety Standards	October 2003
Compressed Natural Gas versus Diesel, Results of Vehicle Testing at Misr Lab	March 2004
Vehicle Emissions and Performance Testing Center Business Plan	March 2004
Sustainability Plan for CNG Bus Pilot Fleet	March 2004

Vehicle Emissions Testing

Vehicle Emissions Testing Plan Financial Analysis	February 1998
Implementing Vehicle Emissions Standards in Egypt, Phase I: Emission Regulations in the United States, Europe and Japan	June 1998

Proposed Amendments to the Executive Regulations for Law 4/1994 Concerning Egyptian Emissions Standards for New Vehicles	June 1998
Egyptian Environmental Affairs Agency (EEAA) Vehicle Emissions Testing Field Operations, Part One (On Road Testing-Low Emissions Tune Up)	March 1999
Tune Up Program Phase I: Survey and Status Report	May 1999
Low Emission Tune Up Capacity Building Strategy Document	July 1999
Technical Specifications and System Requirements for Test System Known as Idle Emissions and Opacity Test and Vehicle Inspection	October 1999
Management Guide for Vehicle Emissions Testing Centers	January 2000
Motorcycle Emissions Report	May 2000
Data Analysis Report for the On Road Testing (ORT) Program	August 2000
Technical Center Implementation Plan	December 2002
Inspection and Maintenance of Transit Buses (IMTB) Program Summary Report	February 2004

Lead Pollution Abatement

Review and Waste Determination of Slag Produced by Awadallah's Lead Smelting Operations	June 1998
Recommendations on Assuring Secondary Lead Smelter Compliance with the Requirements of Law 4/1994	December 1998
Financial Feasibility Assessment (LSAP-SO3) Awadallah Lead Smelter Relocation Plan	December 1998
Technical and Economic Study for Small and Medium Lead Smelters	January 1999

Financial Feasibility Assessment: Small and Medium-Sized Smelter Upgrading and Relocation	February 1999
Private Sector Funding Programs in Egypt	March 1999
Lead Smelters and Lead Foundries in Egypt	June 1999
Support for Selected Activities Under the Lead Smelter Action Plan: Industrial Relocation in Abu Zaabal	February 2000
Preliminary Assessment, Awadallah Secondary Lead Smelter in Shoubra El Kheima	February 2002
Landfill Development and Operations Plan for the Abu Zaabal Quarry	April 2000
Lead Supply and Demand Study	June 2002

Education and Awareness Raising

Findings of the CAIP Communication Baseline Survey	March 1998
Communication Action Plan	June 1998
Communication Strategy for CAIP Public Awareness Component	March 2000
Communication Plan for Launching the Egyptian Vehicle Emissions Testing and Certification Program	January 2003

Monitoring and Analysis

Development of a Lead Emissions Inventory for the Greater Cairo Area	November 1998
Support to the Air Pollution Episode Management Program	May 2000
Baseline Year Monitoring Report	June 2000
User's Guide for the Air Quality Early Warning System (AQEWS)	September 2000

1999 Baseline Lead Emissions Inventory for the Greater Cairo Area	September 2000
1999 Source Attribution Study Final Report	May 2001
Performance Evaluation of the Air Quality Forecasting System for the Greater Cairo Area	July 2001
1999/2000 Air Quality Monitoring Trend Report	September 2001
2000/2001 Air Quality Monitoring Trend Report	June 2002
Lead Emission Inventory Trend Report for the Greater Cairo Area (1999-2001)	August 2003
Greater Cairo Area Source Attribution Study	November 2003

Training and Management

Policy Issue Assessment	February 1998
Training Needs Assessment Report SO7: Reduced Generation of Air Pollution	August 1998
CAIP Sustainability Report	August 1999

CAIP Partners

CAIP was implemented under a grant agreement between the US and Egyptian governments, with funding from USAID. The main implementing partner was the Ministry of State for Environmental Affairs, with the Egyptian Environmental Affairs Agency. Other signatories to the grant agreement were the Ministry of Petroleum and the governorates of Cairo, Giza, and Qalyubia. The ministries of Interior, Local Administration, and Industry were also involved in the project. While CAIP touched a tremendous number of organizations, the following were especially crucial to its success: the Central Traffic Authority and governorate traffic departments; the Cairo Transit Authority and Greater Cairo Bus Company; Misr Petroleum Company and its laboratory at Ghamra; various gas companies including CarGas and GasTech; the Egyptian Organization for Standardization; the Egyptian Meteorological Authority; the Egyptian Geological Survey and Mining Authority; Cairo University; various private non-governmental organizations and Egyptian private sector companies; and the news media.

The CAIP contract was implemented by a consortium led by Chemonics International. US companies involved in the implementation included: CH2M Hill; Stone & Webster; ESP/Envirotest Systems Corp.; Engine, Fuel, & Emissions Engineering, Inc.; Sonoma Technology, Inc.; The Desert Research Institute; West Virginia University; and Charles Licht Engineering Associates; as well as various US technology suppliers. Egyptian subcontractors included Chemonics Egypt, TerraConsult, and Social Planning, Analysis & Administration Consultants.