Hazy days: Berkeley lab tackles pollution in Mongolia

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(Phys.org) -- Scientists at Lawrence Berkeley National Laboratory (Berkeley Lab) are known for designing high-efficiency cookstoves for Darfur and Ethiopia. Now they are applying their expertise to the windswept steppes of Mongolia, whose capital city, Ulaan Baatar, is among the most polluted cities in the world.

The scientists are working with the Millennium Challenge Corporation (MCC), a U.S. foreign aid agency, to improve air quality in the capital city by lowering emissions from outdated stoves and boilers. MCC has a five-year project in Mongolia to reduce poverty and promote sustainable economic growth. In 2010 the agency approached Berkeley Lab's Ashok Gadgil, the driving force behind the Berkeley-Darfur stoves, to lend vision and technical expertise to solving Mongolia's air quality problem.

Through an interagency agreement between MCC and the Department of Energy, a small team of Berkeley Lab scientists led by Maithili Iyer and Larry Dale has been providing technical guidance and support to MCC on the implementation and monitoring and evaluation of the program, respectively. Their focus has been on the coal-burning stoves used for heating and cooking that are found in every ger, a round, tent-like structure that is a common form of housing in Ulaan Baatar.

"Since we have expertise in developing and testing stoves, MCC asked us to provide technical oversight of their program—from assessing the stove performance to providing feedback on the appropriate subsidy levels and other aspects of implementation," said Iyer. "In the long run, Mongolia would benefit from moving away from coal-burning stoves altogether, but in the short term, promoting cleaner stoves is the most cost-effective way to maximize reductions in PM."

Ulaan Baatar's concentrations of particulate matter, or PM, are among the highest in the world. And the highest concentrations of PM, according to a 2011 World Bank report, have been measured in the ger districts, on the outskirts of the capital, inhabited largely by formerly nomadic families. "A lot of Mongolians are migrating to the cities for jobs and better schools for their children," said Dale. "They continue to live in their tents and heat them when it's minus 40 degrees outside with traditional stoves. Now half the city of 1.6 million, maybe more than half, is living in these ger districts."

PM is a mixture of solid particles and liquid droplets. The smaller the particle, the higher chance it has of being inhaled and affecting the heart and lungs. PM is usually grouped into two categories: PM10, for particles less than 10 micrometers in diameter, and PM2.5, for particles less than 2.5 micrometers. PM in Mongolia is most strongly associated with stoves for heating and cooking, which burn mostly coal with some wood on top for lighting, according to the World Bank study. Other sources for PM emissions include dry dust from open roads, power plants, heat-only boilers and vehicle exhaust.

The negative health impacts of PM can be serious, including adverse birth outcomes, irregular heartbeat, nonfatal heart attacks, development of chronic bronchitis and premature death due to heart or lung disease. There is a direct correlation between decreasing PM concentrations and reducing mortality and hospitalization.

According to the World Bank study on air quality in Ulaan Baatar, PM concentrations are “alarmingly high,” reaching as much as 10 times higher than the Mongolian air quality standard for PM10 and 25 times higher for PM2.5. The U.S. standard deems PM10 concentrations exceeding 150 micrograms per cubic meter (mg/m3) to be a health hazard. Winter days in some parts of Ulaan Baatar can see concentrations exceeding 4,000 mg/m3, according to the World Bank study.

“Getting off the airplane in UB is shocking in wintertime,” said Henrik Wallman, a scientist on the implementation team. “It’s not only soot, there’s VOC [volatile organic compounds], so you smell the air, and the winds carry it throughout the city. ”

The MCC began looking for cleaner-burning stoves in 2010. With assistance from the Berkeley Lab experts, two were identified as good candidates, with one in particular showing stellar improvements of five-

fold reduction in PM emissions in laboratory tests. Using a better combustion system, the Silver Minis, manufactured by a Turkish company, burn the coal from top to bottom, while the traditional stoves burned from bottom to top. “With a factor of five, you can make a real impact on UB air quality measurements,” Wallman said.

Distribution of these stoves began around spring of 2011, and by the end of last year, approximately 50,000 of the Turkish stoves had been sold. Thanks to the subsidy provided by the MCC stove program and an additional government subsidy, the stoves cost families only 50,000 tugriks, or about $40. “They had a good distribution system, with kiosks set up in various neighborhoods,” said Jim Lutz, another researcher on the team. “In addition to burning cleaner, the new stoves are also more efficient, so families buy less coal.”

To monitor and evaluate the new stoves, a separate team led by Dale went to Ulaan Baatar to collect data from 20 households. They also imported the Turkish Silver Mini to Berkeley and set it up in the lab to replicate local conditions. “The testing setup was created just for this stove. A chamber at the top helps to replicate the meteorological conditions of Mongolia,” said Agnes Lobscheid, who worked with Dale. “We’re trying to test it according to how people are actually using the stove, and capture the emissions at different stages.”

Dale and Lobscheid found potential challenges associated with consumers’ lighting and refueling the new stove compared to the traditional stoves. “There’s an important role Berkeley Lab can play in understanding, and making sure that consumers understand, the relationship between proper stove operation and maintenance and air pollution reduction so that emissions gains will be realized and sustained,” said Dale.

The next project for the implementation support team is overseeing the

replacement of eight heat-only boilers, which are large boilers for heating schools and office buildings outside the central core of the city where steam heat from power plants is not available. “They’re old coal-fired boilers, like in Dickens’ London,” said Lutz. “UB has about 40 or 50 of them, many from several decades ago.”

The project will also research commercially available low-pressure boilers (LPBs) for heating homes and gers. “We’re investigating if any of them are cleaner than the traditional LPBs, with the intent to increase their market penetration, if they are,” said Iyer.

“While there’s much work to be done, the Lab is helping MCC take real steps towards improving air quality in Mongolia,” said Iyer. “It’s only a matter of finding the right technology and scaling it up in a rational way.”

Provided by Lawrence Berkeley National Laboratory