THE WORLD BANK GROUP

MONGOLIA: HEATING STOVE MARKET TRENDS IN POOR, PERI-URBAN GER AREAS OF ULAANBAATAR AND SELECTED MARKETS OUTSIDE ULAANBAATAR

Stocktaking Report of the Mongolia Clean Stoves Initiative

With generous support from the Australian Government

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ABBREVIATIONS AND GLOSSARY OF MONGOLIAN TERMS

ADB	Asian Development Bank
aimag	Administrative region of Mongolia, equivalent to a province
ASTAE	Asia Sustainable and Alternative Energy Program
AQS	Air Quality Standard
CAF	Clean Air Fund
CDM	Clean Development Mechanism
CHP	Centralized Heating Plant
CSI	Clean Stove Initiative
duureg	Administrative district of Ulaanbaatar City
EAP	East Asia and Pacific
ger	Wood-framed, felt-covered dwelling traditionally used by nomadic households
hashaa	Small fenced-in plot typically occupied by a single household or family
IDA	International Development Association (The World Bank Group)
khoroo	Administrative subdivision of Ulaanbaatar City below the level of *duureg*
kW	Kilowatt
LPB	Low Pressure Boiler
LPG	Liquefied Petroleum Gas
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation
MJ	Megajoule
MVR	monitoring, verification and reporting
PM	Particulate Matter
SEET	Stove Emissions and Efficiency Testing
soum	Administrative division below the level of *aimag*, equivalent to a county or township
Tg	Mongolian Togrog (currency)
UBCAP	Ulaanbaatar Clean Air Project
WHO	World Health Organization
µg	Microgram

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This report is a summary of activities conducted for the initial phase of the Clean Stoves Initiative (CSI) in Mongolia. Funded with generous support from the Australian Government, the CSI is forum for promoting knowledge-sharing and collaboration to improve household access to modern cooking and heating solutions in East Asia and the Pacific. The initiative is comprised of four country-specific programs, in China, Indonesia, Lao PDR, and Mongolia.

The initial phase of the CSI builds on the unique experience that Mongolia has already gained in providing access to clean heating technologies and will share lessons learned with the other countries. Activities for the CSI stocktaking consisted of a survey of 1,000 households in poor, peri-urban ger areas of Ulaanbaatar and a rapid appraisal of market trends in four other cities, Darkhan, Ondorkhaan, Bayankhongor, and Khovd. The 1,000-household survey provides an updating of the World Bank's baseline survey of heating stove market trends in Ulaanbaatar, presented in *Mongolia:* Outputs of the stocktaking, including this report, are intended to inform the development of a national strategy in Mongolia for providing access to clean household energy for heating and cooking during the next phase of CSI. The preliminary findings of the stocktaking were shared with stakeholders in December 2012. The draft report was disseminated for comment at a workshop in Ulaanbaatar held in January 2013.

In addition to managing the CSI, the World Bank is also supporting the Ulaanbaatar Clean Air Project (UBCAP) with a $15-million soft credit financed by the International Development Association, the World Bank's concessional assistance arm. UBCAP will enable consumers in ger areas of Ulaanbaatar to access heating appliances producing less particulate matter emissions. It will also provide technical assistance for the development medium-term particulate matter abatement measures in coordination with development partners, including city greening, district heating, affordable housing, and power plant emissions controls.

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EXECUTIVE SUMMARY

Ulaanbaatar is the coldest capital of the world and remains one of its most polluted. Coal and wood burning for heating of individual residences in ger areas are essential for survival but contribute about 60 percent of the fine particulate ($PM_{2.5}$) concentrations in the city. These levels of exposure are very harmful to health and exceed World Health Organization (WHO) standards many-fold.

The heating appliances causing the pollution are both traditional stoves that have been used for generations and, increasingly, coal fired stove-furnaces (called Low Pressure Boilers or LPBs) used by wealthier households when constructing larger homes. The overwhelming majority of households in the ger areas of Ulaanbaatar (informal settlements surrounding the city), however, are poor, and the population continues to grow as job prospects in Ulaanbaatar attract more migrants. The World Bank estimates that a reduction of 80% of emissions from ger area heating could achieve a 48% reduction in population weighted exposure to $PM_{2.5}$. To achieve this, poor households need to be convinced to permanently switch to less polluting heating solutions, an effort that will require a multi-year, coordinated set of policies and programs.

This study takes stock of recent developments and provides market information on affordability, attitudes, fuel consumption, and other market information for stoves and fuels inside and outside Ulaanbaatar. It provides insights for solutions to the important challenges that remain to achieve a sustainable market transformation to low-emission stoves. Other programs on related issues could benefit, such as those for new fuels and insulation, as well as public awareness campaigns about health problems associated with air pollution.

The report relies primarily on results of a survey among 1,000 households in ger areas of the six central districts (*duureg*) of Ulaanbaatar conducted in July 2012 and a rapid assessment of the market for heating stoves in four cities outside Ulaanbaatar performed in August 2012, as well as information received from XacBank and the Millennium Challenge Account-Mongolia (MCA-Mongolia) on stove sales in a recent stove replacement program. Results from a similar market assessment by the World Bank in 2007-2009[1] are used as a baseline and backdrop for insights into the changes that have happened to the market since then.

With funding support from the Australian Government, this study is part of the World Bank's East Asia and Pacific (EAP) Clean Stove Initiative (CSI) comprising four country-specific programs (China, Indonesia, Lao PDR, and Mongolia) and a regional forum promoting collaboration, learning, and knowledge-sharing on access to modern cooking and heating solutions at the household level. The EAP CSI follows a 2011 report, *One Goal, Two Paths: Achieving Universal Access to Modern Energy in East Asia and the Pacific*, which presents the broader goals and work to be done to provide universal access to modern energy in the region. Achieving this goal in the EAP Region will be challenging given that more than 1 billion people-or every second household in the Region-lack modern cooking/heating solutions.

[1] World Bank, *Mongolia - Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar*. ASTAE (Asia Sustainable and Alternative Energy Program) Report (Washington, DC: World Bank, 2009).

Achieving the universal access to modern energy services by 2030 is also the goal set by the UN, which declared the Year 2012 as the Year of Sustainable Energy for All. If this goal is to be achieved by 2030, access to modern energy must be scaled up massively.

The findings presented in this study capture some of the initial outcomes of a recent stove replacement program in the Ulaanbaatar ger areas. As part of a major effort to reduce outdoor air pollution in Ulaanbaatar, the donor community organized small pilots in 2009-2011. In 2011-2012, MCA-Mongolia financed a scale-up of its pilot program in selected sub-district (*khoroo*) of the five districts that comprised Ulaanbaatar City's Air Pollution Reduction Zone. The Clean Air Fund (CAF) provided additional subsidies for stoves after the launch of the scale-up in 2011. An unprecedented 97,877 low-emission stoves were sold from June 2011 to November 2012. By the end of November 2012, about 55 percent of all households living in the central ger areas of Ulaanbaatar had purchased low-emission stoves, including 69 percent of those households in the targeted khoroo where subsidized stoves were sold. The MCA-Mongolia funded stove replacement project was results-based, providing consumer subsidies that disbursed only upon sale and verified installation of eligible stoves (see chapter 1). The program's rapid sale of new, imported stoves differentiated it from programs in other countries that have experienced a more gradual market development and have included some support of local stove supply. As there are many pathways that point to a solution-such as focusing on either local production or imports from regional or even global suppliers-the experiences and developments of the market for low-emission stoves in Ulaanbaatar form an important case study for the design and support of cleaner cooking and heating solutions internationally.

KEY RESULTS

The results of the survey among Ulaanbaatar ger area households and the rapid assessment of stove markets outside Ulaanbaatar lead to the conclusion that the significant results of stove replacement efforts to date could be jeopardized if it is discontinued. There has been some discussion of curtailing the program after 2013 due to its large sales figures, but results indicate that if this happens, households are likely to revert to purchasing and using traditional stoves. The demographic forces driving growth in the demand for stoves in the ger areas are still at play. Supply chains for low-emission stoves continue to be heavily dependent on the subsidy program, and the traditional stove market, though clearly reduced in Ulaanbaatar, continues to thrive outside Ulaanbaatar without subsidies. If a longer-term intervention is not put in place, the number of traditional stoves used by ger-area households will start pushing upward again along with emissions. The following five findings support this conclusion and summarize the key insights presented in this report.

Finding 1: *Demographics and household dwelling situations are changing*

One of the main contributions of this report is the detailed household, dwelling, and stove use information on households in the six Ulaanbaatar ger areas, presented in chapters 2 and 3. In general, compared with 2007, the markets have grown in absolute numbers and have changed in line with evolving household preferences for larger and more comfortable housing, driven by rising incomes. Markets for heating appliances, both in and outside Ulaanbaatar, consist of three distinct market segments: (i) stoves used in gers and detached homes of one or occasionally two storeys; (ii) stoves attached to heating walls in detached homes; and (iii) LPBs in detached homes with radiators in most rooms and/or piped hot water systems. Most households use their heating stoves to do most of their cooking, especially during the winter months, although some households with LPBs also have another cooking appliance.

Since 2007, the number of households in the six central ger area districts has grown by 36 percent or 43,990 households. According to the household survey, about 44 percent of households have a ger in their *hashaa* (a small fenced-in plot), about 42 percent have a detached home of one or two storeys, and about 14 percent have both a ger and a detached home. The average size of dwellings has increased in all market segments since 2007, correlating with increases in income (see chapter 5). The average floor area of a five-walled ger is 28m^2. The averaged detached house without a heating wall that relies on a space-heating ger stove has a living area of 39 m^2. The average home with a heating wall is slightly larger, with an area of 41 m^2, and homes with LPBs are the largest (73 m^2). Fuel use correlates with dwelling size; ger homes reported using 3.9 tons of coal per year, compared to 4.84 tons for homes with heating walls and 6.3 tons for homes using LPBs (see section 3.2.)

As people become wealthier and move to larger dwellings, they also upgrade heating amenities. Heating walls continue to be the most common form of heating system, although the proportion of detached homes with heating walls dropped from 70 percent in 2007 to 62 percent in 2012. This market share was almost entirely taken by LPBs, considered the high-end of the coal-fired heating

appliance market (and a different technology from traditional stoves). The portion of detached homes with LPBs rose from 16 percent to 23 percent. Homes with stoves without heating walls, a step above living in gers, maintained a stable share at 15 percent of total detached-home households. The survey furthermore shows that around 67% of traditional stove users are interested in switching to a low-emission stove (section 4.3) and that fewer households are buying traditional stoves-the average age of traditional stoves in use by households has risen significantly to 9 years, from 6 years in 2007. Because stoves have an average lifecycle of 10 years, many of the remaining households with traditional stoves will likely buy replacement stoves in the near term. There continue to be large, un-served segments of the ger-area market that use relatively more coal.

Finding 2: ***Consumer preferences must guide stove development, marketing, and stove replacement initiatives***

The ger household heating and cooking preferences and habits, presented in chapter 4, can inform the development, market entrance, or introduction of new stove types. New technologies are more readily accepted by ger-area consumers-and more properly used-when they align more closely with the traditional patterns of cooking and heating behavior.

Although four different types of stoves are offered in the current program, room for more competition exists. Apart from producing less pollution, low-emission stoves are also seen by their users as saving fuel, one of the characteristics that consumers ranked as being most important in their preferences for stoves (section 4.2.1). However, while about two-thirds of low-emission stove users in the survey were satisfied with the ability of their new stoves to heat their homes, the same was not true for cooking. Only 52 percent of low-emission stove users agreed their stoves were easy to cook with, compared to nearly 90 percent of traditional stove users. The survey also reveals that during the winter, households with low-emission stoves tend to cook more with electric hot plates (33 percent) than traditional stove users (13 percent) (section 4.2). Among the top difficulties perceived by users of low-emission stoves are the need to make a fire twice per day (70 percent compared to 45 percent of traditional stove users), difficulties with refueling (60 percent compared to 42 percent of traditional stove users) and time required to heat dwelling (44 percent compared to 25 percent of traditional stove users). This is particularly important because the survey results also indicate that the ability of the stove to heat a room and stay warm (meaning also less refueling, not a popular task) is seen as its most important aspect by consumers. Significantly, respondents who said they had learned about low-emission stoves from friends, neighbors, or relatives were about 35 percent less likely to be low-emission stove owners. If the performance of the low-emission stoves is not well-appreciated, it may be very difficult to get more households to use them. New entrants to the market will need to be careful not to overpromise or under-deliver on stoves to avoid a negative feedback loop.

As market segments more amenable to current low-emission stove offerings saturate, the stove switching program can face stronger head winds selling to households less inclined to buy them, such as households in detached homes using heating walls. Heating walls, which use the flue gas from the stove to heat a larger area, are self-constructed or made by local artisans. Installation of low-emission stoves with heating walls, requiring the purchase of connectors, has been challenging (see section 3.2). Another area that needs more attention is the increased use of low pressure boilers (LPBs), which are like coal fired furnaces distributing hot water through pipes. Some LPBs are pre-fabricated in China while others are made by local artisans. LPBs are completely different technologies than stoves and need to be tested and evaluated separately to set minimum requirements for their emissions performance in the next phase of stove replacement activities.

Finally, related to fuel use (discussed in chapter 5), if policies to introduce alternative fuels such as semi-coke coal are pursued, it is imperative

that the alternative fuels are tested, and that the results are made public, so that estimated impacts on emissions can be evaluated against program costs. Mandating new fuels may also require introducing new types of stoves that are designed specifically for use with those fuels. If the right stove is not paired with the right fuel, emission reduction benefits may be negated. So far, the government has provided significant support to alternative fuel producers (especially for semi-coke coal). Yet, the survey reveals that only 5 percent of all households in the surveyed ger areas reported using semi-coke coal on a regular basis, including only 49 percent of households in the Bayangol District, where raw coal is formally banned. Comparatively, 98 percent of households in the six districts report using coal, while 6 percent burn dried animal dung.

In sum, while the current low-emission stove offerings have been accepted by the market, a wider range of product offerings will be needed to maintain the program's penetration rates.

Finding 3: *Heating fuel expenses remain a high proportion of monthly income, especially for very low-income families*

Although incomes have risen and the spending on fuels as a share of monthly income has declined by 5 percent overall, heating fuel expenses continue to be very high, especially when compared with subsidized district heating enjoyed by residents in the city center. Households in the bottom income quintile spent 31 percent of their monthly income on heating fuels during the winter of 2011/12 (compared to 42 percent in the winter of 2007/08). By comparison, households in the top quintile spent only 6 percent of their monthly income on heating (chapter 5). All households-whether better-off or poor-continue to be exposed to the extremely high levels of particulate concentrations.

Finding 4: *Markets in and outside Ulaanbaatar are intricately linked, suggesting the possible need for a scaled-up program to reach areas outside the capital*

Results of the rapid assessment of markets outside Ulaanbaatar indicate that clear linkages exist between the stove market in Ulaanbaatar and markets in other cities, especially the aimag centers. Even if traditional stove makers in Ulaanbaatar go out of business, producers outside Ulaanbaatar could potentially fill the market with cheaper, traditional stoves when subsidies on low-emission stoves are lifted. It is also likely that some of the low-emission stoves purchased by households in Ulaanbaatar will flow out of the city through resale markets, and that those households will buy traditional stoves as replacements. The structure of the stove markets outside Ulaanbaatar is similar to those in Ulaanbaatar, but they are of a smaller scale and more dispersed in nature. These market characteristics challenge the viability of local production of low-emission stoves, unless costs are significantly reduced. Stoves are supplied by artisanal producers, who would have difficulties ensuring consistent quality when producing the high quantities that are needed to address the also growing concerns over air pollution exposure in the provincial capitals (*aimag* centers) heard during the rapid assessment.

A nationwide stove replacement program could help address the risk of traditional heating stoves out-competing low-emission alternatives. The existing distribution channels for stoves and materials between Ulaanbaatar and outside markets could be exploited to distribute low-emission stoves from larger producers or importers in Ulaanbaatar.

Finding 5: *Technical capacity and materials for maintenance of low-emission stoves are needed*

Private entrepreneurs must be attracted to provide low-emission stoves at lower costs. In addition, necessary skills and spare parts inventories for the repair and maintenance of the new, low-emission stoves need to be developed so that their supply and use can be sustainable. As discussed below as part of the road map, skills of the artisanal producers could be upgraded and programs addressing private sector needs could be adjusted.

ROAD MAP

The road map first presented in the 2009 World Bank report, describing a market-based approach for introducing new technologies that can burn fuel (new or old) more cleanly in Ulaanbaatar, remains largely relevant today and offers a framework for understanding good practices and assessing options to address sustainability challenges of the current program. The seven steps of this road map-with new information based on recent findings-are:

- *Estimate the impact of the proposed mitigation measures on the overall air pollution to ensure the government's investment will meet expectations.* The World Bank's Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts (December 2011) estimates that a 30% to 80% emissions reduction from ger area heating can produce a 18% to 48% reduction in population weighted exposure to $PM_{2.5}$. Under the Ulaanbaatar Clean Air Project (UBCAP), the city will start to implement a program that, among other requirements, that proposes to set a maximum of 70 micrograms of $PM_{2.5}$ per net megajoule (MJ) of heat emitted for ger stoves, for access to subsidies. This is about a 90% reduction in emissions compared to traditional stoves (1,000 µg $PM_{2.5}$/net MJ). Technical assistance for air quality analysis in Ulaanbaatar currently provided by the Japan International Cooperation Agency (JICA) and an evaluation of the MCC-funded stove-switching project being conducted by MCC and MCA-Mongolia may provide an updated forecast of impacts of mitigation measures.

- *Develop a testing program for equipment, with a focus on safety and emissions rather than fuel consumption alone, and set interim performance targets that can eventually be accepted, after practical experience is gained, as new standards, following the Mongolian regulatory process.* Mongolia has three main standards (MNS5216:2002, MNS 5041:2001, MNS 5679:2006) with some updates for stoves, boilers and furnaces, and solid fuels-all of which could be improved. Areas for improvement are summarized in the World Bank's *Mongolia: Heating in Poor, Peri-Urban Ger Areas of Ulaanbaatar* (October 2009).

Standards and certification mechanisms need to be developed after sufficient practical experience is obtained with testing and product performance in the field. A rush to legal standards may inhibit innovation, or worse, set ineffective or unrealistic parameters. Households can deviate from stove manufacturer's instructions, which affect stove emissions performance. These deviations can happen especially if the stove differs significantly from traditional products. A more pragmatic approach to standards development would divide tasks into building blocks: (i) using stove replacement activities to introduce interim standards, or eligibility criteria, as a starting point for developing standards; (ii) establishing sufficient, and preferably local, laboratory capacity to set initial emissions requirements and measure compliance during program implementation (perhaps, too, establishing links with labs outside Mongolia may help build capacity); (iii) building awareness and understanding of the impacts of various parameters that could be included in the eventual standards and emission requirements by publishing testing reports and explaining results to stove producers, taking

into account variations in performance due to possible "misuse" of stoves; and (iv) adjusting protocols and testing interpretations based on feedback from household use (using surveys, observations, repeated lab tests, and field tests of emissions). Monitoring data will provide confidence that the eventual standard is realistic, achieves its objective, and is enforceable in a cost effective manner. However, while field testing is important, it is very difficult to obtain reliable results; field testing results should be interpreted by experienced analysts. Also, all work towards the development of standards, including stove testing and monitoring, should involve the Mongolian Agency for Standardization and Metrology, who will be ultimately responsible for developing and enforcing the eventual standard. Finally, inputs from private stove developers, households, and other stakeholders should also be collected and considered during the standards development process.

In 2011, an Asian Development Bank-financed technical assistance project implemented by the Ministry of Mineral Resources and Energy established a Stove Emissions and Efficiency Testing (SEET) Laboratory, which conducted over eighty tests of various stove models, including some of the Turkish and Chinese-made models that were subsidized by MCA-Mongolia and CAF. Based on this work, Ulaanbaatar City developed eligibility criteria for stoves and producers. These criteria already address some of the deficiencies in the current set of standards, and require that stoves and fuels be tested together for emissions. Although the SEET lab did not receive support after the ADB program was completed and is temporarily dismantled as of the writing of this study, the lab will continue to receive support from the City of Ulaanbaatar through UBCAP, supported by the International Development Association, the concessional assistance arm of the World Bank. MCA-Mongolia conducted field tests but the results are not publicly available at the time of writing this report. Once available, these testing results will be valuable inputs to understanding variations in emissions between lab and home use.

- *Set an enforcement mechanism to address non-compliant products and manufacturers.* Stove switching eligibility criteria for new stoves and vendors should include warranty requirements and minimum after-sales service standards. (Warranties of two years were provided by low-emission stove vendors that received subsidies from MCA-Mongolia and CAF.) During the warranty periods, participating producers should agree to random spot checks of stoves sold (i.e. random lab testing) and monitoring of their service performance. In addition, they must agree to a penalty system for non-compliance, including permanent exclusion from the program in cases of persistent violations. Further, as local sellers of imported stoves might not be available, a likely need will exist for skilled workmen and the availability of good quality spare parts to service the low-emission stoves. Under UBCAP, technical assistance is available through a new Stove Development Center, which could be a source for training. Partnerships with the imported stove producers are encouraged so that appropriate knowledge is with local service providers after warranties expire. The center can also provide short term technical support for producers encountering design or manufacturing problems.

- *Establish a targeted and well-justified subsidy program to make new systems affordable.* Subsidy arrangements should consider: (i) the end point policy objective of the government, which in this case is reducing air pollution (especially particulate matter) exposure; and (ii) the consumers' willingness to switch to new products. Although a well-designed stove replacement program usually brings large net benefits in reduced health risks and fuel savings, the right amount and types of subsidy will depend on the ability of the market to sustain the transformation to the use of cleaner stoves. Based in part on the available data presented in this report, key principles of an appropriate subsidy program include: (i) the ability of consumers

to choose among several stove models, as not only the stove price (which was in fact ranked lower than other positive features of low-emission stoves; see chapter 4), but also by fuel savings and other features; (ii) the payment of subsidies only upon verified installation of the new equipment; (iii) the possibility of rewards for the use of stoves that achieve even larger emission reductions (i.e. considering that the government is willing to subsidize products to achieve public objectives, consumers should be rewarded for using stoves that achieve proportionally better public outcomes); (iv) the use of subsidy levels that reflect the affordability of target households and their willingness to start using another type of stove before the end of their current stove's useful life; and (v) the use of a final consumer's price that is not too low (or free) to ensure stoves are sold to people who will use and maintain it.

During the winter of 2011-2012, the stove replacement program included subsidies of around 249,800 Tg to 408,450 Tg (equivalent to US$195-319) for low-emission stove models. Subsidy amounts included two separate elements, financed by MCC/MCA-Mongolia and later by CAF. The subsidies reduced the sales price of low-emission stoves to roughly 20-25 percent of the price for traditional ger stoves, not including accessories. The prices of larger low-emission stoves ranged from 30-40 percent of traditional stoves used with fittings for heating walls. The pricing strategy employed by the recent stove replacement program achieved its goal of high and rapid sales rates; however, sustaining such levels of demand without the high subsidy elements is unlikely, leaving sustainability challenges for the next phase of the program.

- *Establish credible supply chains, in partnership with the private sector, and use a "third party" verification system for installation and use of new stoves.* The recently implemented stove replacement program used a clear and credible supply chain, involving product centers in designated khoroo (see chapter 1) to control quality and prevent the sale of "copies" - similar but lower quality versions. XacBank, the main distributor of MCA-Mongolia and CAF-subsidized stoves, is also implementing a Clean Development Mechanism (CDM) project for stove switching. The CDM requires strict monitoring of stove installation and use, following an agreed protocol. It also requires independent validation to verify emissions reductions.

Although sales are an important milestone, the final development outcome is achieved only by the sustained use of the low-emission stoves among area households. Although households sign an agreement promising to use the subsidized stove, low-emission stoves are priced below market prices of traditional stoves, creating an incentive for reselling. Evidence of large-scale reselling does not exist, however, perhaps because people who might buy re-sold stoves expect the subsidies to continue. It is extremely difficult to measure the occurrence of leakage. The study team did, however, identify a few low-emission stoves in the aimag and soum centers, outside the program boundaries of Ulaanbaatar. To further mitigate this risk of low-emission stoves not being used by the purchasing households in Ulaanbaatar, possible mechanism include: (i) verifying installation and training consumers in using the stoves before releasing the subsidy (already applied in the current program); (ii) using site visits to customers during the winter (either by producers or by program staff) to verify stoves are in use, provide supplementary training, and check on customer satisfaction; and, (iii) establishing a transparent reporting protocol linked to regular monitoring, providing information to stakeholders about program developments and possible adjustments needed.

- *Remove old equipment from use.* To achieve sufficiently large and sustained emission reductions, the support for cleaner alternatives must happen in parallel with the removal of polluting heating systems.

The July 2012 survey reveals an estimated 212,708 stoves are owned by 164,127 households, of which only 172,055 stoves are in use. The recent stove replacement program required submission of old stoves as part of the sales transaction, but program participants noted that about 7 percent of households received exemptions, and that the stoves that households turned in tended to be in worse condition as the sales season progressed.[2] Stove replacements need to be carefully monitored because households may be tempted to provide unused stoves (or even poor-condition stoves purchased from other households) to meet the requirement. While no fail-safe method exists to ensure honest trade-ins, mitigation measures include the independent verification mechanism discussed above, as well as continued public awareness campaigns on the health impacts of the pollution caused by the older stoves.

- *Market-based approaches to disseminate cleaner heating systems are preferred over nonmarket-based approaches such as stove giveaways.* Broad consensus seems to exist that artisanal stove manufacturing is not going to have sufficient capacity to design and supply the market with low-emission stoves quickly enough and at a large enough scale to bring down unit costs to parity with traditional stoves. The recent stove replacement program collaborated with foreign producers and Mongolian private sector distributors to achieve very rapid penetration rates. The partnership with the private sector is critical to the success of any market-based program as it provides the professional know-how, customer orientation, and innovation needed to provide good customer services and respond to market demand. There have been reports that major private sector participants are no longer interested in participating, which presents a major risk to the program, especially as it faces challenges to find ways to support a transformed, clean stove market without subsidies. Concerns of the private sector should be effectively addressed in the next phase of the program.

Although the current program already includes and has tested features of market based approaches, gaps remain. The program can be supported by the following policy options:

- Continue the program, including maintaining credible supply chains, verification procedures, and consumer subsidies. A publicly announced timetable to scale down the subsidy could encourage households on the fence to participate; however, curtailing the program too quickly could jeopardize results.
- Publish eligibility criteria for stoves and producers. The current program did not publish eligibility criteria. Consequently, the private sector in Mongolia was only able to participate by selling imported stoves (the only products that were identified as being eligible for subsidies). Publishing criteria and undertaking a transparent and objective evaluation and enforcement processes will be critical to encouraging greater private sector participation.
- Encourage development of technical standards for a wider range of products, including heating walls, low pressure boilers, and combinations with new fuels. This can be done through support of the SEET Laboratory.
- Develop skills and spare parts supply chains for servicing current stoves in partnership with the current import suppliers.
- Continue to monitor and evaluate program impacts through household surveys, air quality monitoring, and stakeholder consultations. On the latter, coordination among all stakeholders, donors and government agencies, is a critical factor to ensuring focused and sustainable outcomes.

[2] Author's phone interview with XacBank representative, November 1, 2012.

CHAPTER 1. INTRODUCTION

1.1 Study Context

With funding support from the Australian Government, this study is part of the World Bank's East Asia and Pacific (EAP) Clean Stove Initiative (CSI) comprising four country-specific programs (China, Indonesia, Lao PDR, and Mongolia) and a regional forum promoting collaboration, learning, and knowledge-sharing on access to modern cooking and heating solutions at the household level.

The CSI follows a 2011 World Bank report, *One Goal, Two Paths: Achieving Universal Access to Modern Energy in East Asia and the Pacific*, which identified the necessary work for governments in the EAP region that must be carried out on two paths simultaneously, toward meeting the enormous challenge of providing universal access to modern energy. On the first path, achieving universal electricity access requires accelerating both grid and off-grid programs while employing appropriate policies and innovative technical solutions to reduce costs, improve reliability, and provide timely service to all households. On the second path, a major push is needed to increase access to clean fuels and advanced cooking and heating stoves for poor, primarily rural, households that are likely to continue relying on solid fuels for most of their cooking and heating needs beyond 2030. Achieving universal access to modern energy services by 2030 is the challenging goal set by the UN in 2012 as part of its Sustainable Energy for All initiative.

Closely aligned with the regional program activities, the Clean Stove Initiative for Mongolia (the Mongolia-CSI) was launched in March 2012. Its objective is to strengthen knowledge of practical applications of intervention strategies to develop sustainable, cleaner stove markets-through experience with stove replacement efforts in Ulaanbaatar-and to develop a scalable strategy, if agreed with counterparts, for extending stove replacement to other key stove markets in Mongolia. Mongolia-CSI counterparts are the Mongolian Ministry of Mineral Resources and Energy and, given the dominance of the city's stove market, Ulaanbaatar Municipality.

The first phase of the Mongolia-CSI takes stock of the current market situation in Ulaanbaatar and other select cities. Phase 1 in particular focuses on stove replacement activities in Ulaanbaatar City, including the MCC-funded project, which is the most significant market intervention in the city's recent history. It also included a rapid appraisal of the market for heating stoves in four provincial capitals (aimag centers). Phase 1 will be completed after the dissemination of this study and participation in a regional cross-country workshop in March 2013.

Upon agreement with the two counter parts, the second phase of the Mongolian-CSI will be launched in 2013. Phase 2 will likely consist of a series of activities to monitor and generate knowledge on stove replacement efforts in Ulaanbaatar, as well as support engagement on developing a strategy to scale up activities in Ulaanbaatar to other stove markets in Mongolia. These activities could include: (i) periodic assessments of the stove market in Ulaanbaatar; (ii) developing South-South and North-South networking and knowledge sharing among stove program practitioners (such as dialogues among technical and scientific communities,

twinning arrangements and other collaborative models, and study tours and distance learning activities) to build stronger linkages among relevant scientific and technical communities in Mongolia, international counterparts, and, stove replacement program participants; and (iii) developing a national clean stove scale up strategy, including stakeholder consultations and the study of related issues such as institutional arrangements and long term alternatives to current heating and cooking solutions that might be attainable as Mongolia's economy continues its fast-paced growth.

Mongolia has made great strides in promoting energy access through rural electrification, for example by providing off-grid access to solar home systems for herders. This study aims to provide empirical evidence and lessons learned to support the replacement of traditional heating appliances with affordable, cleaner alternatives. Improving household access to modern energy forms part of a broader engagement by the World Bank with the Mongolian government, private sector, and donor partners on priorities for Mongolia's energy sector.

1.2 Air Pollution in Ulaanbaatar

Mongolia is a large country with severe winters and a small population. Temperatures across the country during winter time routinely fall below -20°C and can reach below -40°C on the coldest days. The country has one of the lowest population densities in the world, with only 2.8 million people and a land area equivalent to Britain, France, Germany and Italy combined. These low economic densities create high infrastructure costs and barriers to modern services; in 2007, only about 54 percent of rural households report to have access to electricity.[3] About 68 percent of the country's people live in urban areas, a share which is a high compared to other East Asian countries. Almost all of this is attributed to the growth of Ulaanbaatar, Mongolia's capital. The city's 1.2 million residents account for more than 40 percent of Mongolia's total population, and more than 60 percent of its urban population.

Ulaanbaatar remains nearly unlivable at certain times during the winter due to severe air pollution. Pollution of very small particulate matter (PM), which is inhaled deep into the lungs and causes major health damage, is severe. In a recent World Bank air pollution study, the worst recorded annual average concentration was more than 10 times higher than the Mongolian Air Quality Standard (AQS) for PM_{10} and 25 times higher than the Mongolian AQS for $PM_{2.5}$.[4] These numbers are extremely high, especially considering that the Mongolian AQS is already 2-3 times higher than WHO standards.[5] As shown in table 1.1, concentrations in ger areas (where the vast majority of the urban poor live) are more severe than in the city center.

Table 1.1. Average annual concentrations of particulate matter in Ulaanbaatar

Area	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	Exceedance Ratio to Air Quality Standards	
			Mongolian	WHO
Central city areas	150–250	75–150	3–6	7–15
Ger areas	350–700	200–350	7–14	17–35

[3] World Bank and Public-Private Infrastructure Advisory Facility, *Mongolia: Foundation for Sustainable Development: Re-thinking Infrastructure Services in Mongolia* (Washington, DC, June 2007).

[4] World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts* (World Bank Sustainable Development Series Discussion Paper, December 2011).

[5] The Mongolian annual ambient air quality standards are 50 µg/m^3 and 25 µg/m^3 for PM_{10} and $PM_{2.5}$, respectively, while the WHO interim targets for developing countries are 70 µg/m^3 for PM_{10} and 35 µg/m^3 for $PM_{2.5}$. See World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar*.

The extreme seasonal variability in air quality-the summer months are relatively clean while wintertime air quality is one of the worst recorded anywhere-reduce annual average concentrations and divert attention from the fact that Ulaanbaatar is one of the world's most polluted capital cities. The alarming PM concentrations in Ulaanbaatar lead to significant health impacts, valued at between US$177 and US$727 million each year (with an average of US$463 million).[6] Emissions from heating in ger areas comprise about 60 percent of total estimated contributions to population-weighted exposures to fine particulates on an annual basis, but can be much higher, even extreme, during winter months in certain parts of the city. For example, the monthly average PM_{10} concentration measured at a railway station in a ger area (the Zuun station) was 1,850 µg/m^3 in January 2009, while the four highest daily average measurements at the same station were in the range of 3,612-4,360 µg/m^3. The highest $PM_{2.5}$ concentrations were measured at the Bayanhoshuu station, also in a ger area, where the monthly average figure was about 1,500 µg/m^3 and the five highest daily concentrations were in the range of 2,310-4,060 µg/m^3.[7]

1.3 Low-emission Stove Initiatives in Mongolia

As part of a major effort to reduce the outdoor air pollution in Ulaanbaatar, the donor community organized a number of small pilots in 2009-2010. Pilots were financed by the Asian Development Bank (ADB), Deutsche Gesellschaft for Internationale Zusammernarbeit (GIZ, formerly GTZ), United States Millennium Challenge Corporation (MCC), the World Bank, and World Vision, and implemented in partnership with the Ministry of Mineral Resources and Energy and City of Ulaanbaatar. In 2011, with financing from the MCC, the United States Millennium Challenge Account–Mongolia (MCA-Mongolia) launched a scaled-up stove-switching project in "air pollution reduction zones" designated by the City of Ulaanbaatar in five districts: Bayanzurkh, Chingeltei, Khan-Uul, Songinokhairkhan, and Sukhbaatar. Additional subsidies were provided by the Mongolian Clean Air Fund (CAF). A total of around 68,850 low-emission stoves were sold and delivered to households in the five districts from June 2011 to June 2012.[8] By the end of November 2012, 97,877 stoves had been sold,[9] reaching 55 percent of all the 177,933 households living in the central ger areas of Ulaanbaatar as of the end of 2012,[10] including 69 percent of those households in the khoroo that were targeted by the MCA-Mongolia project.

The low-emission stoves were imported from Turkey and China and sold exclusively (with some exceptions) through dedicated distribution centers called "Product Centers." The product centers were established in selected khoroo. Each household was eligible to buy one subsidized stove, at the authorized product center in its khoroo. Registries of households living in the khoroo, maintained by khoroo administrators, served as the master list for eligible households that could purchase stoves.

The majority of the stoves (about 88 percent) were distributed through product centers operated by XacBank, a commercial bank with roots in micro-finance in Mongolia that was contracted by MCA-Mongolia for its services. The bank supplied the sales and support staff and offered a micro-loan to finance the purchase of the stove if a household could not pay for the stove with its own funds. XacBank staff initiated the sale in the product center,

6 World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar*.

7 Ibid.

8 As noted below, no stoves were sold in Bayangol District due to a ban on raw coal there.

9 MCA-Mongolia sales data provided to authors via email with MCC representative, December 27, 2012.

10 Overall market share is presented as the percentage of ger-area households in the six districts covered by the survey that purchased low-emission heating stoves as of December 2012. The total number of households includes those households with low-pressure boiler systems as well households in khoroo not targeted by the MCC-funded project, with the understanding that these households should nonetheless be counted among those that have yet to acquire low-emission heating appliances. The total number of households reflects official statistics for the ger-area population as of the end of 2011, the latest data available as of the time of writing. See Ulaanbaatar Statistics Department, http://statis.ub.gov.mn/.

checking household eligibility and signing a user agreement with each household, which inter alia included a commitment by the household to use the stove according to owners' instructions. Importantly, the household as required to hand in their old stove with the purchase of a new one, to remove polluting stoves from use. The household made payment at a XacBank branch, which transferred funds to the stove producer upon verified delivery. A subsidy was then transferred by MCA-Mongolia to the producer also upon verification of delivery and submission of documentation. XacBank also managed the receipt and destruction of the old stoves and, upon confirmation of payment, the distribution of the new stove, which was delivered to household soon after purchase. Upon delivery, the stove producers provided training to household on how to use its new stove. Delivery was confirmed in the field by staff (via an innovative mobile SMS verification system developed by XacBank). Costs of XacBank services were covered substantially by MCA-Mongolia. XacBank has initiated a Clean Development Mechanism (CDM) project that is expected to finance the product centers in the future.

Households were offered a subsidized price for the stoves. Stove models were on display at the product centers with price sheets and other informational materials. Price sheets displayed the actual price, the discount, and the final price. Table 1.2 gives the listed and final prices of stove models sold during the winter 2011/12 sales season.

Table 1.2. Selected List and Subsidized Low Emission Stove Prices, Winter 2011-2012

Stove Model	List Price (Tg)	MCA-Mongolia Subsidy (Tg)	Mongolia Clean Air Fund Subsidy (Tg)	Customer Price (Tg)
Silver Mini	325,000	250,700	50,000	24,300
Silver Turbo	459,250	208,450	200,000	50,800
Royal Single	275,000	209,800	40,000	25,200
Royal Double	330,000	245,000	40,000	45,000

Note: Clean Air Fund subsidy was introduced after the start of the sales season; Source: authors' interviews and correspondence with XacBank representatives, Ulaanbaatar, Mongolia, March 2012.

Not including accessories, after-subsidy prices for smaller capacity low-emission stoves (Silver Mini and Royal Single) were roughly 70-75 percent below the market price for a traditional ger stove in Ulaanbaatar; the after-subsidy prices for the large models (Silver Turbo and Royal Double) were about 60-70 percent lower than the going price for a traditional ger stove with a heat wall fitting.[11] Households also needed to purchase chimneys and heating wall connecters for certain models, which added costs of up to around 25,000 Tg to costumers during the initial months of the program but were eventually given for free.

The four stove models sold under the MCA-Mongolia project constituted the bulk of stove switch-outs in the years and months leading up to the July 2012 survey. Most of the stoves (the Silver models) were supplied by a Turkish manufacturer and imported and distributed by a private Mongolian company with strong distribution capabilities. Other stoves (the Royal models) were manufactured in China. No domestically-manufactured stoves were eligible under the program. MCA-Mongolia did not disclose its selection criteria for stoves and producers.[12]

[11] Traditional ger stove prices are estimated on the basis of asking prices quoted by stove traders at Narantuul Market in Ulaanbaatar, and in the four other cities visited by the study team.

[12] This does not imply that selection criteria were absent, or that MCA-Mongolia did not test the emissions performance of stoves. MCA-Mongolia tested 14 models of domestic and imported stoves that were commercially vi-

Small pilots were conducted during the 2010-2011 winter season under an ADB technical assistance project[13] and the MCA-Mongolia project. The separate ADB and MCA-Mongolia pilots tested the use of a subsidy mechanism to sell more-efficient, emission-reducing heating stoves to ger-area consumers via neighborhood product centers. The ADB pilot, designed and launched jointly with XacBank and World Vision International, sold a model of "improved stove" model that was developed by GTZ and produced in Mongolia; MCA-Mongolia piloted the sale of imported stoves (see box 1.2 for definitions). The product centers, located near high-traffic areas such as water kiosks and bus stops, were also used to sell insulating covers to improve the thermal efficiency of gers.[14]

The ADB project, implemented by the Ministry of Mineral Resources and Energy, also established the Stove Emissions and Efficiency Testing (SEET) Laboratory. It was the first-of-its-kind stove emissions testing facility in Mongolia, capable of reliably measuring particulate emissions. About eighty tests were performed on various models and a testing protocol was developed and independently evaluated by a European testing company. The SEET lab tested the Turkish stoves, showing that the stoves' emissions were significantly less than those of traditional stoves, provided households used the stove according to the users' manual. All heating stoves have two fueling stages-lighting and re-fueling. Traditionally, households would add more coal onto an ongoing fire. The new Turkish stoves required a cold re-fuel for best results, a deviation from traditional refueling practices. The ADB project helped gain additional insights and develop stove and producer eligibility criteria, which were incorporated into the Ulaanbaatar Clean Air Project (UBCAP), a US$15 million IDA soft credit project, implemented by the city of Ulaanbaatar to sustainably increase low emission stove penetration after the MCA-Mongolia program expires in September 2013 or earlier (see box 1.1).

The UBCAP stove emissions criteria are publicly available.[15] Although emission factors under laboratory settings can diverge from those in the field,[16] for the purposes of this study, the stoves sold under the Mongolia-MCA program are referred to in the report as low-emission stoves. During the stove switch-out scale-up, MCA-Mongolia conducted field testing of the stoves with technical input of Lawrence Berkeley National Labs, but the testing results are not yet publicly available.

To test alternative solutions to stoves, the government declared "no raw coal zones" in Bayangol District. MCA-Mongolia and CAF subsidized stoves, which are designed to burn raw coal, were not allowed to be sold in Bayangol.[17] The alternative fuel to raw coal offered to Bayangol households is mainly semi-coke coal briquettes (semi-coke mixed with a binder; if lay is used, ash content can be as high as 50 percent[18]). However, the Bank team is unaware of any reliable, publicly available emissions tests performed using semi-coke coal briquettes in traditional stoves. Stoves should be matched for a specific fuel to ensure the fuel is burned as completely as possible.[19] In the case

able. Testing was performed by the Mongolian University of Science and Technology. MCC and MCA-Mongolia, written comments provided to World Bank authors, February 16, 2013.

13 The ADB project partnered with the Ministry of Mineral Resources and Energy, Ulaanbaatar City, World Bank, GTZ (now GIZ), and WorldVision International (an NGO). For details and project documents, see "43177-012: Ulaanbaatar Clean Air, Project Data Sheet," http://www.adb.org/projects/43177-012/details.

14 XacBank was an early pioneer of the product center model, having first operated centers in ger neighborhoods during the winter of 2009-2010. XacBank, "Market Mechanisms for MCA Energy and Environment Project" (presentation, Ulaanbaatar, Mongolia, March 15, 2010).

15 Emission testing in the field is much more difficult than in the laboratory; however, communications from the testing team seemed to confirm that field and lab tests yield approximately the same results.

16 This was identified as a risk in the safeguards report for UBCAP. Ulaanbaatar Services Improvement Project II Project Implementation Unit, "Mongolia: Ulaanbaatar Clean Air Project Safeguards Report" (internal management report, September 29, 2011).

17 Product centers were still operated in Bayangol to sell other energy efficiency products, such as ger blankets and vestibules.

18 So far, no test results are available. Author's interview with representatives from MAK Mongolyn Alt Corp, World Bank office Ulaanbaatar, Mongolia, April 8, 2008.

19 World Bank, *Mongolia: Heating in Poor-Peri Urban Ger Areas*.

that fuel switching does not produce significant emissions reductions, the stoves will need to be switched to match the new fuel.

The MCA-Mongolia program funded new purchases until the end of November 2012. The CAF and UBCAP are expected to continue stove replacement activities to maximize low emission stove penetration and address sustainability issues.

Box 1.1: Ulaanbaatar Clean Air Project (UBCAP)

The objective of the Ulaanbaatar Clean Air Project (UBCAP), launched in 2012, is to develop selected medium-term particulate matter abatement measures in Ulaanbaatar in coordination with development partners. The project supports the implementation of short-term measures and the development of medium-term measures through three components: (a) the implementation of a stove and low pressure boiler replacement program to reduce particulate matter emissions in the ger areas; (b) the preparation of action plans and policy recommendations to reduce particulate matter in central Ulaanbaatar through district heating, city greening, and other medium-term abatement measures; and (c) public awareness raising and coordination. The project is financed with a US$15 million soft credit from the International Development Association, the World Bank's soft credit arm.

As part of the first component, particulate matter mitigation in ger areas, the UBCAP will cover as many households as possible in the stoves and low pressure boiler market segments that were not covered by previous subsidy programs, and will provide additional market development support needed to help sustain the clean stove technology market. The UBCAP stove replacement program will use the sales and distribution mechanism used by MCA-Mongolia and CAF to maintain continuity and avoid duplication. The UBCAP subsidy program will have clear working arrangements between potential financing sources prior to implementation.

The proposed main implementation and institutional arrangements for stove replacement include:

- **Stove and vendor eligibility.** Selection criteria for stoves and vendors are summarized below. Emissions performance will be tested at the Stove Emissions and Efficiency Testing (SEET) laboratory. The Project Management Unit (PMU) for UBCAP will determine the eligibility of stove models and producers, based on the selection criteria in the operations manual, approved by the Project's Steering Committee. An annual review of the selection criteria is planned, including involvement of stove producers, consumers and other stakeholders. The PMU is encouraged to regularly consult producers and stakeholders on the criteria. A Participation Agreement shall be signed between the PMU and each eligible stove producer, defining the rules for participation in the UBCAP stove replacement program.

  Key Stove Eligibility Criteria
  - *Fuel:* Fuel choice is open; however, the stove and fuel combination needs to be tested.
  - *Capacity of stoves*: More than 3 kW average over test conditions with up to 90% of fuel burned; for houses, with or without heating wall, 5-9 kW depending on size; low pressure boilers, 5-15 kW.
  - *Particulate emissions*: 70 mg/net MJ for $PM_{2.5}$ (net MJ of heat emitted from the stove).
  - *Carbon monoxide emission*: 7 grams/net MJ (complying most of the time with the Mongolian National Standard 5679:2006, i.e., 2% CO/CO_2 emissions).
  - *Cooking time*: a cooking vessel of 400 mm diameter with 8 liter water capacity should reach boiling condition between 30 and 60 minutes after the fire is lit (from cold start).
  - *Workmanship and durability*: safe handling and adequate strong components for at least 5 years.

  Key Stove Producers' Criteria
  - *Legal entity*: Producers must have a valid business license.
  - *Participation Agreement*: Producers must sign a Participation Agreement which confirms agreement with terms and conditions of the project, including penalties for non-compliance.
  - *Production capacity*: Producers must be able to supply a minimum of 100 eligible stoves within a four week period after signing a supply contract.

- *Quality control*: Producers must sign a participation agreement which gives permission to UBCAP PMU to periodically or at random intervals verify quality and performance of stoves produced and give permission to publish production and price statistics.
- *Warranty*: Producers must provide a warranty to the user, guaranteeing that the stove will be repaired or replaced during a 2 year period following the purchase, if there are defects, breakage or component malfunctions due to manufacturing defects.
- *Safeguards*: Producers must demonstrate compliance with project safeguards requirements.
- *Training Customers*: Producers must develop a basic user manual for their stove and deliver a brief hands-on training to the purchaser when the stove is installed.

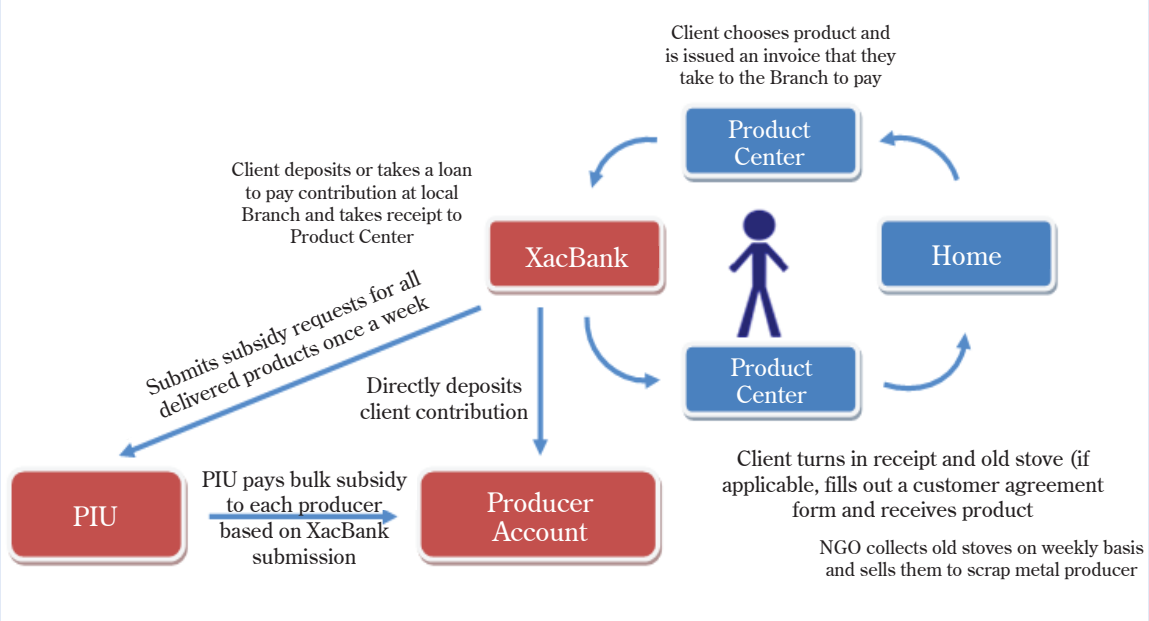
- **Regulating supply chain through Product Centers**. Eligible vendors sell eligible stoves through Product Centers based generally on a consignment business model. This will reduce the risk of copy-cat models sold outside the accepted distribution channel. Eligible models will be shown in the Product Centers, similar to those operated under the MCA-Mongolia project.

- **Subsidy Mechanism**. Eligible stoves will be sold at a subsidized price. The subsidy levels are calculated based on the following principles: (a) equalize the price of the new stove with the price of traditional model (basically, only one model is used in all households); (b) a temporary, additional subsidy to promote more rapid adoption; and (c) a third subsidy, not piloted but proposed for UBCAP, to buy back stoves currently in use. The subsidy is expected to be based on experience gained from the MCA-Mongolia stove replacement project. Criteria which will guide the final value of the UBCAP subsidy may include: (a) consumers should have the freedom to purchase the eligible stove of their choice; (b) consumers should be rewarded proportionally, to the extent possible, for using the stoves that have better emission properties; and (c) consumers' price for the new stoves should not be too low or zero (i.e., no giveaways). The elements considered in the subsidy are: (a) the subsidy should promote a rapid penetration of stoves in a large part of the market (e.g., 90%); (b) the subsidy should include payment for the old stoves consumers will be asked to provide as part of this switch-out program; (c) the pricing provided should not be smaller for eligible models than those already offered, signaling to the market that low prices will not be sustained.

- **Financing Mechanism**. Households will purchase stoves at Product Centers. Households may pay the balance out of pocket or from a XacBank micro-credit. XacBank is utilizing an ongoing Dutch grant-financed project intended to bring down costs of micro-loans to offer financing for household contributions. Payment to the stove vendors is made in two stages: household contributions are first transferred directly to vendor accounts by XacBank. Subsidies are then transferred upon households meeting the following conditions: (a) signed purchase agreement between HHs and the Project (including XacBank) agreeing to purchase and use the stove for purposes intended, hand over the old stove, and monitoring and verification; (b) household counterpart contribution paid in full (XacBank receipt); and (c) verification of installation of the stove in the household. Funds flow would be managed through the commercial bank's internal funds management systems, which can be audited easily.

- **Training, monitoring, verification and reporting (MVR).** A two stage MVR system is envisioned. XacBank plans to verify installation of the stoves in households because it intends to use the sales toward carbon credits. A consulting firm, most likely an NGO, will be selected to verify stove installation, check on proper operation, and perform quality control checks on the supplied products. The quality control mechanism includes a 'three strikes' system including: (a) a warning to first-time violators; (b) temporary exclusion from the program and public disclosure for second-time violators; and (c) removal from the program for three-time violators of the participation agreement.

Figure B1.1 Overview of UBCAP financing and stove distribution



1.4 Study Background and Objectives

In 2007-2009, the World Bank conducted a series of stocktaking activities to establish policy guidance and program design recommendations for transforming Ulaanbaatar's stove market. Included in these activities was a 1,000 household survey conducted between December 2007 and February 2008. A follow-up survey of 1,000 households was conducted in July and August 2012. This report takes stock of the household heating situation in the central ger districts of Ulaanbaatar and draws comparisons with the 2007/2008 baseline. The report also summarizes findings of a rapid assessment of stove markets outside of Ulaanbaatar.

The report's objectives are:

- To describe the characteristics of the stove markets in and outside Ulaanbaatar in Mongolia in July 2012, comparing these to the characteristics of the stove market in 2007/2008 before major efforts were made to promote low-emission stoves.
- To provide insights for the design of stove switching programs, especially focusing on characteristics of a sustainable clean stove market in Ulaanbaatar and how clean stoves might be able to be sold outside Ulaanbaatar
- To share lessons learned with other countries on stove switch-out programs, in particular other countries involved in the World Bank's multi-phase technical assistance project, "East Asia and Pacific Clean Stoves Initiative", namely China, Indonesia, and Lao PDR.

The report makes use of analytical reports listed below in addition to the Bank team's experience gained from the preparation of the World Bank-supported Ulaanbaatar Clean Air Project (IDA credit of $15 million) and overall engagement on air pollution reduction efforts since mid-2007. Given the expected evaluations that shall be conducted by the Millennium Challenge Corporation and other donors, the Ulaanbaatar clean stove work is likely to generate a unique set of analytical work supporting the low-emission stove agenda in many other countries.

1.5 Study Method and Data Sources

The study relied on both primary and secondary sources of data and information. The main primary sources of data are:

- A household survey conducted in six ger districts including Khan-Uul, Bayanzurkh, Bayangol, Sukhbaatar, Chingeltei and Songinokhairkhan;
- Company sales data for individual customers and households that have purchased low emission stoves from XacBank, and official sales statistics from MCA Mongolia;
- A rapid appraisal conducted in four selected cities, Darkhan, Ondorkhaan, Bayankhongor, and Khovd; and
- Interviews with government officials, experts, government officials, and other stakeholders in the field.

Secondary sources of data comprise of a range of published information, including reports for the World Bank's Ulaanbaatar Clean Air Project and Ulaanbaatar Services Improvement Project, as well as data from the Ulaanbaatar Statistical Department and Mongolia Population and Housing Census. In addition, the study makes use of ADB reports from its own "Ulaanbaatar Clean Air Project", as well as several recent reports including *Heating in Poor, Peri-Urban Ger Areas of Ulaanbaatar* (World Bank Asia Sustainable and Alternative Energy Program, December 2009), *Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts* (World Bank Sustainable Development Series Discussion Paper, December 2011); and the *Project Appraisal Document: Ulaanbaatar Clean Air Project* (February 2012, Report No. 66081-MN). The Bank team worked in close collaboration with the Ulaanbaatar Clean Air Project Management Unit, which represented the city of Ulaanbaatar as the counterpart for the Ulaanbaatar part of the Mongolia CSI, and with the Ministry of Energy, which is the counterpart for the overall Mongolia CSI.

Box 1.2: Terminology

In this report, unless otherwise noted:

- *Stoves* refer broadly to traditional space-heating stoves used in gers and detached homes, as well as low-pressure boilers.
- A *low-emission stove* refers to a clean-burning, energy-efficient stove that meets criteria for indoor and outdoor air pollution, safety, and combustion and fuel efficiency.
- An *improved stove* refers to an improved version of a traditional stove and is not considered a low-emission stove because it does not meet all of the criteria described above.
- *Coal* refers to raw coal.

1.6 Structure of this Report

The structure of this report reflects the directional organization of the study. Chapter 2 offers a detailed demographic profile of households in the ger-districts, including socio-economic characteristics, dwelling types, and past experience with banking and credit. Chapter 3 discusses stove ownership and market penetration rates for low-emission stoves in the ger areas. Chapter 4 provides insight into household perceptions of heating stoves and air pollution, along with household heating habits and preferred stove design features. The chapter also explores households' willingness to replace their traditional stoves. Chapter 5 discusses household consumption of heating fuels and expenditures. The chapter offers detailed analysis of differences in fuel consumption by households with and without low-emission stoves, as well as usage rates for semi-coke coal in areas where raw coal has been banned. Chapter 6 assesses heating stove demand and stove supply chains, as well as linkages between the stove markets in Ulaanbaatar and the aimag centers, drawing from the findings of the rapid appraisal conducted in four select cities. An overall conclusion is presented in chapter 7.

CHAPTER 2. HOUSING AND HOUSEHOLD SOCIO-ECONOMIC INFORMATION

This chapter provides detailed demographic and socio-economic information about the households living in the six ger districts/areas included in the survey. Because type of dwelling is closely associated with the type of home heating system and fuel type used, the analyses of the type and size of the homes and type of heating stoves and heating system are described in this chapter. Details on the kinds of insulation used for different types of dwelling unit are also provided, since heating requirements during the winter months are closely associated with the level of insulation of the dwelling unit. Additional information on the socio-economic profiles of the owners or occupants and information of household experiences with banking and credit are presented in the last section. This is because any promotion of the heating stove improvement program would likely involve investments in new heating stoves and/or other heating equipment by home owners or occupants.

2.1 General Characteristics of Ger Districts

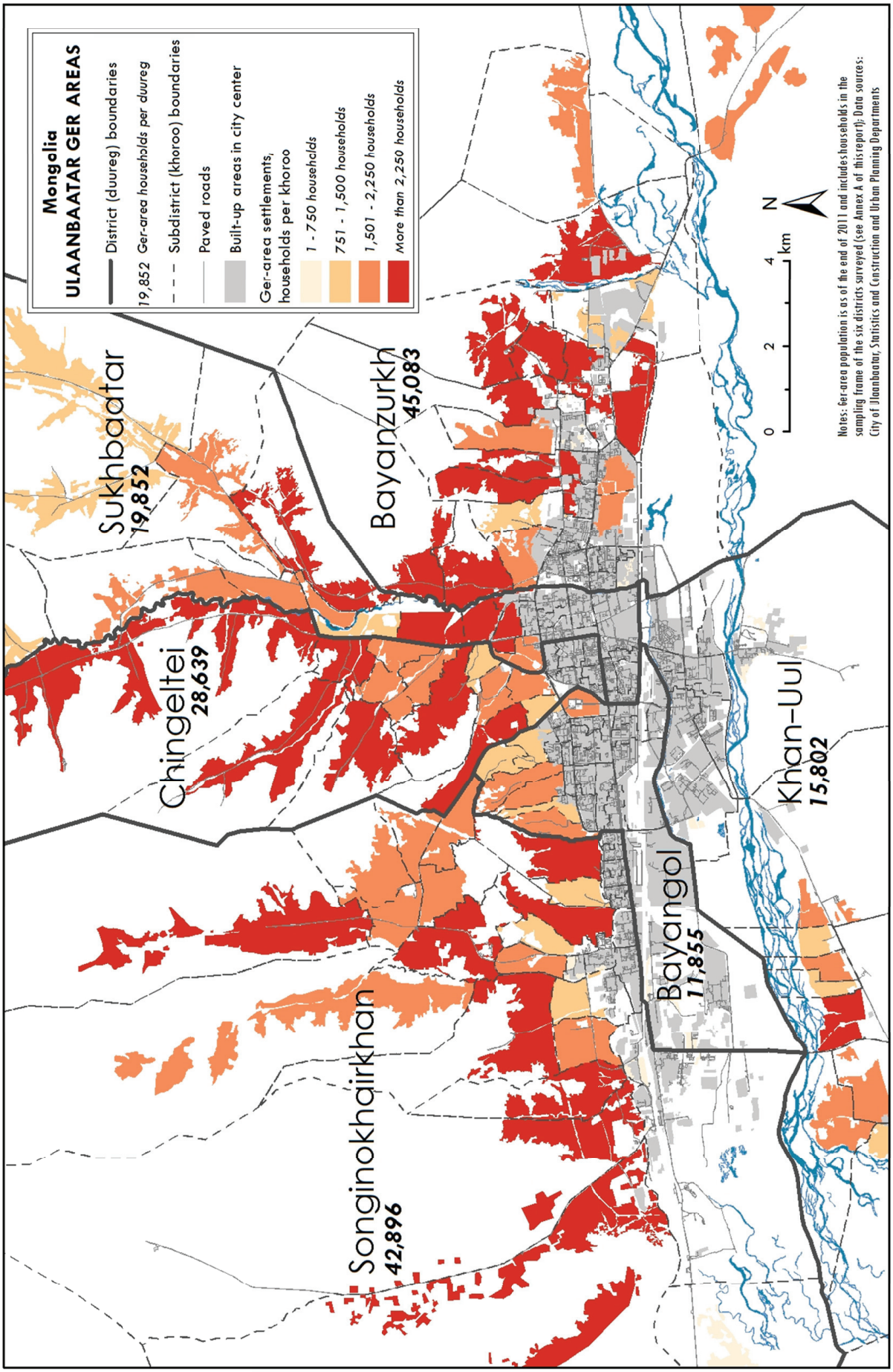
The ger areas of Ulaanbaatar, occasionally referred to as informal settlements, have been a magnet for rural to urban migration since even before market transition. Ulaanbaatar's ger areas have grown considerably over the past two decades, both in terms of population and area, and continue to grow. According to official numbers from the Ulaanbaatar Statistics Department, at the end of 2011 about 164,127 households were living in the ger areas of the six districts surveyed for this study, an increase of about 42,000 since the end of 2007.[20] The actual number of households is likely higher, at around 185,000, because of new arrivals and households not counted in the registries maintained by khoroo administrators.[21,22] Given the size of the ger areas and current economic status of most residents, it is foreseeable that these informal settlements will persist for many years to come.

The ger areas consist mainly of small fenced-in plots (hashaa) with felt-covered tents (ger) and/or simple detached homes. Although the vast majority of households (more than 95 percent) in the ger areas have access to grid electricity, none have running water. Ger-area households must purchase water at the 550 or so kiosks that are scattered throughout ger areas. Most households are located within 100-500 meters of the nearest kiosk. Apart from indoor plumbing, households also lack sewer connections, so most people rely on individual outhouses in their hashaa and public bathhouses. The characteristics of the six ger districts surveyed are similar to other ger areas in Ulaanbaatar (e.g., Nalaikh, Bagakhangai, and Baganuur).

[20] This does not include ger-area households living in apartments, dormitories, or other improved housing.

[21] According to stakeholders from the Mongolian Clean Air Fund (CAF) and National Committee for Reducing Air Pollution (NCRAP), presentations at "Conference for Sustainability of Ulaanbaatar Air Pollution Reduction Activities," workshop hosted by Millennium Challenge Corporation and Millennium Challenge Account-Mongolia, Ulaanbaatar, Mongolia, January 29, 2013.

[22] The total number of households in the surveyed areas is reported as 164,127 throughout the report to be consistent with existing official estimates.

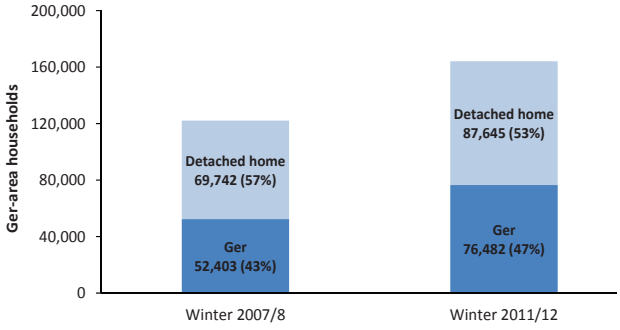

Mongolia
ULAANBAATAR GER AREAS
District (duureg) boundaries
19,852 Ger-area households per duureg
Subdistrict (khoroo) boundaries
Paved roads
Built-up areas in city center
Ger-area settlements, households per khoroo
1 - 750 households
751 - 1,500 households
1,501 - 2,250 households
More than 2,250 households
Sukhbaatar
19,852
Chingeltei
28,639
Bayanzurkh
45,083
Songinokhairkhan
42,896
Bayangol
11,855
Khan-Uul
15,802
0
2
4
km
N
Notes: Ger-area population is as of the end of 2011 and includes households in the sampling frame of the six districts surveyed (see Annex A of this report); Data sources: City of Ulaanbaatar, Statistics and Construction and Urban Planning Departments

2.2 Type and Tenure of Dwelling

Where do ger area households live during the winter months? Do they own or rent? What is the condition of insulation? These are important questions for heating and cooking stove market development. The size of dwellings and the level of insulation largely determine the type and capacity of stove needed (if stoves are too powerful, people will use less fuel in them which can reduce combustion efficiency and increases emissions). Together with income (which was also surveyed and will be presented later in the report), the type and tenure of the dwelling are indicators of the quality of life households have come to expect, including cooking and heating preferences (also surveyed and presented later in the report).

The survey reveals that about 44 percent of households have a ger on their hashaa, and about 42 percent have a detached home with one or two stories. The remaining 14 percent have both a ger and a detached home. Households with both a ger and detached home tend to live in their ger during the summers and move into their houses during the winter heating season. As shown in figure 2.1, about 47 percent of households live in a ger during the winter months, while the rest live in detached homes. Compared to 2007/08, the proportion of households that live in gers during the winter has increased slightly, while the share of households in detached homes has declined.

Figure 2.1. Ger-Area Households in Surveyed Districts, by Primary Winter Residence



Source: ASTAE/World Bank: Baseline Fuel Consumption, Heating Stove, and Household Perception Survey, December 2007; World Bank Clean Stove Initiative Survey, July 2012; Ulaanbaatar Statistics Department

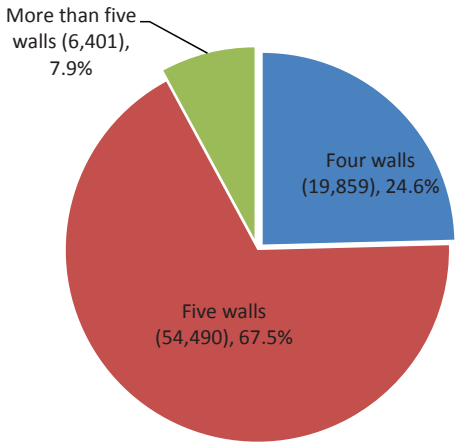
Note: Figure includes only those villages and districts represented in the sampling frame for the 2012 survey. See Annex A for description of sampling. Estimates for the total number of households by dwelling type for 2007 based on shares of dwelling types observed in 2007 survey and extrapolated to the sampling frame of the 2012 survey. Population is as of December 2007 and December 2011.

2.2.1 Characteristics of Gers

Nearly all ger households are home owners. About 92 percent of the households living in gers during the winter heating season own their ger; only a small minority (3 percent) is renting. The remaining 5 percent live rent-free by some other arrangement.

The average size of ger homes has increased slightly since the December 2007 survey. The size of ger homes is reflected by the number of walls they have: the more walls, the larger the ger.[23] In 2007, about 29 percent of gers had four walls, and 64 percent had five or more walls. As shown in figure 2.2, in 2012, about 25 percent of gers had four walls, while 75 percent had five or more walls.

Figure 2.2. Size of Ger (As Indicated by Number of Walls), 2012



Source: World Bank Clean Stove Initiative Survey, July 2012.

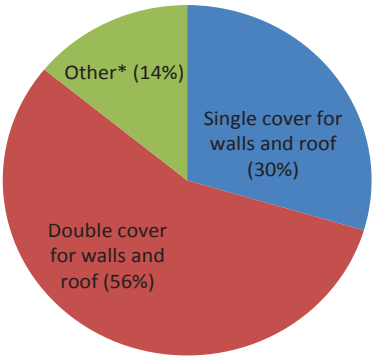
[23] A typical five-walled ger has an area of 28m^2, with a diameter of 5.6 to 6 meters depending on the erected height of the ger.

The 2012 survey results suggest that thermal insulation in gers has worsened, as the portion of gers with only a single felt covering for insulation has increased by more than 9 percent (up from 21 percent in 2007). The insulation of a ger may be improved by covering of the wall and roof with felt blankets, laying rugs or carpets on the floor, adding a skylight around the chimney to seal the opening at the top of the ger, and attaching a vestibule. As shown in figure 2.3, 30 percent of gers have only a single felt cover for the walls and roof, while most (61 percent) have two or more covers for the walls and roof. Virtually all (over 98 percent) have a skylight, and about one-third have a vestibule.

Similar trends are seen in flooring that suggest a widening gap between bigger, more permanent gers with thicker insulation, and smaller, less permanent gers with poorer insulation. Most gers continue to have wood flooring (66 percent in 2012); however, the share of gers with just earthen floors has increased by about 10 percent since 2007, to 24 percent. At the opposite end of the spectrum, about 9 percent of gers now have cement floors, up from only 2 percent in 2007. As expected, the share of gers with single felt covers that also have earthen floors is much higher than the overall average at around 40 percent.

The findings imply that low-emission stoves, which provide more heat with less fuel, can provide significant benefits in terms of more comfort at lower or equivalent fuel costs especially to smaller ger households whose dwellings are less well-insulated and less permanently constructed.

Figure 2.3. Insulating Felt Coverage of Gers



Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: *Single cover for walls and double cover for roof, or double cover for walls and single cover for roof.

2.2.2 Characteristics of Detached Homes

About 53 percent of ger-area households in the six districts are living in a detached single-family home as their main dwelling during the winter months.[24] Detached homes in the ger areas are relatively small. Most have two rooms and a kitchen. The average total living space, excluding the kitchen, is only 48 square meters. About 88 percent of detached homes have only one story, while two-story homes account for 12 percent of detached homes. Also, as with households living in gers, most households in detached homes are homeowners (96 percent). Only 1 percent of households in detached homes are renting. The remaining 3 percent live rent-free by some other arrangement.

Detached homes can be classified into three types based on the type of heating system used:

- detached houses that rely on just a stove for space heating;
- detached houses with a heat wall connected to a space-heating stove;[25] and
- detached houses with a low-pressure boiler (LPB) and radiator system.[26]

The survey results (see figure 2.4) show that heat walls continue to be the most common type of heating system for detached homes, accounting for 62 percent (a decline of about 8 percent compared to five years ago). About 23 percent of detached homes use LPBs (an increase of about 7 percent compared to five years ago). Meanwhile, the proportion of detached houses

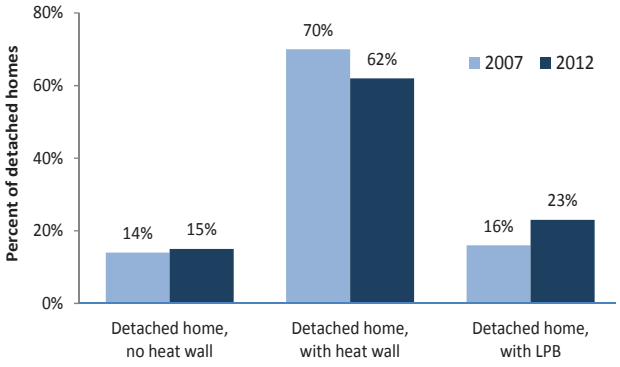
[24] A detached single family home is commonly referred to as a "separated home," using the direct Mongolian to English translation.

[25] A heat wall is a hollow, interior, heat-retaining wall through which flue gases from the stove escape into the atmosphere; this is used to heat the house. The heating wall is a typical extension of stoves in Mongolia. The wall is made of brick or a hollow metal sheet, with the hot fumes from the attached stove led through ducts in the masonry (in the case of brick) or through metal ducts, to heat the whole wall. Since bricks retain heat and metal absorbs it, the heat slowly passes through it to the surrounding environment. The wall makes the stove more effective by providing a large emitter surface for energy absorbed from the smoke, which would otherwise be lost.

[26] LPBs are a heating system designed for larger homes, where radiators can be installed in rooms.

with space-heating stoves and no heat walls has increased by only 1 percent-well within the margin of error from a statistical point of view.

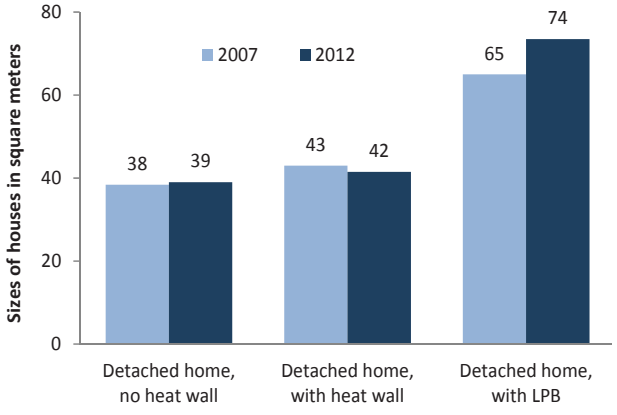
Figure 2.4. Proportions of Detached Houses with Different Types of Heating Systems



Source: ASTAE/World Bank: Baseline Fuel Consumption, Heating Stove, and Household Perception Survey, December 2007; and World Bank Clean Stove Initiative Survey, July 2012.

A comparison of the data from the 2007 and 2012 surveys suggests that more households in the ger areas are moving into bigger homes-or expanding their existing homes-and upgrading their heating systems (figure 2.5). Not only were more homes using LPBs in 2012 versus 2007, the average size of a detached house with an LPB has also increased, from 65 square meters in 2007 to 73.5 square meters in 2012. By contrast, homes that rely on space-heating stoves and heat walls are much more size-constrained-it does not make sense to build a heating wall for a home beyond a certain size. So, it is not surprising that the average size of these homes is about the same in 2012 as it was in 2007. The average size of detached homes that use space-heating stoves without heat walls was between 38 and 39 square meters in 2007 and 2012. Detached houses with heat walls are slightly larger than those without heat walls because heat walls provide a larger heat-emitting surface and can warm a larger area than just a space-heating stove. The average size of those homes was between 42 and 43 square meters in 2007 and 2012.

Figure 2.5. Sizes of Detached Houses with Different Types of Heating Systems



Source: ASTAE/World Bank: Baseline Fuel Consumption, Heating Stove, and Household Perception Survey, December 2007; and World Bank Clean Stove Initiative Survey, July 2012.

2.3 Characteristics of Households in the Ger Areas

The number of people in a household, gender of the head of household, level of schooling, and household income provide important inputs for marketing programs, financiers, and even stove designers. These household characteristics can guide the way that messages are communicated or impact the choice for certain stove design features, such as the size of pots that can be used on the stove (it is more convenient to have a large pot to cook for a larger family, for example).

The average size of households in the surveyed areas was just over 4 persons in 2012 (see table 2.1), slightly lower than it was in 2007. Reported monthly income for households over the previous 12 months rose to 750,082 Tg on average, which is about 80 percent higher in real terms than what was reported in 2007.[27] Similar to the situation in 2007, about one-fifth of ger-area households in 2012 are headed by females.

[27] Average monthly income reported by ger-area households in the 2007 survey was around 408,000 Tg (in year 2011/12 prices). Prices are adjusted using the average monthly consumer price index data from the International Monetary Fund for January to December 2007 and July 2011 to April 2012 (more recent data not yet available at the time of writing). See IMF, "Data and Statistics," http://www.imf.org/external/data.htm#data.

Average income and level of formal schooling varies among ger households and households living in detached homes. Ger households, which continue to represent the largest number of households living in the surveyed areas, are generally the poorest and have the lowest levels of reported educational attainment for household heads. By comparison, income for households living in detached homes with LPBs is about 50 percent higher, and twice as many household heads living in detached homes with LPBs have some post-secondary education. The positive relationships between income, size of dwelling, and educational attainment suggest a common characteristic in most housing markets whereby higher income households start to seek a higher quality of life, including more sophisticated and convenient cooking and heating solutions.

Table 2.1. Socio-Economic Information of Households in the Ger Areas

	Ger	Detach house without heat wall	Detach house with heat wall	Detach house with low pressure boiler	Total
Total Number of Households	76,483	13,623	54,326	19,695	164,127
Household Monthly Income (Tg)	634,770	695,613	850,738	957,906	750,082
Family Size (persons)	4.1	4.0	4.5	4.3	4.2
Female Head of Household (%)	22.5	28.9	21.4	12.5	21.4
Head of Household with post-secondary schooling (%)	18.1	25.3	29.9	35.9	24.7

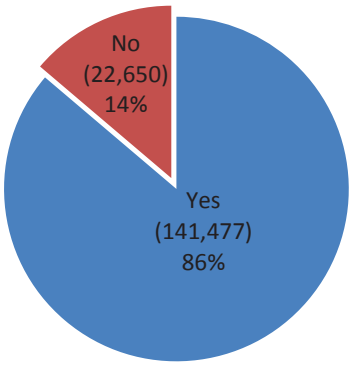
Source: World Bank Clean Stove Initiative Survey, July 2012.

2.4 Household Experience with Banking and Credit

The survey also investigated the linkages between informal and formal banking sources, what households borrow for, and their interest and use of mobile banking (banking by mobile phone, which might be a powerful way of transacting stove purchases in the future). Access to finance is an important feature to consider in designing stove switching programs especially in markets with poor households. Well-designed micro-credit schemes can help households spread out payments for stoves, which can make up a significant share of monthly income for households with little savings capacity. Informal channels of finance are important sources of funds in these communities and should be explored to understand how households might collect funds to pay for a new stove. Yet, formal banking can also open doors to other banking services. XacBank not only offers micro-credit toward the purchase of stoves, it also uses its financial management services to process stove payments to stove suppliers. The bank also offers loans for other energy efficient products.

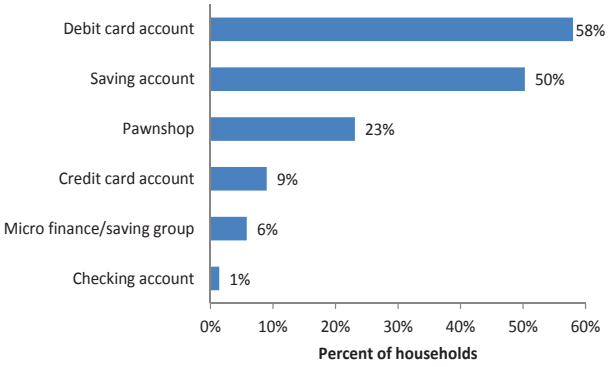
The survey finds that most households in the six surveyed ger districts have experience with formal banking, and about half of the households have experience with formal credit. With respect to banking, about 86 percent of the households (around 141,500) have at least one member with a bank account (figure 2.6). As shown in figure 2.7, debit and savings accounts are most common. Only one-tenth of households have a credit card. Furthermore, about 23 percent of households have an account at a pawn shop, indicating that semi-formal financial institutions continue to have a presence in the ger areas, but are less popular now than formal banking.

Figure 2.6. Share of Households with At Least One Member with a Bank Account



Source: World Bank Clean Stove Initiative Survey, July 2012.

Figure 2.7. Type of Bank Account or Other Financial Account Held by Households



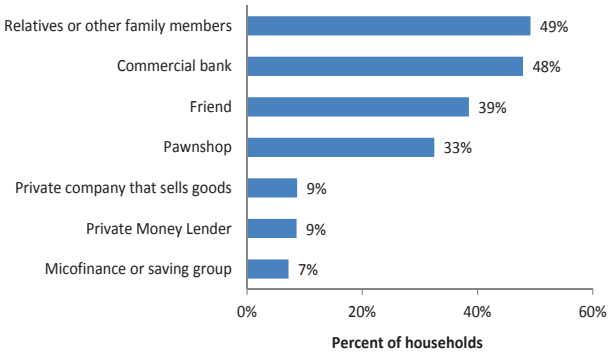
Source: World Bank Clean Stove Initiative Survey, July 2012.

2.4.1 Experience with Credit/Loans

The survey reveals that informal credit continues to dominate, and relatives and friends are the most important source of loans; however, the use of formal credit is expanding. About half of the households surveyed have borrowed money at some point from a commercial bank. On the semi-formal market, about 33 percent of households have borrowed money from a pawnshop before. Only 7 percent have ever borrowed from a micro-lending or savings group. Findings are shown in figure 2.8.\

The main purposes for which households borrow money are to pay for: food and basic living expenses, consumer goods, health care,

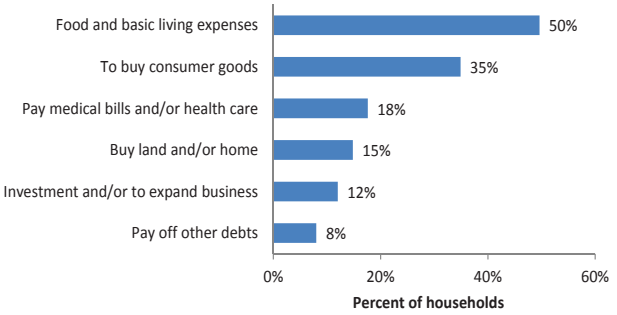
Figure 2.8. Source of Credit or Financing to Ger-Area Households



Source: World Bank Clean Stove Initiative Survey, July 2012.

land and/or home property, business investments, and previous debts. As shown in figure 2.9, about half of the households borrow money for food and living expenses, and about a third have borrowed money for consumer goods.

Figure 2.9. Purpose of Loan



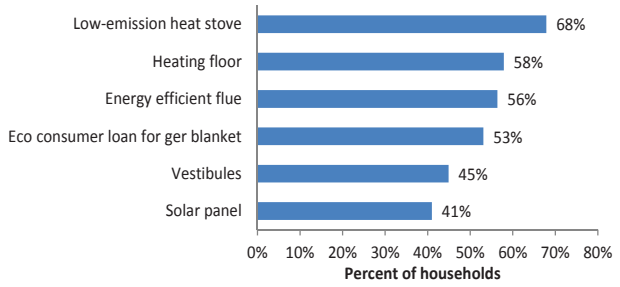
Source: World Bank Clean Stove Initiative Survey, July 2012.

2.4.2 Knowledge of Lending Products and Banking Services

From the point of view of a commercial bank, reaching ger-area households that have past experience with formal banking and/or credit is crucial. Already, some commercial banks in Mongolia have created lending products specifically designed to help households overcome the upfront costs of modern heating solutions and other energy products. These include micro-loans for low-emission stoves, super-insulating ger blankets, vestibules,

heating floors, energy efficient flues, and solar photovoltaic panels. The survey reveals that overall more than half of the households have heard about these loan products offered to consumers by banks.

Figure 2.10. Share of Households that Have Heard of Lending Products Specifically for Heating and other Household Energy Products



Source: World Bank Clean Stove Initiative Survey, July 2012.

2.4.3 Knowledge and Interest in Mobile Banking

Aside from knowledge of specific lending products, the survey also explored households' knowledge and experience regarding the use of mobile phones for banking transactions. Survey results show that every household has at least one mobile phone, with an average of about 3.3 mobile phones per household. This indicates that most household members have their own personal mobile phone. However, only a small portion of the households use text messaging on a regular basis, and only slightly more (17 percent) have ever used a mobile phone for banking. That said, many are aware of the possibility for bank customers to conduct transactions with their mobile phones, and more than half (57 percent) of respondents indicated they are interested in using their mobile phones for banking. This finding is important, since small lending products designed to help households gain access to heating devices typically involve high transaction costs. Use of mobile phones may reduce transaction costs to consumers and administrative costs to banks, potentially lowering the price of loans.

2.5 Conclusion

Analysis of socio-economic characteristics of households in the ger areas confirms that a large number of households are still relatively poor, though income levels have risen. The majority of poorer households live in gers, while households that are financially better off tend to live in detached houses. The portion of households living in gers versus detached homes has also remained the same. Thus, the overall profile of households in the ger areas is largely unchanged since the last survey carried out in 2007. What has changed is the number of households in these areas. Since 2007, the population in the ger areas of the six districts surveyed increased by about 42,000 households, which is significant from the perspective of air pollution in Ulaanbaatar because virtually all of these households are reliant on coal-burning stoves for heating.

Within the overall picture of ger-area households, there are also some disparities that are emerging since the 2007 survey. On one end of the spectrum, a portion of better-off households in detached homes are building larger homes-or expanding their existing homes-and upgrading their heating systems from traditional stoves to LPBs, which burn much more fuel and emit more pollution (the report later discusses fuel use). On the other end of the spectrum, more of the households living in small, four-walled gers have homes that are less well-insulated and less permanently constructed. These findings suggest a widening gap in housing conditions.

With respect to household banking and credit, the 2012 survey finds that the vast majority of households in the six surveyed ger districts have experience with formal banking, and about half have experience with formal credit. Apart from relatives and friends, commercial banks are the most important source of credit or financing for ger-area households. The top two reasons for borrowing money identified by households are to pay for food and basic living expenses and buy consumer goods. In terms of the potential for offering financial products to encourage the

purchase of low-emission stoves, perhaps the most important information from the survey is that about 44 percent of households have already experienced borrowing money from a commercial bank or a retailer to buy consumer goods, and most are aware of the existence of financial products specifically designed for household heating and energy products. This suggests that more households may be comfortable buying low-emission stoves on credit, perhaps for some even through mobile banking.

CHAPTER 3. HEATING STOVE OWNERSHIP AND USE

Stoves and low pressure boilers are the primary heating devices for virtually all households in the six central ger area districts. However, one type of stove does not match the needs of all households. Stoves serve a dual purpose and are used for both heating and cooking during the cold season from early or late September to late April or early May. For space heating, stoves can be used by themselves or, in the case of detached homes, with attached heat walls to increase the distribution of heat to warm a larger area. Some detached homes have furnaces (or stoves attached to a water tank) with piping to circulate hot water to radiators (or to showers) in different rooms throughout the house. These "stoves" are commonly referred to as a low pressure boiler (LPB).

Since around 2008, low-emission and energy-efficient stoves have been discussed as a tool to reduce air pollution in Ulaanbaatar. As discussed in chapter 1, pollution source inventories showed that emissions from traditional heating stoves in the ger areas accounted for around an estimated 60 percent of the concentrations of very small particulates ($PM_{2.5}$) in the city's air.[28] By providing better combustion efficiency, low-emission stoves can lower the level of pollutants emitted and offer an effective means to reduce pollution in the city. As a result, in 2011 the Government of Mongolia and MCA-Mongolia began to provide financing to import and sell low-emission stoves to ger residents in Ulaanbaatar at a subsidized price (see also section 1.3). This project ran at full scale from August 2011 to the end of November 2012. As of July 1, 2012-just before surveying was done for this study-around 69,000 low-emission stoves had been sold to the households in the ger areas. An additional 29,000 stoves were sold in the fall and winter, bringing the total number of stoves distributed under the project to around 98,000.

Based on the household survey conducted in July 2012, the following sections provide a detailed descriptive analysis of heating stove ownership and use in ger areas. The estimated total number of stoves owned and used is also provided to show the level of market penetration by low-emission stoves and the size of the remaining market. The chapter also describes key stove user characteristics.

3.1 Total Number of Heating Stoves Owned and Used

The 2012 survey asked households about the number of stoves they own, and how many they actually used for heating during the previous winter months. From the survey, it is estimated that in 2012, households in the ger areas surveyed owned about 212,700 stoves in total (see table 3.1), which is more than the total number of households (164,127 households) in the survey area. About 9 percent of households reported owning two or more stoves.

The average number of stoves owned per household in 2012 was 1.30. By comparison, the average for the baseline survey in 2007 was 1.03. The difference may be the result of several factors.

[28] Based on population-weighted exposure to PM for Ulaanbaatar City in 2009, calculated using pollution dispersion modeling. World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts* (Sustainable Development Series Discussion Paper, December 2011).

Table 3.1. Total Number of Stoves Owned in Ger Areas, by Stove Type, 2012

	Number	Share
Traditional stoves	128,182	60%
Low-emission stoves	46,449	22%
Locally-made LPBs	17,069	8%
Imported LPBs	3,939	2%
Other stoves	17,069	8%
Total	**212,708**	**100%**

Source: World Bank Clean Stove Initiative Survey, July 2012.

First, the questionnaire used for the 2012 survey contained more detailed questions on stove ownership and usage than the questionnaire used in the 2007 survey. While the questionnaire for the 2012 survey differentiated between number of stoves owned and used, the 2007 survey only asked respondents to identify the stoves that their households were using for heating at the time of survey. Second, the total number of stoves owned by ger-area households may have increased somewhat as a result of the low-emission stove exchange program. Under the program, households had to exchange their old stoves in order to receive new low-emission stoves. Old stoves were removed from the households and taken to be destroyed. However, the study team was given the impression through interviews of participants that a few households that bought new low-emission stoves received an exemption (about 7 percent), including newly-wed couples that had been given traditional stoves as wedding gifts and households that used brick stoves that could not easily be removed. Furthermore, as the program progressed, the stoves that were exchanged tended to be older and in worse condition than those that were turned in at the start of the program.[29] It is therefore conceivable that some old heating stoves were exchanged that were not being used by households, and that the stove exchange program indirectly created a market for old stoves.

Of the 212,700 stoves owned by households in 2012, about 172,000 were reportedly used during the previous winter for heating. Although in practice only one stove is usually used for heating in ger-area homes, about 5 percent of respondents said they used more than one stove. Some households may have used additional stoves to heat workshops, garages, or other structures on their hashaa; and some may have switched to using another stove during the middle of the winter heating season (e.g., by purchasing a low-emission stove). Furthermore, many stoves counted in the "other" category in table 3.1 above are not for heating, including smaller stoves used for cooking by ger households during the warm season.

The number and types of different stoves that were used by ger-area households during the previous winter are shown in table 3.2. Traditional stoves accounted for 65 percent of all stoves used for heating during the winter of 2011/12, while low-emission stoves accounted for 22 percent. Compared with four years ago, reliance on traditional stoves has dropped by 11 percent. Meanwhile, the survey reveals that LPBs account for about 11.6 percent of all heating stoves that households reported to be using during the previous winter, which is about 3 percent higher than in the winter of 2007/08.

Table 3.2. Total Number of Stoves Used in Ger Areas, by Stove Type, 2012

	Number	Share
Traditional stoves	112,427	65%
Low-emission stoves	38,077	22%
Locally-made LPBs	16,249	9%
Imported LPBs	3,775	2%
Other stoves	1,477	1%
Total	**172,055**	**100%**

Source: World Bank Clean Stove Initiative Survey, July 2012.

[29] Author phone interview with XacBank representative, November 1, 2012.

3.2 Age of Stoves Used During the Previous Winter Months

Table 3.3 presents an overview of average age of different stove types. An analysis of stove age reveals that the traditional stoves have been used for an average of just over 9 years.[30] The age of traditional stoves has increased remarkably since the previous survey in 2007, when traditional stoves had been used for less than 6 years on average. This finding has a couple of important implications. First, it is evident that very few households bought new traditional stoves within the past two years. As shown in figure 3.1, the number of traditional stoves acquired each year has dropped significantly from about 13,500 five years ago to around 4,800 in 2011. Of the 112,427 traditional stoves estimated to be in use during the winter of 2011/12, only 6,072 were acquired within the past two years. Low-emission stoves have almost completely replaced traditional stoves on the market, which is not surprising because the subsidized price of the low-emission stoves was much lower than the price for most traditional stoves. Second, because about 90 percent of households replace their stoves within 10 years (as was seen in the 2007/08 baseline survey), most of the traditional stoves that remain in use will likely be replaced within the next couple of years. If stove replacement efforts end in 2013, and the unsubsidized price of low-emission stoves remains the same, then households will have no alternative but to buy another traditional stove.

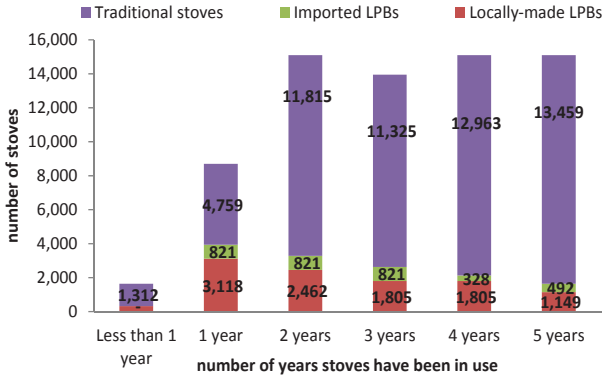
Table 3.3. Average Age of Stoves in Ger Areas, by Stove Type, 2012

Type of Stove	Number of Years in of Use
Traditional stoves	9.2
Low-emission stoves	0.8
Locally-made LPBs	5.5
Imported LPBs	3.1

Source: World Bank Clean Stove Initiative Survey, July 2012.

[30] This is about the same as the average age of traditional stoves owned but not used.

Figure 3.1. Number and Age of Stoves



Source: World Bank Clean Stove Initiative Survey, July 2012.

Note: Survey was conducted in August 2012; one year old stoves were defined as stoves acquired before August or September 2011. Stoves less than one year old were defined as stoves acquired after January 2012.

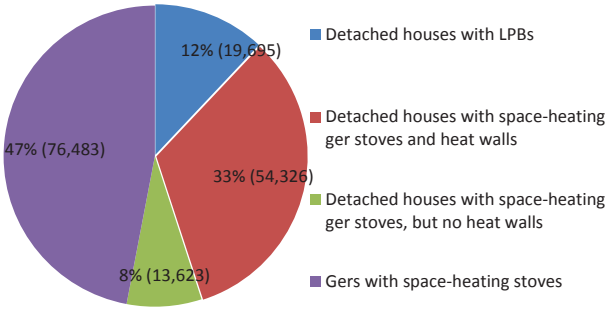
3.3 Heating Stove Use by Dwelling Type

Heating is an important part of everyday life for ger-area households. In the areas of the six districts surveyed, there around 168,000 stoves were in use during the winter of 2011/12, a sizeable increase since 2007/08. The types of stoves used by households are closely associated with the size and type of the dwelling and can be grouped into the following categories:

- Ger using space heating stove
- Detached house low pressure boiler (LPB)
- Detached house with heat wall.
- Detached house without heat wall (using a space-heating stove).

Figure 3.2 illustrates the relative share of these different heating systems among the total number of ger-area households. The following sub-sections provide a detailed description of stoves used for these different types of heating systems and dwelling types.

Figure 3.2. Heating Systems by Dwelling Type, Ger-Area Households, 2012

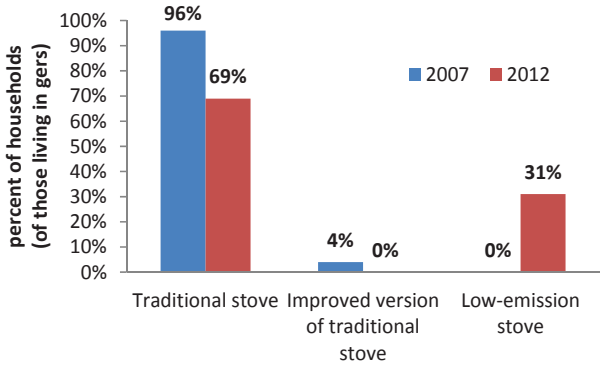


Source: World Bank Clean Stove Initiative Survey, July 2012.

3.3.1 Heating Stoves Used in Gers

All of the ger households in the areas surveyed rely on heating stoves (including LPBs). As shown in figure 3.3, about 69 percent of households that lived in a ger during the previous winter months used some form of traditional heating stoves, including metal sheet, cast iron, and sawdust or brick stoves. While the proportion of ger households using traditional stoves has declined significantly from 96 percent in 2007, there are still about 52,000 households living in the ger areas of the six districts surveyed that continue to rely on traditional stoves; only about 24,000 households living in gers have switched to low-emission stoves.

Figure 3.3. Percentage of Traditional and Low-Emission Stoves Used for Heating in Gers

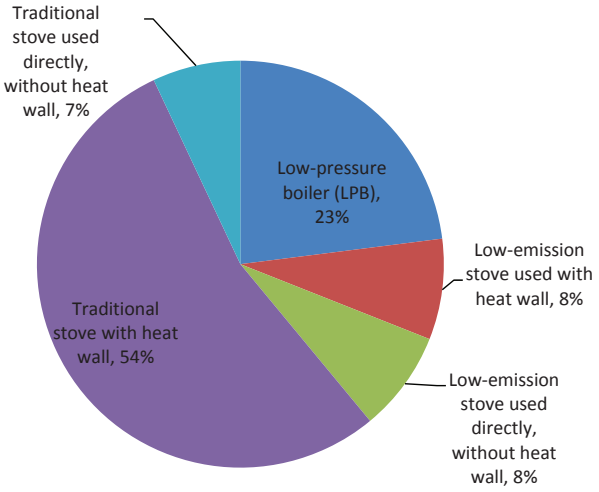


Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: Low-emission stoves had only just been introduced in 2011; prior to 2011 only improved version of traditional stoves were available in the market.

3.3.2 Heating Systems and Stoves Used in Detached Houses

As noted in chapter 2, of the 87,643 households that in 2012 live in the detached houses within the surveyed area, about 62 percent use space-heating stoves with heat walls, 15 percent use stoves without a heat wall, and 23 percent of households use LPBs (figure 3.4). The proportion of detached houses with a heat wall declined by about 6 percent compared to the previous survey, while the proportion of detached houses with LPBs increased by about 6 percent over the same period. The proportion of detached houses without heat wall remained the same. The results indicate that more households are upgrading from relatively simple heating stoves to LPBs, which, as will be discussed in chapter 5, has significant implications for fuel consumption.

Figure 3.4. Heating Systems and Stoves Used in Detached Houses, 2012



Source: World Bank Clean Stove Initiative Survey, July 2012.

With regard to the types of heating stove these households used, the survey reveals that low-emission stoves have not penetrated into this market segment as much as it has for households living in gers. Only about 19 percent (16,700) of the households that live in the detached houses use low-emission stoves, compared to 59 percent (51,400) that use traditional stoves, and 21 percent (18,100) that use LPBs.

Heating walls have different technical characteristics that can influence the performance of stoves, when compared to stoves in gers or detached homes without heating walls. About 54,300 detached homes that have heat walls, equal to 62 percent of detached houses or 33 percent of all households in the surveyed ger areas. Of these houses with heat walls, the survey reveals about 45 percent have a "vertical heat wall," which means the heat walls are constructed to allow flue gases to move vertically to exchange heat before exiting the chimney. About 27 percent of heat walls are "horizontal," which means that flue gases move horizontally to exchange heat before exiting. Another 18 percent have a combination of vertical and horizontal channels. It is important to note that about 10 percent of the households that live in detached houses with a heat wall do not know the type of heat wall they have.

The vast majority of heat walls are made of brick. Heat walls made of exposed metal sheeting are not widely used because the metal can heat to a very high temperature and poses a burn hazard. Furthermore, because heat walls are relatively simple to make, the survey finds that about half were constructed by the home owner, while another 41 were constructed by local masons. The remaining nine percent of households do not know who built their heat walls. On the basis of observation, quality of construction is reported to be highly variable.

Heat walls require regular maintenance and cleaning because soot build-up can block flue gases from escaping and cause the wall to crack or even explode. About 49 percent of the households indicate that their households clean the heat wall once a year, while 20 percent reported cleaning it more than once a year, 11 percent clean it once every two or three years, and 2 percent clean it only once every four or five years. About 18 percent of households had never cleaned their heat wall at all. There is no significant difference in the reported frequency of cleaning between households with and without low-emission stoves. In addition, the survey shows that about 58 percent of the households have done some repair or maintenance of their heat walls.

LPBs appear to have emerged as a preferred type of stove for high-end consumers, but there is still not much known about how households have been using them or about their emissions factors. As mentioned above, from the survey results, it is estimated that about 23 percent of all detached houses in the surveyed ger areas used LPBs for heating during the previous winter. Since detached houses with LPB tend to be bigger than detached houses with heat walls and those that use stoves directly for space heating and hot tap water, some households with LPBs also use other coal heating stoves for supplementary heating and cooking. The survey finds that about 2,000 households living in detached homes with LPBs also own traditional stoves, and that a few hundred households used both low-emission stoves as well as LPBs during the previous winter.

The survey finds that the LPBs that are being use are relatively new: about 60 percent of LPBs were installed within the past four years. With respect to the type of LPB used, the survey reveals that more than three-quarters of LPB stoves are made locally, the remaining are imported, which cost significantly more than the locally made LPB.

If Mongolia's current rates of economic growth continue, it is expected that demand for LPBs will continue to rise as more households are able to pay for LPBs and the internal piping needed, to increase their comfort and heat their (increasingly larger) new homes. About one-third of respondents with LPBs said that their LPB is the first heating system used in their homes. (In other words, these are new homes.) Another 31 percent of LPB users used to have a stove with a heat wall, indicating that these households have recently upgraded their heating systems. About 11 percent indicated that their existing LPBs were replacements for older LPBs. Although the market segment for LPBs is small, it is growing rapidly compared to four years ago. Because LPB stoves require more coal (see chapter 5) and emit more pollution

than traditional space-heating stoves, attention must be paid to this market segment to control air pollution in Ulaanbaatar. Of course, any intervention to phase out high-emission LPBs will need to be targeted differently than previous stove replacement programs because LPBs and ger stoves represent two distinct market segments with two distinct supply chains. Virtually all of the households that use LPBs said they bought their stove from the Ail Market, a construction materials market. The LPB market could be considered as a subset of the construction and plumbing market.

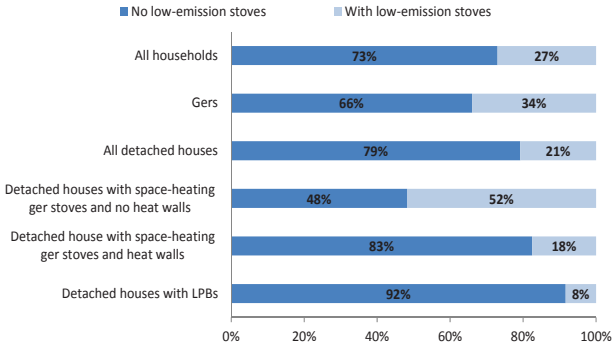
3.4 Low-emission Stove Ownership and Use

Low-emission stoves, which were introduced to the Ulaanbaatar market at subsidized prices via a large-scale stove replacement program launched in June 2011, account for 22 percent of the heating stoves used by households in the ger areas surveyed. Although the estimated number of low-emission stoves households reported owning at the time of survey in July 2012 is 46,449, the number of low-emission stoves reportedly *used* during the previous winter months was estimated at 38,077. The discrepancy of 8,372 stoves between the number of stoves owned and used is due primarily to the fact that a large number of households acquired their low-emission stoves toward the end of the winter or after the heating season was already over. The survey reveals that about 6,400 low-emission stoves were acquired between mid-April and the end of June 2012.

As can be seen in figure 3.5, the market share for low-emission stoves varies considerably by dwelling type. As of July 2012, 31 percent of ger households owned low-emission stoves. The market share for households living in detached homes without heat walls was even higher, at 52 percent. However, only 18 percent of households living in detached homes with heat walls and 8 percent of households in detached homes with LPBs had acquired low-emission stoves.[31]

The contrast in adoption rates for households living in detached homes with and without heat walls is remarkable. While the survey did not include questions to explore why households living in detached houses with heat walls were more resistant to adopting low-emission stoves, it did reveal other differences between households that may shed light on the discrepancy in adoption rates. A comparison of household monthly income between households living in detached houses with and without heat walls suggests that affordability is probably not the reason for higher or lower adoption rates. Reported monthly income for households in detached houses with heat walls was 850,737 Tg compared to 695,613 Tg for those living in detached houses without heat walls and 634,770 Tg for those living in gers, yet households living in detached houses without heat walls or gers were much more likely to acquire low-emission stoves. The same is true with education.

Figure 3.5. Survey-Estimated Market Share of Low-Emission Stoves, by Dwelling Type



Source: World Bank Clean Stove Initiative Survey, July 2012.

Note: Low-emission stoves in detached houses with LPB refers to the typical low-emission space heating stoves, not the not the low-emission LPB stoves. Market shares are estimated on the basis of survey data and not official sales statistics. See footnote 27.

Reported rates of post-secondary schooling were higher for households living in detached homes with heat walls, yet their adoption rates were much lower. These findings suggest that socio-economic characteristics were probably not decisive factors in explaining the low rates

[31] A total of 9,519 households living in detached houses with heating walls that adopt low emission stoves account for only 5.7 percent of all households in the six surveyed ger districts.

of low-emission stove ownership for households with heat walls. Rather, as will be discussed in chapter 4, perceptions about the functionality of low-emission stoves and their use with heat walls may be more influential in shaping the decision by households with heat walls to not acquire the new stoves. Further market studies are needed to closely examine the reasons for this decision in order to increase adoption rates for this group.

3.4.1 Low-Emission Stove Ownership in Different City Districts

The Mongolia-MCA project sold 68,850 low-emission stoves during the 2011/12 heating season, reaching 42 percent of the ger-area households in the six central districts of Ulaanbaatar.[32] An additional subsidy element was financed by CAF. Stoves were sold only to households registered in designated khoroo of five districts where sales centers were operated. These khoroo were identified as "air pollution reduction zones" by the City of Ulaanbaatar. Due to the project's targeting of particular areas, as can be seen in Table 3.4, the market share of low-emission stoves (expressed as a portion of *all* households living in each district) varied considerably across districts. On the one side, in Chingeltei and Sukhbaatar Districts, sales centers were operated in all of the khoroo with sizeable ger-area populations. By the end of the winter, 79 percent of the ger-area households in Chingeltei and 64 percent of the ger-area households in Sukhbaatar had acquired low-emission stoves. On the other side, subsidizes stoves were not sold in Bayangol District due to that district's ban on raw coal (though product centers were still operated in Bayangol to sell other energy efficiency products such as ger blankets and vestibules).[33]

An additional 29,027 low-emission stoves were distributed during the second phase of Mongolia-MCA and CAF subsidies in the fall and winter of 2012. The second phase targeted khoroo farther from the city center, particularly in Bayanzurkh and Songinokhairkhan, where 12,250 and 13,034 stoves were sold, respectively. No stoves were sold in Chingeltei, and only one sales center was operated in Sukhbaatar. As with the previous year, stoves were not sold in Bayangol due to the raw coal ban. In all, the program reached 55 percent of *all* households living in the ger areas of the six central districts, or 69 percent of the households living in those khoroo where stoves were sold.

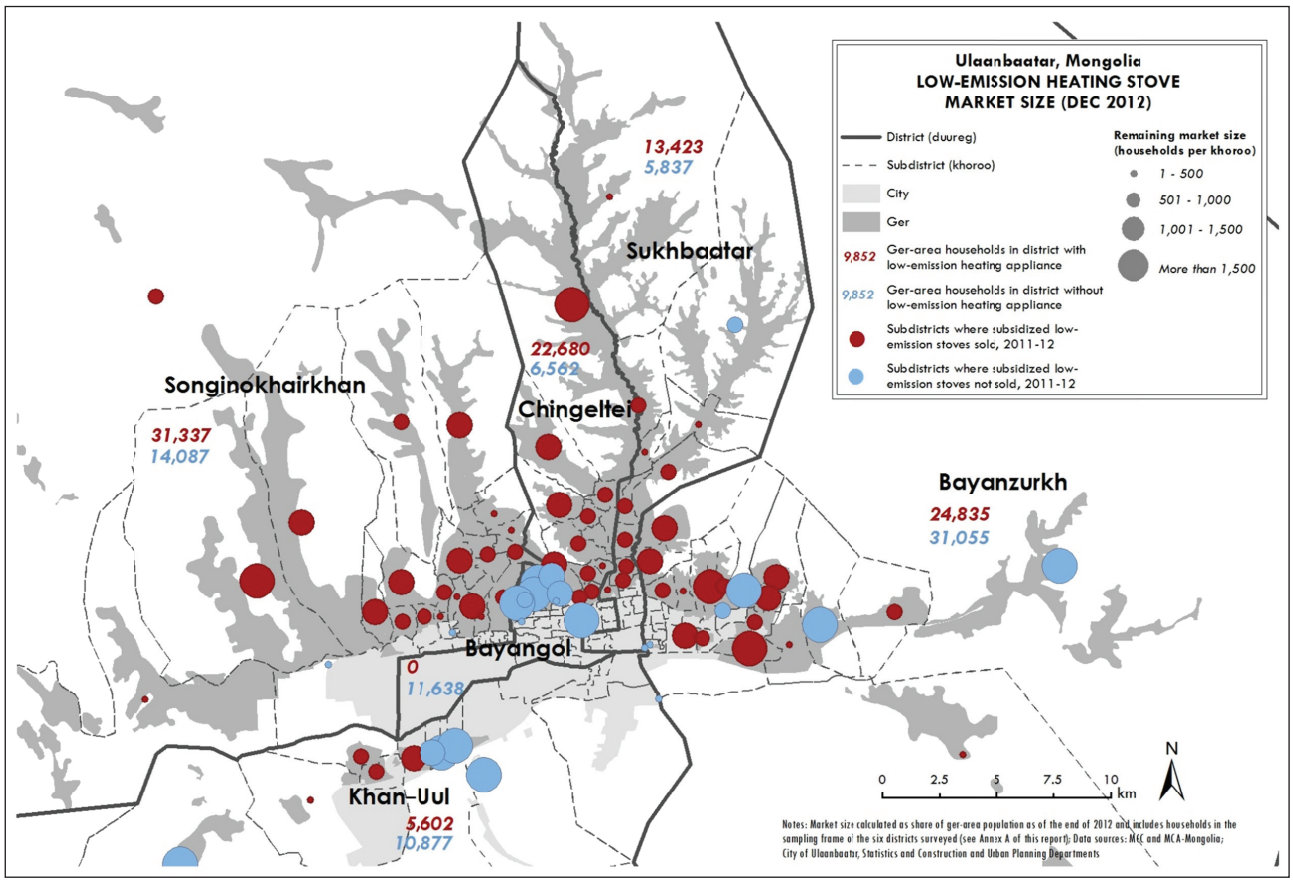
[32] Sales statistics provided to authors via email by MCC representative, December 27, 2012. Note that the World Bank survey estimated that 46,449 households in the surveyed areas owned low-emission stoves as of July 2012. The survey likely underestimated the total number of low-emission stoves due to two factors. First, the survey was intended to provide an overall view of the ger-area market for heating stoves. Sampling was not stratified or weighted according to the khoroo in which the MCA-Mongolia and CAF program was operated. Sales were concentrated in designated khoroo. By chance, the random sampling across all the khoroo under-represented those khoroo where the stoves were sold. Whereas the khoroo where low-emission stoves were sold accounted for 22 percent of the observations in the survey, they represent 27 of the total number of households in the ger areas of the six districts covered in the sampling frame (as of the end of 2011). Second, estimates for the total number of stoves in the survey were extrapolated according to official population statistics for the ger areas. As was discussed in chapter 1 of this report, the actual number of households in the ger areas is probably larger. The survey does not purport to make any quantitative inferences about the possibility of leakage (i.e. households selling or giving away their low-emission stoves to others outside the Ulaanbaatar).

[33] Raw coal is the appropriate fuel for which the models of low-emission stoves distributed by the program are designed to burn. Other fuels, such as semi-coke coal briquettes, are not intended for use with the stoves and may affect emissions performance.

Table 3.4. Low-emission Stove Sales by District and Heating Season

District	Low-emission stoves sold		Ger-area households in district*		Total share of households with low-emission stoves	
	Winter 2011/12	Fall/Winter 2012	End of 2011	End of 2012	Winter 2011/12	Fall/Winter 2012
Bayangol	0	0	11,855	11,638	0%	0%
Bayanzurkh	12,585	12,250	45,083	55,890	28%	44%
Chingeltei	22,680	0	28,639	29,242	79%	78%
Khan-Uul	2,642	2,960	15,802	16,479	17%	34%
Sukhbaatar	12,640	783	19,852	19,260	64%	70%
Songinokhairkhan	18,303	13,034	42,896	45,424	43%	69%
Total	**68,850**	**29,027**	**164,127**	**177,933**	**42%**	**55%**

Source: MCC and MCA-Mongolia stove sales data; Ulaanbaatar Statistics Department population data.
Notes: * ger-area households as of the end of 2011 and 2012, excluding khoroo outside the central area of Ulaanbaatar City; ** cumulative market share is estimated as a share of *all* households in the district as of the end of 2011 and 2012, including those not in designated khoroo where stoves were sold, to provide a fuller view of the remaining market size.



3.4.2 Characteristics of Households that Bought Low-Emission Stoves

The survey finds that 58 percent of households that bought low-emission stoves live in gers. Reported monthly income for households that bought low-emission stoves was about 725,550 Tg, versus 758,785 Tg for households that did not own low-emission stoves. The difference is not statistically significant.

By contrast, there is a much larger difference in reported income between households that said they used their low-emission stoves and households that acquired low-emission stoves but do not use them. The average monthly income of households that use low-emission stoves was 687,816 Tg, compared to 1,025,180 Tg for those that own but do not use their low-emission stoves. This implies that many of the households that acquired their stoves late in the season but did not use them were higher-income households. From the data, it is impossible to say whether these households purchased new stoves with the intention to use the stoves, or whether they simply had extra cash on hand and were motivated to seize on the opportunity to buy a highly-discounted stove while they could before the sales season ended. At any rate, the difference reveals two distinct groups of consumers: poorer households that bought their stoves earlier in the winter sales season and used them to heat their homes, and better-off households that waited until the end of the season to make their purchase but have not yet used their stoves.

There are several reasons for why poorer households in gers tended to be early adopters and users of low-emission stoves. First, heating is a basic necessity for Mongolian households, not a luxury good. Second, although gers are more compact, they are generally not as good as detached houses for retaining heat. Third, households that live in the gers may be more conscious about the overall costs of heating their home because they tend to spend a higher portion of their income on heating each winter. Using a more efficient low-emission stove could reduce spending on heating fuels, while the high upfront cost of the stoves was offset by the subsidies provided by MCA-Mongolia and CAF.

The survey results show that there is no significant difference in reported income or size of ger between households that use low-emission stoves and households that do not use low-emission stoves. The average total household monthly income for ger households that use low-emission stoves is 646,221 Tg, compared with 629,334 Tg for ger households that do not use low-emission stoves.

However, it appears that the ger households that use low-emission stoves live in better-insulated gers than ger households that do not use low-emission stoves. The survey finds that about 70 percent of ger households that use low-emission stoves have two layers of insulating roof covers, while only 52 percent of ger households that do not use low-emission stoves have gers with two layers of roof covers. Similarly, 40 percent of ger households that do use low-emission stoves have two layers of insulating wall covers, while only 22 percent of ger household that do not use low-emission stoves have a double layer of wall covers. This condition suggests that many ger households that purchased low-emission stoves also may have purchased subsidized insulation and other ger retrofit materials that were sold concurrently with the stoves.

An analysis of customer data maintained by XacBank provides additional insight into the characteristics of the individual consumers who purchased the new stoves. XacBank's monitoring and verification database contains demographic information for around 51,000 of the people who bought stoves from XacBank product centers in the six districts where surveying was conducted for this study between June 2011 and July 2012.[34] Customer information

[34] According to the XacBank sales data, a total of 63,043 stoves were purchased from XacBank-operated product centers and delivered to households in the six districts between June 1, 2011 and June 30, 2012 (excluding 1,827 customers for which district of residence was not clearly listed). Of these 63,043 customers, demographic information was not provided or incomplete for 11,619 customers. Sales data provided to authors via email with XacBank representative, November 23, 2012.

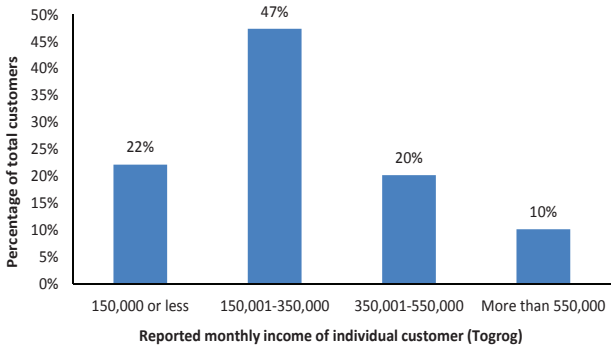
includes district and khoroo of residence, gender (of both the customer and head of household), income, and years living in current residence.

The customer data show that 40 percent of the customers who bought stoves from the XacBank product centers were female. Most of these female customers (67 percent) were heads of household. What this implies is that female-headed households were somewhat more likely to purchase low-emission stoves than male-headed households. While female-headed households accounting for only 21 percent of all households in the ger areas of the six districts surveyed, the share of female-headed households among stove-buying customers was around 27 percent. Yet, female customers also tended to delay their buying decision until farther into the winter sales season, purchasing stoves about two weeks later than male customers on average (a statistically significant difference).[35]

Reported income of individual customers in the XacBank database shows a similar trend to that observed in the survey data. As illustrated in figure 3.6, most customers (about 70 percent) reported a monthly income of 350,000 Tg or less. As for the timing of purchase, customers in the lowest income bracket bought their stoves an average of 8-12 days earlier in the sales season than customers in the middle income brackets. Customers in the highest income bracket also bought their stoves earlier than those in the middle income brackets. Furthermore, the XacBank customer data show that households in the highest-income bracket were not any more likely to purchase their stoves after the end of the heating season than households in the lower income brackets. Households in the highest-income bracket account for only 11 percent of those households that received their stoves after April 30, 2012. Unlike the survey data, the XacBank customer data does not provide information on whether households in the highest income bracket were more or less likely to use their stoves after purchasing them.

[35] The exact date of stove purchase is not provided in the XacBank database. Approximate purchase dates are based on information about the delivery or installation date.

Figure 3.6. Income of Customers Purchasing Low-Emission Stoves from XacBank



Source: XacBank low-emission stove sales data, June 1, 2011 to June 30, 2012.

3.5 Conclusion

The recent low-emission stove replacement program has had a significant impact on stove ownership among households living in the ger areas. However, it is important to emphasize that by the end of the winter just prior to the survey, more than half of all households living in the ger areas were still using traditional stoves. Given the changing demographics and revelations that some households have more than one stove, it is difficult to estimate the remaining market. It is evident that around 20,000 households in detached homes that use LPBs will require attention in the next phase, with additional investigations on this segment of the market. The trends in other market segments also lead to the conclusion that more efforts will be required to ensure that the majority of households will completely switch to and use low-emission stoves.

A comparison of adoption rates for low-emission stoves among different segments of the ger-area market reveals that households living in the detached houses were less likely to have purchased low-emission stoves than households living in gers. Only 18 percent of households living in detached houses with heat walls have acquired low-emission stoves versus 31 percent of households living in gers. This finding suggests that households living in detached houses with heat walls are much more resistant to changing their heating systems. Adoption rates were even

lower for the LPB market segment, which has not yet been targeted by stove replacement programs. However, heating walls and LPBs use more coal and the LPB market is growing rapidly as more households are moving to bigger houses (or expanding their existing houses) and upgrading their heating systems. To ensure that low-emission stoves can achieve higher penetration rates in under-represented market segments, a clear understanding of household preferences and reasons why households are likely or not likely to adopt low-emission stoves is needed.

To ensure that for each low-emission stove added to the market one traditional stove is taken out of use, it is important that traditional stoves are removed from the homes of households buying low-emission stoves. Removal rates for old stoves under the stove exchange program were around 93 percent for the 2011/12 sales season. However, it was observed that the condition of the old stoves exchanged for new low-emission stoves grew worse and worse as the program progressed. It is conceivable that the stove exchange program created an indirect market for old stoves that were not used by households. This unintended consequence of household behavior is not necessarily unusual, especially if the traditional stoves that household must turn in for destruction are still usable and in good condition. While the exchange program put in place rules to prevent households from offering up unusable stoves-and these rules were tightened over time-measures to improve actual replacement rates are needed. This could be done by training and educating households of the harmful effects of traditional stoves in addition to random checking during winter time to identify secondary stove use and perhaps assigning an additional value for turning them in.

CHAPTER 4. HOUSEHOLD PREFERENCES AND PERCEPTIONS OF HEATING STOVES AND AIR POLLUTION

The successful and sustainable promotion of low-emission stoves depends largely on the acceptance of consumers. Stoves must be designed to fit the needs and preferences of households, the ultimate users of low-emission stoves. Households have different and evolving preferences as incomes rise and other characteristics change. Encouraging the growth of innovative private enterprises that offer a variety of good-quality products will increase the likelihood for the rapid, widespread, and sustainable uptake of low-emission stoves by consumers. Otherwise the risk exists that cheap low-emission stoves are purchased for re-sale rather than for household use.

This chapter begins by describing how households utilize their stoves and follows by exploring which stove design features are considered to be important from the point of view of consumers. This discussion on important design features is supplemented by an examination of consumers' perceptions of the performances of their existing stoves. Comparisons are drawn between households that are using traditional stoves and households that have recently purchased and are using low-emission stoves. The main objective of this analysis is to gain a better understanding of the preferred characteristics and design features consumers are interested in. The second part of the chapter gauges households' willingness to switch from traditional to low-emission stoves. The reasons for why households are willing or unwilling to change their stoves are examined as well as the foreseeable obstacles that may prevent households from adopting low-emission stoves. The third section of the chapter discusses household knowledge of low-emission stoves, sources of information about low-emission stoves, attitudes toward air pollution, and perceptions of the causes of air pollution. This information is used to assess the effectiveness of information dissemination methods, experience that can be used for a future program.

4.1 Heating Habits

Heating habits are important for stove designers, emissions testing protocol developers, and stove switching program managers because adoption of new technologies is easier when these technologies more closely match with traditional patterns of cooking and heating behavior. In addition, understanding what affects and does not affect heating habits can also offer insights into constraints and opportunities for adaptation to new technologies. Winters in Mongolia are cold and long. The heating season typically begins around September and last through April or mid-May. Sub-zero temperatures begin in mid - to late November and last until March. The average daily temperature for Ulaanbaatar in winter is about -13°C, with temperatures dropping to as low as -40°C at night, making Ulaanbaatar the coldest capital city in the world. With such cold weather, it is very costly for households living in the ger areas to keep their homes warm and comfortable, especially compared with those who live in apartment buildings and have access to district heating. Most ger-area households rely on raw coal which they burn in their main heating stove to

keep warm. Only a small number of financially better-off households (about 9 percent) use supplemental heating devices, mainly electric space heaters (table 4.1). Slightly less than one percent use heat pumps or gas space heaters. The portion of households that use supplemental heating is only 3 percent higher than in 2007/08, which is within the statistical margin of error.

Table 4.1. Supplemental Heating Devices

Supplemental heating devices	Number of households	Percent of all households
Electric space heater	13,622	8.3%
Heat pump	492	0.3%
Gas space heater	821	0.5%
Total households	164,127	

Source: World Bank Clean Stove Initiative Survey, July 2012.

Each day, ger-area households must repeatedly fire their stoves and add fuel to maintain or increase room temperature. As shown in table 4.2, during the shoulder months from September to November 2011 and from March 2012 to May 2012, households reportedly fired (cold-started) their stoves an average of between 1 and 2 times and added fuel another 1 to 2 times over a 24-hour period. During the peak winter months from December 2011 to February 2012, they fired their stoves more than two times a day and added fuel three times.

The survey finds no relationship between household income and the number of times households fire their stoves or add fuel. This means that financially better off households do not fire their stoves and/or add fuel more often than lower- income households. This finding confirms that households only fire their stoves or add fuel when needed.

Mornings and evenings are the peak times for heating. During the shoulder months, about 84 and 70 percent of the households keep their stoves burning continuously throughout the morning and evening, respectively (table 4.3). Only about 27 percent of the households keep their stoves burning continuously through the afternoon, and only 9 percent keep their stoves burning through the night. As expected, during the peak winter months, just about every household keeps its stove burning continuously through the morning and evening (96 and 94 percent, respectively); about three-quarters keep their stoves burning through the afternoon (77 percent); and just over half keep their stoves burning through the night (58 percent).

These findings confirm that level of heating stove utilization coincides with variation in the severity of air pollution in the city. Hourly measurements of $PM_{2.5}$ from June 2008 to May 2009 at the Western Cross monitoring station located in the city center, fairly close to the ger areas in the north and west, showed that winter concentrations increased sharply in the morning and evening hours when most ger-area households were using their stoves. Source apportionment methods and pollution dispersion modeling have confirmed that ger stove emissions are the primary source of very small particulate matter in the city air, representing 60 percent of population-weighted exposure to $PM_{2.5}$ on average.[36] The World Bank study also showed that peak pollution coincides with the lighting and refueling phases.

Table 4.2. Number of Times per day Households Fire their Stoves and Add Fuel

Month	Number of cold starts per day	Number of times per day fuel is added
Sept - Nov 2011	1.6	1.3
Dec 2011 - Feb 2012	2.3	2.9
Mar - May 2012	1.7	1.3

Source: World Bank Clean Stove Initiative Survey, July 2012.

[36] World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts* (Sustainable Development Series Discussion Paper, December 2011).

Table 4.3. Percentage of Households that Keep their Stove Burning Continuously in the Morning, Afternoon, Evening, and Night

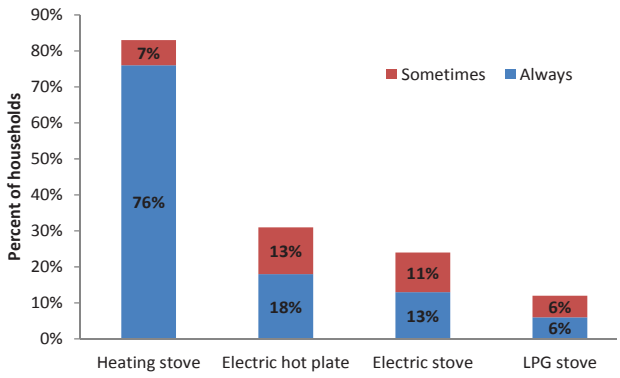
Month	Morning	Afternoon	Evening	Night
Sept - Nov 2011	84	27	70	9
Dec 2011 - Feb 2012	96	77	94	58
Mar - May 2012	84	28	70	9

Source: World Bank Clean Stove Initiative Survey, July 2012.

4.2 Cooking Habits

During the winter months, the vast majority, 76 percent, of households use their coal-burning stoves for both heating and cooking. This is normal practice in Mongolia and is the major reason why households prefer stoves that are good for heating as well as cooking. Some households also use electric stoves for cooking, and, recently, some have even begun to use liquefied petroleum gas (LPG) stoves. Households either use these electric and LPG stoves for supplementary cooking, with their heating stove being their main stove for cooking, or vice versa. In other words, most households do not rely on a single stove for *all* their cooking.

Figure 4.1. Percentage of Households Using Different Stoves for Cooking During Winter



Source: World Bank Clean Stove Initiative Survey, July 2012.

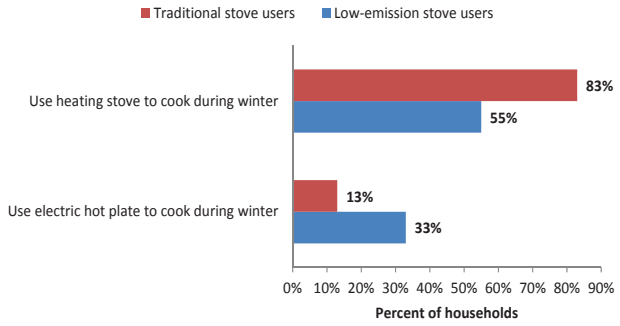
During the summer, the vast majority of households either use electric stoves, LPG stoves, or firewood for cooking. Some households cook outside their gers or houses, either by moving their main heating stove out of their homes or by using another stove, which they may keep in a small shed on their hashaa that serves as a summer kitchen. The survey confirms that 92 percent of households use electricity as a source of fuel for cooking during the summer months, 19 percent use LPG, and 17 percent use firewood. Other less common cooking fuels in the summer are coal, sawdust and briquettes, each accounting for less than 1 percent of households.

Figure 4.2 shows that low-emission stove users are much less likely than traditional stove users to cook with their heating stoves. About half of low-emission stove users say they cook on their heating stoves versus about 80 percent of traditional stove users. Households with low-emission stoves also tend to cook more with electric hot plates during the winters than those with traditional stoves. As will be discussed in a subsequent section, the difference suggests that the low-emission stoves currently are less easy to cook with than traditional stoves. Low-emission stove users have already begun to adjust their cooking habits in the winters to their new stoves. About the same proportion of traditional and low-emission stove users use the electric hot plate for cooking during the summers.

Recognizing that women traditionally do most of the cooking in ger-area households, the survey also took a more granular look at the cooking appliances that female respondents said they use during the winter (Figure 4.3). About 90 percent of women who use traditional stoves said that they always use their heating stove to do their cooking, and another 2 percent said they sometimes use their stove for cooking. By contrast, 61 percent of women with low-emission stoves said they always use their heating stoves to do their cooking, while 7 percent said they sometimes use their stoves for cooking. Female respondents whose households have purchased

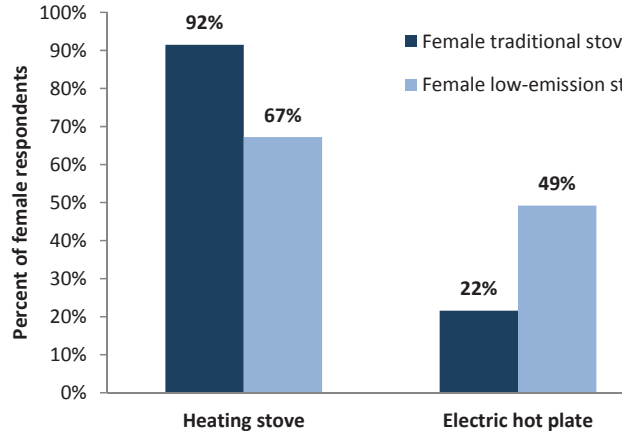
low-emission stoves tend to use electric hot plates to do more of their cooking than those with traditional stove users. Thirty-six percent of female respondents whose households own low-emission stoves said they always use an electric hot plate to do their cooking, versus only 16 percent of women whose households rely on traditional stoves for heating.

Figure 4.2. Appliances Used for Cooking by Traditional and Low-Emission Stove Owners During the Winter*



Note: * includes households who "always" or "sometimes" use the above appliances to cook
Source: World Bank Clean Stove Initiative Survey, July 2012.

Figure 4.3. Stoves Used for Cooking by Female Respondents During the Winter*



Note: * includes respondents who "always" or "sometimes" use the above appliances
Source: World Bank Clean Stove Initiative Survey, July 2012

4.3 Household Preferences and Perceptions of Heating Stove Performance

While price is an important element in a purchasing decision, it alone does not guarantee rapid penetration, nor does it guarantee use after purchase because all consumers, including the poor, have different preferences. Low-emission stoves are not expected to be perfect substitutes for traditional stoves. As written in a report for the World Bank's Ulaanbaatar Clean Air Project, "No one local model may meet all user preferences... All clean-stove technologies per se are imported because the traditional technology used ubiquitously in Ulaanbaatar is highly polluting. Therefore, the impacts of the importation of stoves have less to do with the actual production and more to do with the way in which Mongolian consumers and/or producers absorb the technology and accept it in their daily life. Changing the technology requires new ideas from outside to be adapted in the Mongolian context."[37] Achieving rapid adoption rates for low-emission stoves will depend not only on price but also on the features of the stoves and how they are perceived by consumers in the local market. With this in mind, the survey asked households about stove performance based on a list of key features aside from price. Survey results for the perception of low-emission stove features are compared with results for the perception of traditional stoves because it is assumed that new products would need to at least match or outperform existing stoves across a wide range of features.

4.3.1 Preferred Characteristics and Design Features of Stoves

Designing a stove to fit the needs of consumers is essential to ensuring acceptance by the local market. Stoves that do not meet the needs of consumers or lack key features are likely to be rejected. To assess preferences, the survey asked respondents about 13 different stove design features they might consider important

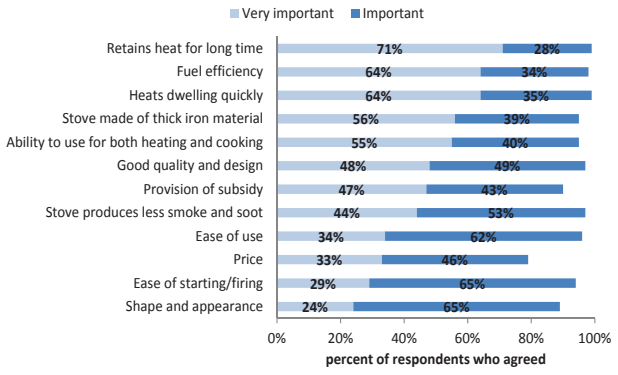
[37] Ulaanbaatar Services Improvement Project II Project Implementation Unit, "Mongolia: Ulaanbaatar Clean Air Project Safeguards Report" (internal management report, September 29, 2011).

when purchasing a stove. Respondents ranked the features as: (i) very important, (ii) important, or (iii) not so important (see figure 4.4).

The results indicate that the ability to heat a room and stay warm is seen as the most important aspect of stoves by consumers. As shown in figure 4.4, about 70 percent of respondents ranked heat retention as a very important design feature; about 65 percent said that the ability of the stove to heat up quickly was very important. This finding underscores the importance of stoves for heating in a very cold climate. The third most-important characteristic is "fuel consumption." Thickness of the iron material, and ability to use the stove for both heating and cooking are ranked as the fourth and fifth most-important characteristics. The least important features were shape and appearance, and ease of lighting. In summary, households look for something that works, is convenient (retention of heat means less need for refueling, not a popular task in early hours), and saves on fuel expenditures.

In addition, it is important to note that only a third of the households think that price is very important when buying a new stove. This may be due partially to a few factors. First, the high level of the subsidy, including the elements financed by MCA-Mongolia and CAF, significantly reduced the price of low-emission stoves. Second, heating stoves are an absolute necessity for ger-area households, and good stove performance is crucial to staying warm and comfortable through the long winters. A corollary of this argument is that even if low-emission stoves are distributed for free, households may still be unwilling to give up their old stoves if the new stoves lack important design features. The government did try stove giveaways in previous programs several years ago that failed for this reason.

Figure 4.4. Importance of Stove Design Features to Ger-Area Consumers

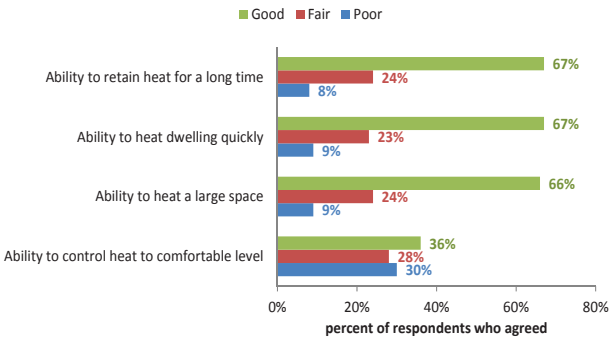


Source: World Bank Clean Stove Initiative Survey, July 2012.

4.3.2 Households' Perceptions of the Performance of Their Existing Stoves

Replacing traditional stoves with low-emission stoves requires that the new stoves perform as well or better than households' existing stoves on important features, so it is important to understand what households think of their current stoves. To gauge how satisfied households are with their existing stoves, the survey asked respondents to rank the performance of their stoves on four key aspects related to heating: (i) the ability to retain heat for a long time; (ii) the ability to heat a large room; (ii) the ability to control heat to a comfortable level; and (iv) the ability to heat up quickly. The results are presented in figure 4.5. The survey finds that about two-thirds of the households are satisfied with the heating performance of their current stoves, with the exception of the ability to control heat. This finding reflects that most heating stoves used in Mongolia are relatively simple and are not equipped with heating control devices. There are no significant differences in perceptions of their system's heating ability between households using traditional stoves and those using low-emission stoves. There was also no significant difference in opinion between households in different dwelling types or across different income quintiles.

Figure 4.5. Rating of Stove Heating Abilities

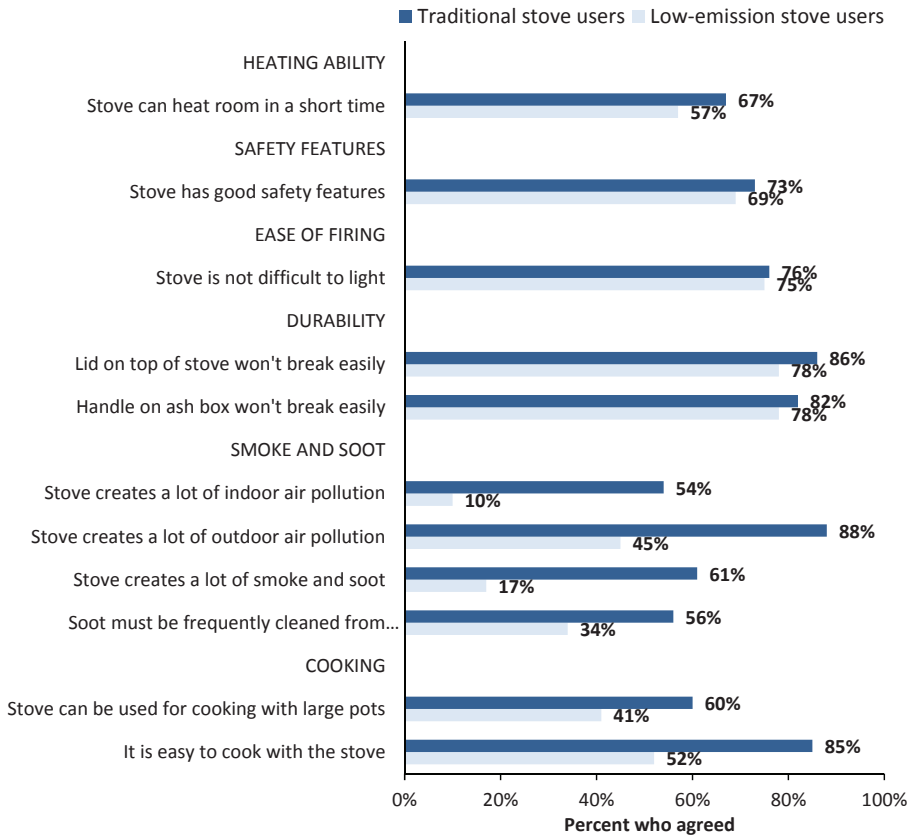


Source: World Bank Clean Stove Initiative Survey, July 2012.

In addition to heating ability, the survey also collected information of household perceptions of stove performance on five other aspects: (i) safety; (ii) ease of lighting/firing; (iii) durability; (iv) smoke and soot production; and (v) use for cooking. Views of stove performance were compared for traditional and low-emission stove users. As can be seen in figure 4.6, views among traditional and low-emission stove users on the safety, ease of lighting/firing, and durability of their stoves were mostly similar.

By comparison, however, there was a much larger divergence in opinion among traditional and low-emission stove users on the amount of smoke and soot created by their stoves. Nearly 90 percent of traditional stove users agreed that their stoves create a lot of outdoor air pollution, versus only 45 percent of the low-emission stove users. Around 55 percent of traditional stove-users agree that their stoves create a lot of smoke indoors, compared with only 10 percent of low-emission stove users. These findings confirm that most low-emission stove users are confident that their stoves do not contribute to outdoor or indoor air pollution. They also indicate that cleaning and maintenance is easier with the low-emission stoves because they produce less soot.

Figure 4.6. Views of Stove Performance among Traditional and Low-Emission Stove Users



Source: World Bank Clean Stove Initiative Survey, July 2012.

Differences were also seen among traditional and low-emission stove users on ease of cooking. As was discussed above, the ability to cook with heating stoves is important because the vast majority of households in the ger areas use their stoves for both heating and cooking during the winter months. Nearly 90 percent of traditional stove users agreed their stoves are easy to cook with, compared to only half of low-emission stove users. Furthermore, about 60 percent of traditional stove users agreed that their stoves can be used for cooking with a large pot or wok, versus only 41 percent of low-emission stove users. Views of stove cooking performance were similar among female and male respondents. Respectively, 90 and 85 percent of female and male traditional stove users agreed that it is easy to cook with their stoves, versus only 52 percent of both female and male low-emission stove users. Similarly, 63 percent and 59 percent of female and male traditional stove users respectively agreed that their stoves can be used to cook with large pots, versus 59 and 42 percent of female and male low-emission stove users. (The differences are within a statistical margin of error.) Perceived difficulties with cooking may reflect the fact that new models of low-emission stoves recently introduced to the Ulaanbaatar market have smaller combustion chambers. Because large pots are common in traditional Mongolian cooking and preferred by ger households, introducing a stove with a large burner or combustion chamber that can accommodate the large pots would be more suited to household cooking habits and customs.

4.4 Willingness to Change Stoves

The survey asked whether households were interested in replacing their current stoves. About 60 percent (97,656) of all households expressed interest, either in the short or long term. Among those households still using traditional stoves, the share of respondents interested in changing their stoves was higher, at 67 percent (equal to 84,525 households)- of which 83 percent said they are interest in replacing their stoves in the near term.

Among the subset of households that have yet to acquire low-emission stoves, 72 percent of respondents living in gers, 85 percent of respondents living in detached houses without heat walls, 64 percent of respondents in homes with heat walls, and 60 percent of those with LPBs said they would be interested in replacing their stoves.

Among the traditional stove users who indicated interest in switching out their stoves, the "Silver Mini" appears to be the most preferred replacement model (named by 29 percent of respondents), followed by the "Silver Turbo," and the "Royal Single" (both named by 14 percent of respondents). Aside from low-emission stoves, about 20 percent of households still using traditional stoves are interested in replacing their stoves with LPBs. Another 2 percent would like to change to low-emission LPBs. Only a very small minority (4 percent) of traditional stove users said they are interested in replacing their existing stoves with another traditional stove.

Table 4.4. Preferred Replacement Models for Traditional Stove Users

Type of stove	Number of Households	Percent
Silver mini	24,455	29
Low pressure boiler	17,069	20
Silver turbo	11,981	14
Royal single	11,653	14
Other	6,073	7
Locally made low-emission stove	5,580	7
Traditional stove	3,447	4
Royal double	2,626	3
Low-emission low pressure boiler stove	1,641	2
Total	84,525	100

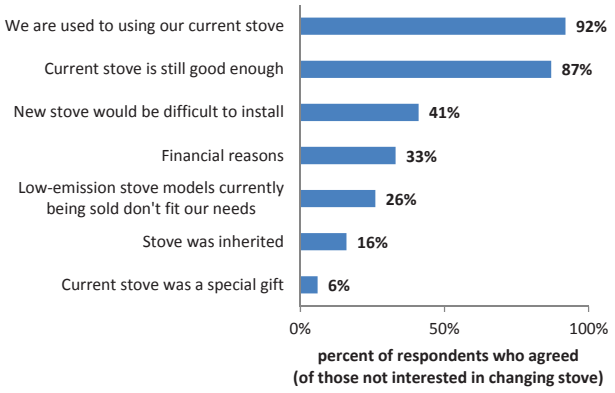
Source: World Bank Clean Stove Initiative Survey, July 2012.

4.4.1 Reasons for Resistance to Changing Stoves

For households that are not interested in changing their stoves, several reasons were noted for their reluctance. As shown in figure 4.6, the two most cited reasons were that they are used to their existing stoves (92 percent) and that their existing stoves are still in good working condition (87 percent). Only a third of respondents agreed that financial reasons would prevent them from replacing their stoves, and about 40 percent cited potential difficulties with installing a new stove in their homes.

Because adoption rates for low-emission stoves among households in detached homes with heating walls were so much lower than households in detached homes without heating walls, reasons for why traditional stove users in these two groups would not want to replace their stoves were also examined. The results show that the perceived difficulty of fitting a heat wall to a new stove is a significant barrier to these households replacing their stoves. About 24 percent of respondents said that their existing heat wall would not fit a new stove.

Figure 4.7. Household Reasons to Not Change Their Stove

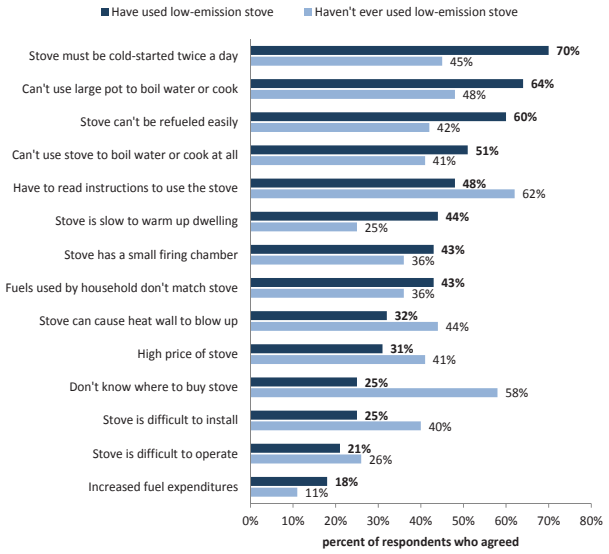


Source: World Bank Clean Stove Initiative Survey, July 2012.

4.4.2 Perceived Difficulties with Using Low-Emission Stoves

Perceptions of difficulties using low-emission stoves differ between traditional stove users and households already using them (figure 4.7). In most cases, fewer than half of traditional stove users believed they would encounter difficulties in using a low-emission stove. On the one hand, traditional stove users tended to over-estimate, compared with responses from users, the difficulties with installing the low-emission stoves and operating them. They were also uncertain about where they could buy low-emission stoves. On the other hand, they tended to under-estimate difficulties with lighting, refueling the stoves, and cooking with them. Also, while only 25 percent of traditional stove users expected that low-emission stoves would take a long time to heat a ger, about 44 percent of households already using a low-emission stove agreed that this is a problem.

Figure 4.8. Perceived Difficulties with Using a Low-emission Stove (Comparing those who have and have not used low-emission stoves already)

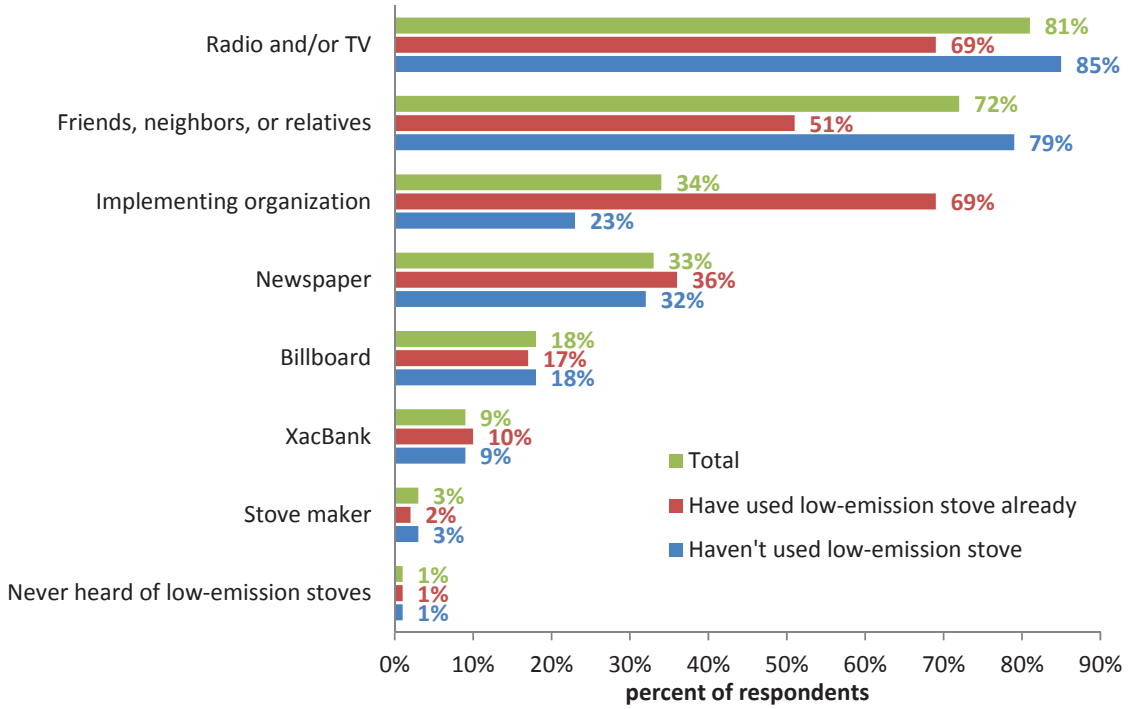


Source: World Bank Clean Stove Initiative Survey, July 2012.

4.5 Source of Information and Knowledge about Low-Emission Stoves

The survey's findings demonstrate that mass media and word of mouth have been the most prevalent means of reaching consumers (figure 4.8). In general, households in the ger areas are already quite familiar with low-emission stoves. Only 1 percent of respondents had never heard of the stoves. About 81 percent of households reportedly learned about the stoves from radio or TV, and 72 percent said they had heard about the stoves from friends, neighbors, or relatives. Other important sources of information about low-emission stoves cited were organizations involved in implementing the stove replacement program (e.g., MCA-Mongolia), and the newspaper. Only a small portion of households reportedly learned about low-emission stoves from billboards (18 percent) or XacBank (9 percent). In terms of effectiveness, direct communication from the implementing organization was highly effective in promoting the new stoves: about 70 percent of low-emission stove users said they had heard about the stoves from the project implementer. Word of mouth was less effective. Respondents who said they had learned about low-emission stoves from friends, neighbors, or relatives were about 35 percent less likely to be low-emission stove owners. If stove performance is not well-appreciated, it may be very difficult to change minds. New entrants to the market will need to be careful not to overpromise or under-deliver on stoves to avoid this negative feedback loop.

Figure 4.9. Where Did You Hear about Low-Emission Stoves?

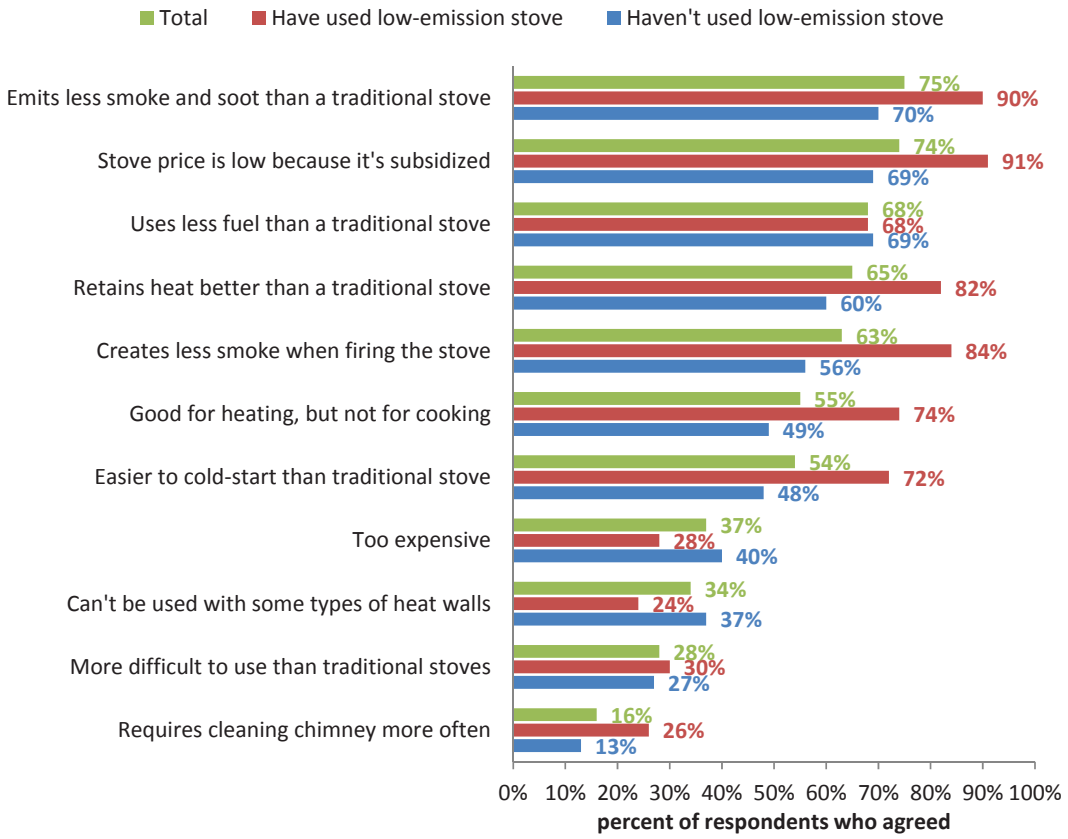


Source: World Bank Clean Stove Initiative Survey, July 2012.

Households also have fairly good knowledge about the features of low-emission stoves. As shown in figure 4.9, most households surveyed agree that the stoves have beneficial aspects. For example, more than 60 percent of the households agree that low-emission stoves produce less smoke and soot, use less fuel, retain heat longer, are easier to start, and are priced low because of the subsidy program. As might be expected, households that had already acquired low-

emission stoves were much more aware of the benefits than households without the stoves, as well as some of the inconveniences. The difference in knowledge is quite significant for most features, except fuel consumption. About 70 percent of both users and non-users of low-emission stoves agreed that the stoves use less fuel than traditional stoves. Moreover, low-emission stove users were less likely to agree that the stoves were not suitable for use with some types of heat walls, and were less likely to say that the stoves were too expensive. On the question of cooking, about 74 percent of the households using low-emission stoves agreed that low-emission stoves are good for heating but not for cooking, versus about half of non-users.

Figure 4.10. Knowledge about Low-Emission Stoves

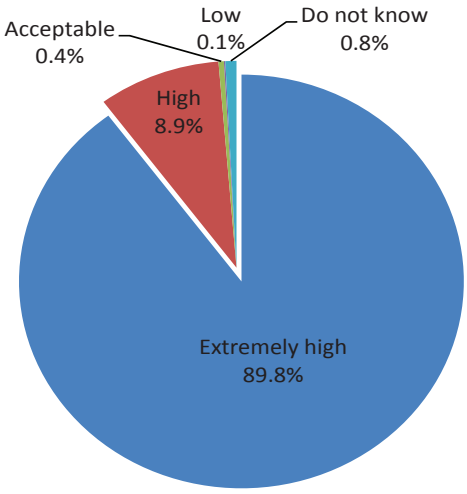


Source: World Bank Clean Stove Initiative Survey, July 2012.

4.6 Household Attitudes toward Air Pollution

Virtually all households in the six surveyed ger districts think that air pollution in Ulaanbaatar is very bad. In fact, about 90 percent of the households think that air pollution in Ulaanbaatar is extremely high and another 9 percent think that it is high (see figure 4.10). Overall, attitudes toward air pollution in the city among ger-area residents are the same as they were in 2007/08, though about 18 percent more respondents in 2012 said that air pollution in Ulaanbaatar is extremely high versus in 2007/08.

Figure 4.11. Opinion of Air Pollution Problem



Source: World Bank Clean Stove Initiative Survey, July 2012.

4.7 Conclusion

Household heating habits are characteristic of living in cold winters and budget constraints. Households only fire (cold start) their stoves or add fuel as needed, suggesting a good understanding of traditional stove operation. The main determinants for how often households fire and add fuel to their stoves are outside temperature and desired level of comfort within budget constraints. Other determinants are type of heating system used, and the size and heating characteristics of the home. A relevant habit is the use of heating stoves for both heating and cooking during the winter months. The survey reveals that about 83 percent of households use the same stove for heating and cooking in the winter. This is a common practice among ger-area households and the main reason households prefer stoves that can be used for both heating and cooking.

Designing stoves to meet the needs of consumers is essential to ensuring acceptance by the local market. The ingrained heating habits are consistent across stove market segments and can present barriers to stoves that do not fit well within these habits. Even if new stoves are used, heating habits are hard to break so new methods of lighting and refueling, for example, required by a new technology may be difficult to absorb. Without sufficient attention to training users, households may "misuse" the stove, which can then significantly under-perform, use more fuel than expected and, worse, emit more particulates than shown in laboratory emissions testing results. The study confirms that heating ability, including retention of heat, is the most important feature of stoves to consumers, followed by fuel efficiency. The thickness of the metal material (durability) and the ability to cook with the stove are also important. Preferred design features appear to coincide with the fact that households start fire and add fuel to their stoves only as needed. Price was a much less important factor cited by households in shaping their purchasing decision.

In general, most households are satisfied with their current stoves, especially when it comes to durability, ease of lighting, and safety. However, a comparison of perceived stove performance among traditional and low-emission stove users reveals that there are also some important differences. About 90 percent of traditional stove users believe that their stoves are a major contributor to outdoor air pollution, versus only 45 percent of low-emission stove users. About two-thirds of low-emission stove users are highly satisfied with the ability of their low-emission stoves to heat their homes-more so than traditional stove users. At the same time, more than half of low-emission stove users say that their stoves are not easy to cook with, while only about 41 percent of traditional stove users say the same. The perceived difficulties of cooking with the low-emission stoves currently on the market have already begun to change household cooking habits, as low-emission stove users are less likely to use their heating stove for cooking in the winter and more likely to use electricity. This may be a risk to sustainability if electricity prices rise and push households back to more convenient coal fired cooking stoves. Despite this, as will be discussed in the next chapter, there are no discernible differences in reported electricity use among low-emission stove users and non-users.

The survey confirms that a significant numbers of households are still interested in acquiring new low-emission stoves. About 70 percent of traditional stove users expressed interest in replacing their stoves, nearly all of whom wanted to acquire a new low-emission stove instead of another traditional stove. Of those respondents who said they are *not* interested in replacing their stoves, the most-cited reasons were that they are used to their existing stoves or their stoves are still in good working condition. Only a third cited financial reasons. Perceived difficulties in switching to low-emission stoves among current non-users included uncertainty about where to buy the stoves, concerns about not being able to use the stoves for cooking, price, difficulty of installing the stoves, and the fear that the stoves would not work properly with heat walls.

CHAPTER 5. HEATING FUEL CONSUMPTION AND EXPENDITURES

Emissions reductions are optimal when stove and fuel match. Previous pilot programs focused on fuel saving, rather than combustion efficiency, which is actually more directly related to emissions reductions. Nevertheless, the fuel-saving characteristics of stoves are very important in decisions by households considering switching to new products, especially for lower-income households. Ulaanbaatar experiences long, harsh winters, and households living in the ger districts must spend a significant percentage of their income (between 16 to 31 percent) on heating fuel each winter. While raw coal continues to be the main heating fuel for 98 percent of households in the ger areas surveyed, a small number of households use other fuels. The following chapter provides a detailed analysis of types of heating fuels, estimated coal and firewood consumption, and household expenditures on all heating fuels.

5.1 Types of Fuels Used by Households

Emissions reductions are achieved when a stove is used with an appropriate fuel and according to instructions. The previous chapters have focused on stove use and preferences, but this is only half of the equation. Trends in fuel use need to be known so that new stove technologies can be designed to match them. There have been initiatives by the central government and the Municipality of Ulaanbaatar to declare "no raw coal" zones, including one for Bayangol District, which was part of the survey. The survey compared penetration rates for alternatives to raw coal across the six central ger districts to gain an understanding of the actual, on-the-ground situation as of August 2012 and reflecting on what happened during the winter or 2011/2012. Results are then compared to the time of the previous survey in 2007/08.

Raw coal and firewood remain the dominant fuels used for heating by ger households in 2012, similar to the situation in 2007. Nearly every household in the ger district relies on these two fuels for heating and cooking during the winter months. In practice, households use raw coal as their primary heating fuel, while firewood is used to light the fire in their stoves. As shown in Table 5.1, a small number of households also use other fuels such as processed coal (semi-coke coal and coal briquettes), sawdust, sawdust briquette, dried animal dung, and "anything that burns." The use of "anything that burns" (such as waste, clothes, bones, and old tires) to supplement coal appears to be a coping mechanism by very poor households. The reported monthly income of these households is less than 380,000 Tg, placing them well within the bottom quintile.

The use of semi-coke coal and other processed fuels such as sawdust briquettes is mainly determined by the households' district of residence. As illustrated in Table 5.2, most of the households that do use semi-coke coal, compressed coal briquettes, or sawdust briquettes live in Bayangol District, where a ban on raw coal has been imposed. While only about 8,400 households use semi-coke coal in the ger areas of the six districts surveyed, 68 percent (5,750) of these households live in Bayangol. Sixty-six percent of the households that use compressed-coal briquettes and 72 percent of the

households that use sawdust briquettes live in Bayangol. The relatively high rates of processed fuel use in Bayangol belie the fact that only a minority of households in Bayangol use these fuels on a regular basis. Most of the households that do use semi-coke coal or briquettes use them only rarely or occasionally, as evidenced by Table 5.3.

Table 5.1. Heating Fuels Used by Households

	Coal	Firewood	Semi-coke coal	Compressed coal briquette	Sawdust	Sawdust briquette	Animal dung	Anything that burns
Households	161,009	154,608	8,370	10,012	2,626	9,355	9,027	3,283
Percent	98%	94%	5%	6%	2%	6%	6%	2%

Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: Some households use more than one type of heating fuel.

Table 5.2. Raw Coal and Processed Fuel Use by Households in Six Districts
(*Percent of households in district that use the following fuels*)

Fuel type	Bayanzurkh	Bayangol	Songino-khairkhan	Sukhbaatar	Khan-Uul	Chingeltei
Raw coal	100%	92%	97%	98%	100%	100%
Semi-coked coal	2%	39%	2%	1%	1%	1%
Compressed-coal briquettes	1%	43%	2%	2%	1%	10%
Sawdust briquettes	2%	44%	0%	2%	0%	8%

Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: Some households use more than one type of heating fuel.

Table 5.3. How Often Households in Bayangol District Use Processed Fuels
(*Percent of households surveyed in Bayangol*)

	Compressed coal briquettes	Sawdust briquettes	Carbonized sawdust briquettes	Semi-coke coal
All the time	9%	14%	10%	18%
Sometimes	14%	19%	13%	13%
Rarely	14%	9%	12%	6%
Haven't used	64%	59%	66%	63%
Total	100%	100%	100%	100%

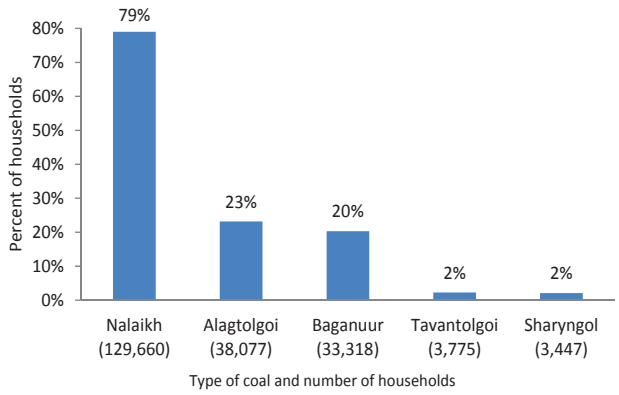
Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: Some households use more than one type of processed fuel.

Fuel characteristics are also important when designing low-emission stoves and the entire burn cycle of the fuel needs to be taken into account. Semi-coke coal may have less ash content in bulk, but it may burn too hot and damage the stove due to its high calorific value. Ash may be needed to reduce the calorific value or as a binding material for briquetting, but this has the counterproductive effect of reintroducing the ash content that was initially removed during the coking process. In addition, coking reduces VOC (volatiles) content. This makes the fuel

difficult to light, requiring more wood (which produces particulates) or an alternative lighting technique. The World Bank's urban air pollution study in Ulaanbaatar noted that the cyclical nature of peak particulate pollution coincided with the lighting cycles of stoves.[38] So, while coking products may be comprised of less VOCs and ash, the need for more fuel (e.g. firewood) to ignite the semi-coke coal may negate these benefits. In any case, emission factors cannot be known unless they are tested in a stove. To date, testing results of semi-coke products in traditional or low-emission stoves are not in the public domain.

With respect to the types and sources of raw coal, Nalaikh coal remains the most popular coal in 2012, as it was in 2008. About 79 percent of the households reported using Nalaikh coal during the 2011/12 winter (compared to 76 percent in 2007/08). Alagtolgoi and Baganuur coal are a distant second and third. Coal is sold in the market either in bulk (typically by the truckload) or in small bags without labeling, so households tend to rely on information from coal traders and/or their own experience to judge the heating value of different types of coal.

Figure 5.1. Sources of Coal Used by Households



Source: World Bank Clean Stove Initiative Survey, July 2012.

Coal from Alagtolgoi has an average heating value in the range of 6,200 kilocalories per kilogram, while both Nalaikh and Baganuur coal have a typical heating value of 3,500 kcal per kg. In practice, many households-especially those that buy coal by the bagful-will use coal from multiple sources.

Some households may try to buy coal from the same trader to make sure that they get the same type of coal, but there is no guarantee of source or quality. Households that buy coal in bulk could, more or less, use the same type of coal for most or the part of the winter season, depending on whether they need to replenish their coal and use the same coal trader.

The size of coal can have important impacts on combustion. Reducing the size of raw coal pieces and making them more uniform can help coal burn more completely-the key objective of a low-emission coal stove initiative. However, on the basis of observation, it is found that the current market is far from standardized and the pieces sold in bags and in bulk are of many different sizes.

5.2 Total Household Heating Fuel Expenditures

Heating expenditures are seasonal and need to be compared with monthly winter income to understand the real impacts on ger area households, especially the poorer ones with weak savings potentials. Total spending by households on all heating fuels, including raw coal, firewood, semi-coke coal, and briquettes, averaged 637,393 Tg during the cold season from September 2011 to May 2012 (table 5.4). An analysis of spending by income bracket reveals that households in the bottom income quintile spent a third (31 percent) of their monthly income on heating fuels in the winter. As shown in table 5.4, although spending on heating fuels increases in absolute terms as income rises, the proportion of income allocated for heating fuel declines. The top two income quintiles only allocated 10 percent or less of their income on heating fuels during the previous winter months. It is clear that heating fuels place a heavy burden on very poor households, though the situation has

[38] World Bank, *Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts* (Sustainable Development Series Discussion Paper, December 2011).

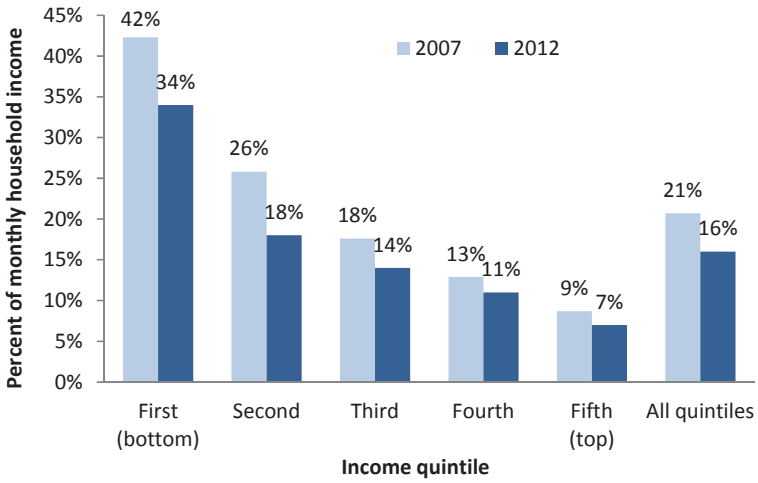
improved somewhat compared to 2007/08 when households in the bottom income quintile reported spending 42 percent of their monthly income during the winter months on heating fuel (figure 5.2). This improvement has been largely a result of an increase in cash income, given that reported monthly spending on heating fuel increased by 57 percent in real terms since 2007/08.[39] This apparently large increase in total spending on heating fuels was due mostly to higher fuel prices over the past four years, but also to a small increase in tons of coal consumed. Regardless, it is clear that the financial burden placed on ger-area households by heating fuel expenditures is still high when compared to households in non-ger areas with access to district heating.

Table 5.4. Average Household Monthly Spending on all Heating Fuels by Income Quintile

Income quintile	Total expenditure on heating fuels (Tg)	Expenditure per heating month (Tg)	Expenditure as % of monthly income during winter
380,000 Tg/mo or less	575,812	74,378	31
Valid N	32,661	33,154	33,154
380,001 to 550,000 Tg/mo	610,184	81,540	18
Valid N	33,482	33,482	33,482
550,001 to 758,000 Tg/mo	652,453	84,170	13
Valid N	31,841	31,841	31,841
758,001 to 1,000,000 Tg/mo	669,670	88,630	10
Valid N	35,780	35,944	35,944
> 1,000,000 Tg/mo	680,750	90,599	6
Valid N	29,707	29,707	29,707
Total	637,393	83,798	16
Valid N	163,470	164,127	145,088

Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: All heating fuels include raw coal, firewood, briquette, and semi-coke coal. Valid N is valid number of households for the variable shown.

Figure 5.2. Heating Fuel Expenditure as Percentage of Monthly Income[39]



Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: See Figure 5.3 for delineation of income quintiles in 2007 and 2012.

[39] Adjusting for inflation, average monthly spending on heating fuels for households in the ger areas was 405,858 Tg per month in 2007/08 (expressed in 2011/12 prices). Prices are adjusted based on the IMF's monthly consumer price index data for Mongolia for the periods of September 2007 to April 2008 and September 2011 to April 2012. IMF, "Data and Statistics," http://www.imf.org/external/data.htm#data.

A comparison of total expenditures on heating fuels by dwelling and heating system type reveals that households living in detached houses without heat walls and households living in gers spend the least on heating fuels in absolute terms. Proportionally, however, ger households spend more of their monthly income on heating fuels because they tend to be the poorest. As expected, households living in larger homes with LPBs spent the most on heating fuels in absolute terms. These patterns of spending on heating fuels are highly similar to those seen in 2007/08.

Table 5.5. Average Household Monthly Spending on all Heating Fuels by Types of Dwelling and Heating System

Type of dwelling and heating system	Monthly household income	Total spending on heating fuels for winter (Tg)	Spending per heating month (Tg)	Spending on fuels as % of monthly income
Ger	634,770	620,346	81,544	18
Valid N	76,483	76,319	76,483	74,514
Detached house with heat wall	850,738	638,551	83,731	14
Valid N	54,326	53,998	54,326	53,326
Detached house without heat wall	695,613	592,160	74,957	14
Valid N	13,622	13,458	13,623	13,623
Detached house with LPB	957,906	731,187	98,848	16
Valid N	19,695	19,695	19,595	19,695
Total	**164,127**	**637,393**	**83,798**	**16**
Valid N		163,470	164,127	161,009

Source: World Bank Clean Stove Initiative Survey, July 2012.

Households that used low-emission stoves during the previous winter months spent slightly less on heating fuels than those using traditional stoves. As will be discussed further below, this finding confirms that the new heating stoves have allowed households to save money on fuels-an important design feature for households considering replacing their stoves.

Table 5.6. Average Household Monthly Spending on Heating Fuels by Types of Stove

Traditional versus low-emission stoves	Average monthly income	Total expenditure per heating month (Tg)	Expenditure as % of monthly income
Low-emission stoves	770,992	84,753	15
Valid N	126,378	126,378	126,378
Traditional stoves	680,080	80,598	17
Valid N	37,749	37,749	37,749
Total	750,082	81,501	16
Valid N	164,127	164,127	164,127

Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: Not all households with low-emission stoves used their stoves throughout the entire winter. A significant number of households acquired low-emission stoves mid-way through the winter.

5.3 Estimated Coal Usage and Expenditures

As noted in the previous sections, the vast majority of households in the ger areas use raw coal as their main heating fuel. The survey shows that individual households used about 4.5 tons of raw coal and spent a total of 424,373 Tg from September 2011 to May 2012 (see table 5.7). In all, it is estimated that the 169,124 households in the surveyed area used 735,750 tons of raw coal during the heating season. Average coal consumption per household is slightly higher than the 4.2 tons reported by households in 2007/08. Average expenditures on coal were 275,372 Tg in 2007/08 (expressed in 2011/12 prices), meaning that spending on coal by households increased by 54 percent in real terms. The increase was due mainly to higher fuel prices.

As was seen in 2007/08, reported coal consumption by households in 2011/12 was positively correlated with household income. Households in the bottom income quintile consumed the least amount of coal, spending 376,132 Tg and consuming a total of 3.7 tons for the entire winter. By comparison, households in the top income quintile spent an average of 482,572 Tg on coal and consumed 5.1 tons for the entire winter. The difference is largely attributable to the fact that higher-income households tend to live in larger homes and have higher heating requirements, especially the households in detached homes with LPBs. Moreover, the relatively small difference in coal consumption between bottom and top income quintiles suggests that demand for coal is relatively inelastic with respect to income.

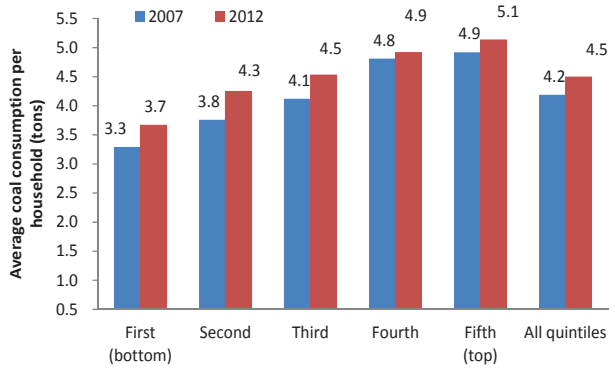
Table 5.7. Household Coal Usage and Expenditure by Income Quintile
(*September 2011 through April/May 2012*)

Income quintile	Total spending per household on coal for winter (Tg)	Coal used per household for entire winter (tons)	Total coal used by all households (tons)
380,000 Tg/mo or less	376,132	3.67	119,944
Valid N	32,661	32,661	32,661
380,001 to 550,000 Tg/mo	396,365	4.26	142,502
Valid N	33,482	33,482	33,482
550,001 to 758,000 Tg/mo	412,247	4.54	144,473
Valid N	31,841	31,841	31,841
758,001 to 1,000,000 Tg/mo	457,090	4.92	176,167
Valid N	35,780	35,780	35,780
> 1,000,000 Tg/mo	482,572	5.14	152,664
Valid N	29,707	29,707	29,707
Total	424,373	4.50	735,750
Valid N	163,470	163,470	163,470

Source: World Bank Clean Stove Initiative Survey, July 2012.

Figure 5.3 compares the average monthly coal consumption during the winter of 2011/12 and 2007/08, showing a slight increase in the average monthly coal consumption per household across all income categories. Although this finding appears to suggest that as income rises households demand a greater level of comfort during the winter months, it could be that higher-income households tend to live in larger homes that require more coal to heat (especially among LPB users). The findings also do not account for differences in weather during the 2007/08 winter and the 2011/12 winter.

Figure 5.3. Comparison of Average Coal Consumption per Household by Income Categories



Source: World Bank Clean Stove Initiative Survey, July 2012, and ASTAE/World Bank: baseline Fuel Consumption, Heating Stove, and Household Perception Survey, December 2007.
Note: Due to an increase of household income (in nominal terms), the income quintile for 2007 and 2012 are based on the following income categories

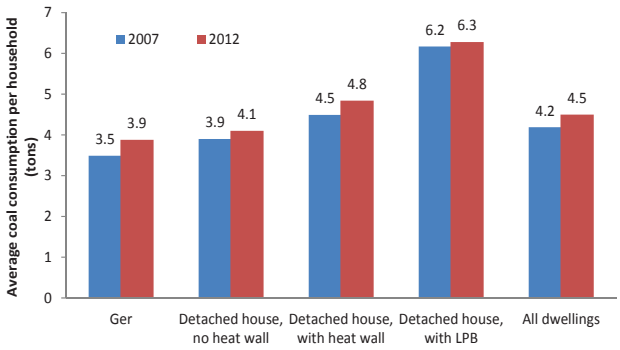
	2007 survey	2012 survey
First quintile	< 111,330 Tg/mo	< 380,000 Tg/mo
Second quintile	111,331 to 172,660 Tg/mo	380,001 to 550,000 Tg/mo
Third quintile	172,661 to 233,990 Tg/mo	550,001 to 758,000 Tg/mo
Fourth quintile	233,991 to 325,869 Tg/mo	758,001 to 1,000,000 Tg/mo
Fifth quintile	> 325,860 Tg/mo	> 1,000,000 Tg/mo

5.3.1 Comparison of Coal Usage between Households Living in Different Types of Dwellings with Different Heating Systems

Households' demand for coal depends on several factors, including the price of coal, the price of comparable alternative fuels, household income, type and size of home, type of heating equipment, and the desired level of comfort. This section only compares the level of coal consumption between households that live in different types of dwellings with different heating systems. As discussed in chapter 2, however, the type of dwelling is closely related to dwelling size. The average floor area of a five-walled ger is 28m^2, versus 39m^2 for a detached house without a heat wall, 41m^2 for a detached house with a heat wall, and 73m^2 for a detached house with an LPB. Furthermore, household income is also positively correlated with dwelling type and heating system. While average monthly income for households living in gers was reported as 634,770 Tg, the average for LPB users in detached homes was 957,906 Tg per household.

Coal consumption varies considerably across the four types of dwellings and heating systems. As shown in table 5.8, coal usage of households that live in ger is the lowest, at only 3.9 tons for the entire winter. Households living in detached houses used more coal, especially those living in larger homes with better heating systems. Coal consumption ranged from 4.1 tons for those in detached homes using space-heating ger stoves without heat walls to 6.3 tons for those in detached homes with LPBs. Coal consumption by dwelling type and heating system showed a similar linear trend for 2007/08, as illustrated in figure 5.4.

Figure 5.4. Comparison of Average Coal Consumption per Household by Dwelling Type and Heating System



Source: World Bank Clean Stove Initiative Survey, July 2012, and ASTAE/World Bank: baseline Fuel Consumption, Heating Stove, and Household Perception Survey, December 2007.

Table 5.8. Household Coal Usage and Expenditure by Type of Dwelling and Heating System
(*September 2011 through April/May 2012*)

Type of dwelling and heating system	Average coal expenditure per winter (Tg)	Coal used per household for the entire winter (tons)	Average household monthly income (Tg)
Ger	390,914	3.88	634,770
Valid N	76,319	76,319	76,483
Detached house without heat wall	392,786	4.09	695,613
Valid N	13,485	13,485	13,623
Detached house with heat wall	434,185	4.84	850,738
Valid N	53,998	53,998	54,326
Detached house with LPB	548,478	6.28	955,775
Valid N	19,859	19,859	19,859
Total	424,373	4.50	750,082
Valid N	163,470	163,470	164,127

Source: World Bank Clean Stove Initiative Survey, July 2012.

5.3.2 Comparison of Coal Usage between Low-emission and Traditional Stoves

Currently, the most prominently used low-emissions stoves in the Ulaanbaatar ger areas are the imported stoves that were subsidized by MCA-Mongolia and CAF. These low-emission stoves use less fuel and burn cleaner than traditional stoves. As shown in table 5.9, average coal use among households that used low-emission stoves during the previous winter months was 4.1 tons, compared to 4.6 tons for households that use traditional stoves, a savings of 11 percent. This means that low-emission stoves reduced household expenditures on raw coal by about 16,553 Tg per heating season per household. It is very important to note, however, this is only an estimated savings because not all low-emission stove users used their stoves throughout the winter. A significant number of households acquired their low-emission stoves mid-way through the winter. When controlling for type of dwelling and heating system, coal consumption by households that use low-emission stoves is lower for all types of dwellings and heating systems. These findings confirm that low-emission stoves outperform traditional stoves on fuel efficiency, which is important because fuel efficiency was identified by consumers as being one of the most important design features they consider when buying a stove (see chapter 4).

5.4 Estimated Firewood Consumption and Expenditure

Generally speaking, firewood is used by ger-area households in the winter to light their stoves and ignite coal. Most households buy firewood by the bag from the market or roadside traders. A few buy large logs or other large pieces. On average, households in the six districts consumed 4.9 cubic meters (m^3) of firewood from September 2011 to April 2012, which is comparable to the 4.7 m^3 reported for 2007/08. The difference falls within the statistical margin of error. Average household expenditures on firewood during the winter months is estimated at 189,970 Tg. Overall, households in the surveyed areas consumed a total of 800,758 cubic meters of firewood during the 2011/12 winter.

Although firewood is typically used to complement or supplement coal, total firewood use and associated expenditures are quite significant. Unlike coal, however, firewood consumption appears to be negatively related to household income. As shown in table 5.10, firewood consumption declines for households in the higher income quintiles.

Table 5.9. Household Coal Usage and Expenditure by Type of Heating Stove
(*September 2011 through April/May 2012*)

Type of stove	Average expenditure per household (Tg)	Average coal used per household* (tons)	Average household monthly income
Do not use low-emission stoves	428,456	4.6	770,992
Valid N	125,721	119,813	126,378
Use low-emission stoves	410,775	4.1	680,080
Valid N	37,749	39,062	37,749
Total	424,373	4.5	750,082
Valid N	163,470	158,875	164,127

Source: World Bank Clean Stove Initiative Survey, July 2012.
Note: The estimated raw coal consumption and expenditure of households that use low-emission stoves are based on raw coal consumption and expenditure from Sept 2011 through April/May 2012. This means that some households that used a low-emission stove may also have used a traditional stove at the beginning of the season and only switched to the low-emission stove at the middle or later in the season. This is due to the fact that not all low-emission stove users acquired their low-emission stove at the beginning of the season; a significant number of households acquired their low-emission stove mid-way through the winter.
* Only includes household that use coal (users only).

Furthermore, households living in gers consume more firewood than households living in detached houses (see table 5.11). Consumption patterns for firewood and raw coal were similar to those seen in 2007/08, and indicate that these two complementary fuels are negatively related. Households that use more raw coal tend to use less firewood and vice versa. This is simple due to the fact that if households add more coal and keep their fires burning longer, they will use less firewood to start their stoves.

Table 5.10. Household Firewood Usage and Expenditure by Income Quintile
(*September 2011 through April/May 2012*)

Income quintile	Average expenditure per household (Tg)	Average firewood used per household (m^3)	Total firewood used by all households (m^3)
380,000 Tg/mo or less	183,344	4.79	158,735
Valid N	33,154	33,154	33,154
380,001 to 550,000 Tg/mo	191,228	5.05	169,154
Valid N	33,482	33,482	33,482
550,001 to 758,000 Tg/mo	217,634	5.33	169,837
Valid N	31,841	31,841	31,841
758,001 to 1,000,000 Tg/mo	184,712	4.93	177,206
Valid N	35,944	35,944	35,944
> 1,000,000 Tg/mo	172,656	4.24	125,825
Valid N	29,707	29,707	29,707
Total	189,970	4.88	800,758
Valid N	164,127	164,127	164,127

Source: World Bank Clean Stove Initiative Survey, July 2012.

Table 5.11. Household Firewood Usage and Expenditure by Type of Dwelling and Heating System
(*September 2011 through April/May 2012*)

Type of dwelling and heating system	Average household monthly income	Average expenditure per household (Tg)	Average coal used per household (m^3)	Monthly household income
Ger	634,770	209,256	5.46	417548
Valid N	76,483	76,483	76,483	76,483
Detached house with heat wall	850,738	178,299	4.56	103,378
Valid N	54,326	54,326	54,326	54,326
Detached house without heat wall	695,613	189,212	4.76	208,552
Valid N	13,622	13,623	13,623	13,623
Detached house with LPB	957,906	147,788	3.59	71,280
Valid N	19,695	19,695	19,695	19,695
Total	164,127	189,970	4.88	800,758
Valid N		164,127	164,127	164,127

Source: World Bank Clean Stove Initiative Survey, July 2012.

Households using low-emission stoves use slightly less firewood than households with traditional stoves. Estimated firewood consumption for low-emission stove users is 4.8m^3, compared to 5.2m^3 for traditional stove users. The difference is equal to about a half cubic meter of firewood for the entire winter, or 17,680 Tg in savings on firewood expenditures for the entire heating season. As with coal savings, the estimated firewood savings are a conservative estimate because they do not account for the fact that a significant number of low-emission stove users acquired their stoves mid-way through the winter.[40] This finding suggests that low-emission stoves save both coal and firewood.

5.5 Conclusion

The survey carried out in 2012 confirmed that coal is still used by just about every ger-area household as its main heating fuel and that firewood is used to start stoves and ignite coal. Nalaikh coal remains the most popular type of coal. However, other fuels are also used by households in the six surveyed ger districts, including semi-coke coal, compressed coal, saw dust, sawdust briquette, animal dung, and "anything that burns." Semi-coke coal is used mainly by households living in Bayangol District, where raw coal has been banned, though usage rates for processed coal are still relatively low with only about half of households in Bayangol reportedly using semi-coke coal on a regular basis.

In real terms, total household spending on heating fuels increased about 57 percent from 406,000 Tg in the 2007/08 heating season to about 637,000 Tg in 2011/12. Fuel consumption was only slightly higher overall, so most of the increase was due to higher fuel prices. Also, because average monthly income reported by households increased by 80 percent, spending on heating fuels as a share of total monthly income actually declined by 5 percent. While the financial burden placed on ger-area households by heating fuel expenditures has eased somewhat, it continues to be very high when compared to households in the city center with access to district heating, especially for the poorest households.

[40] Unlike traditional heating stoves, low-emission stoves require the fire to be started as few times as possible; fire should continue to burn at all times at low heating levels to keep the room warm. Since firewood is usually used to start fire, firewood usage for low-emission stoves should be lower than for traditional stoves.

Households in the bottom income quintile spent 31 percent of their total monthly income on heating fuels during the winter months of 2011/12 (compared with 42 percent for 2007/08). By comparison, households in the top income quintile only spent 6 percent of their income each month on heating fuels during the winter.

As the main heating fuel, raw coal accounts for the largest share of household heating fuel expenditures. The survey shows that ger-area households used about 4.5 tons of raw coal and spent about 424,000 Tg during the heating season from September 2011 to May 2012. It is estimated that households in the surveyed areas used a total of 735,750 tons of raw coal during the 2011/12 heating season. In addition, average coal consumption per household was slightly higher in 2011/12 than it was in 2007/08, when households burned an average of 4.2 tons of coal for the winter. Average monthly coal consumption per household appears to have increased in most income categories as well as for all types of dwellings and heating systems.

With respect to semi-coke coal, the survey reveals that about 8,400 households use semi-coke coal, with 5,750 of those households living in Bayangol District. The findings also indicated that in Bayangol District, where households are not allowed to use raw coal and are supposed to use semi-coke coal, compliance with this regulation is low. Only 2,790 of the about 12,000 households (or 49 percent) in the ger areas in this district report that their households use semi-coke coal on a regular basis. The remaining households only use it occasionally or rarely.

CHAPTER 6. HEATING STOVE DEMAND AND SUPPLY IN FOUR SELECTED CITIES

6.1 Study Background and Objectives

As part of the stocktaking activities in Mongolia under the Clean Stoves Initiative, an assessment was made of the ger-area market for household heating stoves outside Ulaanbaatar. Given Mongolia's large land size and low population density, a survey of the same depth and breadth as the one done in Ulaanbaatar was not feasible. Instead, it was decided that a rapid assessment of four selected cities would be conducted to gather qualitative information about the characteristics and structure of the market for stoves. Upon the recommendation of the Ministry of Energy, which, along with the City of Ulaanbaatar, is the counterpart for this study, four cities were identified: Darkhan, Ondorkhaan, Bayankhongor, and Khovd. The four cities were selected based on hypotheses about the determinants of market size and structure, including proximity to Ulaanbaatar and population size.

The objectives of the assessment were to: (a) gain better understanding on the characteristics of the supply chain and demand for stoves outside Ulaanbaatar; (b) assess similarities and differences of the local markets with the Ulaanbaatar market; and (c) assess linkages with the Ulaanbaatar market. In addition, the assessment gauged household perceptions of local air pollution and knowledge and interest in acquiring low-emission stoves. An estimate of total technical potential demand for low-emission stoves in the four cities was also made. The assessment was conducted with a view toward informing deliberations to expand stove replacement activities underway in Ulaanbaatar to other cities in Mongolia.

This chapter summarizes the main findings of the assessment. Data collection methods are introduced in the first section, followed by a brief overview of the four cities. The chapter then examines the demand for stoves in the ger areas of these cities, as well as the local supply chain. It describes the linkages of the aimag centers to Ulaanbaatar and identifies the main factors that determine the size of the local market and share of locally-produced stoves. Finally, the chapter also presents household perceptions of pollution and knowledge of low-emission stoves, as well as an estimate of the total technical potential demand for low-emission stoves.

6.2 Study Methodology and Data

Rapid appraisal methods were used to quickly assess the characteristics and structure of the market for stoves outside Ulaanbaatar. Information on the market for stoves in Darkhan, Ondorkhaan, Bayankhongor, and Khovd was collected by: (i) visiting the local market and shops where stoves are sold and interviewing shop owners; (ii) visiting local stove production facilities and interviewing stove producers; (iii) visiting households living in the ger areas of each city and interviewing households members; and (iv) and interviewing public officials in the aimag centers responsible for infrastructure and planning as well as representatives from the aimag heating utility companies.

6.3 Overview of the Four Aimag Centers Studied

The four cities included in the rapid assessment of stove markets are Darkhan, Ondorkhaan, Bayankhongor, and Khovd (see figure 6.1).

Figure 6.1. Location of the Four Cities included in the Rapid Assessment of Stove Markets

Darkhan. Darkhan City is located 220 km north of Ulaanbaatar. A total of 20,047 households reside in Darkhan,[41] about 10,000 of which are connected to district heating in the central parts of the city. The remaining households live in the ger areas and rely on stoves. Of the households in the ger areas, about 3,300 live in gers and about 6,600 live in detached houses.

Ondorkhaan. Ondorkhaan City is the capital of Khentii Aimag, and is located about 330 km to the east of Ulaanbaatar. Smaller than Darkhan, only 5,502 households were recorded living in the city as of 2010. About 600 households live in the city center and are serviced by district heating, running water, and sewerage. The remaining households live in the ger areas, requiring stoves for heating. These households include about 3,200 households in gers and about 1,700 in detached homes. Preparations are underway to construct a large centralized heating plant on the northeast edge of the city. The aimag is also building apartments for 540 households in the city.

Bayankhongor. Bayankhongor City is the capital of Bayankhongor Aimag, located 630 km to the southwest of Ulaanbaatar. The city's population has seen rapid growth in past years, rising from around 20,000 in 2005 to more than 33,000 today. Data from the national population and housing census show that there were 8,389 households living in the city in 2010. About 7,300 households live in the ger areas. District heating only provides heating services to about 1,000 households, all of which are living in apartment buildings in the city center.

Khovd. Khovd city is the capital city of Khovd Aimag, located far away from Ulaanbaatar at a distance of 1,425 km to the west. According to the 2010 Census, 7,005 households are living in the city. A total of 1,420 households in the city center are supplied with district heating from the central heating plant.[42] The other 5,585 households live in the ger areas, including about 2,850 households in gers and about 2,735 in detached homes.

Based on the number of ger-area households in each city, the technical potential demand for household heating stoves in the four cities is estimated in table 6.1 below.

[41] National Statistical Office of Mongolia, *Population and Housing Census* (2010).

[42] Because the first plant is already operating at capacity, construction of a second centralized heating plant, located on the southeast edge of the city, was started in early 2012.

Table 6.1. Estimated Technical Potential of Demand for Improved Heating Stoves in Four Select Cities

	Dwelling Types			Total Number of HHs	Number of HHs with Access to District Heating	Technical Potential Demand for Heating Stoves
	Gers	Detached Houses & Apartments	Other dwellings			
Darkhan City	3,328	16,399	320	20,047	10,000	10,047
Ondorkhaan City	3,174	2,298	30	5,502	600	4,100*
Bayankhongor City	6,275	2,923	23	8,389	1,000	7,389
Khovd City	2,849	4,064	92	7,005	1,420	5,585
Total Demand	15,626					27,121

Source: National Statistical Office of Mongolia, *Population and Housing Census* (2010).
* Note: This estimated technical potential demand of 4,100 is taking into account an additional 540 household that will be moving into new apartments being developed by the city government and private investors.

6.4 Characteristics of the Demand for Stoves in the Aimag Centers

Although on a vastly smaller scale, the basic structure of demand for heating stoves in the four cities is similar to that of Ulaanbaatar. Consumers in the ger areas can be grouped into four market segments based on dwelling type and heating system: ger households; households living in detached homes that use space-heating stoves attached to heat walls; households in smaller detached homes without heat walls that just use space-heating stoves; and households living in larger detached homes with LPBs and radiator systems.

The numbers of consumers in each of the four market segments varies from city to city. The size of the ger area and the composition of dwelling types and associated heating systems in each city are good determinants for the size of each market segment. In Ondorkhaan and Bayankhongor, a higher portion of households live in gers and smaller detached homes. From census data and observation, it is estimated that typical space-heating ger stoves account for more than half of all stoves bought by consumers in these two cities. By contrast, in Darkhan, a much larger portion of households live in detached homes and heating stoves retrofitted for use with heat walls dominate the market. In Khovd, the number of households living in gers is about the same as the number of households that live in detached houses.

In each of the four cities, the overwhelming majority of households interviewed purchased their stoves in the central market or from artisanal stove-makers in the aimag center. Few traveled outside the aimag to buy directly from Ulaanbaatar. The asking retail prices for traditional ger stoves sold by retailers in the local markets of the four cities ranged from just under 100,000 Tg to about 150,000 Tg depending on size, the thickness of the metal material, customization (i.e., whether the stove was fit with a heating wall attachment), and workmanship. These asking prices are a rough indicator of the affordable price range for consumers in the aimag centers.

6.4.1 Demand for Low-Emission Stoves and Potential Willingness to Pay

Almost all of the households interviewed in the four cities were well-informed about the low-emission stove exchange program that has been implemented in Ulaanbaatar. Because they are still in the same media market as Ulaanbaatar, they have been exposed to the same information on television and radio as consumers in

Ulaanbaatar. Of the households that had heard about the stove exchange program, many expressed interest in acquiring the new stoves. The chairwoman of one ger-area *bag* (district) in Darkhan, for example, submitted a request to the aimag governor on behalf of households in her district for 1,000 low-emission stoves. (There are roughly 1,600 households living in her *bag*.) Similar requests were made in Ondorkhaan and Bayankhongor.

The study team did not have the opportunity to systematically collect detailed household income data needed to determine the affordability of low-emission stoves in the aimag centers. Despite this, it is expected that households would be willing to pay at least the same price as in Ulaanbaatar, given the strong interest demonstrated by households and the fact that the asking prices for traditional stoves sold on the local market were higher than the subsidized prices for low-emission stoves sold under the MCA-Mongolia program. In the four cities, the survey team also spotted a few second-hand low-emission stoves that were purchased in Ulaanbaatar under the stove exchange program and either re-sold or gifted, including a stove being sold in one local shop in Ondorkhaan for 350,000 Tg.

6.4.2 Demand for Low Pressure Boilers (LPBs)

Following the same trend seen in ger areas of Ulaanbaatar, more households in the aimag centers are building new homes (or expanding their existing homes) and replacing their existing stoves with LPBs. At present, the growing demand for LPBs remains limited to a small segment of high-end consumers. From interviews with LPB owners, retailers, and installers, it was learned that the price of a complete LPB system (including the stove, radiators, piping, and labor) starts around 1.5 million Tg. This puts the cost of an LPB system beyond reach for the majority of households living in the ger areas of these cities; however, given the recent economic prosperity, it is expected that more and more households will be able to afford LPBs and that the size of the market for LPBs will grow.

As shown in chapter 5, households living in detached houses with LPBs consume significantly more coal and firewood than households living in other dwellings or with other types of heating systems. Higher coal consumption also means that LPBs emit more pollutants into the air, unless these LPB stoves are replaced with low-emission models. Any low-emission stove program that is expanded into the aimag centers cannot ignore the growing market for LPBs.

A successfully designed intervention to replace high-emission LPBs in the aimag centers will also have to address problems with low levels of knowledge among consumers. Interviews with LPB suppliers and households that expressed an interest in upgrading their heating systems revealed that potential consumers often do not know that LPBs use more coal than space-heating ger stoves. They do not realize that they must keep their LPB stoves burning throughout the winter to prevent water in the pipes and radiators from freezing, and that this may increase the number of times they have to add fuel to their stoves each day. Furthermore, many households invest in LPBs without improving the thermal insulation of their homes.

6.5 Characteristics and Limitations of Stove Supply Chains

Local stove producers in the aimag centers consist mainly of two types: small workshops and individual welders. In addition to stoves, the workshops visited in Darkhan, Ondorkhaan, and Bayankhongor, all produce other metal items, such as chimneys, pails, and ash boxes. A few even make wooden ger furniture. Stove production is often seasonal. During the coldest months of the winter, production might stop entirely, or the shops might retain one or two employees to make accessories such as chimneys. Only one of the workshops visited, in Bayankhongor, produces stoves throughout the year. Each of the workshops operates a retail storefront (usually no more than a shipping

container) in the main market of the city where the workshop sells its stoves alongside stove accessories and other ger furnishings. The largest of the stove producers visited, in Darkhan, claim to make and sell 500-650 stoves per year. Others, in Bayankhongor and Khovd, report production and sales of 200-300 stoves per year. Peak sales season usually runs from the late summer to early winter. The customer base for these workshops consists of local residents in the aimag center, households from the surrounding soum centers, herders from nearby areas, and even people from neighboring aimag.

Figure 6.2. Stoves for Sale in Central Markets of Darkhan and Bayankhongor

(Left) Local producer's stall in Birj Market, Darkhan selling ger stoves and stoves with heat wall attachments; **(Middle and right)** Stoves on display at local producer's storefront in Bayankhongor central market.

In contrast with the established workshops, individual welders in the aimag centers usually only produce stoves to fill orders placed directly by end users. The welders who were interviewed in the four cities explained that once they receive orders for stoves, the next step for them is then to locate materials, including scrap materials such as old water towers or oil tanks from the Soviet era, or metal sheeting obtained from other producers. The supply chain is much less regular, and only those welders with connections who are able to secure a somewhat reliable supply of materials are able to stay in the stove-making business. The customer base for welders appears to be comprised mainly of herder households from the surrounding areas, at least according to the welders interviewed. Because the artisans typically do not operate a storefront, customers must go directly to the welder's production yard to place orders. In the same way, the welders also produce some made-to-order specialty stoves, such as LPBs, for end users or middlemen (i.e., plumbing contractors) that are not made by the local workshops. Individual welders interviewed in the four cities claimed to produce anywhere from 50 to more than 100 stoves per year.

Figure 6.3. Artisan Welder in Bayankhongor

A Bayankhongor welder in his production yard, making stoves. Scrap materials used to make stoves are shown in the center photo. At right is an LPB made by the welder, which he is selling for 350,000 Tg.

Based on interviews and observation, it can be concluded that stove producers in the four selected cities can all be classified as small artisanal producers serving only the local market. It is possible that the small workshops and individual welders in these cities could make low-emission stove models, if provided with trainings and prototypes to copy. Indeed, at least one artisan reported having attended trainings for making improved stoves in the past.[43] Still, artisan producers remain limited by the supply of materials and the size of the aimag center markets. Local production of low-emission stoves might not achieve the economies of scale needed to be profitable. Ensuring consistent adherence with emissions standards would also be difficult.

Apart from producers, wholesalers and retailers form the remaining links in the stove supply chain for stoves in the four cities. As noted above, local stove producers in larger cities, such as Darkhan, and cities that are located further away from Ulaanbaatar, such as Bayankhongor and Khovd, also own and operate retail shops in the cities' main markets. In the main markets, local producers compete with other well-established retailers that sell stoves from Ulaanbaatar. In general, there are two types of retail shops observed in the central markets that sell stoves from Ulaanbaatar. The first type of retailer buys stoves in bulk from the Narantuul market in Ulaanbaatar and re-sells them. The retailer is responsible for arranging transportation to ship the stoves from Ulaanbaatar to the aimag center. The second type of retailer buys stoves directly from a producer in Ulaanbaatar. Often, the retailer has a pre-existing relationship with the stove maker. The retailer might pay the producer upfront for the entire shipment, or pay in installments as the stoves are sold.

Furthermore, most of the stove retailers in the main markets of the four cities also sell a variety of other products, including ger frames, felt covers for gers, furniture, electric appliances, and other household goods. Stoves might account for a smaller fraction of the retailer's total business compared to that of local producers selling in the main market. Evidence from the four cities suggests that despite the relatively small size of local markets in the aimag centers, distribution channels are well-organized and established.

The supply chain for LPBs in the aimag centers also appears to be well-established, although it is structured differently. Unlike traditional stoves, LPB systems are typically installed by plumbers or other contractors. The stoves may be welded by the contractor, or made-to-order by a local artisan. In two of the cities visited, Khovd and Bayankhongor, homeowners imported prefabricated LPBs directly from China. The mass-produced, Chinese-made LPBs observed in households were comparable in price to locally-welded stoves (around 400,000 to 500,000 Tg), but of vastly better quality. The remaining components, such as radiators and pipes, are primarily bought and sold in construction supply stores situated around the central markets in the aimag centers. According to LPB owners and retailers interviewed, homeowners often accompany the plumber or contractor to the stores to buy the different components. The implication of this finding is that, as in Ulaanbaatar, any intervention to replace high-emission LPBs in the aimag centers will need to use different supply chains than existing stove replacement efforts, and may need to include plumbers and contractors.

[43] An *improved stove* refers to an improved version of a traditional stove and is not considered a low-emission stove because it does not meet all of the criteria for indoor and outdoor air pollution, safety, and combustion and fuel efficiency of a low-emission stove (see box 1.2).

Figure 6.4. Low Pressure Boilers in the Aimag Centers

(**Left**) Chinese-made low-pressure boiler in Khovd household; (**Middle**) Locally-made LPB in Darkhan household; (**Right**) construction supply store in Khovd that sells radiators and piping for LPB systems.

6.6 Linkages of Stove Markets in Ulaanbaatar and the Aimag Centers

On the basis of the rapid appraisal results, along with findings from previous studies for the Ulaanbaatar Clean Air Project (UBCAP),[44] it is evident that clear linkages exist between the stove market in Ulaanbaatar and markets outside this city. The safeguard report for UBCAP estimated that about half of the stoves made by stove producers in Ulaanbaatar were sold to vendors in the Ulaanbaatar market (mainly Narantuul Market), while the other half were sold to households outside Ulaanbaatar. Interviews with local stove retailers, wholesalers, producers, and ger households in the four cities by the rapid appraisal team confirmed that stoves sold in the local aimag center markets consist of stoves made in Ulaanbaatar as well as locally-made stoves.

While it was beyond the scope of the rapid appraisal to estimate the exact share of locally-made stoves and stoves made in Ulaanbaatar in the local aimag center markets, it was hypothesized that market share depends largely on a combination of three factors: (i) distance from Ulaanbaatar; (ii) size of the local market; and (iii) scale of local manufacturing capacity, with factors (ii) and (iii) being interrelated. Households in Ondorkhaan, for example, are dependent primarily on stoves supplied from Ulaanbaatar because Ondorkhaan is within a few hundred kilometers of the capital, has a relatively small population, and no established manufacturing capacity other than individual artisans. Because Darkhan, which is even closer to Ulaanbaatar than Ondorkhaan, has a much larger population, it is thus able to support several larger-scale stove producers as well as individual stove-makers. Consequently, local producers in Darkhan appear to be competing fairly evenly with Ulaanbaatar producers in the aimag center market. Meanwhile, in Bayankhongor and Khovd, which are located further away from Ulaanbaatar, retailers sell both locally-made stoves and stoves from Ulaanbaatar. Locally-made stoves appear to dominate the market, especially in Bayankhongor, which has a couple of well-established manufacturers.

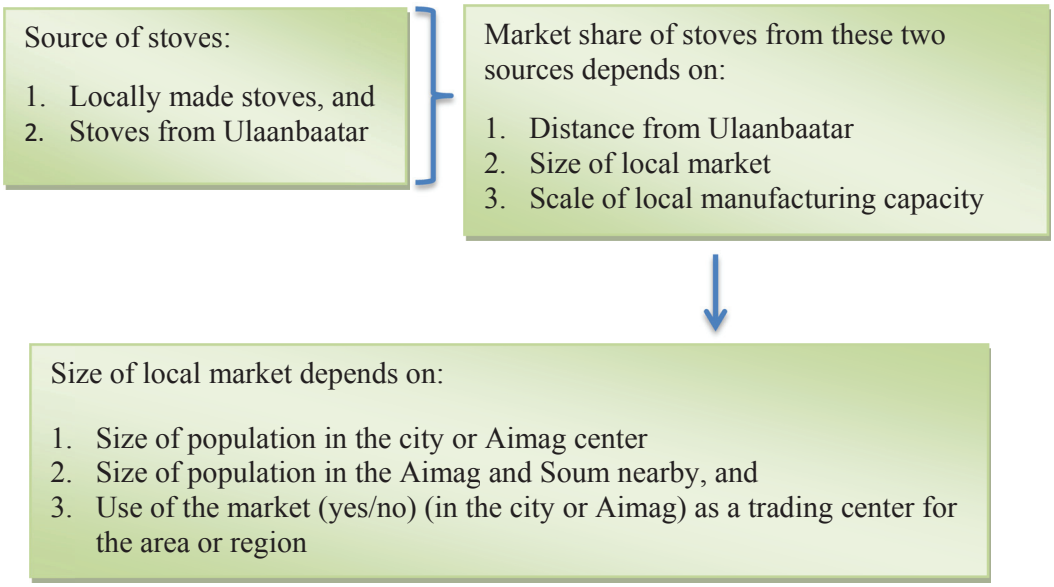
In addition, some local stove producers rely on materials and stove parts from Ulaanbaatar. For example, one workshop in Darkhan that produces about 500 to 650 stoves annually sources its stove tops and covers from Ulaanbaatar. Another producer in Bayankhongor, which claims to produce 200 to 300 stoves per year, purchases metal sheeting from Ulaanbaatar to bend and weld into stove bodies. By contrast,

[44] Ulaanbaatar Services Improvement Project II Project Implementation Unit, "Mongolia: Ulaanbaatar Clean Air Project Safeguards Report" (internal management report, September 29, 2011).

individual stove makers are much less dependent on materials from Ulaanbaatar, instead relying mainly on scrap materials but also whatever other materials they can source locally (e.g., by buying extra metal sheets that local workshops ship from Ulaanbaatar).

Given the linkages between the aimag center markets and stove suppliers in Ulaanbaatar, any disruption of stove production in Ulaanbaatar will likely have a direct impact on the supply of stoves in the aimag centers as well. The severity of the impact will depend largely on the dependency of local households on stoves supplied from Ulaanbaatar and the capacity of local stove production to replace stoves from Ulaanbaatar. Due to market linkages, it is conceivable that if several stove producers in Ulaanbaatar decide to go out of business (perhaps due to repressed demand for traditional stoves from subsidized low-emission stoves), the price of traditional stoves outside Ulaanbaatar will likely increase, at least in the short run. In the longer run, local producers may pick up the slack and push prices down-or they might decide to keep their prices higher because the stove market has become less competitive than before and they face less pressure from manufacturers in Ulaanbaatar. It is also possible in the longer run that large producers and wholesalers outside Ulaanbaatar may supply traditional stoves to consumers in the Ulaanbaatar market and compete with imported low-emission stoves. For smaller cities outside Ulaanbaatar that are highly dependent on traditional stoves from Ulaanbaatar, adjustment may be slow because large-scale local stove producers do not exist.

Figure 6.5. Market Structure and Supply Chains of Stoves outside Ulaanbaatar



Source: Authors.

The linkages between the aimag centers and Ulaanbaatar also have important implications for the long-term success of stove exchange programs in reducing air pollution in Ulaanbaatar. The market for subsidized low-emission stoves is expected to be temporary and could dry up if subsidies are withdrawn, unless the retail price of the stoves significantly declines. Given the linkages between Ulaanbaatar and the aimag centers, however, it can be expected that a steady supply of new and used stoves-including both traditional stoves and low-emission stoves-will continue to flow in and out of Ulaanbaatar. The population in Ulaanbaatar is far from static. With continued migration into the ger areas and the natural

growth of population, the demand for stoves in the Ulaanbaatar will continue strong for a long time to come. Some households in Ulaanbaatar may sell their low-emission stoves and replace them with traditional stoves, especially as the low-emission stoves reach retirement age. These low-emission stoves may be re-sold to consumers outside the capital. The remaining traditional stove producers in Ulaanbaatar may try to fill this demand for new stoves in Ulaanbaatar, or producers in other cities may try to increase their production and enter the market. Thus, the current market share of low-emission stoves in Ulaanbaatar cannot be assumed to be permanent, and this creation of a temporary market for low-emission stoves can only provide a temporary solution to the air pollution problem. Only a permanent and sustained market for low-emission stoves will ensure that problem of air pollution due to use of coal-burning stoves for heating can be solved.

6.7 Perceptions of Air Pollution in the Aimag Centers

Interviewees in all four cities reported that air pollution in their cities is getting worse, to the extent that some interviewees claimed their city's air pollution was "as bad as in Ulaanbaatar."[45] Two main contributors to air pollution identified by respondents are: (1) the proliferating number of heat-only boilers, and (2) household stoves in the ger areas.

Officials in the aimag government departments responsible for infrastructure planning who were interviewed for this study all viewed centralized heating and the provision of new housing to ger-area residents as the long-term solutions to their cities' air pollution problems. Khentii Aimag has issued a moratorium on the construction of new heat-only boilers in Ondorkhaan and hopes to start construction of a large centralized heating plant (CHP) on the edge of the city next year. The plant is expected to cost 8 billion Tg. The aimag has also invested in new apartments for 270 households, with plans to build housing for another 270 households. Bayankhongor is pursuing a similar strategy, with plans to build a CHP that is expected to cost around 12 billion Tg. It is also building two new apartments buildings to house more than 160 households. Khovd has plans to build a second CHP and has set aside land for new housing as well.

In the immediate term, authorities in three of the four cities expressed interest in distributing low-emission stoves to ger-area residents.[46] The aimag governor and city council in Bayankhongor City, for example, have reportedly approved the purchase of 400 low-emission stoves for 100 million Tg. The aimag plans on selling the stoves to ger-area households at subsidized prices. Requests for low-emission stoves were submitted to the governor's offices of Darkhan and Khentii Aimag. While the Khovd Aimag governor's office does not currently have any plans to distribute stoves, representatives expressed support for the idea.

6.8 Conclusion

The findings of the rapid appraisal in the four cities show that demand for heating stoves in cities outside Ulaanbaatar is structured similarly to demand for stoves in Ulaanbaatar. Consumers in the aimag center markets can be grouped into four market segments linked to dwelling type: households living in gers, households in detached homes with space-heating stoves attached to heat walls, households in detached homes with space-heating stoves but no heat walls, and households in detached homes with LPBs. The relative size of each market segment varies from city to city. Also, as in Ulaanbaatar, the current market for LPBs is small but growing quickly.

[45] To the team's knowledge, only Khovd is actively monitoring air quality. It was unknown whether Bayankhongor and Darkhan are also conducting monitoring. No monitoring is being done in Ondorkhaan.

[46] The team was unable to interview representatives from the Darkhan Aimag governor's office, though the team did speak with the CEO of the local district heating company.

Ger-area households in the four cities are highly knowledgeable of the stove replacement program that has been carried out in Ulaanbaatar and expressed interest in acquiring low-emission stoves. While it was beyond the scope of this study to gauge households' willingness to pay for the new stoves, from interviews and observation of prices in the local markets, it is hypothesized that households in the aimag centers would be willing to pay at least the same price for low-emission stoves as traditional stoves currently being sold in the aimag centers. Because air pollution is reportedly growing worse in the aimag centers visited, local authorities have also expressed interest in subsidizing the sale of low-emission stoves to households as a near-term measure for mitigating pollution. However, total technical potential demand for low-emission stoves in the four cities is estimated to only be about 27,000 stoves.

On the supply side of the equation, it was concluded from the rapid appraisal that stove producers in the four cities are comprised entirely of artisan producers, ranging from individual welders to small workshops that might employ a handful of people. While individual welders reportedly only make 50 to 100 stoves per year, the larger workshops might make 500 to 650 stoves per year. Production is seasonal for most stove-makers. Most also produce other items, such as metal pails, ash boxes, chimneys, or even ger furniture. While it is conceivable that artisan producers could make low-emission stoves if provided training and prototypes to copy, ensuring consistent quality and adherence to emission standards would be difficult. Given the small scale of local markets, production of low-emission stoves might not be profitable, unless the cost of making the new stoves can be reduced and policies are introduced by the cities to phase out traditional stoves.

The rapid appraisal also finds that the aimag center markets are intricately linked to the market for stoves in Ulaanbaatar. In each of the four cities visited, stoves made by local producers must compete with stoves from Ulaanbaatar. Retailers in the aimag centers typically purchase stoves wholesale from Narantuul Market and then re-sell them, or source directly from producers in Ulaanbaatar. While it was beyond the scope of the rapid appraisal to estimate the exact share of locally-made stoves in the aimag center markets versus stoves brought in from Ulaanbaatar, it is hypothesized that the market share for locally-made stoves depends mainly on three factors, namely distance from Ulaanbaatar, the size of the local market, and-related to the second factor-the existence of local manufacturing capacity. The co-dependency of the Ulaanbaatar and aimag markets is further reinforced by the fact that larger-scale stove producers in the aimag centers rely on raw materials sourced from Ulaanbaatar.

Given the connection of the aimag centers to Ulaanbaatar, efforts to replace traditional stoves in Ulaanbaatar may have a direct effect on households outside Ulaanbaatar. The elimination of local production in Ulaanbaatar may drive up prices for stoves in the aimag markets in the short run. Also, because the supply chains for stoves in the aimag centers and Ulaanbaatar are interconnected, it is conceivable that if traditional stove producers in Ulaanbaatar go out of business and existing subsidies for low-emission products are then lifted, stove producers in the aimag centers could potentially fill the demand for cheaper traditional stoves in Ulaanbaatar. This implies that there will always be traditional stoves available to compete with low-emission stoves in Ulaanbaatar and the other cities unless a sustainable, nationwide market for low-emission heating technologies is developed. If a nationwide stove replacement effort is pursued, existing distribution channels may be exploited to distribute low-emission stoves from larger producers or importers in Ulaanbaatar.

CHAPTER 7. CONCLUSIONS AND IMPLICATIONS FOR STOVE REPLACEMENT EFFORTS

The results from the survey among ger area households, the rapid assessment of stove markets outside Ulaanbaatar, and outcomes from a recent stove replacement program can inform future efforts to replace traditional heating stoves in Mongolia.

As shown in this report, the recent stove replacement program reached a very large share of the market in a little more than two years. Nearly 69,000 low-emission stoves were sold at subsidized prices in Bayanzurkh, Chingeltei, Khan-Uul, Sukhbaatar, Songinokhairkhan and Bayangol Districts from June 2011 to June 2012. By the end of November 2012, a total of 97,877 stoves had been sold, bringing adoption rates for low-emission stoves by households in the ger areas to around 55 percent.[47]

Despite this initial success, an even higher share of the market is required if the goal is to reduce ger-area stove emissions to the level needed for meaningful improvements in air quality. According to previous analysis done by the World Bank of the severity and sources of air pollution in Ulaanbaatar, reducing population-weighted exposure to very fine particulate matter ($PM_{2.5}$) by about half from the emergency levels measured from 2008 to 2009 would require an 80 percent reduction in ger stove emissions (see figure 7.1).[48] It is unlikely that stove emissions will have been reduced by a large enough margin already for air quality to be improved by this much, given the observed growth in the number of households and stoves in the ger areas since 2008 and the projected market share for low-emission stoves. An on-going program to replace traditional, polluting stoves will be crucial to ensuring that emissions reductions are deepened. Maintaining these reductions into future years will further require the development of a more robust and sustainable market for low-emission stoves.

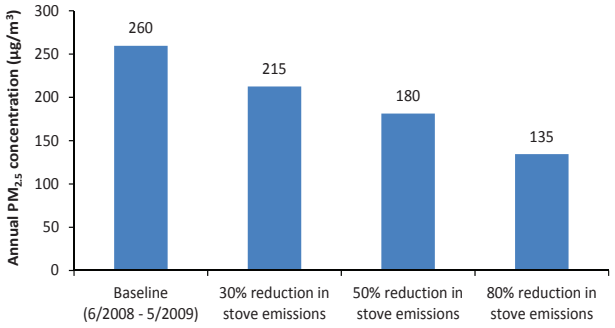
Future stove replacement efforts will need to continue to carry out follow-on market research to monitor changes, and find reasons and solutions for lower adoption rates among some market segments, so that adoption rates can be improved across-the-board. The survey shows that penetration rates for low-emission stoves vary considerably among different segments of the Ulaanbaatar market. While sales data show a 55 percent market share as of December 2012, survey data show adoption rates of specific market segments, such as households living in detached homes with heat walls and low pressure boilers, remain relatively lower than for ger households. The data indicate there is still large potential for increasing the market share of low-emission stoves. Indeed, the survey confirms that about 70 percent of households with traditional stoves are still interested in replacing their existing stoves.

The emerging market for low pressure boilers (LPBs) has not been covered by stove replacement efforts in Ulaanbaatar and also offers an opportunity for intervention.

[47] As a share of the total number of households in the central ger-areas of the six districts as of the end of 2012

[48] At this level, the annual average for population-weighted concentrations of $PM_{2.5}$ would be reduced to around 157μg/m^3, assuming no change in emissions from other sources such as coal-fired power plants and suspended soil and dust compared to 2008/09. These levels are still much higher than Mongolian standards (25μg/m^3) and the most lenient targets set by the World Health Organization for developing countries (35 μg/m^3).

Figure 7.1. Reductions in Population-Weighted Exposure to Air Pollution in Ulaanbaatar Resulting from Lower Ger Stove Emissions



Source: World Bank, Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts, December 2011

Survey data reveal that more households are building bigger homes (or expanding their existing homes) and upgrading their heating systems to LPBs. Since 2007, the proportion of detached homes with LPBs has increased from 16 percent to about 23 percent. The average size of homes with LPBs, meanwhile, has grown from 65 m^2 to around 74 m^2. Households with LPBs burn significantly more coal for heating each winter than other households. LPB users reported using an average of 6.3 tons of raw coal during the winter of 2011/12, compared to 4.7 tons for households living in smaller detached homes without LPBs. Higher coal use by LPB users means more pollution, unless low-emission models are introduced to replace existing LPBs. At the same time, interventions targeted at replacing LPBs will need to follow a different approach than existing stove replacement activities in Ulaanbaatar, because the supply chain for LPB systems is structured much differently than that for traditional ger stoves and the technology is more complicated. Detailed technical requirements for installation, use with existing piping and radiator systems, and proper maintenance will need to be introduced to ensure the proper functioning and safety of low-emission LPBs. Emissions performance of LPBs should be verified with published results of laboratory testing following an appropriate testing protocol.

Future programs will also need to account for the connections between Ulaanbaatar and the aimag center markets. The rapid appraisal of on-the-ground market conditions in four cities, Darkhan, Ondorkhaan, Bayankhongor, and Khovd, revealed that the supply chain for stoves in the aimag centers is closely linked to Ulaanbaatar. Well-established distribution channels exist to move stoves and stove-making materials between Ulaanbaatar and the aimag centers. Intervening in just the Ulaanbaatar market may not be sufficient to totally eliminate supply of traditional stoves, especially once the existing subsidies for low-emission products are lifted. It will be difficult to stop the flow of some low-emission stoves out of the capital into the aimag centers, where households have demonstrated strong interest in acquiring the new stoves. Even if local producers stop making traditional stoves in Ulaanbaatar, it is conceivable that traditional stoves could be supplied to Ulaanbaatar from other markets as households look for replacement stoves. Either way, demand for stoves in Ulaanbaatar and the aimag centers will likely persist.

Recognizing the links between Ulaanbaatar and the aimag centers provides an impetus for stove replacement efforts to be expanded outside the capital city. Two different strategies for a nationwide would be: (i) ensuring that stoves made in the aimag centers comply with new emissions standards by providing assistance to local producers to make low-emission stoves and increasing the size and budget of the inspectorate; or (ii) improving existing distribution channels for low-emission stoves to be supplied to the aimag centers from larger producers or importers in Ulaanbaatar. Because the markets outside Ulaanbaatar are relatively thin (the total technical potential demand for the four cities visited in this study is only around 27,000 stoves), expanding distribution channels may be a more viable strategy than building local production capacity.

The road map first presented in the 2009 World Bank report, describing a market-based approach for introducing new technologies

that can burn fuel (new or old) more cleanly in Ulaanbaatar, remains largely relevant today and offers a framework for understanding good practices and assessing options to address sustainability challenges of the current program. The seven steps of this road map-with new information based on recent findings-are:

- *Estimate the impact of the proposed mitigation measures on the overall air pollution to ensure the government's investment will meet expectations.* The World Bank's Mongolia: Air Quality Analysis of Ulaanbaatar: Improving Air Quality to Reduce Health Impacts (December 2011) estimates that a 30% to 80% emissions reduction from ger area heating can produce a 18% to 48% reduction in population weighted exposure to $PM_{2.5}$. Under the Ulaanbaatar Clean Air Project (UBCAP), the city will start to implement a program that, among other requirements, that proposes to set a maximum of 70 micrograms of $PM_{2.5}$ per net megajoule (MJ) of heat emitted for ger stoves, for access to subsidies. This is about a 90% reduction in emissions compared to traditional stoves (1,000 µg $PM_{2.5}$/net MJ). Technical assistance for air quality analysis in Ulaanbaatar currently provided by the Japan International Cooperation Agency (JICA) and an evaluation of the MCC-funded stove-switching project being conducted by MCC and MCA-Mongolia may provide an updated forecast of impacts of mitigation measures.

- *Develop a testing program for equipment, with a focus on safety and emissions rather than fuel consumption alone, and set interim performance targets that can eventually be accepted, after practical experience is gained, as new standards, following the Mongolian regulatory process.* Mongolia has three main standards (MNS 5216:2002, MNS 5041:2001, MNS 5679:2006) with some updates for stoves, boilers and furnaces, and solid fuels-all of which could be improved. Areas for improvement are summarized in the World Bank's *Mongolia: Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar* (October 2009). Standards and certification mechanisms need to be developed after sufficient practical experience is obtained with testing and product performance in the field. A rush to legal standards may inhibit innovation, or worse, set ineffective or unrealistic parameters. Households can deviate from stove manufacturer's instructions, which affect stove emissions performance. These deviations can happen especially if the stove differs significantly from traditional products. A more pragmatic approach to standards development would divide tasks into building blocks: (i) using stove replacement activities to introduce interim standards, or eligibility criteria, as a starting point for developing standards; (ii) establishing sufficient, and preferably local, laboratory capacity to set initial emissions requirements and measure compliance during program implementation (perhaps, too, establishing links with labs outside Mongolia may help build capacity); (iii) building awareness and understanding of the impacts of various parameters that could be included in the eventual standards and emission requirements by publishing testing reports and explaining results to stove producers, taking into account variations in performance due to possible "misuse" of stoves; and (iv) adjusting protocols and testing interpretations based on feedback from household use (using surveys, observations, repeated lab tests, and field tests of emissions). Monitoring data will provide confidence that the eventual standard is realistic, achieves its objective, and is enforceable in a cost effective manner. However, while field testing is important, it is very difficult to obtain reliable results; field testing results should be interpreted by experienced analysts. Also, all work towards the development of standards, including stove testing and monitoring, should involve the Mongolian Agency for Standardization and Metrology, who will be ultimately responsible for developing and enforcing the eventual standard. Finally, inputs from private stove developers, households, and other stakeholders should also be collected and considered during the standards development process.

In 2011, an Asian Development Bank-financed technical assistance project implemented by the Ministry of Mineral Resources and Energy established a Stove Emissions and Efficiency Testing (SEET) Laboratory, which conducted over eighty tests of various stove models, including some of the Turkish and Chinese-made models that were subsidized by MCA-Mongolia and CAF. Based on this work, Ulaanbaatar City developed eligibility criteria for stoves and producers. These criteria already address some of the deficiencies in the current set of standards, and require that stoves and fuels be tested together for emissions. Although the SEET lab did not receive support after the ADB program was completed and is temporarily dismantled as of the writing of this study, the lab will continue to receive support from the City of Ulaanbaatar through UBCAP, supported by the International Development Association, the concessional assistance arm of the World Bank. MCA-Mongolia conducted field tests but the results are not publicly available. Once available, these testing results will be valuable inputs to understanding variations in emissions between lab and home use.

- *Set an enforcement mechanism to address non-compliant products and manufacturers.* Stove switching eligibility criteria for new stoves and vendors should include warranty requirements and minimum after-sales service standards. (Warranties of two years were provided by low-emission stove vendors that received subsidies from MCA-Mongolia and CAF.) During the warranty periods, participating producers should agree to random spot checks of stoves sold (i.e. random lab testing) and monitoring of their service performance. In addition, they must agree to a penalty system for non-compliance, including permanent exclusion from the program in cases of persistent violations. Further, as local sellers of imported stoves might not be available, a likely need will exist for skilled workmen and the availability of good quality spare parts to service the low-emission stoves. Under UBCAP, technical assistance is available through a new Stove Development Center, which could be a source for training. Partnerships with the imported stove producers are encouraged so that appropriate knowledge is with local service providers after warranties expire. The center can also provide short term technical support for producers encountering design or manufacturing problems.

- *Establish a targeted and well-justified subsidy program to make new systems affordable.* Subsidy arrangements should consider: (i) the end point policy objective of the government, which in this case is reducing air pollution (especially particulate matter) exposure; and (ii) the consumers' willingness to switch to new products. Although a well-designed stove replacement program usually brings large net benefits in reduced health risks and fuel savings, the right amount and types of subsidy will depend on the ability of the market to sustain the transformation to the use of cleaner stoves. Based in part on the available data presented in this report, key principles of an appropriate subsidy program include: (i) the ability of consumers to choose among several stove models, as not only the stove price (which was in fact ranked lower than other positive features of low-emission stoves; see chapter 4), but also by fuel savings and other features; (ii) the payment of subsidies only upon verified installation of the new equipment; (iii) the possibility of rewards for the use of stoves that achieve even larger emission reductions (i.e. considering that the government is willing to subsidize products to achieve public objectives, consumers should be rewarded for using stoves that achieve proportionally better public outcomes); (iv) the use of subsidy levels that reflect the affordability of target households and their willingness to start using another type of stove before the end of their current stove's useful life; and (v) the use of a final consumer's price that is not too low (or free)

to ensure stoves are sold to people who will use and maintain it.

During the winter of 2011-2012, the stove replacement program included subsidies of around 249,800 Tg to 408,450 Tg (equivalent to US$195-319) for low-emission stove models. Subsidy amounts included two separate elements, financed by MCC/MCA-Mongolia and later by CAF. The subsidies reduced the sales price of low-emission stoves to roughly 20-25 percent of the price for traditional ger stoves, not including accessories. The prices of larger low-emission stoves ranged from 30-40 percent of traditional stoves used with fittings for heating walls. The pricing strategy employed by the recent stove replacement program achieved its goal of high and rapid sales rates; however, sustaining such levels of demand without the high subsidy elements is unlikely, leaving sustainability challenges for the next phase of the program.

- *Establish credible supply chains, in partnership with the private sector, and use a "third party" verification system for installation and use of new stoves.* The recently implemented stove replacement program used a clear and credible supply chain, involving product centers in designated khoroo (see chapter 1) to control quality and prevent the sale of "copies" - similar but lower quality versions. XacBank, the main distributor of MCA-Mongolia and CAF-subsidized stoves, is also implementing a Clean Development Mechanism (CDM) project for stove switching. The CDM requires strict monitoring of stove installation and use, following an agreed protocol. It also requires independent validation to verify emissions reductions.

Although sales are an important milestone, the final development outcome is achieved only by the sustained use of the low-emission stoves among area households. Although households sign an agreement promising to use the subsidized stove, low-emission stoves are priced below market prices of traditional stoves, creating an incentive for reselling. Evidence of large-scale reselling does not exist, however, perhaps because people who might buy re-sold stoves expect the subsidies to continue. It is extremely difficult to measure the occurrence of leakage. The study team did, however, identify a few low-emission stoves in the aimag and soum centers, outside the program boundaries of Ulaanbaatar. To further mitigate this risk of low-emission stoves not being used by the purchasing households in Ulaanbaatar, possible mechanism include: (i) verifying installation and training consumers in using the stoves before releasing the subsidy (already applied in the current program); (ii) using site visits to customers during the winter (either by producers or by program staff) to verify stoves are in use, provide supplementary training, and check on customer satisfaction; and, (iii) establishing a transparent reporting protocol linked to regular monitoring, providing information to stakeholders about program developments and possible adjustments needed.

- *Remove old equipment from use.* To achieve sufficiently large and sustained emission reductions, the support for cleaner alternatives must happen in parallel with the removal of polluting heating systems. The July 2012 survey reveals an estimated 212,708 stoves are owned by 164,127 households, of which only 172,055 stoves are in use. The recent stove replacement program required submission of old stoves as part of the sales transaction, but program participants noted that about 7 percent of households received exemptions, and that the stoves that households turned in tended to be in worse condition as the sales season progressed. Stove replacements need to be carefully monitored because households may be tempted to provide unused stoves (or even poor-condition stoves purchased from other households) to meet the requirement. While no fail-safe method exists to ensure honest trade-ins, mitigation measures include the independent verification mechanism discussed above, as well as continued public

awareness campaigns on the health impacts of the pollution caused by the older stoves.

- *Market-based approaches to disseminate cleaner heating systems are preferred over nonmarket-based approaches such as stove giveaways.* Broad consensus seems to exist that artisanal stove manufacturing is not going to have sufficient capacity to design and supply the market with low-emission stoves quickly enough and at a large enough scale to bring down unit costs to parity with traditional stoves. The recent stove replacement program collaborated with foreign producers and Mongolian private sector distributors to achieve very rapid penetration rates. The partnership with the private sector is critical to the success of any market-based program as it provides the professional know-how, customer orientation, and innovation needed to provide good customer services and respond to market demand. There have been reports that major private sector participants are no longer interested in participating, which presents a major risk to the program, especially as it faces challenges to find ways to support a transformed, clean stove market without subsidies. Concerns of the private sector should be effectively addressed in the next phase of the program.

Although the current program already includes and has tested features of market based approaches, gaps remain. The program can be supported by the following policy options:

- Continue the program, including maintaining credible supply chains, verification procedures, and consumer subsidies. A publicly announced timetable to scale down the subsidy could encourage households on the fence to participate; however, curtailing the program too quickly could jeopardize results.
- Publish eligibility criteria for stoves and producers. The current program did not publish eligibility criteria. Consequently, the private sector in Mongolia was only able to participate by selling imported stoves (the only products that were identified as being eligible for subsidies). Publishing criteria and undertaking a transparent and objective evaluation and enforcement processes will be critical to encouraging greater private sector participation.
- Encourage development of technical standards for a wider range of products, including heating walls, low pressure boilers, and combinations with new fuels. This can be done through support of the SEET Laboratory.
- Develop skills and spare parts supply chains for servicing current stoves in partnership with the current import suppliers.

Continue to monitor and evaluate program impacts through household surveys, air quality monitoring, and stakeholder consultations. On the latter, coordination among all stakeholders, donors and government agencies, is a critical factor to ensuring focused and sustainable outcomes.

REFERENCES

ADB. "43177-012: Ulaanbaatar Clean Air, Project Data Sheet." http://www.adb.org/projects/43177-012/details.

Khurelsukh, N. "Clean Air Fund's Plan and Budget Allocation for Air Pollution Reduction Activities." Presentation delivered at Conference for Sustainability of Ulaanbaatar Air Pollution Reduction Activities, Ulaanbaatar, Mongolia, January 29, 2013.

IMF. "Data and Statistics." http://www.imf.org/external/data.htm#data.

Myagmar, R. "Mongolia's Air Pollution Priorities and Work Plan." Presentation delivered at Conference for Sustainability of Ulaanbaatar Air Pollution Reduction Activities, Ulaanbaatar, Mongolia, January 29, 2013.

National Statistical Office of Mongolia. 2010. *Population and Housing Census.* Ulaanbaatar: National Statistical Office of Mongolia.

Ulaanbaatar Statistics Department, http://statis.ub.gov.mn/.

Ulaanbaatar Services Improvement Project II Project Implementation Unit. "Mongolia: Ulaanbaatar Clean Air Project Safeguards Report" (management unit internal report, September 29, 2011).

World Bank and Public-Private Infrastructure Advisory Facility. *Mongolia: Foundation for Sustainable Development: Rethinking Infrastructure Services in Mongolia.* June 2007.

World Bank, *Mongolia – Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar.* ASTAE (Asia Sustainable and Alternative Energy Program) Report, Washington, DC, 2009.

World Bank and Cities Alliances. *Mongolia- Managing Urban Expansion in Mongolia; Best Practices in Scenario-Based Urban Planning.* Washington, DC: World Bank, 2010.

World Bank. "Clean Stove Initiative in the East Asia and Pacific Region." World Bank Concept Note, Washington, DC, 2011.

World Bank. *Mongolia - Air Quality Analysis of Ulaanbaatar; Improving Air Quality to Reduce Health Impacts Vol 1 and 2.* World Bank Sustainable Development Series Discussion Paper, December 2011.

World Bank. *Rapid Assessment of Stove Markets outside Ulaanbaatar – Trip Report.* Internal report for the project. Washington DC: World Bank, 2012.

XacBank. "Market Mechanisms for MCA Energy and Environment Project." Presentation delivered in Ulaanbaatar, Mongolia, March 15, 2010.

ANNEX A: SAMPLING PLAN

Ulaanbaatar is divided into nine districts, or *duureg*. Six of the districts form the central urban area of the capital city, fanning out to the ger areas. Each district is divided into sub-districts, or *khoroo*, of which there are currently 132 in the city. Each *khoroo* is the further divided in micro-districts, or *kheseg*. *Ger* areas are located in all of the nine districts, usually corresponding to lower levels of administrative boundary, the *khoroo*.

The target population of the survey included all households that live in the ger areas of the central six districts of Ulaanbaatar. These districts are Khan-Uul, Bayanzurkh, Bayangol, Sukhbaatar, Chingeltei and Songinokhairkhan. Khoroo located outside Ulaanbaatar city were excluded from the sample frame, including Khoroo 12 and 13 in Khan-Uul, Khoroo 20 in Bayanzurkh, and Khoroo 21 in Songinokhairkhan. Based on the Ulaanbaatar Statistics Department, 164,127 households (in the highlighted columns) were living in the simple separate houses and gers in the surveyed areas of Ulaanbaatar City as of December 2011 (see table A.1).

Table A.1. Total Number of Households (HH) and Population of Selected Districts and Living in Ger Area at the End of 2011

Districts	Total HHs	Total Population	Ger area/ improved separate houses		Ger area/simple separate houses		Ger area/ger	
			Number of HHs	Population	Number of HHs	Population	Number of HHs	Population
Khan-Uul*	28 602	110 087	110	490	10 296	40 554	5 506	21 890
Bayanzurkh*	71 029	276 933	517	1 933	22 310	87 510	22 773	88 469
Bayangol	48 596	192 111	157	732	6 333	25 969	5 522	21 421
Sukhbaatar	36 343	137 834	187	795	11 810	43 900	8 042	32 905
Chingeltei	36 856	153 117	393	1 628	18 497	82 072	10 142	39 503
Songino-khairkhan*	60 989	251 097	413	1 590	21 852	91 137	21 044	89 774
Total	**282 415**	**1 121 179**	**1 777**	**7 168**	**91 098**	**371 142**	**73 029**	**293 962**

Source: Ulaanbaatar Statistics Department, http://statis.ub.gov.mn/
Note: * Excluding *khoroo* outside of Ulaanbaatar city.

An area-based sampling frame was constructed using satellite imagery of the central ger areas of Ulaanbaatar. Khoroo in the frame were partitioned into smaller grids of 100m^2, each of which typically contained one to three households. Grid cells with more than one household were assigned unique numbers. Individual grid cells were then randomly selected from a list. The area-based method was chosen due to a lack of reliable street addresses and household registries in parts of the ger areas. Surveys were completed for a total of 1,000 households.