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Preliminary Market Assessment for Heat-Only Boilers in Mongolia

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Section 1

Report Summary

Background

The United States Agency for International Development (USAID) has sponsored this preliminary assessment of the current market for heat-only boilers (HOBs) in the Republic of Mongolia and the likely development of that market over a 10-year timeframe. The output from this study is to support the World Bank (WB) in its planned concept note to be submitted to the Global Environment Facility (GEF) for a HOB project to increase efficiency and reduce cost of improvements through market transformation in Mongolia. Nexant Inc. was selected by USAID to conduct this assessment and present findings by December 17, 2004.

Mongolian HOB Market Profile

For the purposes of this market assessment, HOBs are defined as those individual boilers delivering steam or hot water at a specified pressure and temperature and having thermal equivalent capacity (size) in the range of 100kW to 30MW. The total installed HOB capacity in Mongolia is estimated at 1,514 MW, predominantly fired with solid fuel, with coal[1] representing over 85%. The liquid and gaseous fuel use for heating is dwarfed by coal and biomass[2] use. Over 95% are installed in public properties, state or municipal, and less than 5% are privately owned. All HOBs are used for heating and there is no data available to break installed units into segments by user groups (commercial, residential or social). While the range of energy efficient HOBs available in the world market is wide, choices are limited in Mongolia.

Existing HOB Stock

Over 73% of the HOBs currently in use are of low-pressure hot water type, and the going trend is to continue converting steam boilers into hot water boilers. Over 95% of HOB are currently used for general heating and domestic hot water applications, and can be segmented by size as follow:

- **100kW to 500kW** range – used in schools, small administrative buildings, small hospitals, health centres, small office buildings and residential buildings (up to 200 flats),
- **500kW and 3MW** range – used in larger administrative buildings, large hospitals, and small communal heating schemes, and
- **3kMW to 30MW** range – used for medium size and larger district heating networks.

Preliminary market intelligence suggest that there are 1,671 HOB units in use of low-pressure hot water in the 100k-3MW range, or 98% of the total installed units and 52% of the total installed capacity. Over 80% are manufactured in Mongolia and operate with low efficiency - around 40% - and tend to have short service life between 5 to 10 years.

[1] Predominantly lignite coal, which is the lowest rank of coal, often referred to as brown coal with high inherent moisture content, sometimes as high as 45 percent. The heat content of lignite ranges from 10 to 20 MJ/kg on a moist, mineral-matter-free basis. Lignite coal makes up to 85% of solid fuel fired in HOB in Mongolia. See Mongolian coal characteristics are shown in Appendix 1.

[2] Local wood, with varying characteristics, which makes of up to 15% of solid fuel fired in HOB in Mongolia

The 3MW–30MW segment is dominated by Russian-made models, designed for steam generation, some already converted into hot water. Their service life ranges from 15 to 25 years, and operate at efficiencies of around 60%.

The combustion systems of HOBs in use are very basic and of lower quality compared to those fitted to HOBs in the USA and the EU. Raw coal, burnt on low quality combustion grates, is a combination, which results in poor boiler efficiencies, often as low as 25%. Even on relatively well-operated and maintained Russian HOBs combustion efficiencies are typically not higher than 75%. Most of the installed ancillary equipment is antiquated and in poor operating condition. Energy efficient pumps, fans, VSD and combustors are not available.

Environmental Regulations

Although, legislation and regulations affecting the HOB market exist, very little reduction in pollution levels has been achieved in urban areas. In fact, air pollution has been increasing, and alarmingly high levels of PM10/dust have been tolerated (Table 1.1).

Table 1.1 Annual Air Pollution Levels in Ulaanbaatar[1]

	1999 (μg/m3)	2000 (μg/m3)	2001 (μg/m3)	2002 (μg/m3)	Mongolia Standard (μg/m3)	WHO Standard (μg/m3)	EU Standard (μg/m3)
Sulphur Dioxide (SO2)	7	7	10	11		50	20
Nitrogen Oxide (NO2)	23	29	28	30		40	40
Dust (PM10)	126	141	163	162		-	30

Economics of HOBs

The incremental costs of energy efficient HOBs over conventional alternatives are significant, and usually present a disincentive to facility owners despite the favorable life-cycle economics of the replacement. At present, the initial investment needs are a key factor in shaping the market potential, despite quality and performance gains.

Examples of typical HOB retrofit projects indicated that investments in the mid range of HOBs (600 KW) would be recovered in approximately 2-3.5 years depending on the type of the installed system. In larger systems however, where the HOB size is around 6 MW, the simple payback period stretches to a 5 to 9-year range. Both Mongolian and imported brands exist in both size categories, and despite the increase in first cost for the imported units, their longer service life is notably higher than their Mongolian counterparts, thus increasing the life-cycle savings by ten fold in the medium range boilers, and by approximately 50% in the larger systems. The economics of both examples are shown in Table 1.2.

[1] Source: Mongolian Statistical Yearbook, 2003 and EU Environmental Standards

Table 1.2 Preliminary Costs and Benefits for HOB Upgrades

Key Assumptions / Parameters For 600 KW HOB	600 KW HOB in use	New HOB Mongolia	New HOB Czech Republic	New HOB Austria
Thermal Energy Efficiency (%):	45	55%	75%	85%
HOB cost (US$/kW):	-	10	34	68
Total Installed Cost (US$)[1]:	0	16,000	30,400	50,800
Annual Cost Savings (US$):	0	4,656	13,728	16,144
Simple Payback (year):	0	3.5	2	3
Average service life (year)	0	6	10	12
Simple life cycle savings (US$):		11,640	109,824	145,296

Key Assumptions /Parameters For 6 MW HOB	6 MW HOB in use	New HOB Mongolia	New HOB Russia	New HOB UK
Thermal Energy Efficiency (%):	65%	85%	85%	85%
HOB cost (US$/kW):	-	45	25	60
Total Installed Cost (US$)[2]:	0	390,000	270,400	480,000
Annual Cost Savings (US$):	0	55,881	55,881	55,881
Simple Payback (year):	0	7	5	9
Average service life (year)	0	15	15	20
Simple life cycle savings (US$):		447,000	558,800	614,700

Market Potential

Preliminary estimates for the future market for energy efficiency HOBs to 2014 were based upon current market conditions and trends, and on the forward plans of the Government of Mongolia for the energy sector. It is anticipated that the following are good candidates for refurbishment or replacement over the next ten years:

- HOBs in the 100kW-3MW range that are older than 7 years, with overall efficiency below 60% and located within 300 km from the fuel source, and
- HOBs in over 3MW range that are older than 20 years, with overall efficiency below 65% and within 300 km from the fuel source.

The annual HOB market potential for the 100kW-3MW segment is estimated at 250 to 350 units with an average size of 600kW, totaling around 150MW to 210MW of new or rehabilitated capacity. In the 3–30MW HOB segment, the annual demand is estimated to range from 2 to 15 units of average size around 6MW resulting on a total of 12-90MW.

Projected Savings

If the market potential listed above is achieved, the attributed energy savings in the 600 KW category ranges from 58,200t to 150,600t of lignite coal, corresponding to 77,988t to 201,804t of

[1] Additional cost for ancillary equipment, HOB transportation and installation are US$10,000.
[2] Additional cost for ancillary equipment, HOB transportation and installation are US$120,000.

CO_2 abatement. In the larger size units, the estimated annual savings are approximately 39,000t of lignite coal, and 52,000t of CO_2 abated per year.

Market Barriers

Despite an increasing emphasis on overall energy efficiency and concerns over air pollution in urban areas in Mongolia, a number of barriers stand in the way of realizing the benefits inherent in implementing energy efficient HOBs on a wide scale. These are:

- Limited access to capital investment and stimulating financing mechanisms lead to a focus on upfront capital consideration versus life-cycle benefits.
- Combustion characteristics of local fuels hamper the penetration of western more efficient HOBs.
- Lack of information and experience with energy efficient HOBs, thus the uncertainty in the ability of these HOBs to meet cost and performance targets.
- Availability and costs of fuel prevent the deployment of modern oil and gas-fired HOB.
- Unreliable coal distribution networks are a challenge for imported coal-fired HOBs.
- Permitting procedures can stretch to up to 24 months, creating a disincentive.
- Current environmental legislations do not provide credit to efficient HOB projects.

Conclusions / Recommendations

As a result of this market assessment, the following recommendations for future activities are proposed to overcome the existing barriers and to enable market transformation:

- Developing financial solutions for HOB upgrade projects.
- Preparing feasibility assessment of fuel preparation (Washing) and Grading facilities at source to reduce fuel transportation cost and improve combustion efficiency of HOBs.
- Improve the capacity of the energy/boiler service industry.
- Assessing the feasibility of using Ground-Source Heat Pump heating systems and renewable energy for urban areas not near solid fuel sources.
- Conducting an assessment of HOBs and diesel generators conversion into combined heat and power plants.

Section 2
Introduction

2.1 BACKGROUND AND OBJECTIVES

The United States Agency for International Development (USAID) has sponsored this preliminary assessment of the current market for heat-only boilers (HOBs) in the Republic of Mongolia and the likely development of that market over a 10-year timeframe. The primary goal of this assessment is to assist the World Bank (WB) in its planned concept note to be submitted to the Global Environment Facility (GEF) for a HOB project to increase efficiency and reduce cost of improvements through market transformation in Mongolia. The output of this market assessment should assist the WB in the preparation of the concept note.

To meet the above-mentioned objectives, the focus of this report was on assessing the current status of HOB market in Mongolia, and on determining the potential for wide-scale adoption of energy efficient HOB systems throughout the country. Included in this assessment is also an identification of key legislation and regulations that influence the current market and its future development.

Market potential was evaluated based on existing information on current use of HOB, available fuels and their cost, projected demand for heat, and availability and economic viability of energy efficient HOB technologies. Other HOB market related data were collected from existing documents and from additional research conducted to uncover new information from potential international and local suppliers of energy efficient HOBs and from other institutions.

2.2 MARKET ASSESSMENT METHODOLOGY

The project team relied primarily on existing secondary data to estimate the current and potential market for HOBs within Mongolia. No specific data collection instruments have been developed, and no surveys with utility representatives, municipalities, agencies and other owners and operators of HOB have been undertaken.

The specific issues that the project team addressed through analysis of existing information and limited data collected from manufacturers and dealers of energy efficient HOBs during this effort included:

- Review of current government standards, regulations and norms affecting HOBs (design, engineering, construction, operation and maintenance) and any other legislation and regulations involving environmental protection and boiler efficiency,
- Review of installed HOBs by age, size, type (determined by heating medium and fuel) and owners (public/private and commercial/residential/social) and typical associated fuel use,
- Review of related information for ancillary equipment (combustion systems, fans, insulation, heat-recovery equipment, pumps, VSDs, water treatment plants, steam traps, controls and instrumentation, piping),

- Review of energy efficient HOB technologies and ancillary equipment relevant to Mongolia,
- Review of available financing options to private and public sector clients from vendors, ESCOs, and local financial institutions,
- Assessment of existing market barriers (technological, institutional/regulatory, financial) that hinder the introduction of energy efficient HOB technology in Mongolia, and identification of opportunities to address these barriers,
- Quantification of preliminary estimates of investment costs and paybacks, energy savings and GHG reduction levels from the deployment of more efficient HOBs.

2.3 DEFINITION OF HEAT-ONLY BOILER

For the purposes of this market assessment, HOBs are defined as any individual boilers delivering steam or hot water at a specified pressure and temperature and having thermal equivalent capacity (size) in the range of 100kW to 30MW.

While the market potential for small HOBs[1] as a substitute for stoves and other domestic heating devices has not been assessed in the context of this report, a reference to small HOB technology is included in Section 4 describing the energy efficient HOB technologies.

[1] HOBs with thermal equivalent capacity of less than 100 kW.

Section 3

Heat-Only Boiler Market Review

3.1 LEGISLATIVE AND REGULATORY ENVIRONMENT

The following preliminary review of legislative and regulatory environment that is affecting the HOB sector in the Republic of Mongolia has been undertaken to support the overall market assessment.

Standards[1], specifying minimum efficiency and performance requirements for low-pressure hot water HOBs and ancillary equipment, were adopted in 2001. Fairly stringent design, operation and certification regulations for high-pressure HOBs, specifying construction quality and pressure integrity requirements were passed in 1996. Mongolian building regulations also include requirements for minimum insulation levels for residential, commercial and office buildings.

No specific standards for fuels have been identified. The lack of these standards is a major prerequisite for poor performance of HOBs, and sets a problem for energy efficient HOBs to operate in compliance with the minimum efficiency and performance standards. If standards for solid fuels, modeled on international fuel standards, are introduced and were to be strictly enforced in Mongolia, local solid fuel suppliers would be required to provide fuels with constant characteristics. The availability of standard fuel with constant characteristics is a key precondition for reaping the benefits of modern HOB technology and its faster penetration.

New energy and environmental laws and regulations have been recently passed in Mongolia. The Clean Air Act, adopted in 1995, mandates the Government of Mongolia to undertake regular air quality monitoring and provide information to concerned organizations and the public. The Act regulates the emission of air pollution from any source, including power plants, factories, cars, trucks, households, or anything that releases pollutants into the air. The Act also requires polluters to apply for permits that includes conditions on which pollutants are being released, how much may be released, and what kinds of steps the source's owner or operator is taking to reduce pollution. The Mongolian Ministry of Nature and Environment has the enforcement powers and is allowed to penalize those who are violating the Clean Air Act.

Surveys on air pollution, that were undertaken by the Mongolian Ministry of Nature and Environment, suggest that air pollution poses a significant environmental problem in urban areas of Mongolia, and Ulaanbaatar in particular, where dispersion of air pollution is exacerbated due to a number of unfavorable geographical and climatic factors. The energy sector contributes over 60% of the air pollution in Mongolia, with heating representing a large share. Air pollution enormously affects air quality in all urban areas and has a strong negative impact on human health. In Ulaanbaatar alone, over 400,000 tons of local lignite coal is used by HOB, and another 200,000 tons are burnt by heating stoves in Gers and wooden houses. In addition to coal, more than 160,000 cubic meters of fuel wood is used each year. On some very cold days, the emission levels may exceed legal limits by four times.

[1]Mongolian Standards for hot water low pressure HOBs include: MNS 5041:2001, MNS 5043:2001, MNS 5045:2001, MNS 5085:2001, MNS 5086:2001, MNS 5087:2001.

Although, environmental legislations have been passed to curtail air pollution and a number of programs initiated in this direction, very little reduction in pollution levels has been achieved in urban areas. In fact, air pollution has been on the increase, and alarmingly high levels of PM10 (dust) have been tolerated, as shown in Table 3.1 below.

Table 3.1 Annual Air Pollution Levels in Ulaanbaatar[1]

	1999 (µg/m3)	2000 (µg/m3)	2001 (µg/m3)	2002 (µg/m3)	Mongolia Standard (µg/m3)	WHO Standard (µg/m3)	EU Standard (µg/m3)
Sulphur Dioxide (SO2)	7	7	10	11		50	20
Nitrogen Oxide (NO2)	23	29	28	30		40	40
Dust (PM10)	126	141	163	162		-	30

A preliminary research indicates that HOBs in smaller cities and villages in Mongolia come under Local Authority Regulation, which do not contain any emission limits.

To achieve compliance with emission regulations in the short term, a great effort should be made to reduce air pollution. In the process of more rigorous enforcement of the environmental legislation in Mongolia, it is expected that a greater emphasis will be placed on ensuring adequate HOB efficiency and emission control.

It is expected that over the next ten years, the environmental regulations will be applied most vigorously in more densely populated urban areas such as Ulaanbaatar, and as the country becomes more affluent, new legislation will drive the need for improved coal quality, thus improving coal burning technology countrywide.

3.2 CURRENT OVERALL MARKET

The size of the current market for HOB was estimated on the basis of total installed capacity and number of units in Mongolia.

3.2.1 Heat-Only Boilers

A better understanding of market segments and trends of the Mongolian market for HOBs is achieved through analyzing the current use of HOBs by size, type (heating medium and fuel), capacity ranges, age, origin of manufacturer, and end-user location.

Tables 3.2 and 3.3 below provide specific information about the market for HOBs and its segments as of 2002[2]. Only limited historic data has been identified to analyze past trends of the market. Some patchy information for 2003 and 2004 has been reviewed which indicate that the current market size should not be significantly different from the 2002 data.

[1] Source: Mongolian Statistical Yearbook, 2003 and EU Environmental Standards
[2] Source: Survey of HOB in use in Mongolia, Dr. Jargal Dorjpurev, 2002

Table 3.2 shows the current overall market size for HOBs in Mongolia in terms of capacity by type and fuel. Mongolia is currently very dependent on coal[1], representing over 85% of all solid fuel used for firing HOB. Solid fuel is transported to HOB by rail or road. Very little liquid and gaseous fuels have been burned. Table 3.2 indicates that liquid and gaseous fuel use for heating is dwarfed by coal and biomass[2] use. Over 73% of the HOBs in use are of low-pressure hot water type, and the going trend is to continue converting steam boilers into hot water boilers.

Table 3.2 HOB Installed Capacity in Mongolia by Type and Fuel

Year	Capacity of HOB in use	Solid Fuel (Coal & Biomass)	Liquid Fuel (Heating Oil)	TOTAL (MW)	Market Share (%)
2002	Steam HOB, (MW)	410	-	410	27 %
	Hot Water HOB, (MW)	1,103	1	1,104	73 %
	TOTAL (MW):	1,513	1	1,514	

Over 95% of HOBs are currently used for general heating and domestic hot water applications. They can be segmented by HOB size as follow:

- **100kW to 500kW** unit range - comprising of heating applications in schools, small administrative buildings, small hospitals, health centres, small office buildings and residential buildings of up to 200 flats,
- **500kW and 3MW** unit range - supplying heat to larger administrative buildings, larger hospitals, and small communal heating schemes, and
- **3kMW to 30MW** unit range –generating heat for medium size and larger district heating networks.

Table 3.3 shows the distribution of HOB by market segment in terms of unit size.

Table 3.3 HOB Current Market Size by Installed Capacity[3]

Year	Capacity of HOB technology in use	HOB Market Segment			
		100-500 kW	500kW – 3MW	3– 30 MW	TOTAL (MW)
2002	Steam HOB, (MW)	-	-	410	410
	Hot Water HOB, (MW)	469	315	320	1104
	TOTAL (MW):	469	315	730	1514
	Market share by segment:	31%	21%	48%	

[1] Predominantly lignite coal, which is the lowest rank of coal, often referred to as brown coal with high inherent moisture content, sometimes as high as 45 percent. The heat content of lignite ranges from 10 to 20 MJ/kg on a moist, mineral-matter-free basis. Lignite coal makes up to 85% of solid fuel fired in HOB in Mongolia. See Mongolian coal characteristics are shown in Appendix 1.

[2] Predominantly local wood, which makes of up to 15% of solid fuel fired in HOB in Mongolia

[3] Source: Survey of HOB in use in Mongolia, Dr. Jargal Dorjpurev, 2002

Table 3.4 shows the distribution of HOB by market segment in terms of number of units.

Table 3.4 HOB Current Market by Number of Installed Units[1]

Year	Capacity of HOB technology in use	HOB Market Segment			Total Market (number)
		100-500 kW	500kW – 3MW	3–30 MW	
2002	Steam HOB, (number)	-	-	25	25
	Hot Water HOB, (number)	1061	610	17	1688
	Total (number):	1061	610	42	1713
	Market share by number of units:	62%	36%	2%	

In Mongolia, there are 1671 units of low-pressure hot water HOB in use with unit size falling in the 100k-3MW range, or 98% of the total installed HOB units or over 52% of the total installed capacity, respectively a total of 784 MW. All HOBs in this range are designed for operation at, or near to, atmospheric pressure and so not requiring adherence to strict constructional and safety codes.

The 'classic' solid fuel fired HOB technology, going back centuries, is commonly seen throughout Mongolia in over 100 variations on the same theme. Typically, this is a vertical design HOB, fired by manually charging solid fuel, usually coal, onto a static grate located near the base of the boiler and manually extracting ash from the chamber beneath. The heating medium (water) is heated to near boiling temperature and is circulated by a pump in one or two separate circuits for domestic hot water and for space heating.

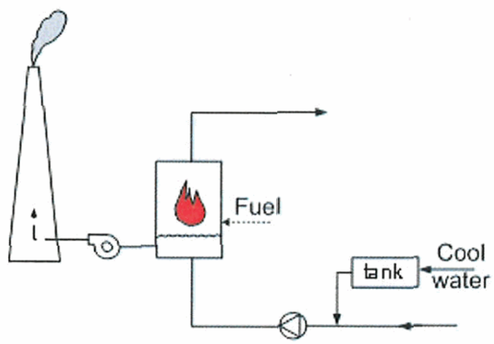
Usually, these HOBs are fired on raw coal, i.e. coal straight from the nearest coal mine, with no prior preparation such as grading, washing or other, and usually have no ancillary equipment fitted to control emissions. This is a very basic and simple HOB technology with low to average energy efficiency in the 30%–65% efficiency range.

The level of efficiency depends primarily on the HOB thermal integrity, combustion chamber size, number of flue-gas passes and overall boiler condition. Over 80%, of the low pressure HOB in use, in the 100k–3MW range, are manufactured in Mongolia, with the rest come from China and a small number from the Czech Republic, Korea, Russia. The most widely used are the following Mongolian made models: HP-18-27, HP-18-54, BZUI-100, and DTH 0.7. Also very common are Chinese made RGL, GLSS8, GLSC, CN and JGR.

[1] Source: Survey of HOB in use in Mongolia, 2002, Dr. Jargal Dorjpurev

A schematic diagram of a typical low pressure HOB installation in use in Mongolia is shown in Figure 3.1 overleaf.

Figure 3.1 Schematic Diagram of Low Pressure Hot Water HOB Installation

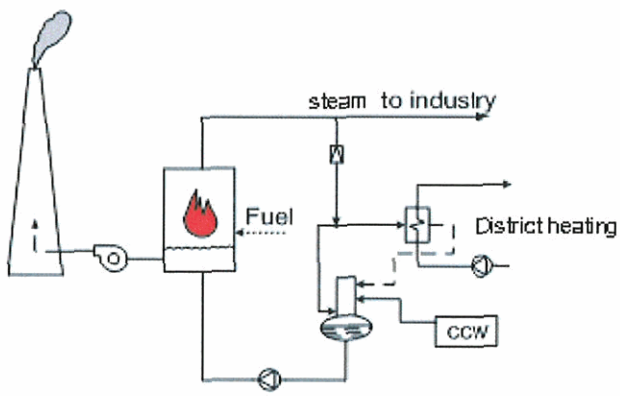


The market segment of HOB in the range of 3–30MW is dominated by Russian-made models, with most commonly used are HOB type KE 25-14, KE 20-14, KBTC 20-10, designed for steam generation. However, Mongolian engineers have already converted some of these into hot water boilers. Most of HOBs in this segment are of water-tube design with forced circulation coupled with traditional chain grate and traveling bar combustion technology. Seven Russian HOB have been remodeled to use bubbling fluidized bed combustion.

No advanced "western" foreign technology is currently in use in Mongolia due to higher capital costs. As it is the case in most developing countries, the Mongolian HOB market conditions indicate that initial cost considerations take a higher priority over quality and performance gains.

A schematic diagram of a typical low-pressure steam HOB installation in use in Mongolia is shown in Figure 3.2.

Figure 3.2 Schematic Diagram of Low Pressure Steam HOB Installation



Larger size HOBs, in the range 3–30MW, tend to have longer service life, usually between 15 and 25 years, due to better operation and maintenance. HOB in the 100kW–3MW range are less durable with an average life of 5-10 years. Poor design and construction of locally manufactured HOBs is the primary cause for their short service life. The number of HOB units in use in the 100kW-3MW segment is listed by age and urban area in Table 3.5.

Table 3.5 Hot Water HOB 100k-3MW Segment by Age and Urban Area[1]

Urban Area	Number of HOB units in use by age (100kW-3MW market segment)			
	< 7 years	7 – 14 years	> 14 years	Total
Arkhangai	51	5	23	79
Bayan-Ulgii	41	0	1	42
Bayanhongor	30	4	4	38
Bulgan	71	17	2	90
Govi-Altai	49	15	0	64
Govisumber	13	2	0	15
Darkhan –Uul	15	3	4	20
Dornogovi	86	0	0	86
Dornod	30	30	4	64
Dundgovi	85	13	25	123
Zavkhan	17	19	1	37
Uvurhangai	69	3	7	79
Umnugovi	64	0	14	78
Sukhbaatar	45	2	31	78
Selenge	60	19	18	97
Tuv	91	12	14	117
Uvs	43	12	18	73
Hovd	68	10	6	84
Huvsugul	105	0	10	115
Hentii	90	20	2	112
Ulaanbaatar	74	16	91	181
Total:	1196	202	273	1671

Table 3.6 illustrates the average energy efficiency of existing HOB by market segment. Larger size boilers tend to be more efficient. Many hot water HOBs fail to comply with the environmental regulations of Mongolia.

Table 3.6 HOB Average Energy Efficiency by Market Segment[2]

Year	Capacity of HOB technology in use	HOB Market Segment			
		< 100 kW	100-500 kW	500kW – 3MW	3 – 30 MW
2002	Steam HOB, (energy efficiency, %)	-	-		50-65
	Hot Water HOB, (energy efficiency, %)	20-45	35-50	45-65	55-65

[1] Source: Survey of HOB in use in Mongolia, Dr. Jargal Dorjpurev, 2002
[2] Source: Survey of HOB in use in Mongolia, Dr. Jargal Dorjpurev, 2002

Over 95% of the HOBs in use in Mongolia are in public properties, state or municipal, and less than 5% are privately owned. There are no data available to break the existing HOBs into segments by user groups (commercial, residential or social).

3.2.2 Ancillary Equipment for Heat-Only Boilers

The combustion systems of existing HOBs in Mongolia are very basic and of lower quality compared to those fitted to HOBs in the USA and the EU. Although the boilers themselves are often constructed to an efficient specification, the ancillary equipment, in particular the combustion grates, suffer from unacceptably low efficiency. Raw coal, burnt on low quality combustion grates, is a combination, which results in poor boiler efficiencies (as low as 25%).

Even on relatively well operated and maintained Russian made larger HOB fitted with chain/traveling grate coal-burning systems, combustion efficiencies are typically not higher than 75% and total HOB efficiencies never exceed 60%-65%.

Smaller HOB, fitted with static grate combustors, are reported to have boiler efficiencies often below 50%. The Mongolian national stock of 1,713 units of HOBs wastes significant amounts of coal by having combustion efficiencies of 15–45% lower than their western counterparts. Thus, improving combustion efficiency would lead to improved total boiler energy efficiency and much lower pollution resulting from improved fuel burning, unnecessary mining and coal transportation.

Most HOB systems currently in use in Mongolia are fairly simple and manually operated with very little instrumentation and controls. Most of the ancillary equipment in use is antiquated and in poor condition. Energy efficient pumps, fans, VSD and combustors are not available. Russian boilers are usually fitted with Russian made economizers, however, often not well maintained with heat transfer surfaces fouled with fly ash and condensation, hence lower boiler efficiency and also need for higher pressure forced draught (air) and induced draught (flue gas) fans, which means more powerful fan motors and higher electricity use.

3.3 PROJECTED OVERALL FUTURE MARKET

The preliminary estimates of overall future market for HOBs to 2014 are based upon current market conditions and trends as outlined earlier in this section and the forward plans of the Government of Mongolia for the energy sector (presented in the Energy Sector Development Strategy for Mongolia - developed and adopted by the Government in 2002[1]).

It is expected that over the next ten years, the environmental regulations will be applied more vigorously in urban areas and as the country becomes more affluent new legislation will drive the need for improved coal quality and consequently improved coal burning technology. These requirements will mean that price of HOB solutions can no longer be the sole issue for consideration by HOB owners when purchasing HOB technology and selecting their fuel

[1] A key principle in the strategy is "to promote energy efficiency, consumer choice and environmental sustainability through improved energy use through taking advantage of new technologies and sources of energy".

suppliers, and very likely in this process greater preference will be given to more energy efficient and less polluting HOB technology.

Most HOBs currently serve commercial, public and residential buildings via distribution networks with enormous heat losses, supplying heat with no independent heat control, encouraging heat waste. Demand-side management improvement programs for heating networks are identified as a priority for Mongolia in the Energy Sector Development Strategy, and it is anticipated that actions in this direction will be taken in the near-term, hence reducing the demand for heat from HOBs.

If the implementation of comprehensive DSM programs and other cost-effective alternatives, such as HOB conversions into Combined Heat and Power plants, proceed on a large scale over the next ten years, market growth for HOB will be limited.

Based on our preliminary estimates for current market size and the key market drivers reviewed above, it is anticipated that the following are good candidates for refurbishment or replacement over the next ten years:

- HOBs in the 100kW-3MW range that are older than 7 years, with overall efficiency below 60% and located within 300 km from the fuel source, and
- HOBs in over 3MW range that are older than 20 years, with overall efficiency below 65% and located within 300 km from the fuel source.

This translates into an annual market potential for the 100kW-3MW segment ranging from 250 to 350 units with an average size of 600kW, totaling 150MW to 210MW of new or rehabilitated capacity.

In the 3-30MW segment, the annual demand is estimated to range from 2 to 15 units of average size around 6MW resulting in a total of 12MW to 90MW.

At present, the price of the HOB technology is a key factor in shaping the market potential, despite quality and performance gains.

Section 4
Energy Efficient Heat-Only Boiler Market Intelligence

4.1 ENERGY EFFICIENT BOILER TECHNOLOGIES

This section provides a review of some of the latest energy efficient HOB technologies that merit further consideration and support for introduction to the Mongolian market over the next ten years. As identified in Section 3 of this report, solid fuels are predominantly used for firing HOB, and are expected to sustain for the next ten years, providing strong justification to focus this review on solid fuel-fired HOBs only.

Most of the modern HOBs, that are manufactured in developed countries or under license in less developed countries, are not only energy efficient but also are designed to comply with stringent environmental regulations on the emission and particulates from solid fuel firing. Although efficiency and environmental technological improvements of modern solid fuel fired HOBs have been achieved, it should be noted that the efficient and environmentally acceptable use of solid fuel can only be realized by a thorough appreciation of the inherent capabilities of the HOB, its firing system, the characteristics of available solid fuels and the demand-side requirements of the system to which HOBs serve. This combination of skills and knowledge are paramount for achieving the highest level of energy efficiency in each particular application and successful utilization of solid fuels by HOBs in Mongolia.

4.1.1 Technology Definition

Most modern HOB technologies provide such flexibility that combustion systems could be either integrated into the boiler design and construction or fitted as separate units and therefore, both HOB types and matching combustion systems are featured in this review. HOB technologies that require more sophisticated solid fuel preparation such as small-scale pulverized fuel or multi-fuel firing HOB are excluded from the review. The high costs of on-site fuel preparation makes them economically unattractive at present, and most likely over the next ten years.

4.1.1.1 Small Energy Efficient HOB Technology (rated output less than 100kW)

Smaller freestanding independent energy efficient HOB[1] (with overall efficiency of over 75%) are designed to provide domestic hot water and enough central heating for a small house or cottage, while larger models could provide domestic hot water and central heating for very small administrative or commercial buildings. Solid fuel HOBs provide all domestic hot water needs and heat for the radiators in the building. The system may be also run from an open coal fire with a back boiler, a room-heater, or a multi-fuel stove. Controlling the heat output of modern solid fuel appliances is easy and, once set, they may be left unattended for long periods to guarantee energy efficient operation of the system and low level of emissions. There are two main types of small energy efficient HOB, gravity feed and batch feed, available in a wide range of outputs (predominantly from 5-100kW):

[1] The energy efficiency improvement of urban stoves is a priority for the Government of Mongolia in its Strategy to increase the efficient use of energy and reduce greenhouse gas emission and air pollutions. A number of household stove improvement initiatives are already underway.

- **Gravity feed boilers** incorporate a large hopper above the firebox, which can hold, depending on demand, several days supply of small sized solid fuel. The fuel descends on to the fire, fed as required, and an inbuilt thermostatically controlled fan assists combustion, providing a quick response to demand. To achieve high efficiency and environmentally acceptable operation, solid fuel should comply with boiler design requirements. Efficiency of up to 85% is achievable but may not be sustained if the HOB is fired with poor quality fuel.
- **Batch feed boilers** are manual ('hand fired') and therefore require more frequent refuelling than the gravity feed boilers. A batch feed boiler can however be less expensive and, in some installations, will operate without an electrical supply, so continuing to provide hot water and central heating during a power failure. This type of boiler is less susceptible to solid fuel specifications and efficiency levels typically achieved are in the range of 65-75%.

4.1.1.2 Energy Efficient HOB Technology (rated output from 100kW to 30MW)

The range of equipment available for coal and other solid fuel firing is wide and varied. For this reason, it was appropriate to review HOB technologies in terms of boiler size, heating medium (steam or hot water), and boiler design which usually dictate the firing method that can be used.

As identified in the HOB market review in Section 3, the existing HOB in Mongolia are being used for general heating and domestic hot water for the following applications:

- Heating applications in schools, small administrative buildings, small hospitals, health centres, small office buildings and residential buildings of up to 200 flats that would typically require HOBs in the range of **100kW to 500kW**,
- Larger administrative buildings, larger hospitals, and small communal heating schemes that are supplied by HOBs in the range between **500kW and 3MW**,
- Medium size and larger district heating networks that are connected to HOBs with rated output from **3kMW to 30MW**.

The market sector for energy efficiency HOB in the range of 100kW-3MW predominantly utilizes technologies that are based on low-pressure hot water as heat distribution medium. There are three generic boiler designs used extensively within this market in the developed countries: 1) magazine boilers, 2) sectional boilers, and 3) welded steel 'horseshoe' boilers equipped with different coal-fired combustion systems.

The specific combination of boiler design with combustion system depends on many different factors, including fuel specification, boiler house location, and operating regimes. In our expert opinion, a major constraint to wide-scale deployment of energy efficient HOBs in the range of 100kW-3MW could be the solid fuel specifications available in Mongolia. Further investigations should be conducted to assess the quality of available fuels and their consistency as well as identify what HOB technology and modifications might be required for securing the most efficient coal combustion and overall HOB efficiency when utilizing local solid fuels.

Most widely used solid-fuel-fired energy efficiency HOB in the range of 100kW–3MW are of the multi-tubular shell (also known as "fire-tube") type design, capable of generating steam or hot water at pressures up to 20bara, but more normally operating between 5bara and 15bara with a variety of combustion firing system. Multi-tubular shell boilers comprise by far the largest share of the energy efficient HOB market worldwide.

Higher operating pressures and boiler outputs would normally be accommodated with purpose built water-tube boilers coupled with stand-alone or build-in bubbling and circulating fluidized bed combustors. These two energy efficient technologies are most widely used for such applications worldwide and can be implemented to re-power older conventional HOB coal-fired plants or build on new sites. Seven re-powered boilers with fluidized bed combustors are already in use Mongolia and proven very successful. These are the most advance and energy efficient solid fuel burning technologies today and merit further consideration for wider deployment in Mongolia.

The energy efficiency HOB technologies best applicable to serve heat demands in the range of 100kW-3MW and their optimal combustion systems are shown in Figure 4.1.[1]

Figure 4.1 Energy Efficient HOB (100kW-3MW) by Type, Heat Demand and Combustion

Combustion Technology	Heat Demand 100 (kW)	Heat Demand 500 (kW)	Heat Demand 5,000 (kW)	Heat Demand 10,000 (kW)	Heat Demand 15,000 (kW)	Heat Demand 20,000 (kW)	Heat Demand >30,000 (kW)	HOB Type
Gravity Feed System	⟷	⟷						Hot Water/ Magazin
Underfeed Stoker	⟷	⟷	⟷					Hot Water/ Sectional
Mini-Coking Stoker		⟷	⟷					Hot Water/ "Horseshoe"

The energy efficiency HOB technologies that are best applicable to serve heat demands in the range of 3-30MW and their optimal combustion systems are shown in Figure 4.2.[2]

[1] Combustion systems can be matched with other boiler types when technically feasible but may require additional engineering work.
[2] Combustion systems can be matched with other boiler types when technically feasible but may require additional engineering work.

Figure 4.2 Energy Efficient HOB (3-30MW) by Type, Demand and Combustion

Combustion Technology	Heat Demand 100 (kW)	Heat Demand 500 (kW)	Heat Demand 5,000 (kW)	Heat Demand 10,000 (kW)	Heat Demand 15,000 (kW)	Heat Demand 20,000 (kW)	Heat Demand >30,000 (kW)	HOB Type
Static Grate Stoker		↔	↔	↔	↔			Steam/HW Shell type
Coking Stoker			↔	↔	↔	↔		Steam/HW Shell type
Chain/Travelling Grate Stoker			↔	↔	↔	↔	↔	Steam/HW Shell Type
Bubbling Fluidised Bed					↔	↔	↔	Steam/ HW Purpose design
Circulating Fluidised Bed					↔	↔	↔	Steam/HW Purpose design

A more detailed review of the solid fuel fired HOB technologies outlined in Figure 4.1 and Figure 4.2 as well as fuel requirements are included below.

Magazine HOB technology

This particular design of boiler is invariably combined with a gravity-feed combustion system. The boiler is normally fabricated from welded steel, combining flue-gas passes and waterways, within a self-contained unit, which usually incorporates a small fuel storage hopper and combustion system. This design provides an inexpensive, well-proven, efficient and flexible unit capable of prolonged periods of operation with minimal manual attention. The gravity-feed combustion system is a simple technique with a minimum of moving parts. The fuel is delivered by gravity from a hopper into the fire-bed. The fuel should not cake or swell on reaching the combustion zone and the volatile matter content should be low in order to avoid potential for burn-back into the fuel storage hopper. Also, in order for the system to operate successfully, the fuel must flow readily under gravity. This requires reliable and consistent size grading and moisture content of the fuel. Graded anthracite and briquettes are highly suitable fuels to guarantee high performance and low emissions.

Sectional HOB technology

The sectional vertical boiler is a traditional design constructed from a number of U-shaped sections. When connected together, the sections form the waterways and flue gas passages of the boiler. The sections are normally cast in high-grade iron and are, therefore, extremely durable when operated correctly. Some of the boilers imported to Mongolia are of this design. In addition, the sectional construction allows damaged or worn sections to be replaced without total boiler replacement. Boiler thermal output can be varied through a combination of modifying the section design and altering the number of sections. This fact allows thermal output of an existing boiler to be increased by the addition of further sections, often some time after initial installation. Modern designs incorporate extended heat transfer surfaces for convective heat producing a boiler efficiency of over 80%.

The Sectional HOB typically utilizes the underfeed stoker, or its derivatives, for a combustion system. This combustion system is flexible, inexpensive, well proven and controllable. The preferred fuels for this type of combustion system are bituminous and lignite coals with low swelling and poor caking characteristics, however, it is possible to use some higher-swelling coals and low quality solid fuels similar to those identified as most widely used in Mongolia, which makes it a highly suitable energy efficient HOB for Mongolia. This type of system has been very successfully demonstrated in Central and Eastern Europe firing lignite and other poor quality solid fuels.

Welded Steel (also known as "horseshoe") HOB technology

Welded steel boilers suitable for coal firing are normally of the open bottom or 'horseshoe' design. The top of the boiler is basically a two-pass shell and tube ("fire-tube") heat exchanger located above a water-jacketed combustion chamber, usually fitted with a mini-coking stoker, which is a derivative of the traditional coking stoker design. Its major benefits relate to increased automation of operation. In addition, manual attention to release clinker build-up from the sides of the combustion chamber is no longer required with the mini-coking stoker due to the inclusion of water-cooled 'side-cheeks'. Bituminous and lignite coal, with low swelling, is the preferred fuel for this combustion system. Lower grade coals could be fired if hardware refinements are made to the boiler and its combustion system.

Shell and tube HOB technology

Multi-tubular shell boilers are widely used worldwide and readily available as packaged units, generating steam and hot water for a range of applications. Most modern designs are of the three-pass type. For coal, the combustion system occupies a significant volume of the furnace (or first pass). The furnace chamber and the first-pass reversal chamber are responsible for around 40% of the total heat transferred in the boiler at maximum continuous rating (MCR). The arrangement and diameter of the tubes control the boiler exit gas temperature which is a key parameter determining the overall boiler thermal efficiency. Small-diameter tubes improve heat transfer but with coal firing the minimum acceptable tube diameter is restricted due to the possibility of deposit build-up at the tube inlet. Usually shell and tube type boilers are matched with the following combustion technologies:

- **Static grate**: this technology provides a very flexible coal firing method for use in shell boilers. It provides a relatively low-cost package unit over a wide range of boiler output (600kW to 11MW) with a turn down ratio of up to 4:1 and efficiency of over 75%. The energy efficiency of this HOB technology is further improved by implementing modern control systems and installation of variable speed drive motors for the main air fans and coal feed screws. These modifications improve the air distribution and air/fuel ratios, leading to higher combustion efficiency and also reduced heat loss to flue gases and thus higher boiler efficiency over the whole operating range. The static grate system requires a coal with low swelling characteristics and size-graded between nominally 32mm top-size and 12.5mm bottom size. Ash content is normally restricted to 5-12% mainly to avoid frequent de-ashing.

- **Coking stoker:** this technology has proved its reliability over the years. However, modifications to the design have created a good system for automated, minimally attended boiler operation. Coking stokers are normally employed in boilers with outputs between 1.8MW and 6MW. A ram feeds the coal from a hopper, mounted at the front of the boiler, onto a grate consisting of a number of reciprocating bars.

  The reciprocating bars move in sequence, driven via a system of cams, in such a way that the coal is walked along the length of the grate bars. As the coal travels along the grate, primary air is drawn up through the grate bars by an induced draught fan allowing combustion to take place. Secondary air may be supplied above the fire-bed or, alternatively, steam jets may be used to create turbulence above the fire, thereby minimising smoke emission.

  Incorporation of variable speed motor drives and the 'firebreak' results in better control of air: fuel ratio control, thus improving combustion performance and achieving high thermal efficiency. The coking stokers are able to use coal of a wider size range with a top size of 25mm to 32mm, but this may increase the loss of unburned coal dropping through the grate bars and reduce efficiency.

- **Chain grate stoker/travelling grate stoker:** these systems are particularly important for the larger end of HOB technology market. The outputs available using these systems, however, vary widely (1.5MW to 40MW) and they offer a versatile coal firing system consisting of a partially flexible, looped 'mat' made up of metallic links connected to a drive system. The top surface of the mat remains under tension and acts as a continuously moving grate. As with the coking stoker system, the coal is fed from a hopper at the front of the boiler. The top surface of the grate is driven so that it moves away from the front of the boiler moving the coal with it. Primary combustion air is provided by a forced draught fan feeding into a plenum chamber under the grate and then up through the bed of coal on the grate.

  To improve energy efficiency baffles and control dampers in the plenum chamber control air distribution through the fire-bed effectively. The boiler output is controlled by a combination of initial coal-bed thickness and the speed of the grate movement. By introducing a variable speed motor drive instead of a gearbox, the grate speed can be varied widely, allowing a very wide turndown ratio to be achieved, hence maintaining high efficiency at varying heat demands. Energy efficient HOB are fitted with instrumentation to control key parameters such as: grate speed, bed thickness, air distribution, air-fuel ratio achieving consistent energy efficiency of over 75% over a wide range of loads typically from 15-85%.

Insulation improvements and combustion condition monitoring have resulted in a new packaged boiler/stoker system combination. The main disadvantages of chain grate type of stokers are higher capital cost and a comparatively high maintenance requirement. The main advantage is that it is possible with some modification to use some higher-swelling coals and low quality solid fuels similar to those identified as most widely used in Mongolia. In addition, there is experience with similar technology in Mongolia, most Russian HOBs are fitted with such combustion systems, and energy efficiency upgrades of existing stock may merit further assessment.

Atmospheric-Pressure Fluidized Bed HOB Technology

The use of an atmospheric fluidized bed system, either circulating or bubbling, usually requires a purpose-designed package of boiler and combustor. A bed of inert material (such as silica sand) is agitated by a flow of air, from a forced draught fan, through a distributor plate. The air constitutes the primary combustion air and maintains the bed in a fluidized state. The bed is first heated to around 500°C, usually with gas or oil, and then crushed lump coal or other solid fuel is fed to the bed. Secondary air can also be supplied above the bed to help combustion of volatile matters and fine carbon particles escaping the bed.

Once the coal is ignited, the bed is maintained at a temperature between 800°C and 950°C with combustion of solid fuel alone without any need of gas/oil support. A fluidized bed exhibits extremely good mixing characteristics between the solids and the gas and significantly enhances heat transfer between the bed of material and the combustor surfaces. Fluidized bed combustors are capable of handling a very wide range of fuels, including low-grade fuels and waste-derived materials.

NOx emissions from fluidized beds are generally low due to the use of low combustion temperature. Fluidized bed combustion also offers the possibility of sulphur reduction in the bed by the addition of limestone, which reacts with SO2 formed during combustion of coal. Calcium oxide from limestone absorbs SO2 producing solid calcium sulphate for disposal as a waste. High thermal efficiency of over 90% can be achieved but the turndown ratio is relatively low (2.5:1) that makes him a good base load HOB.

Relatively high-pressure drop across the fluidized bed also results in higher consumption of electricity by the forced draught fan and associated higher costs. Great care should be taken in the design of the fuel and ash handling system as these are often neglected, leading to operational reliability problems with the plant. Fluidized beds are generally used with combination water tube and shell boilers, often linked with combined heat and power schemes. The main disadvantages of fluidized bed technology are high capital cost and comparatively high maintenance requirements. The key advantage for Mongolia is that no preparation or grading of fuel is required and fuel with varying characteristics can be burnt efficiently.

4.1.1.3 Critical Ancillary Equipment Required for HOB Technologies

Fuel Handling Systems

A wide range of fuel handling system exists that are designed to operate efficiently and reliably matching the requirements of the various HOB technologies. Reliability of fuel handling systems is paramount to ensure consistency of HOB operation and emissions, freedom from excessive maintenance and intervention, hence reliable supply of heat to the end users.

Energy Efficient Pumps and Fans and Associated Drives

All HOB boilers should be fitted with properly sized and controlled fans and pumps to achieve best performance and fuel economy. The latest generation of pumps and fans offer high levels of reliability and genuine energy savings through low running costs in a wide range of applications. Often fitted with VSD technology to adjust their performance automatically in line with varying system demands. Some of them incorporate a de-jamming system, which enables it to free direct and minor debris, thereby improving operating reliability and minimizing the need for servicing.

Water Treatment Plants

The use of feed water treatment for HOB to control scaling and corrosion is long established and a large number of technologies and manufacturers exist worldwide. Selection of the appropriate water treatment/water conditioning techniques is critical to make best use of the HOB and expand its service life through eliminating or minimising corrosion and deposition.

Quality Instrumentation and Control Systems

Modern measuring and control equipment utilized on HOB systems to monitor various key parameters (air flow rate, fuel feed rate, steam flow rate, oxygen level in flue gases, flue gas temperature at boiler exit, blow-down frequency etc) and provide appropriate control of these parameters to achieve optimum performance in terms of combustion, thermal efficiency and emissions. Preventive maintenance against boiler fouling and corrosion, safe operation and reduced fuel and operating costs are also achieved with such instrumentation and control systems. Monitoring of various pollutants such as smoke, particulates, SO2, NOx and carbon monoxide in flue gases are also needed in order to reduce these emissions and meet the requirements of legislation.

Insulation

Wide ranges of insulation materials exist for specific applications for all HOB hot parts - boiler surfaces, pipes, valves and flanges should be properly insulated and insulation kept in good condition.

4.1.2 Supply Chains

Energy Efficiency HOB technology Supply Chain

Based on phone interviews with HOB supplier, Internet research and existing data of technical condition of current stock of HOBs in Mongolia, the Consultant is under the impression that the vast majority of local engineering and consultancy firms, manufacturers, dealers, installers, operation and maintenance firms are not fully abreast with the best energy efficient HOB technologies and ancillary equipment. Some level of capacity building needs to be undertaken to bring them up to speed and raise their awareness and knowledge. This will enable them to actively participate and effectively support the roll out of energy efficient HOB technologies in Mongolia in the future.

It has been determined that a limited number of foreign manufactures from Korea, Czech Republic, China and Russia already sell energy efficient equipment through local manufacturers or independent agents, however, our preliminary data suggests that no distribution networks exist nor any after sales service is provided, which, in turn, is causing some deterioration of HOB energy performance.

Apart from Russian made HOBs, most imported equipment is small in capacity and used in heating applications for schools, small administrative buildings, small hospitals, healthcare centers, small office buildings and residential buildings of up to 200 flats that would typically require HOBs in the range of 100-500kW or less than 100kW. Although some of these HOBs are inexpensive, easy to service and might be operating at reasonably high efficiency of over 75% burning low quality solid fuels, they are of relatively simple design, often batch fed, and not able to perform consistently in compliance with more stringent environmental regulations. For example, the Czech Republic made Viadrus in the 100-400kW capacity range, are not for sale in the Czech Republic due to non compliance with EU legislation.[1]

Only one model of Mongolian HOB has been identified as energy efficient. This is the Mon Zuuh XXI model, water-tube boiler with moving chain stoker, manufactured by the Mon San Co limited, a German-Mongolian Joint Venture. The rest of the locally manufactured HOB are very inefficient with obsolete design and production methods that urgently require technical assistance to improve their performance and reliability.[2]

Fuel Supply Chain

The preliminary information reviewed indicates that the Mongolian fuel supply chain is underdeveloped and not in a position to supply standard quality fuels required by modern energy efficient HOBs. There is a need to establish a rigorous coal quality supply chain to guarantee standard quality of coal, which, in turn, will allow for a wide range of standard energy efficient HOB technology to be deployed easily and cost effectively in Mongolia.

4.1.3 Market Potential for Energy Efficient Heat-Only Boilers

At present, the uptake of modern energy efficient HOBs in Mongolia has been very slow due to a number of factors addressed in more detail in sub-section 4.3. However, potential market opportunities for energy efficient HOBs exist and could be facilitated through market transformation programs supported by the Government of Mongolia and the donor community.

4.1.3.1 Small HOB technology (rated capacity less than 100kW)

A number of donor-supported projects to introduce efficient stoves in Mongolia have been carried out over the last decade. There is no data available with regards to the penetration of the efficient stove improvement "kit" and the market potential for small HOB technology as a substitute for stoves and other domestic devices for heating and hot water. This market segment

[1] Source: Viadrus web site.

[2] Mongolia HOB manufacturers, energy end-users and general public will benefit from a programme supporting the introduction of 'affordable energy efficient and cleaner boiler designs' drawing on the experience gained from the WB/GEF Industrial Boiler Project in China.

needs to be further researched to establish the demand for small HOB technology and estimated its market potential. Our preliminary market review suggests that an increasing number of energy efficient HOB in this particular market segment have been sold on the Mongolian market with products of Kitarumi (South Korea), with efficiencies of over 80%, being in the lead in terms of energy efficiency performance.

4.1.3.2 HOB technology (rated capacity in the range of 100kW – 30MW)

The HOB market review in Section 3 identified that the majority of existing HOB systems in Mongolia are being used for general heating and domestic hot water applications that fall into the following market segments in terms of HOB system size:

- **100kW to 500kW** range, comprising of stand alone heating applications in schools, small administrative buildings, small hospitals, health centres, small office buildings and residential buildings of up to 200 flats,
- **500kW and 3MW** range, supplying heat to larger administrative buildings, larger hospitals, and small communal heating schemes, and
- **3MW to 30MW** range, generating heat for medium size and larger district heating networks.

Upgrading and replacing existing coal-fired HOBs with energy efficient HOBs, operated and maintained as the manufacturer intended, can improve the overall performance of the heating system by making it more economic, reliable and environmentally acceptable.

The overall market potential for HOB is assessed on the basis of economically viable and technically feasible upgrades or replacement of obsolete HOB systems, those over 7 to 15 years of operation. It is assumed that there will be very slow growth of market demand due to the implementation of a wide range of demand-side management improvements. Lack of long term financing for energy efficiency HOBs, low price of local solid fuel and lax enforcement of environmental laws, especially on municipal level, are also taken into account.

Some evidence suggests that investment decision-making is susceptive to short term investment horizons, with preference given to investments in low-cost HOBs over the more expensive energy efficiency technology which is economically viable longer-term.

Preliminary estimates of annual market potential for upgrading or replacing current HOBs with energy efficient technologies with optimal combustion systems are shown in Figure 4.3 and Figure 4.4[1]

It is estimated that the annual potential market in Mongolia for energy efficient HOB in the 100kW –3MW segment may vary from 50MW to 200MW, with and average size of 600 KW per HOB, and at the rate of 85 to 335 units per year.

[1] Combustion systems can be matched with other boiler types when technically feasible but may require additional engineering work.

Investment needs for this potential are estimated at $1.7M - $6.7M[1] based on less efficient and manually operated Czech HOBs that are currently available on the Mongolian market, or at $3.4M - $13.4M[2] based on automated highly efficient HOB imported from Europe or USA.

Figure 4.3 Energy Efficient HOB (100kW-3MW) Market by Installed Capacity

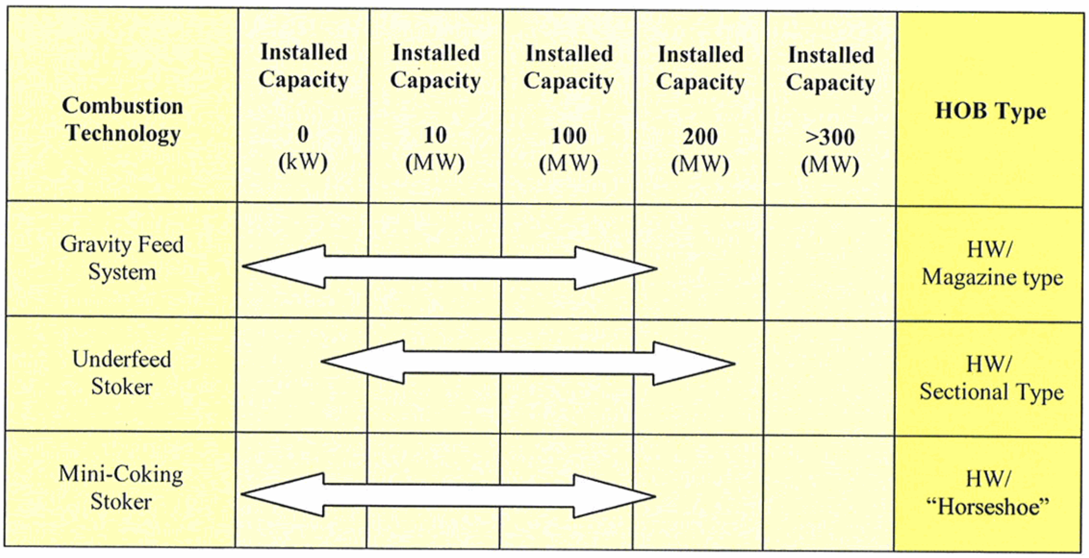
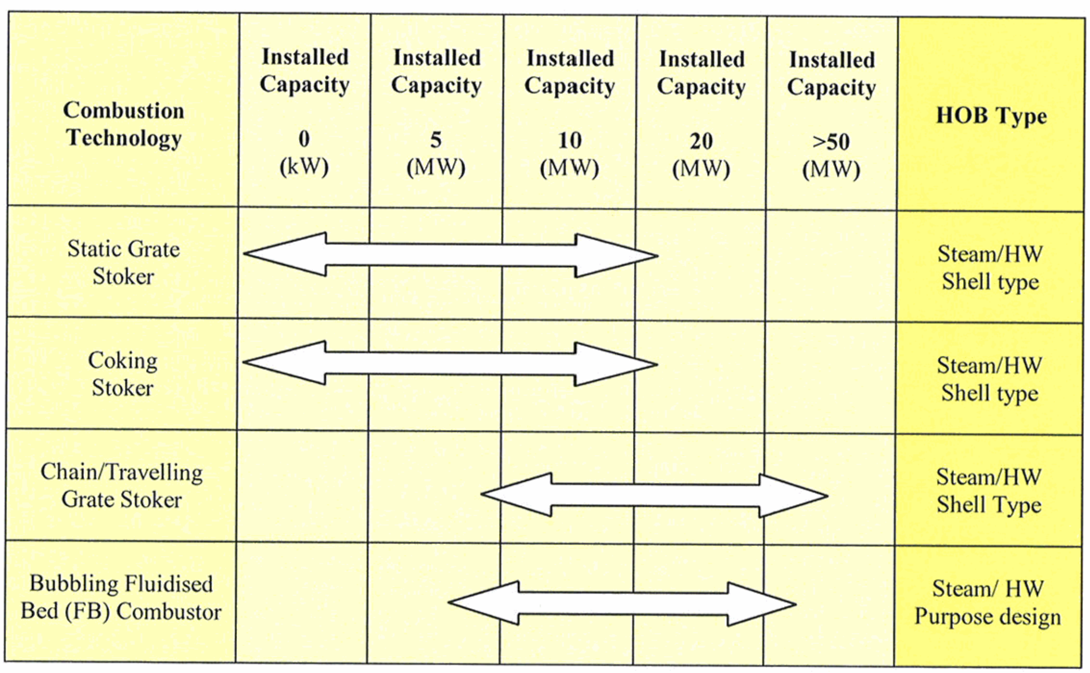


Figure 4.4 Energy Efficient HOB (3kW-30MW) Market by Installed Capacity



[1] Based on budget estimates for HOB (sectional type, boiler, gravity feed combustion system, Czech Republic)
[2] Based on budget estimates for HOB (sectional type, boiler, underfeed stoker combustion system, Austria)

Market potential for the energy efficient HOBs in the 3–30MW range may vary from 5-50MW with an average HOB unit size of around 6MW, which translates to about 1 to 10 units per year for a total investment size of $120k to $1.2M[1] per year.

4.2 FINANCING OPTION

Availability of financing mechanisms is critical to accelerating the deployment of energy efficient HOBs. Unfortunately, equipment finance options for HOB or for any equipment have not been identified in Mongolia.

Further investigation is required to assess whether funding for energy efficiency projects and equipment can be provided in the form of grants, operating and financing leases, non-recourse project finance, commercial loans, vendor financing, ESCO service contracts or other innovative financing tools including funds for carbon trade under the UNFCCC and Keyoto protocol.

4.3 MARKET BARRIERS

Despite an increasing emphasis on overall energy efficiency and concerns over air pollution in urban areas in Mongolia, a number of market barriers hinder the implementation of such projects on a wide scale. The use of energy efficient HOBs is currently limited in Mongolia due to a combination of financial, technological, and institutional barriers. These barriers typically lead end-users to favor less efficient and polluting “traditional” HOB or other heat supply approaches.

The following is a detailed review of the various market barriers that have been identified in Mongolia:

4.3.1 Economic and Tax Treatment

The economic attributes of new energy efficient HOB projects and the related tax implications usually rank high in the decision making process of potential end-users and facility owners. The incremental costs over conventional alternatives are significant, and usually present a disincentive to HOB owners despite the favorable life-cycle economics of the project. Therefore, the high upfront cost and lack of long-term financing mechanisms remain a major stumbling block to successful project development.

However, there is an emerging trend of increasing interest by third parties such as development banks and some local banks in supporting the development of the energy efficient and pollution-abating HOB projects. Furthermore, some groundwork has been done to introduce the ESCO concept to Mongolia. While currently there are no ESCOs operating in Mongolia, energy service providers that are backed by equipment manufacturers as well as financing institutions might be encouraged through preferential tax treatment to develop options to overcome the initial capital investment barrier.

No leasing companies in Mongolia have been identified. If leasing options are available, HOB system owners and users could effectively purchase energy efficient HOB systems without any capital outlay.

[1] Based on budget estimates for HOB (shell type, chain grate combustion system, Russia)

No tax incentives exist for energy efficient HOB systems. If the Government of Mongolia could make tax credits available for selected energy efficient HOB equipment, this would help defray project capital cost and stimulate compliance with environmental regulations. Other means of improving the tax implications is reducing the asset life to allow for accelerated depreciation.

4.3.2 Products and Fuel Availability

While conventional HOBs are manufactured in Mongolia and in its neighboring countries, and have been introduced for over ten years, such systems are not easily available and often there are after sales service problems and lack of spare parts supply. The penetration of western energy efficiency HOB is hampered due to varying combustion characteristics of local fuels, coal in particular, that often has a negative impact on the overall performance of the energy efficient HOB. Although some modern combustion stokers could improve HOB performance in Mongolia, design modifications might be required to cope with poor quality of local coal.

On the positive side, there are some indications that some energy efficiency upgrades have been implemented, yet some resistance or lack of knowledge still exist within the design community. Lack of awareness in Mongolia of energy efficient HOB that have already been introduced in other countries with a good track record contributes to the underlying uncertainty in the ability of energy efficiency HOB to meet cost and performance targets. This presents an obstacle to aggressive marketing and implementation of these technologies.

Although Russian chain grate coal HOB technology is well established in Mongolia, more efficient HOB manufactured in the UK and USA with higher efficiency by 10-15% are unknown and not easily available on the local market.

The lack of well functioning coal distribution networks makes it difficult for an imported high performance coal fired HOB to receive regular supply of manufacturer's specified coal, hence achieve its rated output and efficiency levels. Coal used in Mongolia is almost always raw coal, not even size graded much less 'washed'. Ash content averages 20%, with Uvs coal reaching values as high as 35%. There is no separation of coal by its swelling (coking) properties.

Gas and oil availability and their high costs are the biggest obstacles to deployment of modern energy efficient and environmentally friendly oil and gas fired HOB.

These factors all contribute to low efficiency performance of the HOBs operating in Mongolia.

4.3.3 Awareness, Information and Education

The users of HOBs in Mongolia tend to be risk-averse, favoring the "tried and known" systems and not interested in options that they have not experienced before. Moreover, HOB owners focus on upfront capital cost versus life-cycle cost. Energy efficiency HOB penetration suffers from these issues, and from unfamiliarity with all the benefits from modern technology. In addition, a major consideration with energy efficiency HOBs is the lack of well-trained staff with required knowledge and skills to operate and maintain them.

4.3.4 Policies and Regulations

Energy efficient HOBs are affected by energy and environmental policies, building codes and standards. While many of the local codes and requirements may not result in additional equipment or operating costs, the process of determining what the requirements are is often not clear and may require time to get necessary certifications and approvals.

Energy efficiency HOB projects are typically subject to permitting procedures at the state and local level which can stretch for a long period (sometimes 24 months or longer). Such delays can be frustrating and may result in abandoning new energy efficiency HOB projects. Streamlined permitting procedures may provide a major boost to energy efficient HOB technology penetration.

4.3.5 Environmental Regulations

Current environmental regulations do not provide credit to energy efficiency HOB projects for energy saving and reduction in emissions. Broadening the environmental laws to provide incentive for more efficient HOB would offer expanded market reach to energy efficient options.

Preliminary research indicates that existing HOBs in smaller cities and villages in Mongolia come under Local Authority Regulation, which do not contain any emission limits. To achieve compliance with emission regulations in the short term, an effort should be made to reduce air pollution through more rigorous enforcement of the environmental legislation, which will act as a catalyst to increase demand on more energy efficient and clean HOB technologies.

4.3.6 Supporting Market Infrastructure

Energy efficiency HOB options are offered on the market through fairly limited distribution and service networks, with a short supply of trained service staff and spare parts on a nationwide basis. Better after sale support is required to achieve higher market penetration. As more boiler professionals gain experience with energy efficient HOB system's design, operation and maintenance, an increase in requests for these options will likely boost sales, and therefore, raise the visibility of these products. Donor technical assistance will be helpful in support of promotional and sales efforts through demonstration projects undertaken jointly with international manufacturers/dealers of modern HOB equipment.

4.4 PRELIMINARY COST/BENEFIT ANALYSIS OF ENERGY SAVING AND CO2 REDUCTION

As identified in the preliminary assessment of the energy efficiency HOB market, the average unit size is around 600kW in the 100kW–3MW segment, and 6MW in the 3-30MW range. The costs and benefits from project implementation, involving upgrades or replacement of existing HOB with more energy efficient option are demonstrated in the following examples of two typical projects using the "average" size units.

Example 1. An existing "classic" design 600kW HOB that is nearing the end of its service time runs at an average efficiency of 45%. Replacing it with a new Mongolian HOB of the same size and design will increase efficiency to 55% and will cost around US$10/kW. The same size Czech HOB has a rated efficiency of 75% and costs around US$34/kW, while a more sophisticated Austrian 650kW HOB, fitted with underfeed stoker, boasts an efficiency of up to 85% and has a price tag of US$ 68/kW. These are all budget prices, ex-works, for a HOB complete with its firing system, but without additional ancillary equipment such as coal hoppers and flue gas cleaning.

Preliminary costs and benefits of replacing a 600 kW HOB with a more efficient unit of the same size are shown in Table 4.1 below.

Table 4.1 Preliminary Costs and Benefits for a 600 kW HOB Upgrade Project

Key Assumptions and Parameters	HOB in use	New HOB Mongolia	New HOB Czech Republic	New HOB Austria
Annual operation (hour):	5000	5000	5000	5000
Size (kW)[1]:	600	600	600	600
Thermal Energy Efficiency (%):	45	55	75	85
HOB cost (US$/kW):	-	10	34	68
HOB cost ex works (US$):	0	6,000	20,400	40,800
Total Installed Cost (US$)[2]:	0	16,000	30,400	50,800
Fuel:	Coal	Coal	Coal	Coal
Calorific value (MJ/kg):	15	15	15	15
Coal price (US$/t):	16	16	16	16
Annual Heat Production (kWh):	3,000,000	3,000,000	3,000,000	3,000,000
Annual Energy Use (kWh):	6,666,667	5,454,545	4,000,000	3,529,412
Annual Coal Use (t):	1,600	1,309	960	847
Annual Fuel Savings (t):	0	291	640	753
Annual CO2 Reduction (t)[3]:	0	390	858	1009
Annual Cost Savings (US$):	0	4,656	13,728	16,144
Simple Payback (year):	0	3.5	2	3
Average service life (year)	0	6	10	12
Simple life cycle savings (US$):		11,640	109,824	145,296

An estimated annual market of 200 retrofits with 600kW HOB units will result in energy savings from 58,200t to 150,600t of lignite coal per annum. This corresponds to 77,988t to 201,804t of CO2 abated per year.

Example 2. A typical water-tube existing 6MW HOB, with a moving grate stoker, operating at 65% efficiency, can be upgraded to a new HOB, manufactured by a Mongolian-German manufacturer with a rated efficiency of 85% and a price tag of US$ 45/kW. A new Russian-made HOB with similar specifications, however, costs in the region of US$20-$30/kW, while a new British made HOB is around US$60/kW. These are all budget prices, ex-works, for a HOB complete with its firing system but without additional ancillary equipment such as coal hoppers and flue gas cleaning.

[1] For the purpose of this analysis, all unit sizes have been unified at 600 KW.

[2] Additional cost for ancillary equipment, HOB transportation and installation are US$10,000.

[3] One kilogram of "raw" Mongolian lignite coal (Q=15MJ/kg) fired in a coal boiler emits 1.34 kg of CO2.

Preliminary costs and benefits of replacing a typical 6MW HOB with a more efficient unit of the same size are shown in Table 4.2 below.

Table 4.2 Preliminary Costs and Benefits for a 6MW HOB Upgrade Project

Key Assumptions and Parameters	HOB in use	New HOB Mongolia	New HOB Russia	New HOB UK
Annual operation (hour):	5000	5000	5000	5000
Size (kW)[1]:	6,000	6,000	6,000	6,000
Thermal Energy Efficiency (%):	65	85	85	85
HOB cost (US$/kW):	-	45	25	60
HOB cost ex works (US$):	0	270,000	150,000	360,000
Total Installed Cost (US$)[2]:	0	390,000	270,400	480,000
Fuel:	Coal	Coal	Coal	Coal
Calorific value (MJ/kg):	15	15	15	15
Coal price (US$/t):	16	16	16	16
Annual Heat Production (kWh)	30,000,000	30,000,000	30,000,000	30,000,000
Annual Energy Use (kWh):	46,153,846	35,294,117	35,294,117	3,529,417
Annual Coal Use (t):	11,077	8,471	8,471	8,471
Annual Fuel Savings (t):	0	2,606	2,606	2,606
Annual CO2 Reduction (t)[3]:	0	3,492	3,492	3,492
Annual Cost Savings (US$):	0	55,881	55,881	55,881
Simple Payback (year):	0	7	5	9
Average service life (year)	0	15	15	20
Simple life cycle savings (US$):		447,000	558,800	614,700

An estimated annual market of 4 energy efficiency upgrades of 6MW HOB will result in energy savings totaling around 39,000t of lignite coal per annum, and around 52,000t of CO2 abatement.

[1] For the purpose of this analysis, all unit sizes have been unified at 6 MW.
[2] Additional cost for ancillary equipment, HOB transportation and installation are US$120,000.
[3] One kilogram of "raw" Mongolian lignite coal (Q=15MJ/kg) fired in a coal boiler emits 1.34 kg of CO2.

Section 5
Conclusions and Recommendation for Future Activities

5.1 CONCLUSIONS

Mongolian HOB owners will not undertake any HOB upgrade projects unless it is critical, i.e. only when the HOB becomes completely unusable. Those, who are in need for upgrading their systems, are often faced with the high costs of either replacing the existing boilers with new modern units or with rehabilitating the existing ones. Securing financing is difficult, therefore, a better understanding of the possible methods and sources of financial support for improved technology deployment is needed and further support extended to exploring and structuring a wide range of financing mechanisms for energy efficient HOBs.

HOB owners lack knowledge and information of the benefits of more efficient HOBs and need support in their decision-making process related to HOB upgrades.

The development of the market for efficient and clean HOBs requires the co-operation of Governments (especially regional and municipal authorities who own most of the installed HOB), consulting and engineering companies, manufacturers and distributors to raise the understanding of specific heating applications, and to identify best upgrade solution. A number of demonstration projects to develop success stories should also be supported by all shareholders.

It is critical that the introduction of low cost, fast payback rehabilitation measures for improving the energy efficiency and environmental performance of existing HOBs is fully assessed and explored in terms of best rehabilitation or alternative solution. Special attention should be paid to fluidized-bed combustor that can be fitted to existing boilers.

To make the best use of the wide range of modern HOB technologies, the local suppliers of coal need to make investments in coal quality improvement through coal preparation and grading. Efficient coal burning process is critical for the HOB system overall efficiency.

Establishing environmental policies and regulations without the proper means of enforcement will be insufficient to secure the targeted level of penetration of energy efficiency technology.

Building a strong local manufacturing capacity, based on modern technologies, can act as a catalyst for the fast deployment of efficient and clean HOB technologies. Additional support mechanisms should be developed to avail capital assistance, information and advice, operational support, a conducive planning climate and promotional activities to ensure that local HOB manufacturers are in a strong position to roll out new energy efficient product on the local market.

Improved supply networks for HOB technology and standard quality fuel is a key pre-requisite for future market growth.

5.2 RECOMMNDATION FOR FUTURE ACTIVITIES

5.2.1 Development of Financial Solutions for Heat-Only Boiler Upgrade Projects

As a key to influencing end users' decision with regard to energy efficiency HOB upgrades, compatible financing options to the Mongolian business climate should be evaluated, and efforts should be directed to the development of attractive mechanisms. The noticeable interest of third parties including development banks and other donors should be leveraged in such efforts.

5.2.2 Comprehensive Energy Audits of Heat-Only Boiler in Use and Pilot Projects

A comprehensive energy audit program should be initiated to assess operation modes, technical conditions and overall HOB efficiency and identify upgrade needs. Such a program would be phased to ultimately include a demonstration of western energy efficient combustion and particulate capture technologies to show the potential for efficiency gains and emissions control.

In order to address the urgent need for dissemination to policy makers and other interested stakeholders of local and international success stories highlighting the status of clean and efficient combustion technologies for the HOB sector, the creation of an electronic database clearing house should be explored. An inventory of HOBs could be created and a report identifying the best energy efficiency solutions and expected cost and benefits highlighted. Such a report would facilitate the development of the necessary Government and donor supported further programs.

5.2.3 Feasibility Assessment of Fuel Preparation (Washing) and Grading Facilities at Source to Reduce Fuel Transportation Cost and Improve Combustion Efficiency of Heat-Only Boilers

Most of the coal used in the more developed countries is standardized and pretreated "washed" i.e. is subjected to a variety of water based techniques, to remove inert material and separate out the finest (dust sized) particles. It is also selected to have low swell characteristics and graded.

The cost of coal preparation and grading should be assessed against the benefits of efficient, reliable and clean combustion in HOB (97% burning efficiency is normal), guaranteed HOB thermal output, increased overall boiler efficiency, predictable stack emissions, as is the performance of emission control equipment. Further benefits include lower transportation cost, dust and good incentive to use energy efficient HOBs. Availability of standard quality fuel can become the major market driver for energy efficient HOB technology in Mongolia.

5.2.4 Improve the Capacity of the Energy/Boiler Service Industry

Engineering expertise available in Mongolia in all aspects of HOB technology is critical for the successful rollout of energy efficient HOB technologies in Mongolia. Knowledge and skills in the following areas are highly required to facilitate the implementation of energy efficient HOB:

1) combustion and heat transfer processes and technologies to meet the specific application needs in the most energy efficient manner; 2) engineering design of HOB systems and their components; 3) evaluation of fuel characteristics; 4) testing of boiler efficiency; 5) operation and maintenance of energy efficient HOB systems; 6) assessment and implementation of the most

technically feasible and economically viable refurbishment and upgrade solutions for the existing stock of HOB systems; 7) construction and installation of energy efficient HOB systems.

5.2.5 Feasibility Assessment of Ground Source Heat Pump Heating Systems and Renewable Energy for Urban Areas Located far from Solid Fuel Sources

Heat pump based electric heating should be assessed in terms of its viability as an alternative to HOB applications in remote locations where coal is not available or much more expensive in comparison with coal price for the power plants.

5.2.6 Feasibility Assessment of Heat-Only Boilers and Diesel Generators Conversion into Combined Heat and Power Plants

Combined Heat and Power plant could be a viable alternative to HOB and obsolete diesel generators in remote locations, not connected to the national grid system. This alternative has already been identified in the Energy Strategy and further assessment of its viability is highly recommended.

Section 6
References

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2. Energy Sector Development Strategy for Mongolia, Government of Mongolia, 2002
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4. Coal Issues, the International Energy Agency Clean Coal Centre web site, 2004
5. The State of Environment, the Ministry of Nature and Environment of Mongolia, 2002
6. Pre-Feasibility Study on High Efficiency Industrial Boilers, GEF Project CPR/91/G32/IG/42, 1994.
7. Survey of HOB in use in Mongolia, Dr. Jargal Dorjpurev, Mongolia, 2002
8. National Report on Asia Least-Cost Greenhouse Abatement Strategy (ALGAS), Ulaanbaatar, 1998
9. Climate Change National Action Program, Ulaanbaatar, 2000
10. Coal and Biomass Heat-Only Boiler Manufacturers' Brochures and Budget Prices, 2004

Quality and particulars structure list of main using coals in Mongolia

No	Coal	Mining location	Particulars structure							Fuel quality	
			Moisture W, %	Ash A, %	Sulfer S, %	Carbon C, %	Hydrogen H, %	Nitrogen N, %	Oxygen O,%	Heating value Q, MJ/kg	V, %
1	Aduun chuluu	Dornod	48.25	4.76	1.14	35.4	2	0.25	8.2	9.2	45
2	Baga nuur	Tuv	33	12	0.335	39.8	3.11	0.579	12.1	14.72	42
3	Bayan teeg	Bayankhongor	16.6	19	0.35	35.4	3.6	0.55	24.5	14.4	47
4	Maanit	Tuv	25	24.2	0.55	39.15	2.2	0.9	8	21.7	
5	Mogoin gol	Khuvsgul	17.9	18.1	0.4	40.9	1.7	0.8	20.2	20.3	35
6	Nalaikh	Tuv	27	16.6	0.5	40.6	2.8	0.7	11.8	14.65	42.5
7	Nuurst khotgor	Uvs	10	35	0.5	33.7	2	0.8	18	18	36.2
8	Uvdug khudag	Dundgobi	35	15	2.8	46.4	3	46.2	1.6	11.7	43
9	Ulziit	Sukhbaatar	14.5	18	0.78	58.2	3.71	36.2	1.04	11.4	35.8
10	Saikhan ovoo	Bulgan	16	24	0.5	37.3	1.9	0.6	19.7	14.4	23
11	Tavan tolgoi	Umnugobi	8.5	15.3	0.4	63.6	1.3	0.7	10.5	21.4	33
12	Tal bulag	Sukhbaatar	30	20	1.37	72.4	4.99	20	0.97	11.4	42.5
13	Tevshiin gobi	Dundgobi	25	25	0.65	70.65	3.9	23.7	1.1	10.5	50
14	Khar tarbagatai	Uvs	12	32	0.6	29.6	1.9	0.9	23	18.3	37.6
15	Khushuut	Khovd	7	19	0.5	69.9	5	24	0.6	20.9	40
16	Tsagaan ovoo	Dundgobi	6.5	16.9	1.59	69.7	4.44	23.5	0.78	24.2	48.5
17	Tsakhiurt	Gobi-Altai	7.3	27.4	0.45	64.6	2.75	30.7	1.53	18.3	27.7
18	Chandgan tal	Khentii	30	13	0.64	71.3	4.26	22.9	0.9	12.6	34.5
19	Shariin gol	Selenge	19.5	23.7	1.1	42.8	2.8	0.6	9.5	17.2	44.6
20	Shivee ovoo	Dornogobi	35	15	0.45	34.15	2.75	0.35	12.3	11.2	45
21	Eldev	Dornogobi	10.8	9.6	0.91	60.3	4.2	0.78	13.41	22.9	34.8
22	Alag tolgoi	Dornogobi	9.2	27.8	0.92	60.2	4.0	0.87	13.5	21.2	37.5

Pam:

Thank you for your e-mail dated December 13, providing comments on the draft Preliminary Market Assessment for HOB in Mongolia. We have reviewed your comments. Our explanatory clarifications are presented below:

Comment # 1:

"EE boiler market: There is no discussion of any technology from China, which seems a glaring omission given China's geographical proximity and similar reliance on coal, as well as its own efforts to improve boiler efficiency. Perhaps the report can look into the feasibility of some of the technologies being developed under the China GEF boiler project; let me know if you need me to provide the contact info.*"*

Response # 1:

In the draft Preliminary Assessment, it is implied that the Chinese-made HOBs in the 100kW – 3MW range are second in numbers to the Mongolian-made models as indicated in the last paragraph on page 3-4. Unfortunately, we were not able to unearth detailed data on numbers, types and annual imports of Chinese-made HOBs. Some local sources indicate that most of the small HOBs from China are of simple design and efficiency levels very similar to the Mongolian-made HOBs. Existing studies suggest that a few Chinese boilermakers produce a limited range of energy efficient HOBs and a few energy efficient were sold in Mongolia. A reference to this fact is made on Page 4-9 in the draft Preliminary Assessment. Further research will be undertaken in Phase II to determine what potential there might be for expanding the presence of Chinese energy efficiency HOBs in the Mongolian market. The potential might not prove to be very high, and we base our opinion on a GEF study that suggested that China boiler technology still lag substantially behind international levels in terms of efficiency and performance.[1]

Comment # 2:

"Current boiler operations: while the report indicates that boiler maintenance can be a problem in Mongolia, it does not indicate whether the HOBs are able to provide the service required (i.e., heat 24 hrs/day 7 days/week or whatever). Are there times when schools or hospitals are without heat due to boiler problems or insufficient coal supply? If so, those disruptions could affect the overall cost/benefit analysis of the potential GEF project, and should be indicated.*"*

Response # 2:

[1] Source: GEF Energy Efficient Product Portfolio, Monitoring and Evaluation Working Paper, June 2002, page 17.

Our local consultant has advised us that most heating systems in Mongolia were designed with serious consideration given to back-up equipment to accommodate emergency repairs and maintenance. The cold weather in Mongolia cannot tolerate "downtime", therefore, all measures are taken to ensure that heating services is not interrupted and provided 24 hrs/day, 7 days/week during the winter.

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Comment # 3:

"*Taxes*: Is imported boiler and ancillary equipment subject to import duties and taxes? If so, how much? Are such taxes included in your HOB upgrades table? Does that table assume a constant cost for coal and electricity over the next 10 years?"

Response # 3:

Under the existing custom's and excise legislation, imported HOB and ancillary equipment is subject to levies as high as 20.75% including import duties and VAT. Such taxes are not included in the HOB upgrades tables that represent a preliminary cost/benefit analysis to provide an "order of magnitude" estimate. It is explicitly said in the draft Preliminary Assessment that the analysis is based on budget prices, ex-works, for a HOB complete with its firing system, but without additional ancillary equipment such as coal hoppers and flue gas cleaning.[2] However, assumptions for additional cost for ancillary equipment, HOB transportation and installation have been made and accounted for. The tables assume a constant cost of $16/t of coal.

Comment # 4:

"*Ancillary equipment*: As I understand it, the cost/benefit analysis for this equipment is not included in Table 1.2; is that correct? Is it possible to add another table including some of this analysis?"

Response # 4:

For the purpose of this preliminary assessment, the total installed costs include an allowance for ancillary equipment. See footnotes on pages 4-15 and 4-16. As HOB applications vary in terms of type and cost of ancillary equipment required. A detailed cost/benefit analysis for a particular HOB application could be undertaken in Phase II if needed.

Comment # 5:

"*Building insulation standards/codes*: Are these adequate to promote efficiency efforts? Are they enforced? I gather from the paper that the environmental standards are not being enforced, correct? (and that HOB users are not obtaining the requisite permits)"

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[2] See Preliminary Assessment for HOBs in Mongolia, page 4-15.

Response # 5:

Although some building insulation standards exist, they seem to be inadequate to promote energy efficiency efforts. In addition, the enforcement of legislation in Mongolia is weak, hindered by the lack of adequate facilities and manpower. Often, HOB users will operate systems that are not in compliance with the legislation.

Comment # 6:

"*Fuel standards*: Have the authorities deliberately avoided passing fuel standards (because they are not realistic/certain constituencies oppose them), or is this simply an issue they have not had time/capacity to address?"

Response # 6:

This is an issue to be further investigated in Phase II.

Comment # 7:

"*Permitting procedures*: is the long period required typical for any new investment, or is there some special procedure/review for the efficient HOB? (or is it for imported equipment?) It was not clear to me from the text whether this inconvenience applied across the board to the purchase of any new HOB, or just to energy efficiency HOBs."

Response # 7:

Apparently, this procedure is applied to any modifications to existing HOB installations. Further information will be gathered during Phase II.

Comment # 8:

"*Recommendations*: we would like to pare these down. Based on our understanding of GEF proclivities, please remove 3 of the recommendations: the market assessment for HOB technology as a substitute for stoves, development of HOB production in Mongolia, and the fuel switching for HOBs far from the coal mines. Re-word the capacity building rec to something along the lines of "improve the capacity of the energy/boiler service industry." Also, is there any room for co-gen with the HOBs?"

Response # 8:

We have pared the recommendations down as advised. As identified in recommendation # 5.2.9 Co-gen, also known as Combined Heat and Power (CHP) plant), could be a viable alternative to HOB and obsolete diesel generators in remote locations, not connected to the national grid system. This alternative has already been identified in the Energy Strategy and further assessment of its viability is highly recommended.

Comment # 9:

"*Public sector budgeting/financing*: I'm assuming the Bank will contain most of the info we need for this section so am listing it last, but I will raise it here for you/Dorjpurev as well, as he may know some of the answers. For the concept note we will need to know:

- are public procurement officers legally mandated to buy lowest-cost equipment? If so, can they use life-cycle cost analysis? (the report indicates purchasing least cost is the inclination, but does not say if it is a requirement)
- Do public sector entities (like schools and hospitals) actually buy/pay for their own coal, or do they receive an allocated amount from the government?

Is there a capital equipment budget for public facilities to buy new boilers?"

Response # 9:

These are all valid points. At this junction, we are not in a position to address them. However, we will plan to pay careful attention to them during Phase II.

Boris Petkov