ADB

Technical Assistance Consultant's Report

Project Number: 43079
September 2013

Mongolia: Updating the Energy Sector Development Plan

(Financed by the Japan Fund for Poverty Reduction)

Prepared by E. Gen Consultants Ltd. Bangladesh in association with MVV decon GmbH, Germany, and Mon-Energy Consult, Mongolia

For Ministry of Energy, Mongolia

Asian Development Bank

Updating Energy Sector Development Plan

Project Number: TA No. 7619-MON

FINAL REPORT

PART B: Volume - IV of X

HEAT FORECASTS

Prepared for

The Asian Development Bank

and

The Mongolian Ministry of Mineral Resources and Energy

Prepared by

e.Gen Consultants Ltd.

in association with

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ABBREVIATIONS

ADB	–	Asian Development Bank
BOO	–	Build-Own-Operate
BOT	–	Build-Operate-Transfer
CEE	–	Central Eastern Europe
CES	–	Central Energy System
CFB	–	Circulating Fluidized Bed
CHP	–	Combine Heat Power
COD	–	Commencement Operation Date
CO_2	–	Carbon Dioxide
CoUE	–	Cost of Un-Served Energy (Power)
CoUHE	–	Cost of Un-Served Heat Energy
FSU	–	Former Soviet Union
GDP	–	Gross Domestic Product
GHG	–	Greenhouse Gases
HOB	–	Heat Only Boilers
MOE	–	Ministry of Energy
MOF	–	Ministry of Finance
NDC	–	National Dispatch Center
NDIC	–	National Development and Innovation Committee
NOx	–	Nitrogen Oxides
NPV	–	Net Present Value
O&M	–	Operation and Maintenance
PIU	–	Project Implementation Unit
PM	–	Particulate Matters
PPP	–	Public Private Partnership
SOx	–	Sulfur Oxides
TOR	–	Terms of Reference
UB	–	Ulaanbaatar
UBCG	–	Ulaanbaatar City Government

UNITS OF MEASURE

BTU	-	British thermal unit
GCal	-	Gigacalorie (one million kilocalories)
GJ	-	Gigajoule (one thousand megajoules)
kJ	-	Kilojoule
kWh	-	Kilowatt-hour
MWh	-	Megawatt-hour
MWel	-	Megawatt electric
MWth	-	Megawatt thermal
PJ	-	Petajoule
TSC (TPU)	-	Tons of standard coal
TJ	-	Terajoule

WEIGHTS AND MEASURES

GW (giga watt)	–	1,000,000,000 calories
GJ (giga joules)	–	1,000,000,000 joules
GW (giga watt)	–	1,000,000,000 watts
kVA (kilovolt-ampere)	–	1,000 volt-amperes
kW (kilowatt)	–	1,000 watts
kWh (kilowatt-hour)	–	1,000 watts-hour
MW (megawatt)	–	1,000,000 watts
W (watt)	–	unit of active power

CONVERSION FACTORS

1 GCal	=	4.19 GJ
1 BTU	=	1.05506 kJ
1 Gcal	=	1.1615 MWh = 4.19 GJ = 1.75 steam tons/hour
1 GJ	=	0.278 MWh = 0.239 Gcal = 0.42 steam tons/hour
1 MW	=	0.86 Gcal = 3.6 GJ = 1.52 steam tons/hour
1 TSC	=	7 Gcal = 29.3 GJ = 8.15 MWh

NOTE

In this report, “$” refers to US dollars.

CONTENTS

I. INTRODUCTION

A. General

1. Mongolia's population depends largely on centralized heating systems as a matter of survival during the long and very cold Mongolian winters. As a consequence it is an imperative that the development of an Energy Masterplan addresses the security and availability of the supply of heat to the population.

2. Many small HOBs, independent boilers and water-heaters are used in the Mongolian countryside for space heating and domestic hot water production, and to provide steam to industry.

3. One of the challenges Mongolian energy policy makers face is what policy to adopt in relation to the heating systems servicing the urban centers of the Aimags, particularly where there is no significant industrial base on which steam supplies could justify ancillary heat and electricity supplies to the local community.

4. As a general observation, the ex-CEE/FSU countries have all struggled with the following questions:-

i. Which factors determine the choice of the economically preferred heating option from a set of options?

ii. Under which circumstances is District Heating, decentralized heating with natural gas, or another alternative the preferred option?

iii. How does the institutional environment have to change in order to foster cost-effective heat supply and demand?

5. This report provides an inventory of heat supply systems, including assets and historical asset performance, and heat demand forecasts as basic information needed to answer the above questions.

6. This report is important because provision of an adequate supply of heat and power may assist in stemming the rural drift from small towns to larger cities. Whilst other factors such as education and employment opportunities are significant factors, nevertheless adequate services are a part of the problem. Not only is this drift creating pressures on the larger cities to invest in the infrastructure needed to support a population that is growing due to migration, but in the long term such a drift is likely to hold back the economic development of Mongolia, particularly in the areas of agriculture, mining, forestry and eco-tourism as people leave the countryside.

B. Temperature Trends

7. Mongolia is a landlocked country, surrounded by high mountains with an average elevation of close to 1500m above sea level. The country forms a transition zone between the Great Siberian taiga and Central Asian desert. The climate is continental with long winters, short summers, high fluctuations in temperature, and low precipitation. Around 70-80% of annual precipitation falls in summer and there are a high number of clear sky days throughout the year.

8. Mongolia's winter are affected by extreme weather events known as Dzud. According to a reputable study[1], Dzuds have occurred everywhere in Mongolia as frequently as 1-2 times every 10 years from 1961-1990. These events often lead to high livestock mortality due to long lasting harsh winter, which directly affects the livelihoods of herders.

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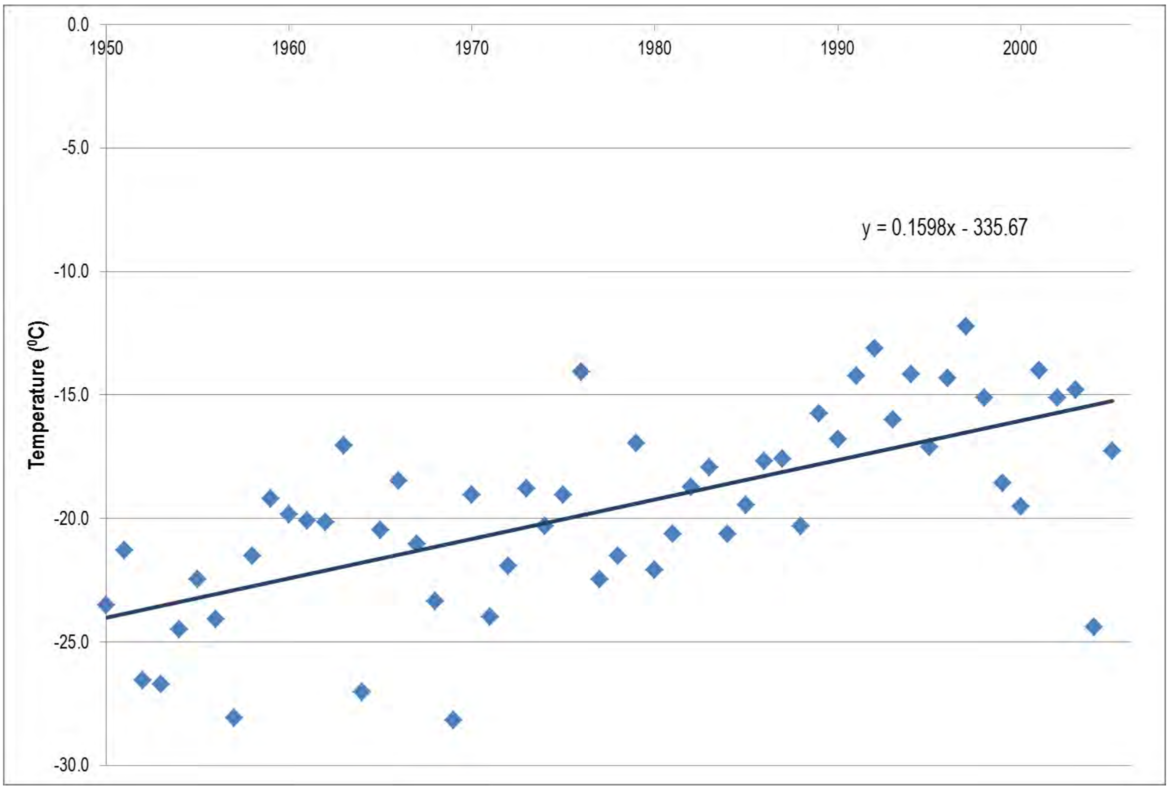
[1] *Vulnerability of Rural People to Extreme Climate Events in Mongolia, 2008; P. Gomboluudev*

9. Dzuds depend significantly on the conditions during the previous summer, and often follow a drought period. According to one study the frequencies of Dzud events in the North-Western and Eastern part of Mongolia are expected to increase in future due to climate change resulting in more drought periods. The significance of the Dzud events is that they offer a criterion against which heat demand needs to be considered. On the other hand, if the frequency and severity of Dzud events increase, it may lead to further migration of the rural population into town and city centres.

10. According to one study[2], the long term trend in temperature has been for the mean average February temperature to rise by 1^{0}C each year since 1950.

Figure I-1: Long-Term Temperature Change from 1950 to 2005



Sources: Vulnerability of Rural People to Extreme Climate Events in Mongolia, 2008; P. Gomboluudev

11. The impact of this rise in temperature on heating degree days (the difference between 18^{0}C and the ambient temperature) has been modelled using Monte Carlo analysis. The temperature is represented by quartiles as shown in **Table I-2**. The average mean February temperature is set to -29.7^{0}C.

Table I-2: Temperature Quartiles by Month

	Temperature		
	Min	Max	Average
Jan	-40.0	2.9	-36.1
Feb	-37.0	7.0	-29.7
Mar	-30.0	14.9	-17.2
Apr	-16.0	23.4	1.5

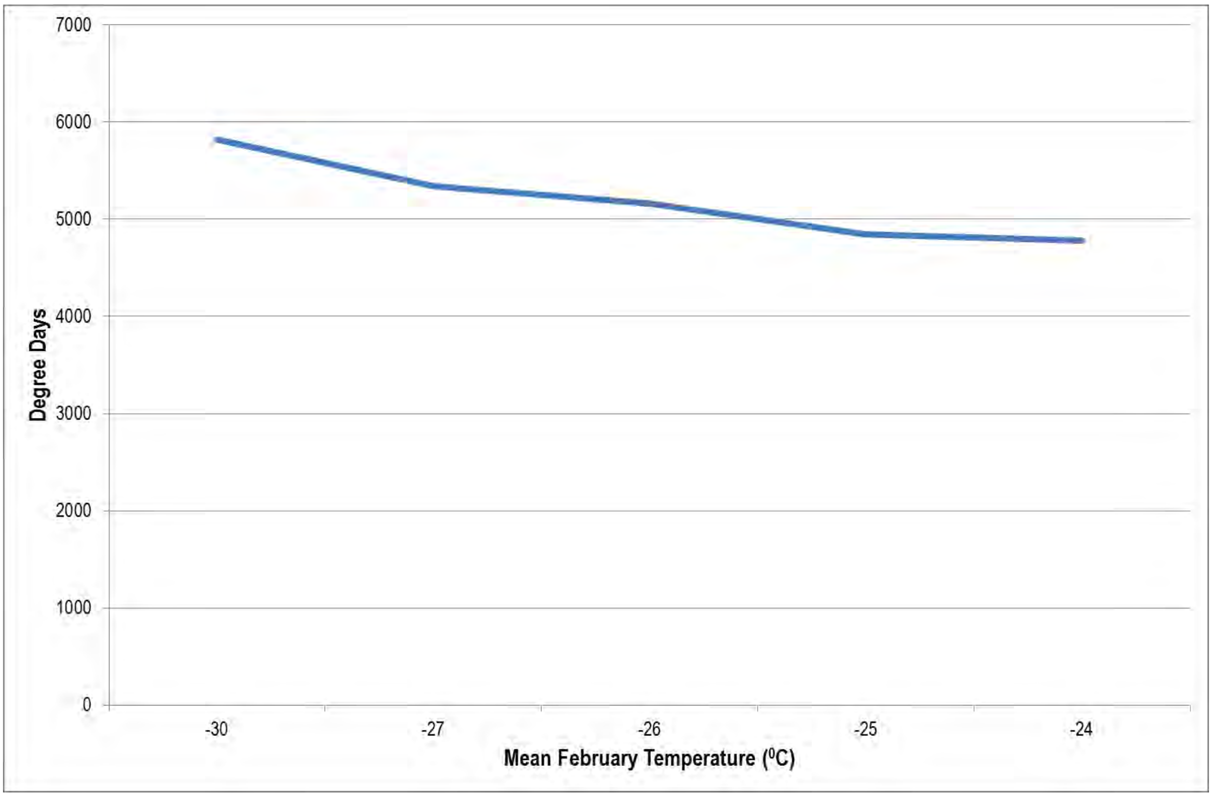
[2] *Diverging climate trends in Mongolian taiga forests influence growth and regeneration of Larix sibirica; Oecologia (2010) 163:1091–1102*

	Temperature		
	Min	Max	Average
May	-10.0	29.8	13.9
Jun	-1.0	32.5	22.9
Jul	3.0	34.1	27.2
Aug	0.0	32.8	23.4
Sep	-6.0	28.3	14.6
Oct	-16.0	21.2	6.3
Nov	-28.0	13.6	-0.3
Dec	-36.0	5.6	-11.0

Sources: Bureau of Meteorology

12. As the mean February temperature is raised the heating degree days reduce. The study of temperature trends suggests that this effect of this magnitude would be felt in Ulaanbaatar by 2020 if trends continue at the present rate.

Figure I-3: Degree Heating Days & Mean February Temperature



Sources: Consultants' estimate

13. According to another study[3], linear trend estimations of temperature and precipitation changes over the period from 1940 to 2007 (using data from 41 meteorological stations equally distributed over the country), saw annual temperature increase by only 2.1^{0}C, albeit with most of the increase taking place in winter (3.6^{0}C). Spring and fall temperature have increased by 1.8 and 1.9^{0}C respectively and summer temperature by 1.1^{0}C.

[3] *Vulnerability of Rural People to Extreme Climate Events in Mongolia, 2008; P. Gomboluudev*

14. The warming trend has been observed over the whole territory of Mongolia; however, there is weak intensity of this effect in the flat steppe and Gobi desert region, and high intensity in the high mountain and forest steppe region of the Western and Central part of Mongolia

15. In conclusion, it appears to be reasonable to base heat forecasts for Ulaanbaatar according to an expected rise of 1^0C per annum. In the countryside, heat forecasts should be based on Dzud extreme weather events according to the January temperatures experienced in recent years.

II. ULAANBAATAR HEAT SUPPLY

C. Summary

16. Heat forecasts have been developed for the central areas of UB city that can be supplied from the District Heating system.

17. Top-down and bottom-up forecasts were prepared. The bottom-up forecasts are considered to be robust as they compare well to JICA forecasts that were prepared in 2009. It is established that heat supply expansion should be based on the low growth scenario allowing a minimum reserve margin of 20 – 25% to cater for the possibility of realization of the medium growth scenario.

18. The heat supply system is currently a production system and so the 'sent-out' heat forecasts are summarized here, in tabular format.

Table II-1: UB City Heat Bottom-Up Forecasts (Sent Out)

	Low			Medium			High		
	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR
2013	5,369	1,576	1.5%	5,556	1,631	5.1%	5,743	1,686	8.6%
2014	5,548	1,629	3.3%	5,919	1,738	6.5%	6,290	1,847	9.5%
2015	5,732	1,683	3.3%	6,285	1,845	6.2%	6,839	2,008	8.7%
2016	5,922	1,739	3.3%	6,657	1,954	5.9%	7,392	2,170	8.1%
2017	6,119	1,797	3.3%	7,035	2,065	5.7%	7,950	2,334	7.6%
2018	6,323	1,856	3.3%	7,419	2,178	5.5%	8,515	2,500	7.1%
2019	6,533	1,918	3.3%	7,811	2,293	5.3%	9,088	2,668	6.7%
2020	6,750	1,982	3.3%	8,211	2,411	5.1%	9,671	2,839	6.4%
2021	6,974	2,048	3.3%	8,620	2,531	5.0%	10,265	3,014	6.1%
2022	7,206	2,116	3.3%	9,039	2,654	4.9%	10,871	3,192	5.9%
2023	7,446	2,186	3.3%	9,468	2,780	4.7%	11,490	3,373	5.7%
2024	7,693	2,259	3.3%	9,908	2,909	4.6%	12,122	3,559	5.5%
2025	7,949	2,334	3.3%	10,360	3,041	4.6%	12,770	3,749	5.3%
			3.3%			4.5%			5.5%

III. UB HEAT FORECASTING METHODOLOGY

D. Background

19. The heat demand of Ulaanbaatar has been the subject of studies by the Asian Development Bank (CHP5 TA), World Bank, JICA, the Ulaanbaatar Municipal City Government, the Mongolian Ministry of Energy and others.

20. Most of the studies have relied on the UB Municipal Government's forecasts of growth within the city. These forecasts are updated from time to time, and provide a basis for forecasting the total growth in heat demand as a function of demographics, i.e. the population growth and locations in which city development is expected. The location of anticipated growth is important as it determines the allocation of heat production, whether from CHP plants or HOBs.

21. This study of heat demand is also based on the UB Municipal Government's forecast of growth in heat demand. The drivers of heat consumption, namely population, floor space of apartments and volume of public/commercial buildings are used as a basis for projecting heat consumption. Hot water consumption relates to two end-use categories, those of hot tap water (HTW) and space heating. In addition heat is used by industrial consumers, in the form of hot water used for industrial processes, as well as steam.

22. Residential and commercial heat consumption can be described by empirical formulae, written in terms of area and volume heated, typically in GCal per cubic metre or equivalent. Hot tap water consumption is typically described in terms of kCal per person. The use of empirical formulae requires calibration of constants and parameters that characterize the behaviour of the population, and quality of the housing and commercial/public building stock. The calibration process is based on historical heat consumption statistics.

23. The heat forecasting process began with the collection of historical heat driver information to 2003.

24. The Ministry of Energy (Energy Regulatory Authority) undertook a heat consumption survey in 2009, which provided a useful breakdown of heat consumption by end-use category.

25. The UB District Heating Company provided population and household data, apartment floor space and commercial / public building volume data, suitable for use in calibrating the parameters in the empirical formulae.

26. Historical heat production data was provided by CHPs 2, 3 and 4, for years 2004 to 2010, and by the Ministry of Energy for years 2011 and 2012.

27. The UB Municipal Government provided a forecast of population growth and the location of the growth within the city for years 2009 to 2030. The growth was forecast for each District and sub-District within the city.

28. The second step in the forecasting process involved developing a top-down forecast based on regression of heat demand against the estimated GDP of UB city. A strong correlation was observed between these variables, supporting the use of a correlation formula to predict the future heat demand in line with anticipated economic growth of UB city.

29. The third step in the forecasting process involved developing a bottom-up forecast to validate the top-down forecast. Traditional low, medium and high growth heat forecasts were developed based on an end-use model. The residential demand (space heat and hot tap water), and commercial / public building demand forecasts were prepared using empirical formulae describing heat supply in terms of the drivers of heat consumption. The low forecast was based

on extrapolation of historical consumption driver trends over the last 10 years. The high forecast was based on the growth rates of the drivers predicted by the UB Municipal Government in 2009; the actual growth rates between 2009 and 2013 were lower than the municipal forecasts. The medium forecast was centred between the low and high forecast. The industrial heat consumption forecast was based on historical growth trends. Steam sales are small relative to the other categories and were forecast separately; the growth in steam sales was based on historical growth trends.

30. Consumption growth forecasts were prepared for individual consumer categories and aggregated. The modelling of heat demand revealed that suppressed demand is likely to be of the order of 6 to 8%.

IV. UB HEAT CONSUMPTION DATA

E. Ministry of Energy

31. The Ministry of Energy (formerly ERA) tabled a survey of heat consumption in 2011.

Table IV-1: Heat Consumption by Consumer Class (2011)

	Consumer Class	Heat Consumption Gcal	%	Gcal per hour
1	Industrial users and enterprises with heat meterig	1,021,527	29.80%	433
2	Heating for HH residential apartments	995,191	29.00%	495
3	Hot water use of HH	453,096	13.20%	287
4	Process hot water use	274,940	8.00%	117
5	Apartments with heat metering	249,655	7.30%	124
6	Organizations	246,077	7.20%	56
7	Others	188,857	5.50%	43
	TOTAL	3,429,344	100.00%	1,555

32. The survey provides a useful basis for reconciling the disaggregation of heat consumption by end-use category.

F. UB District Heating Company

33. The UB District Heating Company provided data related to residential and public/commercial space heat and hot water consumption.

34. The trends in the dataset were erratic in nature in some years. There were very marked swings in population, in the number of residential apartments and public buildings. Such changes seem not be compatible with a city experiencing steady growth. Furthermore a robust forecast requires that the heat consumption driver data is reasonably linear over time. Accordingly 'smoothing' adjustments have been made to the data, whilst preserving the data entries for 2013.

35. Smoothed heat driver data follows:-

Table IV-2: Smoothed Heat Driver Data

Year	Residential Population (thous.)	Residential Apartments (sq.metres)	Public / Commercial Buildings (cubic metres)
2003	213.7	23,108,961	2,456,248
2004	229.4	23,983,546	2,912,496
2005	237.1	24,858,131	3,368,744
2006	240.0	25,732,716	3,824,992

Year	Residential Population (thous.)	Residential Apartments (sq.metres)	Public / Commercial Buildings (cubic metres)
2007	243.0	26,607,302	4,281,240
2008	249.2	27,481,887	4,737,488
2009	255.5	28,356,472	5,193,736
2010	261.8	29,231,057	5,649,984
2011	277.0	30,105,643	6,106,232
2012	287.2	30,980,228	6,562,480
2013	291.6	31,854,813	7,018,728

G. UB Municipal Government

36. The UB Municipal Government provided growth forecasts by District, in terms of households requiring heat from the UB District Heating Network. The information was analysed and is provided as Appendix A. The Consultant has related the forecasts to UB city Districts and also allocated the additional heat demand to

37. Estimates have been made of the hot tap water, space heat and heat losses.

38. Steam production for use by industry was reported separately by the CHP's and was netted from the totals so that non-industrial consumer consumption could be forecast as a separate category.

H. CHP Production Data

39. The CHP operators provided heat production statistics for years 2004 to 2010. Steam production for use by industry was reported separately by the CHP's and was netted from the totals so that non-industrial consumer consumption could be forecast as a separate category. The CHP heat production statistics for the period 2004 to 2010 are provided as follows:-

Table IV-3: UB CHP Heat Production 2001 to 2010

		2001	2004	2005	2006	2007	2008	2009	2010
PP2									
Heat supply	Gcal	118	112	111	118	126	140	147	163
Steam	Gcal	2	6	5	4	9	9	9	14
Hot water	Gcal	116	105	107	114	117	131	138	150
PP3									
Heat supply	Gcal	1,260	1,412	1,469	1,301	1,495	1,683	1,703	1,802
Steam	Gcal	156	168	189	191	211	216	211	232
Hot water	Gcal	1,105	1,244	1,280	1,110	1,284	1,468	1,492	1,570
PP4									
Heat supply	Gcal	2,555	2,614	2,784	2,760	2,819	2,878	3,053	3,107
Steam	Gcal	93	80	85	81	95	95	106	112
Hot water	Gcal	2,462	2,535	2,699	2,679	2,724	2,783	2,947	2,994

40. The Ministry of Energy provided monthly heat production statistics, on gross and net basis, for CHP2, CHP3 and CHP4 for years 2011, and 2012. The statistics are as follows:-

Table IV-4: UB CHP 2011 Heat Production

	Power Plants			Quarter-1	Quarter-2	Half year	Quarter-3	Quarter-4	Annual
Heat	PP-2	Generated	Thous.Gkal	84.58	11.89	96.48	2.85	71.79	171.11
		supplied	Thous.Gkal	80.85	11.41	92.26	2.85	68.99	164.10
	PP-3	Generated	Thous.Gkal	778.27	239.39	1,017.66	123.87	733.53	1,875.05
		supplied	Thous.Gkal	768.68	237.77	1,006.45	121.20	720.20	1,847.84
	PP-4	Generated	Thous.Gkal	1,163.24	531.95	1,695.19	381.00	1,052.64	3,128.83
		supplied	Thous.Gkal	1,135.82	524.23	1,660.05	376.47	1,032.67	3,069.19
	DPP	Generated	Thous.Gkal	198.37	66.60	264.97	38.41	181.49	484.86
		supplied	Thous.Gkal	184.00	63.34	247.34	37.69	168.60	453.63
	EPP	Generated	Thous.Gkal	227.08	88.94	316.02	36.34	199.16	551.52
		supplied	Thous.Gkal	214.57	84.09	298.66	35.15	187.86	521.67
	system	Generated	Thous.Gkal	2,451.54	938.77	3,390.31	582.46	2,238.60	6,211.38
		supplied	Thous.Gkal	2,383.93	920.83	3,304.75	573.35	2,178.33	6,056.43

Table IV-5: UB CHP 2012 Heat Production

	Power Plants			Quarter-1	Quarter-2	Half year	Quarter-3	Quarter-4	Annual
Heat	PP-2	Generated	Thous.Gkal	79.03	19.05	98.08	1.85	74.91	174.83
		supplied	Thous.Gkal	74.85	18.35	93.20	1.85	72.04	167.09
	PP-3	Generated	Thous.Gkal	867.85	233.50	1,101.35	100.28	733.52	1,935.14
		supplied	Thous.Gkal	854.74	230.57	1,085.30	98.18	719.24	1,902.72
	PP-4	Generated	Thous.Gkal	1,249.95	522.88	1,772.82	384.3	1,129.11	3,286.21
		supplied	Thous.Gkal	1,227.94	508.87	1,736.81	378.40	1,102.45	3,217.67
	DPP	Generated	Thous.Gkal	210.55	63.13	273.68	34.09	178.66	486.43
		supplied	Thous.Gkal	196.14	61.17	257.31	33.06	168.64	459.01
	EPP	Generated	Thous.Gkal	224.12	81.67	305.79	51.62	195.45	552.87
		supplied	Thous.Gkal	209.11	76.89	286.00	49.50	185.95	521.45
	total	Generated	Thous.Gkal	2,631.50	920.22	3,551.72	572.1	2,311.66	6,435.49
		supplied	Thous.Gkal	2,562.78	895.85	3,458.63	560.99	2,248.32	6,267.93

V. UB HEAT CONSUMPTION DRIVER TRENDS

I. Empirical Heat Consumption Formulae

41. The historical growth in heat consumption has been used to calibrate a heat forecasting model. The model is based on formulae with empirically-derived constants modifying variables represented by heat consumption drivers[4]. Separate formulas exist for forecasting residential consumption of space heat and hot tap water, and for commercial / public building hot water consumption. Industrial consumption cannot be forecast using empirical formulae, and trend statistics are used to make predictions.

42. The empirical formula determine the thermal power units

43. The formula for residential heating consumption is

$B_{res} = c_1 . V^{5/6} . w. neta_k^{-1}$

Where

C_1 = an empirical constant determined as 0.0185,

V = volume of heated apartment space,

w = corrective factor determined empirically as 1.58, and

$neta_k$ = efficiency of 0.5 for boilers fired as solid fuel.

44. The formula for hot tap water consumption per household is

$B_{htw} = c_5 . n_m . neta_{cwu}^{-1}$

Where

C_5 = an empirical constant determined as 0.051,

n_m = number of persons per HH,

w = corrective factor determined empirically as 1.58, and

$neta_{cwu}$ = determined as 0.5 for solid-fuel hot tap water heating.

45. The formula for commercial building heat consumption is

$B_{comm/pub} = c_2 . V. neta_k^{-1}$

Where

C_2 = an empirical constant determined as 0.016,

V = volume of heated space, and

$neta_k$ = boiler efficiency determined as 0.7 for boilers fired with solid fuel.

46. The above formulae depend on forecasts of the drivers of heat consumption, specifically UB city population expected to take heat supply from the District Heating network, apartment heated volume and commercial / public building heated volumes. The following sections explain and summarize the forecasts of the heat drivers. The detailed heat driver forecasts are provided in Appendix B.

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[4] The empirical constants are derived in the medium heat forecast worksheet of the bottom-up heat model

J. Population Growth

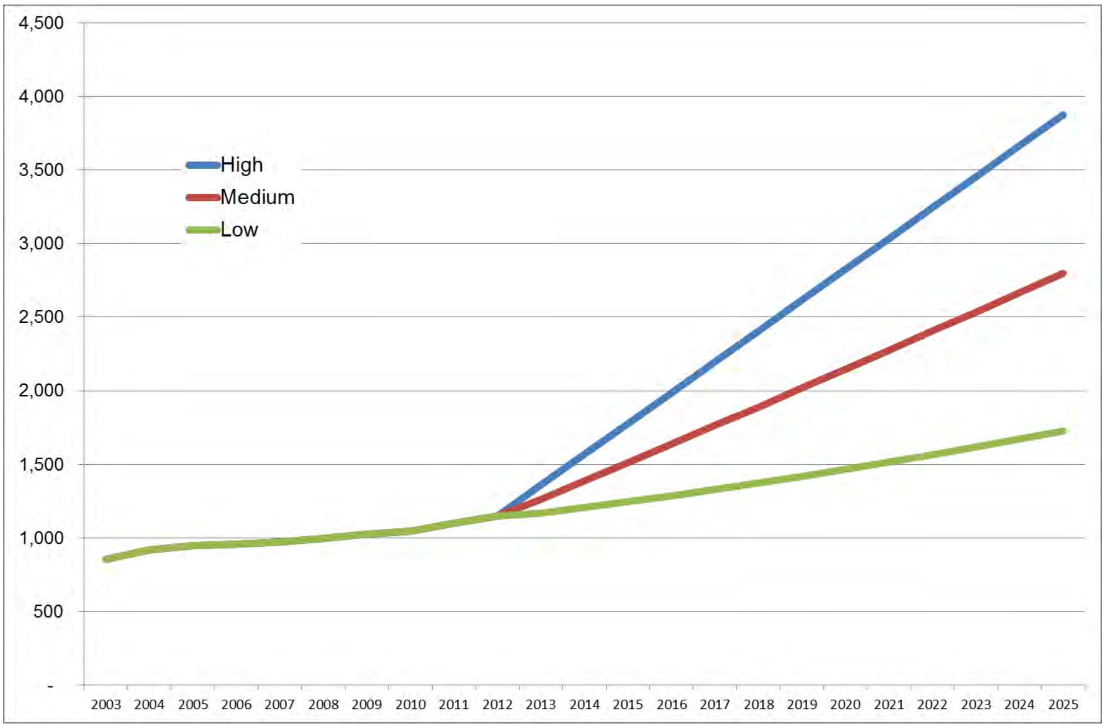
47. The UB city population is expected to continue to grow with movement of the rural population to the major city centres.

48. In 2009, the UB Municipal Government forecast the UB city population growth to double by around 2015.

49. The growth forecast based on the population trend of the last five years, to 2013, would see a doubling of the population by around 2030.

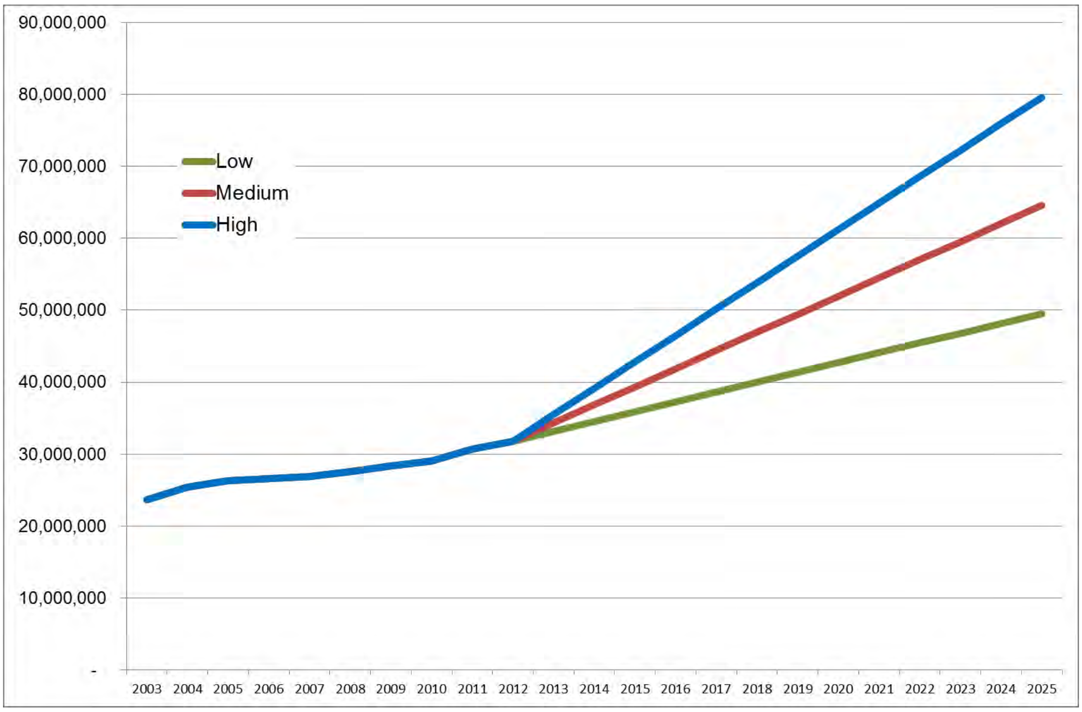
50. Table V-1 shows a UB city population forecast where the low forecast is based on recent trends, the high forecast is based on the UB Municipal Government expectation in 2009, and the medium forecast falls between the low and high forecast.

Table V-1: UB City Forecast Population Growth ('000s)



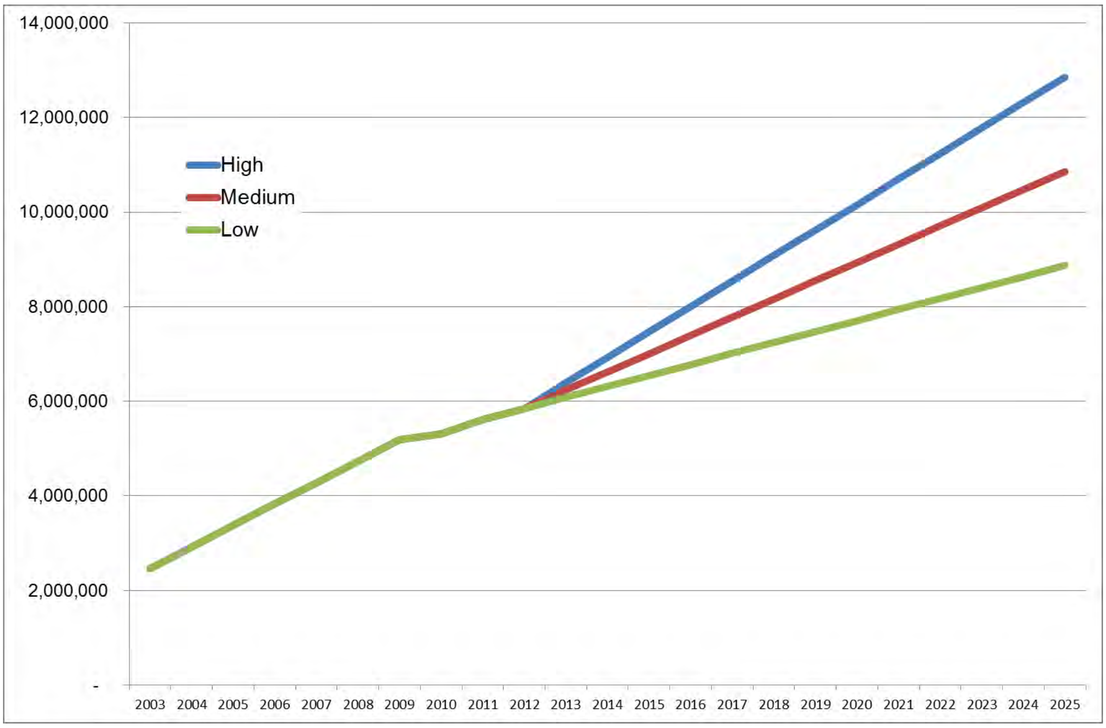
51. The growth in apartments is forecast similarly to that of population. The low growth scenario is based on recent trends. The high growth scenario is based on the UB Municipal Government's 2009 forecast, and the medium growth scenario falls between these scenarios.

Table V-2: Growth in Apartment Heated Area (square meters)



52. The growth in the heated volume of commercial / public buildings is forecast to maintain a volume relative to the growth in heated apartments.

Table V-3: Growth in Commercial / Public Buildings (cubic meters)



K. Ger Areas Surrounding UB

53. The cost of additional pipeline infrastructure needed for connecting all Ger area households to the District Heating network would be high. Where Ger areas are located in hilly areas above the Ulaanbaatar plateau, to maintain an adequate District Heating hydraulic regime would involve costly pressure boosting stations or may not be feasible at all.

54. Heat losses would also be high because there would be many distribution pipelines running outside from house to house.

55. It would not be cost effective to meter the heat consumption of an individual Ger; an equitable charging regime would be difficult, e.g. if one Ger was well-insulated compared to another.

56. Management of the DH system is already a complex undertaking and Ger-area heating load would result in additional complexity, perhaps compromising the heating supply to the city centre.

57. The cost of heating with electricity would be prohibitive, due the intensity of the heat load during the long winter months. The cost of heat supplied by electricity, borne by a Ger resident, has been estimated by the World Bank to be two to three times as high as the cost of heat supplied by a coal-burning stove. Unless the income of Ger residents was to rise sharply, the willingness to pay for heat supplied by electricity is considered to be low.

58. A World Bank study of heating in the peri-urban areas of Ulaanbaatar, examined the use of high-efficiency coal burning stoves for heating, and Ger insulation has been investigated. These approaches reduce coal consumption and emissions and appear to offer the only realistic solution to improved efficiency and reduced environmental impact of Ger area heating. The only alternative means to improve Ulaanbaatar's air quality would be to enact a city zoning strategy that would see Ger residents re-located to more remote areas.

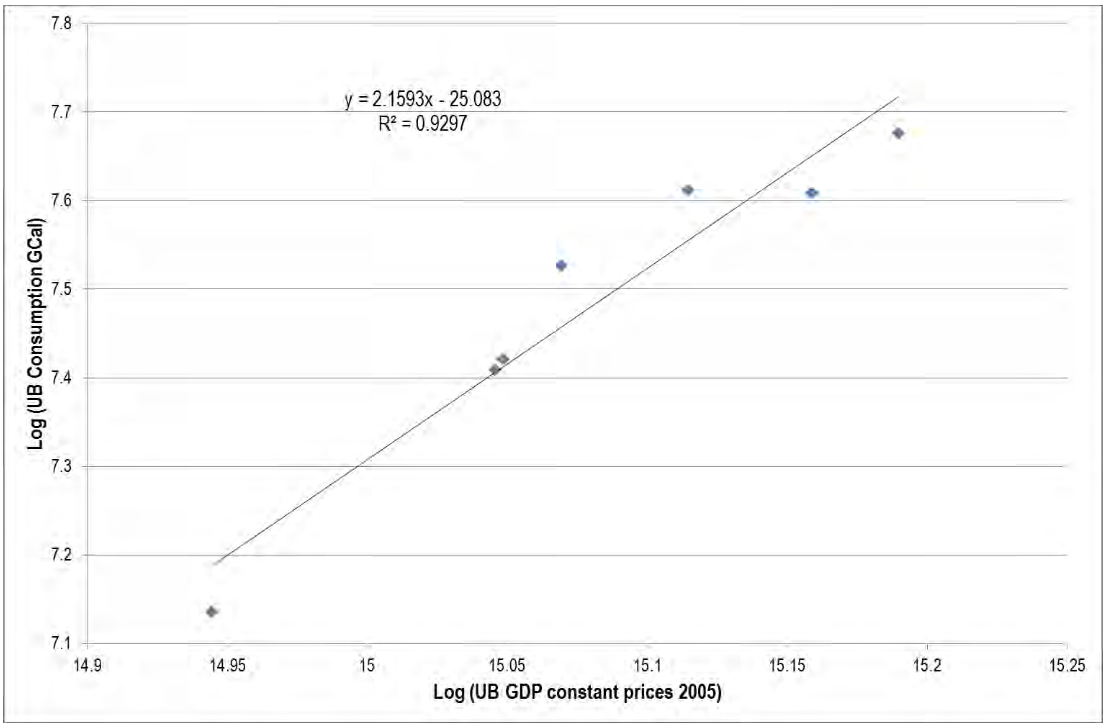
59. In conclusion it is not realistic to plan for the heating company to connect Ger households in the areas surrounding Ulaanbaatar to the DH network.

VI. ULAANBAATAR HEAT FORECASTS

L. Top-Down Forecast

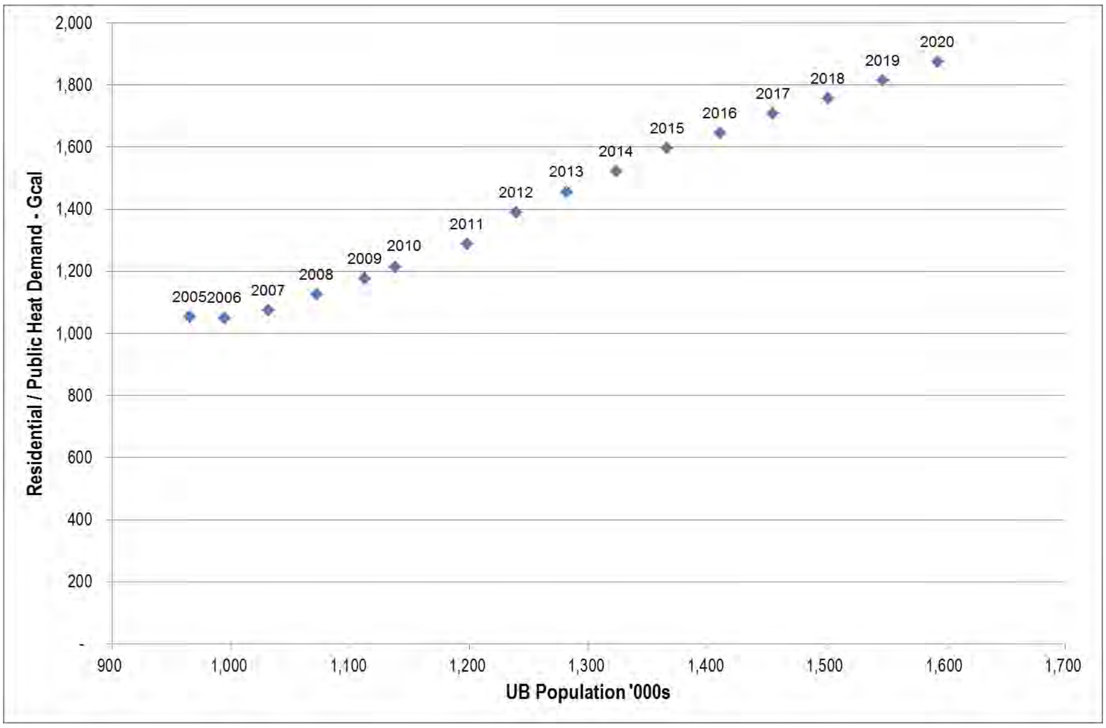
60. Historical heat consumption of Ulaanbaatar city is regressed against estimated GDP of the city, on logarithmic base, showing a high correlation of 0.93. This relationship is therefore useful for city heat forecasting.

Table VI-1: Correlation Heat Consumption vs. GDP



61. Using the regression relationship to forecast heat consumption, and converting to heat demand, results in the heat demand forecast plotted as a function of the UB city population as shown in Figure VI-2.

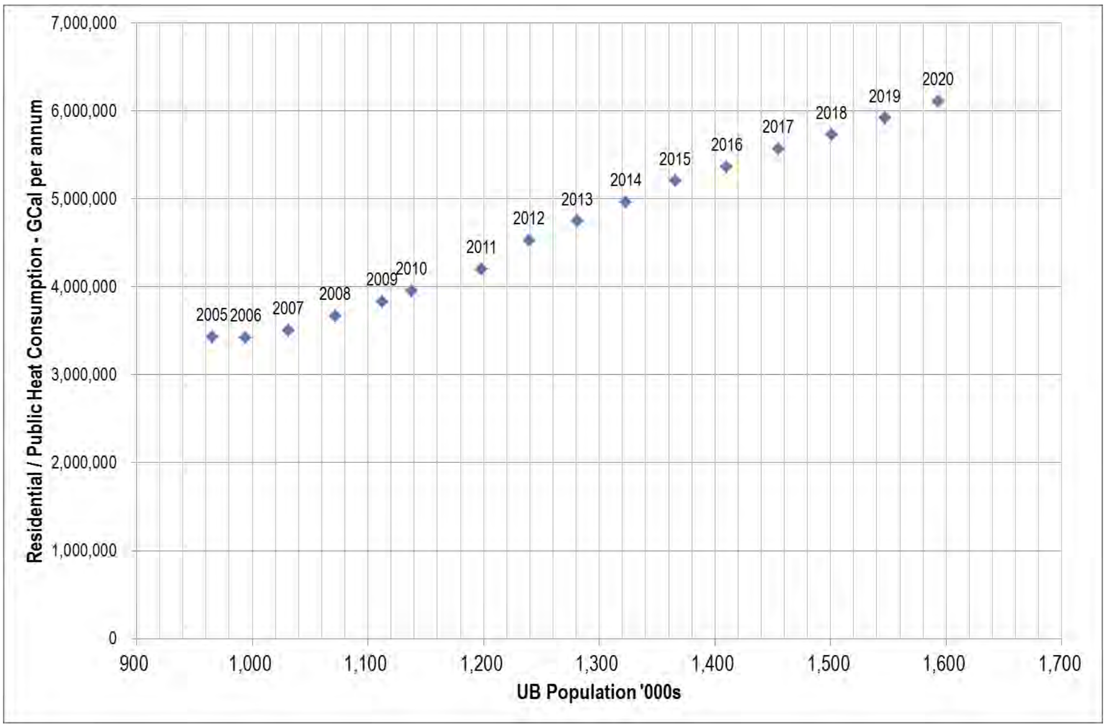
Figure VI-2: UB City Demand Forecast (GCal/h)



62. The city heat demand is forecast to rise to around 1,900 GCal/h by 2020.

63. The corresponding consumption forecast, as a function of UB city population, follows:-

Figure VI-3: UB City Consumption Forecast (GCal)



64. The total UB heat load produced by the CHPs in 2009 has been reported by MoE to be around 1,555 GCal/h, including station losses.

65. Figure VI-2 plots heat demand as hot water produced minus losses, which is equivalent to consumer space heat and hot tap water demand. The regression method estimates heat demand in 2020 at 1,860 GCal/h. Adding production and delivery losses of 18% increases the forecast to 2,190 GCal/h.

66. In 2009, the Ministry of Energy predicted a total UB heat load of 2,555 GCal/h by 2020. JICA predicted a total UB heat load of around 2,300 GCal/h by 2020. Both forecasts are higher than a forecast based on top-down regression. However, the top-down forecast may be understated if there has been ‘suppressed’ demand at any time; suppressed demand will not be reflected in the regression formula.

67. To reduce forecasting uncertainty, the top-down forecast is validated by a bottom-up heat forecast based on the trend in drivers of heat consumption. A bottom-up forecast has been prepared and follows in the next section of this report.

M. Bottom-Up Forecast

68. The bottom-up forecast is based on the empirical formulae described in Section IV of this report. The bottom-up forecasting model is provided as Appendix B.

69. The heat forecast is formulated according to low, medium and high growth scenarios. The low scenario is based on growth in the heat consumption drivers according to trends over the last decade, including recent high growth. This low scenario does not capture suppressed demand. The high growth scenario is based on the growth trends predicted by the UB Municipal Government in 2009, which have proven to be optimistic in the preceding years to 2012. The medium growth scenario falls mid-way between the low and high growth scenarios.

70. The consumption forecasts are provided in tabular form:-

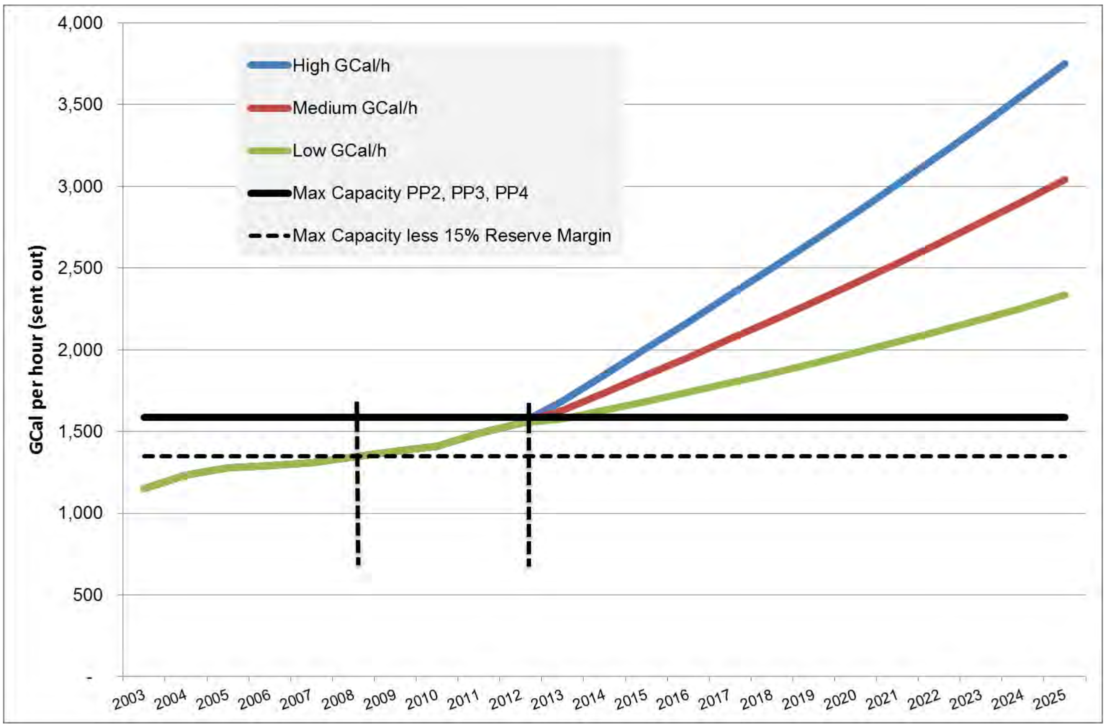
Table VI-4: UB City Heat Bottom-Up Forecasts (Sent Out)

	Low			Medium			High		
	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR
2003	3,920	1,151		3,920	1,151		3,920	1,151	
2004	4,208	1,235	7.3%	4,208	1,235	7.3%	4,208	1,235	7.3%
2005	4,349	1,277	3.4%	4,349	1,277	3.4%	4,349	1,277	3.4%
2006	4,403	1,293	1.2%	4,403	1,293	1.2%	4,403	1,293	1.2%
2007	4,458	1,309	1.2%	4,458	1,309	1.2%	4,458	1,309	1.2%
2008	4,572	1,342	2.6%	4,572	1,342	2.6%	4,572	1,342	2.6%
2009	4,696	1,379	2.7%	4,696	1,379	2.7%	4,696	1,379	2.7%
2010	4,802	1,410	2.3%	4,802	1,410	2.3%	4,802	1,410	2.3%
2011	5,081	1,492	5.8%	5,081	1,492	5.8%	5,081	1,492	5.8%
2012	5,288	1,552	4.1%	5,288	1,552	4.1%	5,288	1,552	4.1%
2013	5,369	1,576	1.5%	5,556	1,631	5.1%	5,743	1,686	8.6%
2014	5,548	1,629	3.3%	5,919	1,738	6.5%	6,290	1,847	9.5%
2015	5,732	1,683	3.3%	6,285	1,845	6.2%	6,839	2,008	8.7%
2016	5,922	1,739	3.3%	6,657	1,954	5.9%	7,392	2,170	8.1%
2017	6,119	1,797	3.3%	7,035	2,065	5.7%	7,950	2,334	7.6%
2018	6,323	1,856	3.3%	7,419	2,178	5.5%	8,515	2,500	7.1%

	Low			Medium			High		
	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR	kGcal	Gcal/h	CAGR
2019	6,533	1,918	3.3%	7,811	2,293	5.3%	9,088	2,668	6.7%
2020	6,750	1,982	3.3%	8,211	2,411	5.1%	9,671	2,839	6.4%
2021	6,974	2,048	3.3%	8,620	2,531	5.0%	10,265	3,014	6.1%
2022	7,206	2,116	3.3%	9,039	2,654	4.9%	10,871	3,192	5.9%
2023	7,446	2,186	3.3%	9,468	2,780	4.7%	11,490	3,373	5.7%
2024	7,693	2,259	3.3%	9,908	2,909	4.6%	12,122	3,559	5.5%
2025	7,949	2,334	3.3%	10,360	3,041	4.6%	12,770	3,749	5.3%
			3.3%			4.5%			5.5%

71. The consumption forecast is charted as follows:-

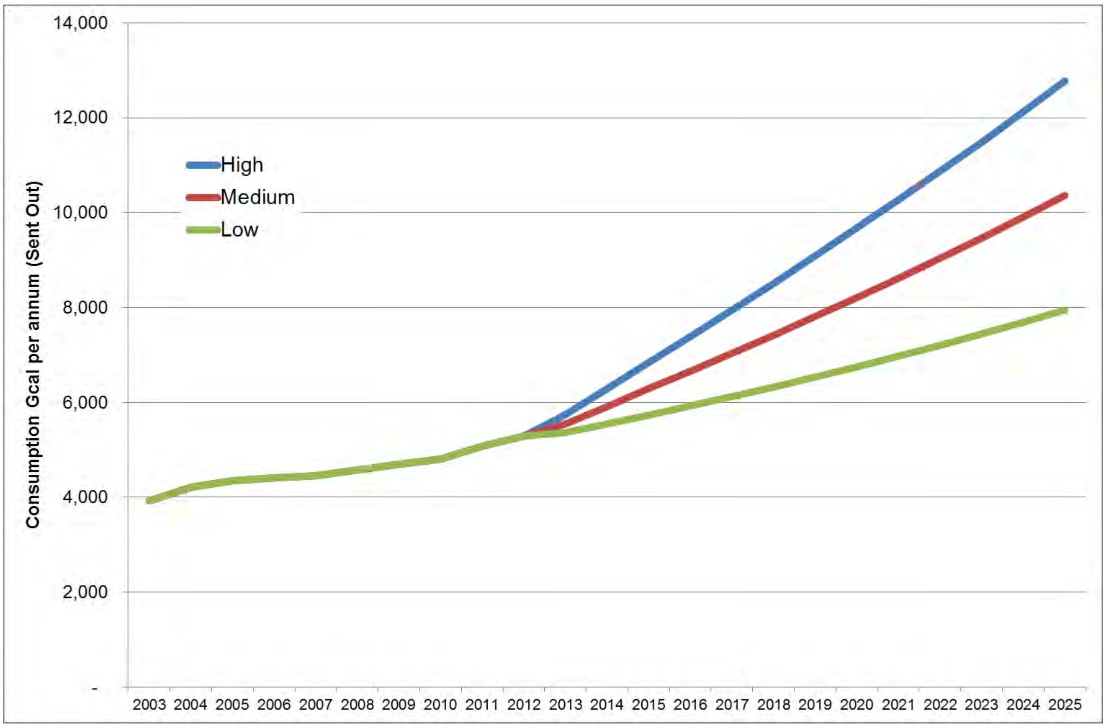
Figure VI-5: UB City Sent Out Demand Forecast (GCal/h)



72. The bottom-up forecast shows that the reserve margin (15%) was passed in 2008, and there is no spare capacity in the heating system in 2012. This result is worsened by adding station heat loss of 2 – 3%.

73. The consumption forecast is charted in Figure VI-6.

Figure VI-6: UB City Consumption Forecast (GCal per annum)



N. Reconciliation of Top-Down & Bottom-Up Forecasts

74. The top-down Gcal/h sent out demand forecast is compared to the bottom-up forecast for 2020.

Table VI-7: Reconciliation

	Bottom-Up			
	Low	Medium	High	Top Down
	Gcal/h	Gcal/h	Gcal/h	Gcal/h
2020	1,982	2,411	2,839	1,860
	Base reference	+22%	+40%	

75. The top-down forecast is 7% lower than the bottom-up low forecast, which can be explained by the influence of suppressed demand.

76. The medium forecast falls between the JICA forecast of 2,300 GCal/h prepared in 2009, but lower than the UB Municipal City Government forecast of 2,555 GCal/h of 2009.

77. The high forecast is the least likely scenario forecast at 40% higher than the low case. It is considered that the bottom-up low forecast should be adopted for the purpose of heat supply expansion planning, and the possibility of the medium growth scenario should be addressed by maintaining a heat reserve margin of 20 – 25%.

VII. MAJOR POPULATION CENTRES

A. Background

78. The Consultant has prepared a heat forecast for the major centres of Erdenet, Darkhan, Choibalsan, Dalanzadgad, Baganuur, Nailakh and Bagakhangai.

B. Erdenet

79. Erdenet (Mongolian: Эрдэнэт, literally "with treasure") is the second-largest city in Mongolia and the capital of the aimag (province) of Orkhon.

80. Located in the northern part of the country, it lies in a valley between the Selenge and Orkhon rivers about 150 miles (240 km) (as the bird flies) northwest of Ulan Bator, the capital.

81. The city was built in 1974 to exploit Asia's largest deposit of copper ore and has the fourth largest copper mine in the world. The "Erdenet Mining Corporation" is a joint Mongolian-Russian venture, and accounts for a majority of Mongolia's hard currency income, nothwithstanding the impact of Oyu Tolgoi. Erdenet mines 22 million tons of ore per year, producing 126,700 tons of copper and 1,954 tons of molybdenum. About 8.000 people are employed in the mine.

82. The town is supplied with heat produced by the Erdenet Power Plant. The plant was established in years 1984 to 1990. First boiler firing was held on 30 December, 1986 and first turbine operation put in to operation 27 September 1987.

83. The main equipment of Erdenet Power Plant are 7 units of boilers, model BKZ-75-39, 1 turbine PT-12-35/10, 2 units of backpressure turbines model R-12-235/6 and 3 sets of generators type of T-12-2UZ.

1. Demand for Heat

84. The number of households taking heat supply in 2012 is reported to be around 26,000.

85. The Consultant has modelled the heat demand for Erdenet based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation.

Table VII-1: Erdenet - Heat Demand

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	57,040	22,548	2516.2	1.5%	415,169	151.4
2005	57,729	22,863	2551.4	1.4%	420,706	153.4
2006	58,378	23,161	2584.6	1.3%	425,919	155.3
2007	59,541	23,164	2597.3	0.5%	428,831	156.2
2008	62,180	23,743	2647.5	1.9%	435,636	158.9
2009	64,360	23,981	2674.0	1.0%	439,793	160.5
2010	69,343	24,220	2700.7	1.0%	443,980	162.0

Year	Urban Pop'n No.	HH's with heat No.	District Heat Area sq km	Growth Rate %	Annual Heat Consumption GCal	Maximum Demand GCal/h
2011	72,737	24,947	2781.7	3.0%	456,667	166.7
2012	76,213	25,695	2865.2	3.0%	469,726	171.5
2013	79,770	26,466	2951.1	3.0%	483,160	176.4
2014	83,408	27,260	3039.7	3.0%	496,976	181.5
2015	87,127	28,078	3130.9	3.0%	511,198	186.8
2020	106,939	37,036	3,630	3.2%	560,604	212

Sources: Licensees, EA data & Consultants' estimate

86. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table VII-2: Erdenet – Heat Model (Per Annum)

Year	Urban Population with heat	Apartments m^2	Public Buildings m^3	Residential Space Heat PJ	Public Buildings Heat PJ	Residential Hot Tap Water PJ	Total GCal	Per person GCal
2012	102,781	1,719,107	3,209,000	0.546	1.115	0.307	469,726	4.57

Sources: Licensees, EA data & Consultants' estimate

2. Heat Model

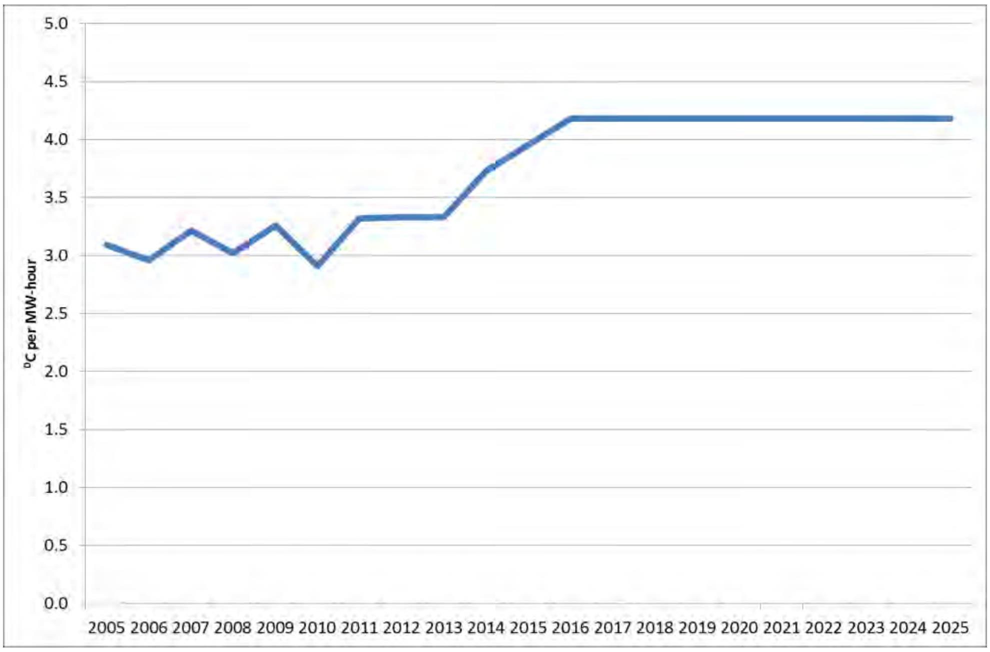
87. The heat driver statistics and heat model outputs are tabled as Table VII-4 and Table VII-5 respectively.

3. Validation of Demand Forecast for Heat

88. The Consultant's heat model has been calibrated to the sent-out heat production reported by the Erdenet Power Plant. The Consultant considers the heat forecast to fall within the normal range of accuracy for heat planning purposes.

89. A heat production model was also developed based on heating degree hours for the purpose of estimating the heat production and associated available power for each hour of each year of the planning horizon, from 2013 to 2025. The estimated heat production statistics and forecast is tabled as Table VII-6 and Table VII-7.

Figure VII-3: Erdenet Heat Consumption Indicator



Sources: Consultants' estimate

Table VII-4: Erdenet – Heat Driver Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	1,486	-	2,780	-	2,479	-
2004	57.0	-	22.5	1,509	1.5%	2,822	1.5%	2,516	1.5%
2005	57.7	1.2%	22.9	1,530	1.4%	2,861	1.4%	2,551	1.4%
2006	58.4	1.1%	23.2	1,550	1.3%	2,898	1.3%	2,585	1.3%
2007	59.5	2.0%	23.2	1,550	0.5%	2,933	1.2%	2,597	0.5%
2008	62.2	4.4%	23.7	1,589	1.9%	2,965	1.1%	2,648	1.9%
2009	64.4	3.5%	24.0	1,604	1.0%	2,995	1.0%	2,674	1.0%
2010	69.3	7.7%	24.2	1,620	1.0%	3,025	1.0%	2,701	1.0%
Average 2003 - 2010	-	3.3%	-	-	1.2%	-	1.2%	-	1.2%
Forecast									
2011	72.7	4.9%	24.9	1,669	3.0%	3,116	3.0%	2,782	3.0%
2012	76.2	4.8%	25.7	1,719	3.0%	3,209	1.0%	2,865	3.0%
2013	79.8	4.7%	26.5	1,771	3.0%	3,305	1.1%	2,951	3.0%
2014	83.4	4.6%	27.3	1,824	3.0%	3,404	1.1%	3,040	3.0%
2015	87.1	4.5%	28.1	1,879	3.0%	3,507	1.1%	3,131	3.0%
Average 2011 - 2015	-	4.7%	26.5	-	3.0%	-	1.5%	-	3.0%
2015	87.1	0.1%	28.1	1,879	3.0%	3,507	1.1%	3,131	3.0%
2020	106.9	0.5%	37.0	1,998	6.4%	3,705	1.5%	3,630	15.9%
2025	-	-	-	2,126	6.4%	3,914	1.5%	4,208	15.9%

Sources: Consultants' estimate

Table VII-5: Erdenet 'End-Use' Empirical Heat Supply Model Output

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	90,191	3,771,339	2,821,500	116,894	233,945	64,331	350,839	415,169	105.47	45.90
2005	91,453	3,824,107	2,861,000	118,255	237,220	65,231	355,475	420,706	106.86	46.54
2006	92,642	3,873,839	2,898,200	119,535	240,305	66,079	359,840	425,919	108.18	47.15
2007	92,657	3,874,464	2,933,000	119,552	243,190	66,090	362,742	428,831	109.05	47.15
2008	94,972	3,971,250	2,965,200	122,035	245,860	67,741	367,895	435,636	110.60	48.33
2009	95,922	4,010,982	2,994,900	123,052	248,322	68,418	371,374	439,793	111.64	48.81
2010	96,881	4,051,071	3,024,800	124,076	250,802	69,102	374,877	443,980	112.70	49.30
2011	99,787	4,172,589	3,115,500	127,170	258,322	71,175	385,492	456,667	115.89	50.78
2012	102,781	4,297,768	3,209,000	130,341	266,075	73,310	396,416	469,726	119.17	52.30
2013	105,864	4,426,696	3,305,300	133,591	274,059	75,510	407,651	483,160	122.55	53.87
2014	109,041	4,559,554	3,404,400	136,924	282,276	77,776	419,201	496,976	126.02	55.49
2015	112,312	4,696,339	3,506,600	140,339	290,750	80,109	431,089	511,198	129.60	57.16
2020	148,144	4,995,997	3,704,697	147,762	307,175	105,666	454,938	560,604	136.77	75.39

Sources: Consultants' estimate

Table VII-6: Erdenet CHP – Heat Production Estimates (2004 – 2014)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Station Losses	%		4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%		3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%		15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C					-33C	-33C	-38C	-38C			
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%		5%	5%	5%	5%	5%	5%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours	0.0	3.1	3.0	3.2	3.0	3.3	2.9	3.3	3.3	3.3	3.7
HCI Growth	%			-4.3%	8.6%	-6.0%	8.0%	-10.7%	14.1%	0.4%	-0.1%	12.2%
Average	%							-0.9%				
Space Heat	MWh	-	544,480	520,857	565,534	531,315	573,818	512,100	584,077	586,273	585,944	657,307
Hot Tap Water	MWh		29,207	28,916	31,706	30,182	32,020	29,741	34,639	34,769	34,749	38,981
Station Losses	MWh	-	24,095	23,090	25,084	23,583	25,445	22,757	25,986	26,084	26,069	29,244
Pipe Losses	MWh	-	96,331	95,458	104,694	99,692	105,716	86,366	97,897	98,246	98,194	109,533
Steam	MWh	-	66,461	84,007	97,694	100,018	95,963	32,913	32,913	32,913	32,913	32,913
Steam Losses	MWh	-	2,060	2,604	3,029	3,101	2,975	1,020	1,020	1,020	1,020	1,020
Steam Consumption	MWh	-	64,400	81,403	94,665	96,917	92,988	31,893	31,893	31,893	31,893	31,893
Station Gate Production	MWh	-	642,208	636,385	697,963	664,615	704,776	575,775	652,649	654,975	654,626	730,221
Total Production (incl losses)	MWh	-	666,303	659,475	723,047	688,198	730,221	598,532	678,635	681,059	680,695	759,465

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Household Consumption	MWh	-	545,877	540,927	593,268	564,923	599,060	489,409	554,752	556,729	556,432	620,688
ERA Heat supply	Gcal	-	550	545	598	569	603	561	560	562	562	627
Steam	Gcal		57.1	72.2	84.0	86.0	82.5	28.3	28.3	28.3	28.3	28.3
Hot water	Gcal		493	473	514	483	521	466	532	534	534	599
ERA Heat supply	GWh	-	640	634	695	662	702	652	652	654	654	729
Steam	GWh	-	66.5	84.0	97.7	100.0	96.0	32.9	32.9	32.9	32.9	32.9
Hot water	GWh	-	574	550	597	561	606	542	619	621	621	696
Hours of Operation	Count	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Load Factor	LF	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Peak Demand	MWth	-	209.7	207.6	227.6	216.7	229.9	213.5	213.5	214.2	214.1	238.9
Hot Tap Water	%		5.4%	5.6%	5.6%	5.7%	5.6%	5.8%	5.6%	5.6%	5.6%	5.6%
Average	%							5.6%				
Space Heat	%			-4.3%	8.6%	-6.1%	8.0%	-10.8%	-0.9%	-0.9%	-0.9%	-0.9%
Average	%							-0.9%				
Steam Load Growth	%			26.4%	16.3%	2.4%	-4.1%	-65.7%	0.0%	0.0%	0.0%	0.0%
Average	%							0.0%				

Sources: Consultants' estimate

Table VII-7: Erdenet CHP – Heat Production Estimates (2015 – 2025)

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C											
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours	4.0	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
HCI Growth	%	5.9%	5.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	%											
Space Heat	MWh	695,843	736,574	736,574	736,574	736,574	736,574	736,574	736,574	736,574	736,574	736,574
Hot Tap Water	MWh	41,267	43,682	43,682	43,682	43,682	43,682	43,682	43,682	43,682	43,682	43,682
Station Losses	MWh	30,959	32,771	32,771	32,771	32,771	32,771	32,771	32,771	32,771	32,771	32,771
Pipe Losses	MWh	115,656	122,128	122,128	122,128	122,128	122,128	122,128	122,128	122,128	122,128	122,128
Steam	MWh	32,913	32,913	32,913	32,913	32,913	32,913	32,913	32,913	32,913	32,913	32,913
Steam Losses	MWh	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020
Steam Consumption	MWh	31,893	31,893	31,893	31,893	31,893	31,893	31,893	31,893	31,893	31,893	31,893
Station Gate Production	MWh	771,043	814,190	814,190	814,190	814,190	814,190	814,190	814,190	814,190	814,190	814,190
Total Production (incl losses)	MWh	802,001	846,961	846,961	846,961	846,961	846,961	846,961	846,961	846,961	846,961	846,961

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Household Consumption	MWh	655,386	692,061	692,061	692,061	692,061	692,061	692,061	692,061	692,061	692,061	692,061
ERA Heat supply	Gcal	662	699	699	699	699	699	699	699	699	699	699
Steam	Gcal	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3
Hot water	Gcal	634	671	671	671	671	671	671	671	671	671	671
ERA Heat supply	GWh	770	813	813	813	813	813	813	813	813	813	813
Steam	GWh	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9
Hot water	GWh	737	780	780	780	780	780	780	780	780	780	780
Hours of Operation	Count	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Load Factor	LF	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Peak Demand	MWth	252.2	266.4	266.4	266.4	**266.4**	266.4	266.4	266.4	266.4	266.4	266.4
Hot Tap Water	%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%	5.6%
Average	%											
Space Heat	%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
Average	%											
Steam Load Growth	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	%											

Sources: Consultants' estimate

C. Darkhan

90. Darkhan is Mongolia's third largest city.

91. The city is a mostly industrial region and is the home of some 82% of the aimag's population. Some 86% of the city's population live in residential apartments, with the remaining population living in yurts (gers) on the outskirts of the city.

92. The city is home to the Darkhan steel smelter.

93. The town is supplied with heat produced by the Darkhan Power Plant. Darkhan Power Plant was established in 1965 and first boilers BKZ-75-39PhB started on 8 May 1965. After that three boilers 75 t/h of steam generation capacity each installed in years 1985 to 1987. The type and model of main equipment of Darkhan Power Plant are same as low pressure side of Power Plant #3. Darkhan Power Plant has 9 boilers of model BKZ-75-39 and four turbines, each with 12 MW capacity. Installed electricity generation capacity is 48 MW, heat supply capacity is 349 Gcal/h.

4. Demand for Heat

94. The number of households taking heat supply in 2012 is reported to be around 18,000.

95. The Consultant has modelled the heat demand for Darkhan based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation.

Table VII-8: Darkhan - Heat Demand

	Urban Pop'n	**HH's with heat**	**District Heat Area**	**Growth Rate**	**Annual Heat Consumption**	**Maximum Demand**
Year	**No.**	**No.**	**sq km**	**%**	**GCal**	**GCal/h**
2004	61,990	15,623	2276.0	1.5%	419,620	134.8
2005	63,376	16,842	2375.4	4.4%	433,027	140.3
2006	62,858	16,941	2396.7	0.9%	437,171	141.5
2007	63,385	17,065	2409.2	0.5%	439,091	142.2
2008	63,868	17,089	2425.0	0.7%	442,565	143.2
2009	65,691	17,093	2443.0	0.7%	446,715	144.3
2010	66,403	17,176	2455.2	0.5%	448,886	145.0
2011	67,734	17,663	2514.3	2.4%	458,719	148.3
2012	69,079	18,162	2574.8	2.4%	468,757	151.7
2013	70,436	18,673	2636.7	2.4%	479,004	155.2
2014	71,807	19,196	2699.9	2.4%	489,465	158.8
2015	73,191	19,733	2764.6	2.4%	500,143	162.5
2020	22,510	3112.1	2.5%	556,790	181.8	22,510

Sources: Licensees, EA data & Consultants' estimate

96. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table VII-9: Darkhan – Heat Model (Per Annum)

Year	Urban Population with heat	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	90,808	1,271,309	3,649,827	0.425	1.268	0.271	468,757	5.16

Sources: Licensees, EA data & Consultants' estimate

5. Heat Model

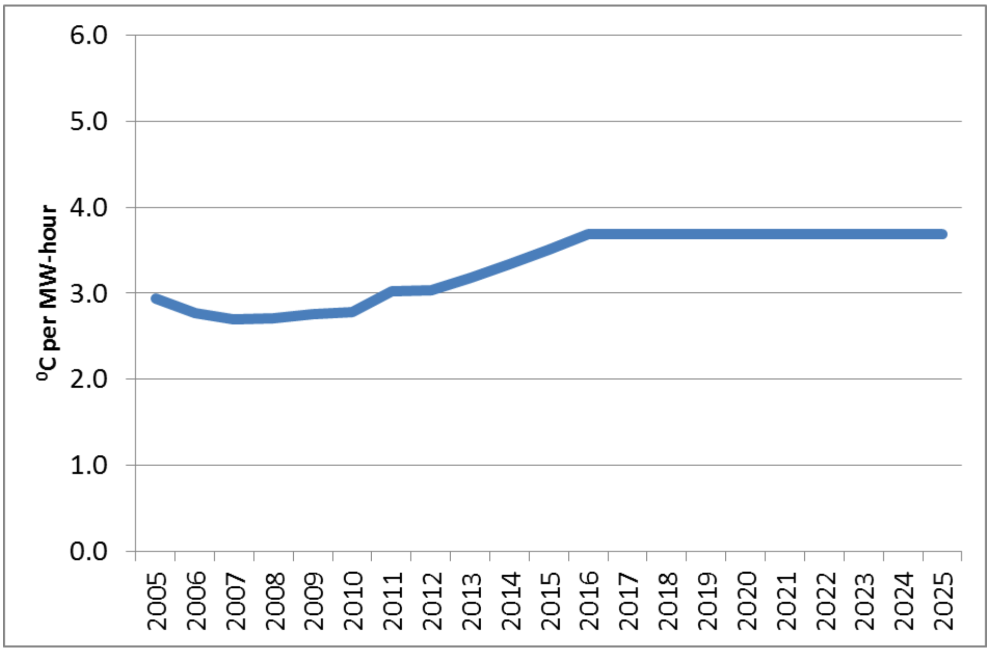
97. The heat driver statistics and heat model outputs are tabled as Table VII-11 and Table VII-12 respectively.

6. Validation of Demand Forecast for Heat

98. The Consultant's heat model has been calibrated to the sent-out heat production reported by the Darkhan Power Plant. The Consultant considers the heat forecast to fall within the normal range of accuracy for heat planning purposes.

99. A heat production model was also developed based on heating degree hours for the purpose of estimating the heat production and associated available power for each hour of each year of the planning horizon, from 2013 to 2025. The estimated heat production statistics and forecast is tabled as Table VII-13 and Table VII-14.

Table VII-10: Darkhan Heat Consumption Indicator



Sources: Consultants' estimate

Table VII-11: Darkhan – Heat Driver Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	1,061	-	3,306	-	2,241	-
2004	62.0	-	15.6	1,094	1.5%	3,311	0.1%	2,276	1.5%
2005	63.4	2.2%	16.8	1,179	4.4%	3,350	1.2%	2,375	4.4%
2006	62.9	-0.8%	16.9	1,186	0.9%	3,390	1.2%	2,397	0.9%
2007	63.4	0.8%	17.1	1,195	0.5%	3,401	0.3%	2,409	0.5%
2008	63.9	0.8%	17.1	1,196	0.7%	3,441	1.2%	2,425	0.7%
2009	65.7	2.9%	17.1	1,197	0.7%	3,490	1.4%	2,443	0.7%
2010	66.4	1.1%	17.2	1,202	0.5%	3,508	0.5%	2,455	0.5%
Average 2003 - 2010	-	1.2%	-	-	1.3%	-	0.9%	-	1.3%
Forecast									
2011	67.7	2.0%	17.7	1,236	2.4%	3,578	2.0%	2,514	2.4%
2012	69.1	2.0%	18.2	1,271	2.4%	3,650	2.0%	2,575	2.4%
2013	70.4	2.0%	18.7	1,307	2.4%	3,723	2.0%	2,637	2.4%
2014	71.8	1.9%	19.2	1,344	2.4%	3,797	2.0%	2,700	2.4%
2015	73.2	1.9%	19.7	1,381	2.4%	3,873	2.0%	2,765	2.4%
Average 2011 - 2015	-	2.0%	18.7	-	2.4%	-	2.0%	-	2.4%
2015	73.2	0.1%	19.7	1,381	2.4%	3,873	2.0%	2,765	2.4%
2020	81.1	0.5%	18.7	1,587	14.9%	4,276	2.0%	3,112	12.6%
2025	-	-	-	1,823	14.9%	4,721	2.0%	3,503	12.6%

Sources: Consultants' estimate

Table VII-12: Darkhan 'End-Use' Empirical Heat Supply Model Output

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	78,117	2,734,107	3,310,500	89,411	274,490	55,719	363,902	419,620	95.06	39.75
2005	84,212	2,947,411	3,350,100	95,187	277,774	60,066	372,961	433,027	97.43	42.86
2006	84,707	2,964,732	3,390,200	95,653	281,099	60,419	376,752	437,171	98.42	43.11
2007	85,327	2,986,429	3,401,000	96,236	281,994	60,861	378,231	439,091	98.81	43.42
2008	85,446	2,990,625	3,440,500	96,349	285,269	60,946	381,618	442,565	99.69	43.48
2009	85,464	2,991,250	3,490,200	96,366	289,390	60,959	385,756	446,715	100.77	43.49
2010	85,880	3,005,804	3,508,100	96,756	290,874	61,256	387,631	448,886	101.26	43.70
2011	88,314	3,090,984	3,578,262	99,036	296,692	62,992	395,728	458,719	103.38	44.94
2012	90,808	3,178,274	3,649,827	101,361	302,626	64,770	403,987	468,757	105.53	46.21
2013	93,363	3,267,722	3,722,824	103,733	308,678	66,593	412,411	479,004	107.74	47.51
2014	95,982	3,359,378	3,797,280	106,152	314,852	68,461	421,004	489,465	109.98	48.85
2015	98,665	3,453,292	3,873,226	108,619	321,149	70,375	429,768	500,143	112.27	50.21
2020	112,550	3,967,401	4,276,354	121,937	354,574	80,279	476,511	556,790	124.48	57.28

Sources: Consultants' estimate

Table VII-13: Darkhan CHP – Heat Production Estimates (2004 – 2014)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Station Losses	%		4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%		3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%		15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C					-33C	-33C	-38C	-38C			
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%		5%	5%	5%	5%	5%	5%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours	0.0	2.9	2.8	2.7	2.7	2.8	2.8	3.0	3.0	3.2	3.3
HCI Growth	%			-5.8%	-2.3%	0.2%	2.0%	0.5%	8.7%	0.3%	5.0%	5.0%
Average	%							-1.1%				
Space Heat	MWh	-	517,450	487,483	476,309	477,290	487,081	489,544	532,239	533,939	560,780	588,945
Hot Tap Water	MWh		25,438	23,889	23,435	23,730	23,949	24,037	27,556	27,644	29,034	30,492
Station Losses	MWh	-	22,801	21,478	20,989	21,043	21,463	21,570	23,511	23,586	24,772	26,016
Pipe Losses	MWh	-	83,699	78,594	77,110	78,106	78,802	79,088	86,031	86,310	90,556	95,011
Steam	MWh	-	14,654	12,212	13,896	19,096	13,887	13,258	13,331	13,404	13,477	13,551
Steam Losses	MWh	-	454	379	431	592	431	411	413	416	418	420
Steam Consumption	MWh	-	14,200	11,833	13,465	18,504	13,457	12,847	12,918	12,988	13,060	13,131
Station Gate Production	MWh	-	557,996	523,961	514,070	520,708	525,348	527,250	573,540	575,403	603,709	633,409
Total Production (incl losses)	MWh	-	580,798	545,439	535,059	541,751	546,812	548,820	597,051	598,989	628,481	659,425

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Household Consumption	MWh	-	474,297	445,367	436,959	442,602	446,546	448,163	487,509	489,092	513,153	538,398
ERA Heat supply	Gcal	-	479	450	442	447	451	453	493	494	519	544
Steam	Gcal		12.6	10.5	11.9	16.4	11.9	11.4	11.5	11.5	11.6	11.7
Hot water	Gcal		467	440	430	431	439	442	481	483	507	533
ERA Heat supply	GWh	-	558	524	514	520	525	527	573	575	603	633
Steam	GWh	-	14.7	12.2	13.9	19.1	13.9	13.3	13.3	13.4	13.5	13.6
Hot water	GWh	-	543	511	500	501	511	514	560	562	590	619
Hours of Operation	Count	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Load Factor	LF	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Peak Demand	MWth	-	182.6	171.5	168.3	170.4	171.9	172.6	187.7	188.3	197.6	207.3
Hot Tap Water	%		4.9%	4.9%	4.9%	5.0%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%
Average	%							4.9%				
Space Heat	%			-5.8%	-2.3%	0.2%	2.1%	0.5%	-1.1%	-1.1%	-1.1%	-1.1%
Average	%							-1.1%				
Steam Load Growth	%			-16.7%	13.8%	37.4%	-27.3%	-4.5%	0.5%	0.5%	0.5%	0.5%
Average	%							0.5%				

Sources: Consultants' estimate

Table VII-14: Darkhan CHP – Heat Production Estimates (2015 – 2025)

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C											
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours	3.5	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
HCI Growth	%	5.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	%											
Space Heat	MWh	618,500	649,513	649,513	649,513	649,513	649,513	649,513	649,513	649,513	649,513	649,513
Hot Tap Water	MWh	32,022	33,628	33,628	33,628	33,628	33,628	33,628	33,628	33,628	33,628	33,628
Station Losses	MWh	27,322	28,692	28,692	28,692	28,692	28,692	28,692	28,692	28,692	28,692	28,692
Pipe Losses	MWh	99,686	104,590	104,590	104,590	104,590	104,590	104,590	104,590	104,590	104,590	104,590
Steam	MWh	13,626	13,700	13,700	13,700	13,700	13,700	13,700	13,700	13,700	13,700	13,700
Steam Losses	MWh	422	425	425	425	425	425	425	425	425	425	425
Steam Consumption	MWh	13,203	13,276	13,276	13,276	13,276	13,276	13,276	13,276	13,276	13,276	13,276
Station Gate Production	MWh	664,571	697,266	697,266	697,266	697,266	697,266	697,266	697,266	697,266	697,266	697,266
Total Production (incl losses)	MWh	691,893	725,958	725,958	725,958	725,958	725,958	725,958	725,958	725,958	725,958	725,958

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Household Consumption	MWh	564,885	592,676	592,676	592,676	592,676	592,676	592,676	592,676	592,676	592,676	592,676
ERA Heat supply	Gcal	571	599	629	660	692	726	762	799	839	880	923
Steam	Gcal	11.7	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
Hot water	Gcal	559	587	587	587	587	587	587	587	587	587	587
ERA Heat supply	GWh	664	697	731	767	805	845	886	930	975	1,023	1,074
Steam	GWh	13.6	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
Hot water	GWh	651	683	683	683	683	683	683	683	683	683	683
Hours of Operation	Count	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Load Factor	LF	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Peak Demand	MWth	217.6	228.3	239.5	251.3	**263.7**	276.6	290.3	304.5	319.5	335.3	351.8
Hot Tap Water	%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%
Average	%											
Space Heat	%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
Average	%											
Steam Load Growth	%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Average	%											

Sources: Consultants' estimate

D. Choibalsan (Dornod)

100. Choibalsan (Mongolian: Чойбалсан) is the fourth-largest city in Mongolia. The name of the city was Bayan Tu'men (Баян Түмэн) until 1941, when it was renamed after the communist leader Khorloogiin Choibalsan. It is the capital of the province of Dornod. It is situated at the Kherlen River, at an elevation of 747 m above sea level.

101. The location has been a post on a trading route for centuries. In the 19th century it grew into a city, and became the economic hub of eastern Mongolia in the twentieth century. After democratization in 1992, when the Russian workers left, large parts of the economy collapsed. Since then, the city has suffered from one of the highest unemployment rates in Mongolia.

102. The city is supplied by the Choibalsan CHP plant. The installed power capacity is 36 MW. Main equipment: 6 boilers, 3x35 t/h, 3x75 t/h; Turbines: 2x6 MW,2x12 MW. The first units commenced in 1961.

7. Demand for Heat

103. The number of households taking heat supply in 2012 is reported to be around 10,000.

104. The Consultant has modelled the heat demand for Choibalsan based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation.

Table VII-15: Choibalsan - Heat Demand

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	28,321	8,850	869.3	1.2%	154,015	56.7
2005	28,877	8,965	879.9	1.2%	155,744	57.4
2006	29,089	9,072	890.5	1.2%	157,517	58.0
2007	28,538	9,172	901.0	1.2%	159,323	58.7
2008	27,735	9,264	911.4	1.2%	161,170	59.4
2009	28,872	9,380	923.8	1.4%	163,293	60.1
2010	42,271	9,520	937.6	1.5%	165,610	61.0
2011	40,241	9,806	965.7	3.0%	170,320	62.8
2012	38,261	10,100	994.7	3.0%	175,164	64.6
2013	36,331	10,403	1024.5	3.0%	180,147	66.4
2014	34,450	10,715	1055.3	3.0%	185,268	68.3
2015	32,620	11,037	1086.9	3.0%	190,543	70.3
2020	36,015	14,571	1260.2	3.2%	196,514	76.2

Sources: Licensees, EA data & Consultants' estimate

105. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table VII-16: Choibalsan – Heat Model (Per Annum)

	Urban Population with heat	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	40,399	596,786	1,114,100	0.226	0.387	0.121	175,164	4.34

Sources: Licensees, EA data & Consultants' estimate

8. Heat Model

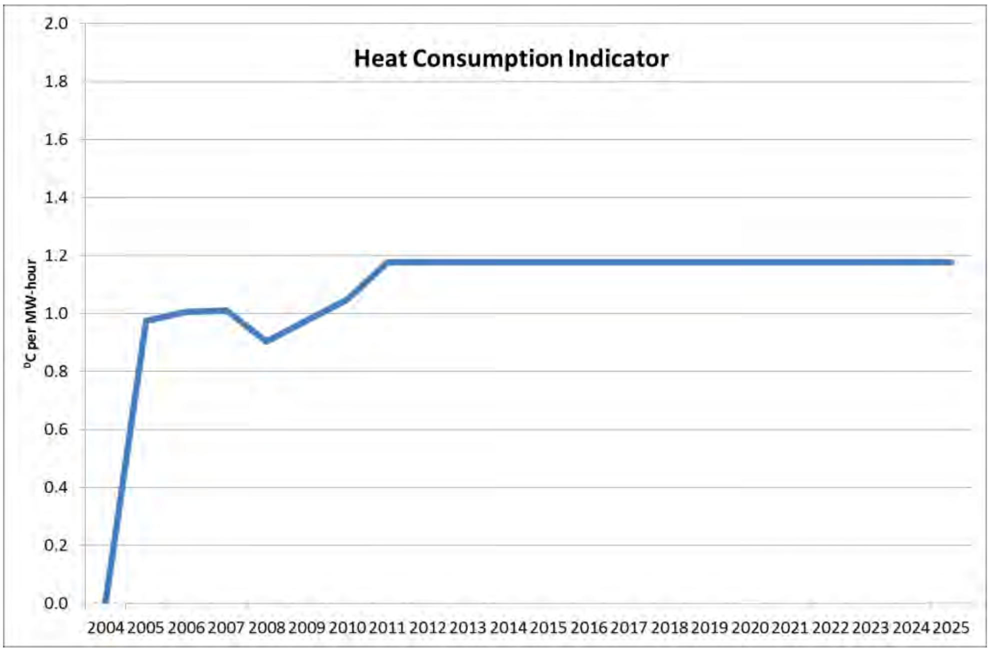
106. The heat driver statistics and heat model outputs are tabled as Table VII-18 and Table VII-19 respectively.

9. Validation of Demand Forecast for Heat

107. The Consultant's heat model has been calibrated to the sent-out heat production reported by the Choibalsan Power Plant. The Consultant considers the heat forecast to fall within the normal range of accuracy for heat planning purposes.

108. A heat production model was also developed based on heating degree hours for the purpose of estimating the heat production and associated available power for each hour of each year of the planning horizon, from 2013 to 2025. The estimated heat production statistics and forecast is tabled as Table VII-20 and Table VII-21.

Table VII-17: Choibalsan Heat Consumption Indicator



Sources: Consultants' estimate

Table VII-18: Choibalsan – Heat Driver Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	515.7	-	960	-	858.7	-
2004	28.3	-	8.8	522.9	1.2%	970	1.0%	869.3	1.2%
2005	28.9	2.0%	9.0	529.7	1.2%	981	1.1%	879.9	1.2%
2006	29.1	0.7%	9.1	536.1	1.2%	992	1.2%	890.5	1.2%
2007	28.5	-1.9%	9.2	542.0	1.2%	1,005	1.3%	901.0	1.2%
2008	27.7	-2.8%	9.3	547.4	1.2%	1,019	1.4%	911.4	1.2%
2009	28.9	4.1%	9.4	554.3	1.4%	1,035	1.5%	923.8	1.4%
2010	42.3	46.4%	9.5	562.5	1.5%	1,050	1.5%	937.6	1.5%
Average 2003 - 2010	-	8.1%	-	-	1.3%	-	1.3%	-	1.3%
Forecast									
2011	40.2	-4.8%	9.8	579.4	3.0%	1,082	3.0%	966	3.0%
2012	38.3	-4.9%	10.1	596.8	3.0%	1,114	-1.6%	995	3.0%
2013	36.3	-5.0%	10.4	614.7	3.0%	1,148	-1.5%	1,025	3.0%
2014	34.5	-5.2%	10.7	633.1	3.0%	1,182	-1.5%	1,055	3.0%
2015	32.6	-5.3%	11.0	652.1	3.0%	1,217	-1.5%	1,087	3.0%
Average 2011 - 2015	-	-5.1%	10.4	-	3.0%	-	-0.6%	-	3.0%
2015	32.6	0.1%	11.0	652.1	3.0%	1,217	-1.5%	1,087	3.0%
2020	36.0	0.5%	14.6	693.9	6.4%	1,131	-7.1%	1,260	3.0%
2025	-	-	-	738.4	6.4%	1,050	-7.1%	1,461	3.0%

Sources: Consultants' estimate

Table VII-19: Choibalsan 'End-Use' Empirical Heat Supply Model Output

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	35,399	1,307,321	969,900	48,346	80,419	25,249	128,766	154,015	38.71	18.01
2005	35,858	1,324,286	980,500	48,869	81,298	25,577	130,167	155,744	39.13	18.25
2006	36,289	1,340,179	992,300	49,357	82,277	25,884	131,634	157,517	39.57	18.47
2007	36,688	1,354,911	1,005,200	49,809	83,346	26,168	133,155	159,323	40.03	18.67
2008	37,055	1,368,482	1,019,300	50,224	84,515	26,430	134,739	161,170	40.51	18.86
2009	37,519	1,385,625	1,034,600	50,748	85,784	26,761	136,532	163,293	41.04	19.09
2010	38,080	1,406,339	1,050,100	51,379	87,069	27,161	138,448	165,610	41.62	19.38
2011	39,224	1,448,571	1,081,600	52,662	89,681	27,977	142,343	170,320	42.79	19.96
2012	40,399	1,491,964	1,114,100	53,973	92,376	28,815	146,349	175,164	44.00	20.56
2013	41,612	1,536,786	1,147,500	55,321	95,145	29,681	150,466	180,147	45.23	21.18
2014	42,860	1,582,857	1,181,900	56,700	97,997	30,571	154,697	185,268	46.51	21.81
2015	44,146	1,630,357	1,217,400	58,114	100,941	31,488	159,055	190,543	47.82	22.47
2020	58,283	1,734,775	1,130,585	61,200	93,743	41,571	154,942	196,514	46.58	29.66

Sources: Consultants' estimate

Table VII-20: Choibalsan CHP – Heat Production Estimates (2004 – 2014)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C					-33C	-33C	-38C	-38C			
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%		5%	5%	5%	5%	5%	5%	5%	5%	5%	14%
Heat Consumption Indicator	MW/^{0}C-hours											
HCI Growth	%	0.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2
Average	%			0.4%	4.2%	4.0%	3.9%	3.7%	-0.3%	0.0%	0.0%	0.0%
Space Heat	MWh							3.3%				
Hot Tap Water	MWh	-	177,035	177,812	185,276	192,741	200,205	207,669	207,084	207,084	207,084	207,084
Station Losses	MWh		8,463	8,501	8,857	9,214	9,571	9,928	10,397	10,397	10,397	10,397
Pipe Losses	MWh	-	7,791	7,825	8,154	8,482	8,811	9,139	9,134	9,134	9,134	9,134
Steam	MWh	-	27,825	27,947	29,120	30,293	31,466	32,640	32,622	32,622	32,622	32,622
Steam Losses	MWh	-	-	-	-	-	-	-	-	-	-	-
Steam Consumption	MWh	-	-	-	-	-	-	-	-	-	-	-
Station Gate Production	MWh	-	-	-	-	-	-	-	-	-	-	-
Total Production (incl losses)	MWh	-	185,499	186,313	194,134	201,955	209,776	217,597	217,481	217,481	217,481	217,481

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Household Consumption	MWh	-	193,289	194,138	202,287	210,437	218,587	226,736	226,615	226,615	226,615	226,615
ERA Heat supply	Gcal	-	157,674	158,366	165,014	171,662	178,310	184,958	184,859	184,859	184,859	184,859
Steam	Gcal	-	160	160	167	174	180	187	187	187	187	187
Hot water	Gcal		-	-	-	-	-	-	-	-	-	-
ERA Heat supply	GWh		160	160	167	174	180	187	187	187	187	187
Steam	GWh	-	185	186	194	202	210	218	217	217	217	217
Hot water	GWh	-	-	-	-	-	-	-	-	-	-	-
Hours of Operation	Count	-	185	186	194	202	210	218	217	217	217	217
Load Factor	LF	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Peak Demand	MWth	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Hot Tap Water	%	-	60.8	61.0	63.6	66.2	68.7	71.3	71.2	71.2	71.2	71.2
Average	%		4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%
Space Heat	%							4.8%				
Average	%			0.4%	4.2%	4.0%	3.9%	3.7%	3.3%	3.3%	3.3%	3.3%
Steam Load Growth	%							3.3%				
Average	%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Sources: Consultants' estimate

Table VII-21: Choibalsan CHP – Heat Production Estimates (2015 – 2025)

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C											
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours											
HCI Growth	%	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Average	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Space Heat	MWh											
Hot Tap Water	MWh	207,084	207,084	207,084	207,084	207,084	207,084	207,084	207,084	207,084	207,084	207,084
Station Losses	MWh	10,397	10,397	10,397	10,397	10,397	10,397	10,397	10,397	10,397	10,397	10,397
Pipe Losses	MWh	9,134	9,134	9,134	9,134	9,134	9,134	9,134	9,134	9,134	9,134	9,134
Steam	MWh	32,622	32,622	32,622	32,622	32,622	32,622	32,622	32,622	32,622	32,622	32,622
Steam Losses	MWh	-	-	-	-	-	-	-	-	-	-	-
Steam Consumption	MWh	-	-	-	-	-	-	-	-	-	-	-
Station Gate Production	MWh	-	-	-	-	-	-	-	-	-	-	-
Total Production (incl losses)	MWh	217,481	217,481	217,481	217,481	217,481	217,481	217,481	217,481	217,481	217,481	217,481

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Household Consumption	MWh	226,615	226,615	226,615	226,615	226,615	226,615	226,615	226,615	226,615	226,615	226,615
ERA Heat supply	Gcal	184,859	184,859	184,859	184,859	184,859	184,859	184,859	184,859	184,859	184,859	184,859
Steam	Gcal	187	187	187	187	187	187	187	187	187	187	187
Hot water	Gcal	-	-	-	-	-	-	-	-	-	-	-
ERA Heat supply	GWh	187	187	187	187	187	187	187	187	187	187	187
Steam	GWh	217	217	217	217	217	217	217	217	217	217	217
Hot water	GWh	-	-	-	-	-	-	-	-	-	-	-
Hours of Operation	Count	217	217	217	217	217	217	217	217	217	217	217
Load Factor	LF	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Peak Demand	MWth	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Hot Tap Water	%	71.2	71.2	71.2	71.2	**71.2**	71.2	71.2	71.2	71.2	71.2	71.2
Average	%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%
Space Heat	%											
Average	%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
Steam Load Growth	%											
Average	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Sources: Consultants' estimate

E. Dalanzadgad

109. Dalanzadgad (Mongolian: Даланзадгад) is the capital of Ömnögovi Aimag in Mongolia. It is located 540 kilometers (340 mi) south of the national capital Ulaanbaatar. The altitude of the city center is 1,470 meters (4,823 feet).

110. The town is supplied with heat produced by the Dalanzadgad CHP Power Plant.

10. Demand for Heat

111. The number of households taking heat supply in 2012 is reported to be around 650.

112. The Consultant has modelled the heat demand for Dalanzadgad based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation.

Table VII-22: Dalanzadgad - Heat Demand

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	6,965	551	44.1	1.5%	10,587	4.5
2005	6,886	559	44.8	1.5%	10,734	4.6
2006	6,552	568	45.4	1.5%	10,889	4.6
2007	6,951	576	46.1	1.5%	11,045	4.7
2008	7,326	585	46.8	1.5%	11,200	4.8
2009	8,239	594	47.5	1.5%	11,363	4.8
2010	11,986	603	48.2	1.5%	11,526	4.9
2011	12,687	629	50.3	4.4%	12,007	5.1
2012	13,408	656	52.5	4.3%	12,499	5.3
2013	14,149	684	54.7	4.2%	13,001	5.5
2014	14,910	712	57.0	4.1%	13,516	5.8
2015	15,690	741	59.3	4.1%	14,041	6.0
2020	25,749	897	72.4	4.4%	17,000	7.3

Sources: Licensees, EA data & Consultants' estimate

113. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table VII-23: Dalanzadgad – Heat Model (Per Annum)

	Urban Population with heat	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	2,624	20,992	88,165	0.014	0.031	0.008	12,499	4.76

Sources: Licensees, EA data & Consultants' estimate

11. Heat Model

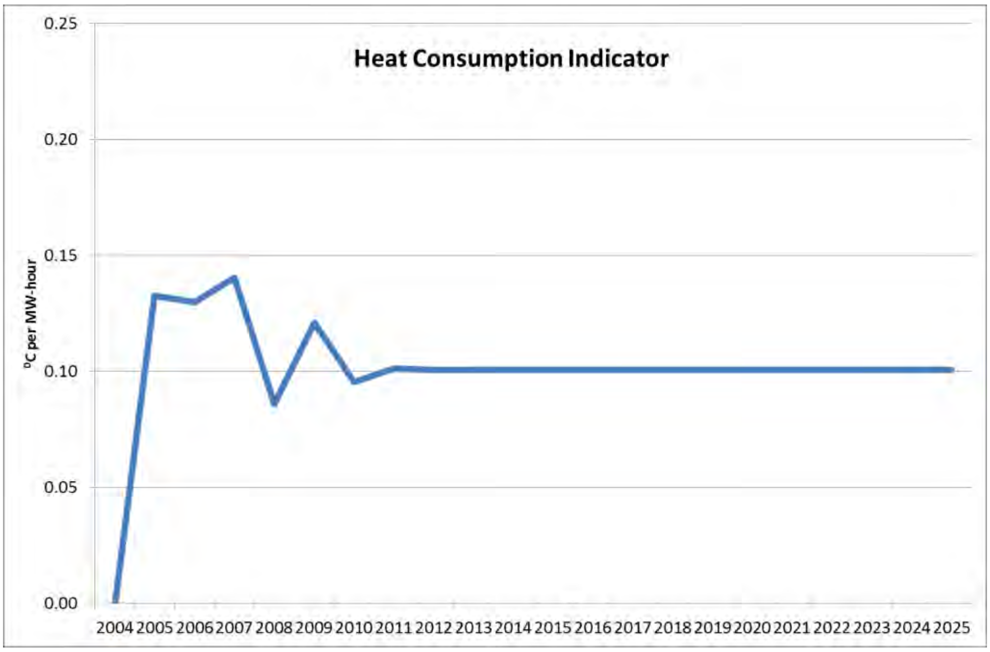
The heat driver statistics and heat model outputs are tabled as Table VII-25.

12. Validation of Demand Forecast for Heat

114. The Consultant's heat model has been calibrated to the sent-out heat production reported by the Dalanzadgad CHP Power Plant. The Consultant considers the heat forecast to fall within the normal range of accuracy for heat planning purposes.

115. A heat production model was also developed based on heating degree hours for the purpose of estimating the heat production and associated available power for each hour of each year of the planning horizon, from 2013 to 2025. The estimated heat production statistics and forecast is tabled as Table VII-27 and Table VII-28.

Table VII-24: Dalanzadgad Heat Consumption Indicator



Sources: Consultants' estimate

Table VII-25: Dalanzadgad – Heat Driver Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	17.4	-	73.0	-	43.5	-
2004	7.0	-	0.6	17.6	1.5%	74.1	1.5%	44.1	1.5%
2005	6.9	-1.1%	0.6	17.9	1.5%	75.2	1.5%	44.8	1.5%
2006	6.6	-4.9%	0.6	18.2	1.5%	76.3	1.5%	45.4	1.5%
2007	7.0	6.1%	0.6	18.4	1.5%	77.5	1.6%	46.1	1.5%
2008	7.3	5.4%	0.6	18.7	1.5%	78.6	1.4%	46.8	1.5%
2009	8.2	12.5%	0.6	19.0	1.5%	79.8	1.5%	47.5	1.5%
2010	12.0	45.5%	0.6	19.3	1.5%	81.0	1.5%	48.2	1.5%
Average 2003 - 2010	-	10.6%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	12.7	5.8%	0.6	20.1	4.4%	84.5	4.4%	50.3	4.4%
2012	13.4	5.7%	0.7	21.0	4.3%	88.2	4.3%	52.5	4.3%
2013	14.1	5.5%	0.7	21.9	4.2%	91.9	4.2%	54.7	4.2%
2014	14.9	5.4%	0.7	22.8	4.1%	95.7	4.1%	57.0	4.1%
2015	15.7	5.2%	0.7	23.7	4.1%	99.6	4.1%	59.3	4.1%
Average 2011 - 2015	-	5.5%	0.7	-	4.2%	-	4.2%	-	4.2%
2015	15.7	0.1%	0.7	23.7	4.1%	99.6	4.1%	59.3	4.1%
2020	25.7	0.5%	0.7	29.1	22.9%	121.6	4.2%	72.4	22.1%
2025	-	-	-	35.8	22.9%	148.4	4.2%	88.3	22.1%

Sources: Consultants' estimate

Table VII-26: Dalanzadgad 'End-Use' Empirical Heat Supply Model Output

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,205	44,107	74,100	2,869	6,144	1,573	9,013	10,587	2.71	1.80
2005	2,237	44,732	75,200	2,903	6,235	1,595	9,139	10,734	2.75	1.82
2006	2,272	45,446	76,300	2,942	6,326	1,621	9,268	10,889	2.79	1.85
2007	2,304	46,071	77,500	2,976	6,426	1,643	9,402	11,045	2.83	1.88
2008	2,339	46,786	78,600	3,014	6,517	1,669	9,531	11,200	2.87	1.90
2009	2,375	47,500	79,800	3,052	6,617	1,694	9,669	11,363	2.91	1.93
2010	2,411	48,214	81,000	3,090	6,716	1,719	9,807	11,526	2.95	1.96
2011	2,516	50,321	84,539	3,203	7,010	1,795	10,212	12,007	3.07	2.05
2012	2,624	52,479	88,165	3,317	7,310	1,872	10,627	12,499	3.19	2.14
2013	2,735	54,690	91,879	3,433	7,618	1,950	11,051	13,001	3.32	2.23
2014	2,848	56,954	95,683	3,551	7,934	2,031	11,484	13,516	3.45	2.32
2015	2,964	59,273	99,579	3,671	8,257	2,114	11,927	14,041	3.59	2.41
2020	3,589	72,869	121,571	4,360	10,080	2,560	14,440	17,000	4.34	2.92

Sources: Consultants' estimate

Table VII-27: Dalanzadgad CHP – Heat Production Estimates (2004 – 2014)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^{0}C					-33C	-33C	-38C	-38C			
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%		5%	5%	5%	5%	5%	5%	5%	5%	5%	14%
Heat Consumption Indicator	MW/^{0}C-hours											
HCI Growth	%	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Average	%			-2.1%	8.3%	-38.8%	40.8%	-21.1%	5.9%	-0.5%	0.0%	0.0%
Space Heat	MWh							-2.6%				
Hot Tap Water	MWh	-	23,353	22,865	24,752	15,140	21,311	16,815	17,806	17,718	17,718	17,718
Station Losses	MWh		1,116	1,093	1,183	724	1,019	804	894	890	890	890
Pipe Losses	MWh	-	1,028	1,006	1,089	666	938	740	785	782	782	782
Steam	MWh	-	3,670	3,594	3,890	2,379	3,349	2,643	2,805	2,791	2,791	2,791
Steam Losses	MWh	-	-	-	-	-	-	-	-	-	-	-
Steam Consumption	MWh	-	-	-	-	-	-	-	-	-	-	-
Station Gate Production	MWh	-	-	-	-	-	-	-	-	-	-	-
Total Production (incl losses)	MWh	-	24,470	23,958	25,935	15,863	22,330	17,619	18,700	18,608	18,608	18,608

		2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Household Consumption	MWh	-	25,497	24,964	27,024	16,530	23,267	18,358	19,485	19,390	19,390	19,390
ERA Heat supply	Gcal	-	20,799	20,364	22,045	13,484	18,980	14,976	15,895	15,817	15,817	15,817
Steam	Gcal	-	21	21	22	14	19	15	16	16	16	16
Hot water	Gcal		-	-	-	-	-	-	-	-	-	-
ERA Heat supply	GWh		21	21	22	14	19	15	16	16	16	16
Steam	GWh	-	24	24	26	16	22	18	19	19	19	19
Hot water	GWh	-	-	-	-	-	-	-	-	-	-	-
Hours of Operation	Count	-	24	24	26	16	22	18	19	19	19	19
Load Factor	LF	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Peak Demand	MWth	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Hot Tap Water	%	-	8.0	7.8	8.5	5.2	7.3	5.8	6.1	6.1	6.1	6.1
Average	%		4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%
Space Heat	%							4.8%				
Average	%			-2.1%	8.3%	-38.8%	40.8%	-21.1%	-2.6%	-2.6%	-2.6%	-2.6%
Steam Load Growth	%							-2.6%				
Average	%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Sources: Consultants' estimate

Table VII-28: Dalanzadgad CHP – Heat Production Estimates (2015 – 2025)

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Station Losses	%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%	4.20%
Steam Losses	%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%	3.10%
Pipe Losses	%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Outside Minimum Temperature	^0C											
Degree Hours	Hours	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000	184,000
Hot tap water production	%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Heat Consumption Indicator	MW/^{0}C-hours											
HCI Growth	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Average	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Space Heat	MWh											
Hot Tap Water	MWh	17,718	17,718	17,718	17,718	17,718	17,718	17,718	17,718	17,718	17,718	17,718
Station Losses	MWh	890	890	890	890	890	890	890	890	890	890	890
Pipe Losses	MWh	782	782	782	782	782	782	782	782	782	782	782
Steam	MWh	2,791	2,791	2,791	2,791	2,791	2,791	2,791	2,791	2,791	2,791	2,791
Steam Losses	MWh	-	-	-	-	-	-	-	-	-	-	-
Steam Consumption	MWh	-	-	-	-	-	-	-	-	-	-	-
Station Gate Production	MWh	-	-	-	-	-	-	-	-	-	-	-
Total Production (incl losses)	MWh	18,608	18,608	18,608	18,608	18,608	18,608	18,608	18,608	18,608	18,608	18,608

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Household Consumption	MWh	19,390	19,390	19,390	19,390	19,390	19,390	19,390	19,390	19,390	19,390	19,390
ERA Heat supply	Gcal	15,817	15,817	15,817	15,817	15,817	15,817	15,817	15,817	15,817	15,817	15,817
Steam	Gcal	16	16	16	16	16	16	16	16	16	16	187
Hot water	Gcal	-	-	-	-	-	-	-	-	-	-	-
ERA Heat supply	GWh	16	16	16	16	16	16	16	16	16	16	16
Steam	GWh	19	19	19	19	19	19	19	19	19	19	217
Hot water	GWh	-	-	-	-	-	-	-	-	-	-	-
Hours of Operation	Count	19	19	19	19	19	19	19	19	19	19	19
Load Factor	LF	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088	5,088
Peak Demand	MWth	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Hot Tap Water	%	6.1	6.1	6.1	6.1	**6.1**	6.1	6.1	6.1	6.1	6.1	71.2
Average	%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%
Space Heat	%											
Average	%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%	-2.6%
Steam Load Growth	%											
Average	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Sources: Consultants' estimate

F. Baganuur

116. Baganuur is one of the nine Districts of Ulaanbaatar. Baganuur is a separate city, located as an enclave at the border between the Töv and Khentii Aimags. It was created as a Soviet military base. Later the Soviet Union built the largest open pit coal mine in Mongolia.

117. Baganuur city is one of the largest industrial production locations in Mongolia, and ranks amongst the country's ten largest cities. In time it may become an independent city.

13. Demand for Heat

118. The number of households taking heat supply in 2012 is reported to be around 29,000. The population with heat is expected to almost double by 2025 as this industrial centre further develops.

119. The Consultant has modelled the heat demand of Baganuur based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation. The model is calibrated by reported heat consumption data.

Table VII-29: Baganuur – Heat Demand Forecast

	Population	Apartments				Commercial	Total
	No.	No.	sq. m	Gcal/h	Gcal/h per 1000 residents	GCal/h	GCal/h
2006	25,731	12,056	482,231	36	2.0	53	89
2007	25,969	12,873	514,929	39	2.0	53	92
2008	25,877	13,691	547,627	41	1.8	53	94
2009	25,875	14,508	580,324	44	1.7	53	97
2010	26,905	15,326	613,022	46	1.6	53	99
2011	27,036	16,143	645,720	48	1.5	53	101
2012	29,254	16,960	678,418	51	1.5	53	104
2013	31,472	17,778	711,116	53	1.4	53	106
2014	33,691	18,595	743,813	56	1.3	53	109
2015	35,909	19,413	776,511	58	1.3	53	111
2016	38,127	20,230	809,209	61	1.2	57	118
2017	40,345	21,048	841,907	63	1.1	59	122
2018	42,564	21,865	874,604	66	1.0	60	125
2019	44,782	22,683	907,302	68	1.0	61	129
2020	47,000	23,500	940,000	71	0.9	62	133
2021	52,300	27,150	1,086,000	81	0.9	64	145
2022	57,600	30,800	1,232,000	92	0.8	65	157
2023	62,900	34,450	1,378,000	103	0.8	66	170
2024	68,200	38,100	1,524,000	114	0.8	67	182
2025	73,500	41,750	1,670,000	125	0.7	69	194

Sources: Ministry of Energy, Consultants' estimate

G. Nailakh

120. Nailakh is one of the nine Districts of Ulaanbaatar.

14. Demand for Heat

121. The number of households taking heat supply in 2012 is reported to be around 35,000.

122. The Consultant has modelled the heat demand of Nailakh based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation. The model is calibrated by reported heat consumption data. There appears currently to be a significant level of suppressed demand.

123. The population with heat is expected to increase by around 60% by 2025.

Table VII-30: Nailakh – Heat Demand Forecast

	Population	Apartments				Commercial	Total
	No.	No.	sq. m	Gcal/h	Gcal/h per 1000 residents	GCal/h	GCal/h
2006	27,297	-	-	-	-	-	-
2007	28,152	-	-	-	-	-	-
2008	29,115	-	-	-	-	-	-
2009	30,215	-	-	-	-	-	-
2010	31,458	23,282	838,140	12	0.3	9	22
2011	32,513	23,530	847,080	12	0.4	14	26
2012	34,734	23,778	856,020	12	0.5	19	31
2013	36,955	24,027	864,960	65	1.7	64	129
2014	39,175	24,275	873,900	66	1.6	63	129
2015	41,396	24,523	882,840	66	1.5	63	130
2016	43,617	24,772	891,780	67	1.5	63	130
2017	45,838	25,020	900,720	68	1.4	63	131
2018	48,058	25,268	909,660	68	1.3	63	132
2019	50,279	25,517	918,600	69	1.3	63	132
2020	52,500	25,765	927,540	70	1.2	64	134
2021	54,250	25,989	935,586	70	1.1	61	131
2022	56,000	26,212	943,632	71	1.0	58	129
2023	57,750	26,436	951,678	71	1.0	56	127
2024	59,500	26,659	959,724	72	0.9	54	126
2025	61,250	26,883	967,770	73	0.9	53	126

Sources: Ministry of Energy, Consultants' estimate

H. Bagakhangai

124. Bagakhangai is one of the nine Districts of Ulaanbaatar. It was originally established as the home of a Soviet airbase.

15. Demand for Heat

125. The number of households taking heat supply in 2012 is reported to be around 4,000.

126. The Consultant has modelled the heat demand of Bagakhangai based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation. The model is calibrated by reported heat consumption data. There appears currently to be a significant level of suppressed demand.

127. The population with heat is expected to double by 2025.

Table VII-31: Bagakhangai – Heat Demand Forecast

	Population	Apartments			Commercial		Total
	No.	No.	sq. m	Gcal/h	Gcal/h per 1000 residents	GCal/h	GCal/h
2006	3,827	-	-	-	-	-	-
2007	3,864	1,911	68,808	1.8	-	-	2
2008	3,742	1,851	66,636	1.7	-	-	2
2009	3,615	1,788	64,374	1.6	-	-	2
2010	3,647	1,804	64,944	1.7	0.1	0.2	2
2011	3,727	1,805	64,980	1.7	0.3	1.1	3
2012	4,202	2,084	75,040	1.9	0.5	2.3	4
2013	4,677	2,364	85,100	6.4	1.7	8.1	14
2014	5,151	2,643	95,160	7.1	1.6	8.3	15
2015	5,626	2,923	105,220	7.9	1.5	8.6	17
2016	6,101	3,202	115,280	8.6	1.5	8.9	18
2017	6,576	3,482	125,340	9.4	1.4	9.1	18
2018	7,050	3,761	135,400	10	1.3	9.3	19
2019	7,525	4,041	145,460	11	1.3	9.5	20
2020	8,000	4,320	155,520	12	1.2	10	21
2021	9,200	5,088	183,168	14	1.1	10	24
2022	10,400	5,856	210,816	16	1.0	11	27
2023	11,600	6,624	238,464	18	1.0	11	29
2024	12,800	7,392	266,112	20	0.9	12	32
2025	14,000	8,160	293,760	22	0.9	12	34

Sources: Ministry of Energy, Consultants' estimate

VIII. AIMAG HEAT SUPPLY

I. Background

128. The Consultant has prepared an Aimag heat supply inventory covering the heating systems that supply heat to the urban centers of seventeen Aimags. The inventory provides the basis on which heat supply planning has been conducted.

129. Heating systems were found to fall into two categories, a) Independent boilers supplying buildings or small groups of buildings, b) Heat Only Boilers supplying heat to a district area via a District Heating network. Amongst this group of Aimag towns there were no CHP heating systems in operation in 2012.

130. More specifically, the inventory does not include the CHP heating systems in Ulan Baatar, Erdenet, Darkhan, Choibalsan and Dalanzadgad. These larger energy systems are dealt with in Section 3A.

131. The heating systems of the Aimag town centers that are included in the inventory are shown in Table VIII-1.

Table VIII-1: Aimags & Town Centers with Heat Supply

No	Aimag	Town Centre
1	Govi-Altai	Altai
2	Uvurhangai	Arvaiheer
3	Suhbaatar	Baruun -Urt
4	Bayanhongor	Bayanhongor
5	Bulgan	Bulgan
6	Tuv	Zuunmod
7	Dundgovy	Mandalgovi
8	Huvsgul	Muren
9	Ulgii-Bayan	Ulgii
10	Hentii	Ondorhaan
11	Dornogovi	Sainshand
12	Seleng	Suhbaatar
13	Uvs	Ulaangom
14	Zavhan	Uliastai
15	Hovd	Hovd
16	Arhangai	Tsetserleg
17	Govy-Sumber	Choir

132. The inventory provides an assessment of the existing heating plant assets in terms of historical heat demands and forecasts, heating capacities, losses, expected operating life and other salient information. Where District Heating networks are present, the details of these assets are also included in the inventory. An inventory summary is provided as **Table VIII-1**; the specific details are recorded by Aimag in Section 0.

133. The history of the Aimag heating systems is important as it provides a necessary understanding of the performance and challenges faced by the countryside heat sector. At the end of 1950s, heating systems were introduced in the Aimag urban centers to supply heat to organizations such as schools, hospitals, etc. These heating plants comprised small Heat Only Boilers (NR-18, BZUI type boilers). Consumers were supplied with hot water at 95 ^{0}C and the return temperature was 70 ^{0}C depending on ambient temperature. These systems did not supply domestic hot water and as a result consumers siphoned hot water from the district heating networks resulting in high water losses and low efficiency. Today these systems still exist in twelve of the Aimag urban centres and are the prevalent sources of heat.

134. In the period from 1970-1980, medium sized heating plants replaced small HOB systems in ten of the Aimag centres as the demand for industrial process steam increased. The district heating networks of these small HOB systems were retained and the HOB premises were converted to heat substations wherein heating pumps, domestic hot water heaters, secondary contour and mixing pumps were installed. These heating plants were capable of producing 6-25 ton steam per hour (8-13 ATM pressure) at a supply temperature of 150^{0}C and return temperature of 70^{0}C, where at the consumer premises the water temperature was meant to be maintained at 90^{0}C.

135. In the 1990s the demand for industrial steam ceased. As a result the heating plants of Altai, Mandalgobi and Baruun-Urt towns shut down. The heating plant in Uliastai shut down because the plant was unprofitable due to insufficient heat demand. A heating plant in Zuunmod town was built but never operated because it was over-sized for the demand.

136. Since the 1990's there has been little investment in the heating systems, and as is generally the case in the ex-CES / FSU countries, the heating systems are in very poor condition. The heat boilers have passed the end of their technical life and are inefficient, with poor environmental performance. District heating pipelines are severely corroded due to lack of water treatment, breakage and the effects of ground water. There are no heat meters or control instruments which means that hydraulic balancing and heat delivery is inconsistent.

137. All district heating pipelines should be replaced within a 3-year period. The heat plants should be rehabilitated where capacity is sufficient to meet the heat demand for the next 10 years, or replaced by modern equivalent where the growth in heat demand requires an increase in capacity. Table VIII-2 provides a summary of the current status of the small heat plant and district heating pipelines in the rural Aimags.

138. The raw data used for compilation of this inventory was drawn from information provided by the Energy Authority and by the licensed operators. The licensed operators provided up-to-date information in response to a comprehensive set of surveys, covering individual CHP power plants, Aimag heating and diesel power systems, renewable energy systems, and the transmission and distribution networks. Information capture included historical and current asset and asset performance statistics.

Table VIII-2: Aimag Central Heating Systems – Summary Statistics (2012)

No	Aimag center	Boiler Types	Boiler Units	Rated capacity	Heat Substations	District Heating Pipelines	DH Pipeline Maximum Diameter	Heat Systems Ownership[5]	Source of Coal	Aimag Center to Coal Mine	Coal Consumption
			No.	GCal/h	No.	km	mm			km	thous. ton / yr
1	Altai	BZUI, NR, CLRS	29	30.4	10	8.8	200	P & G	Zeegt	210	24.1
2	Arvaiheer	BZUI, NR, MDZ, RJG	20	13.5	7	4.4	150	P & G	Bayanteeg	130	13.2
3	Baruun-Urt	DZL	18	17.5	5	5.6	200	G	Talbulag	35	30.0
4	Bayanhongor	BZUI, NR	23	13.4	8	7.4	150	P & G	Bayanteeg	90	25.9
5	Bulgan	BZUI, NR, CWWQ	19	14.0	7	7.5	150	G	Shivee-Ovoo	758	
6	Zuunmod	BZUI, NR	29	25.8	10	24.0	200	G	Nalaih	45	
7	Mandalgovi	DTH, NR, RJG, CWWQ	15	16.4	7	12.8	250	P & G	Tavantolgoi	300	19.1
8	Muren	BZUI, NR, DTH	24	31.5	13	19.3	150	G	Mogoingol	217	29.3
9	Ulgii	KE-25-14	4	25.8	8	9.2	300	B-P, NW- G	Nuurst hotgor	140	31.2
10	Ondorhaan	BZUI, NR, DTH, DZL	23	16.5	8	17.5	150	P & G	Chandgan tal	59	24.7
11	Sainshand	KE-25-14	3	30.2	8	10.0	350	G	Shivee-Ovoo	220	35.1
12	Suhbaatar	KE-25-14, KVTS-10	4	33.6	7	6.5	400	G	Shivee-Ovoo	630	33.6
13	Ulaangom	KE-25-14	3	28.6	2	3.5	250	B-TI-P, DI- G	Har tarvagatai	90	28.1
14	Uliastai	NR, Su	30	18.1	13	14.1	250	P & G	Mogoingol	140	34.7
15	Hovd	KE-25-14, KVTS-20	3	34.3	4	7.6	350	B-TI-DI-P	Har tarvagatai	196	33.6
16	Tsetserleg	BZUI, NR	26	14.4	8	4.5	150	P & G	Bayanteeg	402	21.9
17	Choir	BZUI, NR	12	13.5	2	4.7	250	G	Shivee-Ovoo	35	16.5

[5] Legend:- P – Private; G – Government; B – Boiler House; TI – Transmission Pipeline; DI – Distribution Pipeline; NW – District Heating Network

J. Heat Supply Planning

139. The following methodology has been adopted for heat supply planning.

140. The rated capacity, production capacity and capacity losses were established based on reports provided by the licensed operators of the heat plants through a survey mechanism.

141. The demand was modelled using an empirical method applied successfully to model heat demand in rural communes in Poland. The model describes consumption of final energy for space heating and provision of hot tap water for meal preparation by apartment dwellers, and for space heating of public buildings. The model has been calibrated using historical consumption data captured in the heat supply inventory.

142. The capacity and demand were compared to establish the year in which a shortfall of capacity was expected.

143. The optimal heating system and technology was identified based on the use of the heat intensity metric (MW / km).

144. Each heating system was examined and a refurbishment / replacement program developed according to the known condition of the heating plant and associated District Heating pipe network. A program for new capacity, covering heat plant and pipelines was developed.

145. The responsibility for the internal heating system within customer's premises rests with the customer and has not been costed in this masterplan.

K. Capacity & Heat Losses

146. The determination of energy losses of the Aimag heating systems is based on estimation techniques as there is no consumer end metering on which to establish an energy balance.

147. What is observed are low boiler efficiencies, low steam/water cycle efficiencies, high consumption of internal heat and power, low condensate return temperature and high-energy losses (radiation, leakage, etc). The total fuel efficiency[6] of the existing Aimag heating plants is believed to be in the range of 30 - 40% for all HOB heating plants.

148. The losses in the district heating networks are high because the District Heating pipeline insulation has been breached by ground water ingress. This results in external corrosion and when added to internal corrosion the wall thickness of pipes becomes very thin, resulting in heat losses, and cracks develop through which water and heat is lost. Hot water is siphoned from the heating system by consumers resulting in further efficiency losses as the water temperature is reduced.

149. The heat production reported by the local authorities in the Aimags was examined against estimates of production based on heat demand modelling, allowing for total downstream heat losses of the order of 30% to 40%. Losses in the pipeline networks are estimated at 15 – 20%, commensurate with losses reported in the CEE / FSU countries; as a comparison a modern equivalent plastic insulated pipeline has heat losses of around 5 to 6%. The remaining heat losses are incurred in consumer's premises as a result of the siphoning of water, due to corrosion of internal piping systems, and wherever the weatherization of housing and buildings falls outside the norms for the Aimag housing stock.

[6] Fuel utilization efficiency is a ratio of the net energy (electricity and / or heat) production to the total fuel input to the boiler.

150. There are some cases where the production capacity of the Aimag heating system is lower than the heat demand established by modelling. In these cases, the quality of the heat service received by consumers will be very poor during times of peak demand with room temperatures falling below 18^{0}C. The situation will be controlled to the extent that consumers refrain from siphoning hot water for domestic use whenever the temperature is at its lowest point during the heating season, say less than -30^{0}C. Nevertheless these heating systems remain a priority for capacity upgrade.

Table VIII-3: Aimag Central Heating Systems – Available Capacity (2012)

No	Aimag center	Rated capacity	Production Capacity	Downstream Capacity Loss
		GCal/h	GCal/h	GCal/h
1	Altai	30.4	20.1	6.1
2	Arvaiheer	13.5	9.5	3.5
3	Baruun-Urt	17.5	17.5	7.4
4	Bayanhongor	13.4	13.4	2.4
5	Bulgan	14.0	13.4	6.3
6	Zuunmod	25.8	15.9	(3.8)
7	Mandalgovi	16.4	11.5	4.2
8	Muren	31.5	26.2	7.5
9	Ulgii	25.8	18.0	7.7
10	Ondorhaan	16.5	13.2	3.6
11	Sainshand	30.2	18.9	7.5
12	Suhbaatar	33.6	23.5	8.5
13	Ulaangom	28.6	20.0	7.6
14	Uliastai	18.1	13.4	2.2
15	Hovd	34.3	24.0	9.2
16	Tsetserleg	14.4	10.6	2.5
17	Choir	13.5	11.6	3.4

Sources: Licensees & Consultants' estimate

L. Expected Operating Life

151. The technical life of a heating system is taken to be 20 years for small to medium coal-fired boilers and CHP plant. The technical life of a District Heating pipeline network is taken to be 10 to 15 years when installed properly and maintained.

152. The majority of the Aimag heating system assets have reached the end of their technical life and need to be rehabilitated where feasible or to otherwise be replaced. The usual practice of investing in sustaining capital has not taken place consistently during the last 15 – 20 years and as a result the heating systems have deteriorated badly.

153. Without investment in rehabilitation and replacement, the heating plants and District Heating pipeline networks can continue to function for another five years, after which the available capacity will be so degraded that consumers will be forced to seek alternative heating options, most likely moving out of the town to establish their own heat supply as a Ger dweller or moving to a larger town where heat supply is superior.

M. Demand Forecasts

154. The rural heat demand has been modelled using an empirical approach developed by a Polish university to model heat demand in the rural communes of Poland. Poland's winter heating period and temperature range is similar to that of Mongolia and the empirical formula applies well to Mongolian conditions. Care was taken to ensure that the constants in the empirical formulae are correct for Mongolian conditions, using historical production data, and heat floor space and volumes as reported by the licensed operators and captured in the heat supply inventory.

155. The provision of hot tap water for meal preparation has been included in the heat demand forecasts. Whilst there are arguments against the provision of hot tap water, viz a viz such load contributes to a high peak demand but only low consumption, provision has been included because hot water is taken from the heating system by consumers in most if not all parts of the country and it is expected that this practice will continue into the future. It is preferable to normalize the supply of hot water on the grounds of overall efficiency.

156. The modelling describes consumption of final energy for space heating and provision of hot tap water for meal preparation by apartment dwellers, and for space heating of public buildings. The model is driven by the count of heat consumers, residential floor area heated and public building volumes heated. The heat demand has been modelled from 2003 to 2020, and the results have been compared against reported heat production, allowing for typical delivery losses in an aged heating system. The reconciliations between modelled demand and reported demand are found to match consistently across the Aimags. Accordingly, it is considered that the demand forecasts are robust. However, it is understood that the Government has a programme to build apartments and to relocate families living in gers. While the impact of this programme is uncertain, it is reasonable to allow an uplift in heat demand of 15 - 20% by 2025 to allow for these new apartments. This uplift is considered during heat expansion planning when selecting the nearest standard boiler capacities and heat reserve margin.

157. The results of the demand forecasting for the Aimags as a whole is provided as Table VIII-4.

Table VIII-4: Aimag Heat Summary Forecast

Year	Total Population '000s	Urban Population '000s	Urban Population with Heating	% Urban Population with Heating	District Heating Area	Growth Rate	Annual Heat Consumption	Maximum Demand
	thous.	thous.	thous.	%	sq. km	%	GCal	GCal/h
2004	1,313	310	61	20%	2,035	-	457,065	152
2005	1,311	316	62	20%	2,073	1.9%	465,470	155
2006	1,314	324	64	20%	2,129	2.7%	477,853	159
2007	1,317	311	65	21%	2,180	2.4%	489,149	162
2008	1,320	328	68	21%	2,258	3.6%	506,492	168
2009	1,328	336	70	21%	2,327	3.1%	522,035	173
2010	1,181	270	75	28%	2,433	4.5%	545,015	182
2011	1,176	269	79	29%	2,492	2.4%	558,182	187
2012	1,171	267	82	31%	2,553	2.4%	571,664	192
2013	1,166	266	85	32%	2,609	2.2%	583,866	196
2014	1,161	265	89	33%	2,663	2.1%	595,620	201
2015	1,156	264	93	35%	2,719	2.1%	607,657	205

Year	Total Population '000s	Urban Population '000s	Urban Population with Heating	% Urban Population with Heating	District Heating Area	Growth Rate	Annual Heat Consumption	Maximum Demand
	thous.	thous.	thous.	%	sq. km	%	GCal	GCal/h
2020	1,132	347	108	31%	3,012	35%	669,930	229

Sources: Licensees & Consultants' estimate

N. Aimag Heat Forecasting

158. Section IX of this report contains a description of the heating systems in each of the Aimags, the historical and forecast heat demand and consumption. Other salient information is captured for each Aimag.

IX. HEAT DEMAND & SUPPLY BY AIMAG

O. Bayan (Ulgii)

159. Bayan Aimag is located at the central extreme western edge of Mongolia. The population is around 100,000.

160. Ulgii, the urban center has a population of around 33,000. Ulgii is sited 1,715m above sea level, has an average annual temperature of 0.6˚C, with annual heating days of 232. The average annual precipitation is 118mm and average relative moisture is 48%. The nearest mountain is Tavanbogd and the nearest river Hovd.

16. Demand for Heat

161. The number of households taking heat supply is estimated at 850 or around 13% of the Ulgii population. The District Heating network supplies hot water to apartments and public buildings for space heating, domestic hot water mainly to apartments, and process steam to industry. Ulgii's development is taking place in the down town/central part of the city in the form of private houses and public buildings. Attempts are being made to revive small and medium-scale industries for processing agricultural products. It is planned for the buildings located distant from HOBs to be supplied with heat from an integrated group of HOBs, and the residential area heat supply of single and two-storey private houses to have a separate heat supply. The Consultant has modelled the heat demand for Ulgii based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-1: Ulgii - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	30,900	738	147.4	1.5%	29,534	10.0
2005	30,100	748	149.6	1.5%	29,960	10.1
2006	30,461	759	151.8	1.5%	30,380	10.3
2007	30,279	771	154.2	1.6%	30,837	10.4
2008	32,427	783	156.5	1.5%	31,278	10.6
2009	33,435	794	158.8	1.5%	31,718	10.7
2010	24,399	806	161.2	1.5%	32,174	10.9
2011	24,473	821	166.0	1.0%	32,729	11.0
2012	24,546	836	164.4	1.0%	33,294	11.2
2013	24,694	851	166.1	1.0%	33,869	11.4
2014	24,842	866	167.7	1.0%	34,453	11.6
2015	24,991	882	169.4	1.0%	35,047	11.8
2020	29,595	961	178.1	1.0%	38,165	12.9

Sources: Licensees, EA data & Consultants' estimate

162. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-2: Ulgii – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	836	66,851	260,582	0.036	0.091	0.012	33,294	8.0

Sources: Licensees, EA data & Consultants' estimate

17. Validation of Demand Forecast for Heat

163. The local authority reported that in 2012 the total heat production was 18.0 GCal/h which compared to the Consultant's end-use forecast of 11.2 GCal/h, indicates a 38% loss in the DH pipelines and at the consumer's premises.

164. The average heat consumption in Poland rural communes is 25GJ per person. In Ulgii 8.0 GCal per person equates to 34GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Ulgii where it is 16 m^2.

165. Overall, the Consultant considers the heat forecast of **Table IX-1** to be valid and within the normal range of accuracy for heat planning purposes.

18. Existing Heat Supply

166. The town is supplied by medium-size HOB's and a DH network. There are also thirteen individual heating systems.

167. The rated capacity, reported production capacity, spare capacity and estimated capacity loss is provided as Table IX-3.

Table IX-3: Ulgii - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
25.8	N	N.A.	18.0	7.7	6.8	38%

Sources: Licensees, EA data

168. The Ulgii heat plant comprises 4 steam boilers of KE-25-14E type.

169. The DH network has 10 heat substations. The total length of the network is 5.6 km.

170. The HOBs and DH network were installed in 1986 (average age – 25 years) and little refurbishment has taken place since that time. Over 60% of the DH system is old and deteriorated. The remaining technical life is estimated at 5 years.

19. Fuel Prices

171. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-4: Ulgii - HOB Fuel Performance

Boiler	Rated Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
KE-25-14E	7.5	1.4	33.6	7.8	19,500	152
KE-25-14E	7.5	1.4	33.6	7.8	19,500	152
KE-25-14E	7.5	1.4	33.6	7.8	19,500	152
KE-25-14E	7.5	1.4	33.6	7.8	19,500	152
Total	30	5.6	134.4	31.2	19,500	608

Sources: Licensees, EA data & Consultants' data

20. Economic Benefits for Ulgii

172. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

173. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

174. Coal is transported by trucks from the "Nuurst Khotgor" coal mine of the neighboring Uvs province located 140 km away from Ulgii. A substantial reduction in coal transport costs will result if modern boilers are introduced.

175. These benefits strongly support the case for refurbishment of Ulgii's heat supply system.

21. Ownership

176. The Ulgii HOB facilities were privatized in 2007.

177. All district heating networks belong to the municipal Government. The responsibility for operation and maintenance of the district heating system rests with the state-owned "District Heating Network" company.

178. In addition there are thirteen individually-owned heating systems comprising seven Chinese, two HP, one BARS, and three small HOBs.

Table IX-5: Ulgii – Heating Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	58.1	-	226.5	-	145.2	-
2004	30.9	-	3.7	59.0	1.5%	229.8	1.5%	147.4	1.5%
2005	30.1	-2.6%	3.7	59.8	1.4%	233.5	1.6%	149.6	1.5%
2006	30.5	1.2%	3.8	60.7	1.5%	236.9	1.4%	151.8	1.5%
2007	30.3	-0.6%	3.9	61.7	1.6%	240.5	1.5%	154.2	1.6%
2008	32.4	7.1%	3.9	62.6	1.5%	244.1	1.5%	156.5	1.5%
2009	33.4	3.1%	4.0	63.5	1.4%	247.8	1.5%	158.8	1.5%
2010	24.4	-27.0%	4.0	64.5	1.6%	251.4	1.5%	161.2	1.5%
Average 2003 - 2010	-	-3.1%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	24.5	0.3%	4.1	65.7	1.8%	256.0	1.8%	162.8	1.0%
2012	24.5	0.3%	4.2	66.9	1.8%	260.6	1.8%	164.4	1.0%
2013	24.7	0.6%	4.3	68.1	1.8%	265.3	1.8%	166.1	1.0%
2014	24.8	0.6%	4.3	69.3	1.8%	270.1	1.8%	167.7	1.0%
2015	25.0	0.6%	4.4	70.5	1.8%	274.9	1.8%	169.4	1.0%
Average 2011 - 2015	-	0.5%	4.3	-	1.8%	-	1.8%	-	1.0%
2015	25.0	0.1%	4.4	70.5	1.8%	274.9	1.8%	169.4	1.0%
2020	29.6	0.5%	4.8	77.1	9.4%	300.6	9.3%	178.1	5.1%
2025	-	-	-	84.3	9.4%	328.7	9.3%	187.1	5.1%

Table IX-6: Ulgii Heat Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	3,688	147,500	229,840	7,847	19,057	2,630	26,904	29,534	8.1	10.0
2005	3,738	149,500	233,480	7,936	19,359	2,666	27,295	29,960	8.2	10.1
2006	3,794	151,750	236,860	8,035	19,639	2,706	27,674	30,380	8.3	10.3
2007	3,856	154,250	240,500	8,145	19,941	2,751	28,086	30,837	8.4	10.4
2008	3,913	156,500	244,140	8,244	20,243	2,791	28,487	31,278	8.6	10.6
2009	3,969	158,750	247,780	8,343	20,545	2,831	28,887	31,718	8.7	10.7
2010	4,031	161,250	251,420	8,452	20,847	2,875	29,299	32,174	8.8	10.9
2011	4,104	164,163	255,961	8,579	21,223	2,927	29,802	32,729	9.0	11.0
2012	4,178	167,126	260,582	8,708	21,606	2,980	30,314	33,294	9.1	11.2
2013	4,254	170,142	265,284	8,839	21,996	3,034	30,835	33,869	9.3	11.4
2014	4,330	173,211	270,069	8,971	22,393	3,089	31,364	34,453	9.4	11.6
2015	4,408	176,333	274,937	9,106	22,796	3,144	31,902	35,047	9.6	11.8
2020	4,806	192,827	300,628	9,810	24,927	3,428	34,737	38,165	10.4	12.9

P. Dornogovy Aimag (Sainshand)

179. Dornogovy Aimag is located in the south-east of Mongolia. The population is around 60,000. Sainshand, the urban centre has a population of around 21,000. Sainshand is sited 956m above sea level, has an average annual temperature of 3.7˚C with annual heating days of 195. The average annual precipitation is 114m and average relative moisture is 41%. There are no mountains or rivers in the vicinity.

22. Demand for Heat

180. The number of households taking heat supply in 2012 is estimated to be 1,400 or around 13% of the Sainshand population.

181. Industrial steam was supplied from 1986 to 1991, but following the closure of the food, timber processing and meat processing factories, demand for steam ceased. Since then the heating plants have produced only heat where the demand for heat is mainly for space heating, with the demand for hot tap water being small but increasing over time.

182. Over 80 public and apartment buildings are supplied with heating and all are directly connected to the District Heating network. In 2012, only five user inlets with hot water heaters were functioning. There are 260 apartments without hot water, comprising two apartment buildings of 80 households each, one of 48 households, five of 8 households each, and one of 12 households. Consumer heat delivery cannot be controlled and the heat delivered to users is lower than specified, e.g. the remotely located hospital and secondary school No.1 do not receive their full entitlement.

183. The Consultant has modelled the heat demand for Sainshand based on the supply of space heating to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-7: Sainshand - Heat Demand

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	14,493	1,194	146.3	1.5%	29,700	10.1
2005	15,483	1,212	148.5	1.5%	30,126	10.2
2006	16,990	1,231	150.7	1.5%	30,551	10.4
2007	17,373	1,249	153.0	1.5%	30,998	10.5
2008	18,715	1,267	155.3	1.5%	31,445	10.7
2009	20,359	1,288	157.7	1.5%	31,907	10.9
2010	19,717	1,306	160.0	1.5%	32,354	11.0
2011	20,364	1,347	164.8	3.0%	33,319	11.3
2012	21,023	1,389	169.1	2.6%	34,305	11.7
2013	21,691	1,431	174.8	3.4%	35,312	12.0
2014	22,371	1,475	180.0	3.0%	36,341	12.4
2015	23,060	1,519	185.5	3.1%	37,392	12.7
2020	40,056	1,753	215.6	3.2%	43,116	14.7

Sources: Licensees, EA data & Consultants' estimate

184. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-8: Sainshand – Heat Model (Per Annum)

	Urban Population with heat	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	4,860	68,040	265,355	0.037	0.092	0.015	34,305	7.1

Sources: Licensees, EA data & Consultants' estimate

23. Validation of Demand Forecast for Heat

185. The local authority reported that in 2012 the total heat production was 18.9 GCal/h which compared to the Consultant's end-use forecast of 11.4 GCal/h, indicates a 39% loss in the DH pipelines and at the consumer's premises.

186. The average heat consumption in Poland rural communes is 29GJ per person. In Sainshand a 7.1 GCal consumption per person equates to 30GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Sainshand where it is 14 m^2.

187. Overall, the Consultant considers the heat forecast of **Table IX-7** to be valid and within the normal range of accuracy for heat planning purposes.

24. Existing Heat Supply

188. The town is supplied with heat by HOB's and a DH network. Heat is supplied to apartments and public buildings, domestic hot water mainly to apartments, and process steam to industry.

189. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-9.

Table IX-9: Sainshand – Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
30.2	Y	N.A.	18.9	11.3	7.5	39%

Sources: Licensees, EA data

190. The heating plant has 3 steam generation boilers, of KE-25-14 type with grates, each rated for 25 tons of steam at 14 bar pressure per hour.

191. There are 3 heat substations with pipe heat exchangers. The three substations are equipped with pipe heat exchangers for domestic hot water. The pipe network is underground and above ground with double lines totalling 10km. The maximum diameter of the network is 350

mm.

192. The HOBs and DH network were installed in 1986 (average age reported at 25 years) and no capital repairs have been made since that time; as a result boilers cannot be operated at their rated capacity.

193. In 1999 Boiler No. 2 was converted to 'fluidized bed' combustion according to designs of the Technical University. Since then the operation of the boiler has been good and efficiency and capacity have increased because fuel is burnt completely. Boiler No. 2 was converted to 'fluidized bed' combustion in 2000. Equipment installed on Boiler No. 3 is broken and the boiler has not operated since 1996. In 2008 a Chinese boiler of type SHL was installed and capacity increased by 8.6 Gcal/h.

194. There are 4 PVP steam-water heaters, one consisting of two parts: steam, with a heating surface of 58 m2, and condensation cooling of 5.9 m^2. Two heaters are in operation per shift, but they cannot operate at design capacity because their tubes are damaged as a result of (i) the network often being empty of water and (ii) water quality not meeting requirements. The steam-water heaters' tubing should be replaced.

195. Condensate from the heaters is accumulated in an un-insulated 25 m^3 tank, and 2 pumps of K-90/35 type are used to pump in order to make up network losses. According to the design the condensate should be delivered to the de-aerator and not to the tank, but it was modified to compensate for the losses in the network.

196. There are three parallel connected network water pumps of D-320/70 type delivering the heat to users at appropriate pressure. They breakdown periodically, mainly due to failing working wheels and bearings, and should be replaced in the near future. Pressure generated by the existing pump is not sufficient and does not meet the requirements because hydraulic estimation and balancing of heat load is not undertaken.

25. Fuel Prices

197. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-10: Sainshand – HOB Fuel Performance

Boiler house	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Sainshand	18.9	7.5	180.0	35.1	16,430	577
Total	18.9	7.5	180.0	35.1	16,430	577

Sources: Licensees, EA data & Consultants' data

26. Economic Benefits for Sainshand

198. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

199. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

200. Coal is transported by rail from Shivee- Ovoo coal mine 220 km away. A substantial reduction in coal transport costs will result if modern boilers are introduced.

201. The open heating units and radiators use the water of the heating system for their hot water needs which results in enormous losses to the heating network. Survey indicates that network

water losses amount to 32-40 tons of water per hour, and the thermal plant operator incurs considerable expense in order to make up these losses; the normal operation of the DH network is affected and the water losses cause breakdowns in the system.

27. Ownership

202. The thermal plant, main network and substations fall under the responsibility of the Government-owned Chandman-Ilch company; branch lines are the users' responsibility (most of these are observed to be in bad condition).

Table IX-11: Sainshand - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	57.7	-	224.9	-	144.2	-
2004	14.5	-	4.2	58.5	1.4%	228.3	1.5%	146.3	1.5%
2005	15.5	6.8%	4.2	59.4	1.5%	231.7	1.5%	148.5	1.5%
2006	17.0	9.7%	4.3	60.3	1.5%	235.0	1.5%	150.7	1.5%
2007	17.4	2.3%	4.4	61.2	1.5%	238.7	1.5%	153.0	1.5%
2008	18.7	7.7%	4.4	62.1	1.5%	242.3	1.5%	155.3	1.5%
2009	20.4	8.8%	4.5	63.1	1.6%	246.0	1.5%	157.7	1.5%
2010	19.7	-3.2%	4.6	64.0	1.4%	249.6	1.5%	160.0	1.5%
Average 2003 - 2010	-	5.4%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	20.4	3.3%	4.7	66.0	3.1%	257.4	3.1%	164.8	3.0%
2012	21.0	3.2%	4.9	68.0	3.1%	265.4	3.1%	169.1	2.6%
2013	21.7	3.2%	5.0	70.1	3.1%	273.5	3.1%	174.8	3.4%
2014	22.4	3.1%	5.2	72.3	3.0%	281.8	3.0%	180.0	3.0%
2015	23.1	3.1%	5.3	74.4	3.0%	290.3	3.0%	185.5	3.1%
Average 2011 - 2015	-	3.18%	5.0	-	3.1%	-	3.1%	-	3.0%
2015	23.1	0.10%	5.3	74.4	3.0%	290.3	3.0%	185.5	3.1%
2020	40.1	0.50%	6.1	86.6	16.3%	336.9	3.1%	215.6	16.2%
2025	-	-	-	100.7	16.3%	391.0	3.1%	250.6	16.2%

Table IX-12: Sainshand Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		Heat Consumption					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	4,179	146,250	228,280	7,792	18,928	2,980	26,719	29,700	8.0	2.1
2005	4,243	148,500	231,660	7,891	19,208	3,026	27,099	30,126	8.1	2.2
2006	4,307	150,750	235,040	7,991	19,488	3,072	27,479	30,551	8.2	2.2
2007	4,371	153,000	238,680	8,090	19,790	3,118	27,880	30,998	8.3	2.2
2008	4,436	155,250	242,320	8,189	20,092	3,164	28,281	31,445	8.4	2.3
2009	4,507	157,750	245,960	8,299	20,394	3,215	28,693	31,907	8.6	2.3
2010	4,571	160,000	249,600	8,397	20,696	3,261	29,093	32,354	8.7	2.3
2011	4,714	164,993	257,389	8,615	21,341	3,362	29,957	33,319	8.9	2.4
2012	4,860	170,099	265,355	8,837	22,002	3,466	30,839	34,305	9.2	2.5
2013	5,009	175,320	273,499	9,062	22,677	3,573	31,740	35,312	9.5	2.5
2014	5,162	180,658	281,827	9,292	23,368	3,682	32,659	36,341	9.7	2.6
2015	5,318	186,116	290,341	9,525	24,074	3,793	33,599	37,392	10.0	2.7
2020	6,134	216,495	336,930	10,804	27,937	4,375	38,741	43,116	11.6	3.1

Q. Seleng Aimag

203. Seleng Aimag is located in central Mongolia. The population is around 100,000. Suhbaatar, the urban centre has a population of around 30,000. Each year around 800 people move to Ulaanbaatar, Darkhan, Erdenet and other cities. The poverty rate is high at 60%.

204. Suhbaatar is sited 992m above sea level, has an average annual temperature of 0.8 ˚C with annual heating days of 223. The average annual precipitation is 203mm and average relative moisture is 48%.

28. Demand for Heat

205. The number of households taking heat supply in 2012 is estimated to be 1,260 or around 20% of the Suhbaatar population.

206. Out of a total of six heat substations, three are installed in apartments with domestic hot water heaters, one in a hospital and seven in schools that have their own domestic hot water heaters. Old apartments designed for one or two households have no domestic hot water heaters. Railway heat substations have small HOBs to heat domestic hot water.

207. The heat delivered to consumers is reported to be in breach of minimum acceptable standards. Consumers who have no domestic hot water system take hot water from the DH network illegally.

208. Under the umbrella of the "40,000 households housing" project, one apartment block for 40 households and another for 20 households will be built. The Consultant has modelled the heat demand for Suhbaatar based on supply of space heating to apartments and public buildings and hot tap water for domestic use.

Table IX-13: Suhbaatar – Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	28,653	996	154.2	3.0%	36,858	12.0
2005	30,577	1,026	158.8	3.0%	37,942	12.4
2006	33,266	1,056	163.6	3.0%	39,057	12.7
2007	27,170	1,088	168.5	3.0%	40,205	13.1
2008	34,064	1,121	173.5	3.0%	41,387	13.5
2009	34,708	1,154	178.7	3.0%	42,603	13.9
2010	28,987	1,189	179.2	0.3%	42,731	14.0
2011	29,019	1,224	179.6	0.2%	42,818	14.1
2012	29,051	1,261	192.8	7.4%	45,898	15.0
2013	29,083	1,298	199.3	3.4%	47,407	15.5
2014	29,115	1,337	200.4	0.6%	47,682	15.6
2015	29,147	1,376	200.8	0.2%	47,779	15.7
2020	30,610	1,568	202.8	0.2%	48,254	16.1

Sources: Licensees, EA data & Consultants' estimate

209. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-14: Suhbaatar –Heat Model (Per Annum)

	Urban Population	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	6,303	37,819	434,000	0.023	0.151	0.019	45,898	7.3

Sources: Licensees, EA data & Consultants' estimate

29. Validation of Demand Forecast for Heat

210. The local authority reported that in 2012 the total heat production was 23.5 GCal/h which compared to the Consultant's end-use forecast of 15.0 GCal/h, indicates a 36% loss in the DH pipelines and at the consumer's premises.

211. The average heat consumption in Poland rural communes is 25GJ per person. In Suhbaatar a consumption of 7.3 GCal per person equates to 31GJ per person. However the average square meter per person of residential space heated in Poland is around 20 m^2 compared to Suhbaatar where it is only 6 m^2. This discrepancy suggests that there is a chronic level of downstream losses in the heating system, most likely due to the siphoning of hot water as mentioned above.

212. Overall however, the Consultant considers the forecast in Table IX-13 to be valid for heat planning purposes.

30. Existing Heat Supply

213. Suhbaatar is supplied by HOB's and a DH network.

214. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-15.

Table IX-15: Suhbaatar – Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
33.6	Y	10.0	23.5	10.3	8.5	36%

Sources: Licensees, EA data

215. The HOBs and DH network were installed in 1989 (average age is 22 years) and no capital repairs have been made since that time; as a result boilers cannot be operated at rated capacity, and the technical condition of branch pipelines, manholes and chambers is poor.

216. There are 4 steam boilers of type KE-25-14. In 2003, 2004 and 2005, Boilers No.1, 2 and 4 were respectively converted to HOBs. Boiler No. 3 provides steam to industry. There is a spare location available to install an additional Boiler.

217. There are 7 heat substations. The total length of district heating line and branch double lines is 19.2 km. The diameter of pipes varies from 70 – 400 mm.

218. Boiler water-walls are reportedly often clogged, swell and blow up. Grates and air heaters are aging and deteriorating. The main and branch district heating pipelines started to be punctured and cracked as well as the pipelines between buildings. Valves leak when fully closed.

219. The operating regime is designed for hot water supply and return temperatures of 120/70˚C producing 28.3 Gcal/h heat (470 ton/h), but at present the water temperature cannot be increased above 90/55 ˚C. The volume of water circulating in the DH system is higher than necessary due to insufficient boiler capacity, non-automated system, corroded and rusted heating facilities and adjustment inaccuracy.

220. Domestic hot water heat exchangers are worn out and temperature control devices are missing.

221. Some DH network valves are replaced during the annual summer repair program but the economic life of the heating system has expired. The remaining technical life is estimated to be 5 years.

31. Fuel Prices

222. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-16: Suhbaatar – HOB Fuel Performance

Boilers	Available Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
#1	3 x 7	4.1	100-200	33000	27,816	27.82
#2	1x2.5	0.6	6	600	27,816	27.82
Total	23.5	4.6-9.6	106-206	33600		55.63

Sources: Licensees, EA data & Consultants' data

32. Economic Benefits for Suhbaatar

223. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

224. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities. Heat loss of apartment buildings constructed with pre-fabricated blocks is extremely high since this form of construction does not meet minimum standards.

225. Coal is transported from Shariin Gol, Baganuur and Shivee-Ovoo coal mines from a distance of 630km. A substantial reduction in coal transport costs will result if modern boilers are introduced.

226. Water is supplied from two dedicated wells in the Orkhon river flood plain and from a centralized water supply system.

33. Ownership

227. The thermal plant, heat transmission and distribution networks are under the ownership of the local government authority.

Table IX-17: Subhaatar - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	29.0	-	337.9	-	149.7	-
2004	28.7	-	5.0	29.9	3.0%	348.0	3.0%	154.2	3.0%
2005	30.6	6.7%	5.1	30.8	3.0%	358.5	3.0%	158.8	3.0%
2006	33.3	8.8%	5.3	31.7	3.0%	369.2	3.0%	163.6	3.0%
2007	27.2	-18.3%	5.4	32.6	3.0%	380.3	3.0%	168.5	3.0%
2008	34.1	25.4%	5.6	33.6	3.0%	391.7	3.0%	173.5	3.0%
2009	34.7	1.9%	5.8	34.6	3.0%	403.5	3.0%	178.7	3.0%
2010	29.0	-16.5%	5.9	35.7	0.3%	402.0	6.1%	179.2	0.3%
Average 2003 - 2010	-	1.3%	-	-	2.6%	-	3.4%	-	2.6%
Forecast									
2011	29.0	0.1%	6.1	36.7	0.2%	400.0	-0.5%	179.6	0.2%
2012	29.1	0.1%	6.3	37.8	7.4%	434.0	8.5%	192.8	7.4%
2013	29.1	0.1%	6.5	38.9	3.4%	449.0	3.4%	199.3	3.4%
2014	29.1	0.1%	6.7	40.1	0.6%	449.0	0.0%	200.4	0.6%
2015	29.1	0.1%	6.9	41.3	0.2%	446.7	-0.5%	200.8	0.2%
Average 2011 - 2015	-	0.1%	6.5	-	2.3%	-	2.2%	-	2.3%
2015	29.1	0.1%	6.9	41.3	0.2%	446.7	-0.5%	200.8	0.2%
2020	30.6	0.5%	7.8	47.4	14.7%	435.7	2.2%	202.8	2.3%
2025	-	-	-	54.3	14.7%	425.0	2.2%	204.8	2.3%

Table IX-18: Subhaatar Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption -----------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	4,978	74,675	348,037	4,450	28,858	3,551	33,308	36,858	9.5	2.5
2005	5,128	76,915	358,478	4,561	29,723	3,657	34,284	37,942	9.8	2.6
2006	5,282	79,223	369,232	4,675	30,615	3,767	35,290	39,057	10.1	2.7
2007	5,440	81,599	380,309	4,791	31,533	3,880	36,325	40,205	10.3	2.8
2008	5,603	84,047	391,719	4,911	32,479	3,997	37,390	41,387	10.6	2.9
2009	5,771	86,569	403,470	5,033	33,454	4,116	38,487	42,603	11.0	2.9
2010	5,944	89,166	402,000	5,159	33,332	4,240	38,491	42,731	11.0	3.0
2011	6,121	91,817	400,000	5,286	33,166	4,366	38,452	42,818	11.0	3.1
2012	6,303	94,547	434,000	5,417	35,985	4,496	41,402	45,898	11.8	3.2
2013	6,491	97,358	448,971	5,551	37,227	4,630	42,777	47,407	12.2	3.3
2014	6,684	100,253	448,971	5,688	37,227	4,767	42,915	47,682	12.2	3.4
2015	6,882	103,234	446,738	5,829	37,041	4,909	42,870	47,779	12.2	3.5
2020	7,838	118,396	435,735	6,534	36,129	5,591	42,663	48,254	12.2	4.0

R. Uvs Aimag

228. Uvs Aimag is located in the north-west of Mongolia. In 2012, Uvs province was reported to have a population of 73,000.

229. Ulaangom, the provincial capital was reported to have 23,000 inhabitants. The rural drift from Ulaangom is pronounced – poverty stands at 30.7% and in recent years on average 2,680 people have moved to Ulaanbaatar, Darkhan, Erdenet and other towns.

230. Ulaangom is sited 936m above sea level, has an average annual temperature of -3.7 ˚C with annual heating days of 259. The average annual precipitation is 259mm and average relative moisture is 46%. The nearest mountain is Harhiraa and the nearest river Gashuun, Turgen, Teel.

34. Demand for Heat

231. The number of households taking heat supply in 2012 is estimated to be 900 or around 12% of the Ulaangom population.

232. In the mid-80's there was a demand from Ulaangom's industry and offices for supply of process steam and heat, and a district heating mains pipeline was commissioned in 1986. The DH network soon developed to supply heat to apartments and public buildings.

233. The Consultant has modelled the heat demand for Ulaangom based on supply of heating to apartments and public buildings, and hot tap water for domestic use.

Table IX-19: Ulaangom – Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	18,240	797	85.1	39.4%	20,315	7.3
2005	19,229	809	93.5	9.9%	22,280	7.9
2006	18,534	821	103.0	10.1%	24,474	8.5
2007	17,647	833	113.5	10.2%	26,924	9.3
2008	18,340	846	125.3	10.4%	29,662	10.1
2009	18,566	859	138.5	10.5%	32,722	11.0
2010	17,236	877	153.3	10.7%	36,166	12.0
2011	17,063	890	156.3	1.9%	36,857	12.2
2012	16,891	903	159.3	1.9%	37,562	12.4
2013	16,720	917	162.4	1.9%	38,281	12.7
2014	16,550	931	165.5	1.9%	39,013	12.9
2015	16,381	944	168.8	1.9%	39,760	13.2
2020	21,598	1,015	185.8	2.0%	43,713	14.4

Sources: Licensees, EA data & Consultants' estimate

234. The Consultant's heat demand forecast is derived from a GCal per person estimate based

on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-20: Ulaangom –Heat Model (Per Annum)

	Urban Population	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	2,710	18,967	392,950	0.013	0.137	0.008	37,562	13.9

Sources: Licensees, EA data & Consultants' estimate

35. Validation of Demand Forecast for Heat

235. The local authority reported that in 2012 the total heat production was 20.05 GCal/h which compared to the Consultant's end-use forecast of 12.4 GCal/h, indicates a 38% loss in the DH pipelines and at the consumer's premises.

236. The average heat consumption in Poland rural communes is 25GJ per person. In Ulaangom a consumption of 13.9 GCal per person equates to 58GJ per person. However the average square meter per person of residential space heated in Poland is around 20 m^2 compared to Ulaangom where it is only 7 m^2. This discrepancy suggests that there is a chronic level of downstream losses in the heating system, most likely due to the siphoning of hot water as mentioned above.

237. Overall however, the Consultant considers the forecast in **Table IX-19** to be valid for heat planning purposes.

36. Existing Heat Supply

238. Ulaangom is supplied by HOB's and a DH network.

239. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-22.

Table IX-21: Ulaangom - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
28.6	N	0.0	20.0	10.3	7.6	38%

Sources: Licensees, EA data

240. The HOBs and DH network were installed in 1986 (age of 19 years).

241. The heating plant has 3 steam generation boilers, of KE-25-14 type with grates, each rated for 25 tons of steam at 14 bar pressure per hour. In 2003, 2004 and 2005, Boilers No.1, 2 and 4 were respectively converted to HOBs; Boiler No. 3 is as a steam processing unit. There is a spare location available to install an additional Boiler.

242. An attempt was made to convert one of the boilers to fluidized bed combustion but conversion failed and the boiler is out of service.

243. The water walls of two of the KE-25 boilers, grates and convection heating surfaces were

replaced in 2006-2007.

244. The 360 ton/h water in the district heating system can be heated up to 90/70oC by 2 boilers, but by 1 boiler up to 80/60oC, respectively.

245. There are 2 pumps of Д -320-70 type and 1 pump of Д- 320-90 type in the district heating system. According to the regime calculation 1 pump works in the network has to provide 8.3 Gcal/h rated load pumping up to 245 ton/h water by 9/3 kgs/cm2 pressure and 105/70oC temperature regimes. There is one de-aerator for additional water and sodium cationic softeners for first and second stage water treatment. There are 2 additional water pumps of K-45/30 type, one of them is always in service and adds 22 tons/h water to the network. The thermal plant is supplied by two dedicated deep wells with ETsV-10 pumps installed.

246. Today Ulaangom has 5 heat substations. The total length of the DH pipeline is 4.5km. The diameter of the district heating outlet pipe is 250 mm at the thermal plant and 150 mm at the heat substations.

247. Testing conducted in 2006 found that the technical condition of the main pipelines was good. Branch pipelines were installed much earlier than the mains, and were found to have reached the end of their technical life. They were partially replaced. The technical condition of manholes and valves is poor.

248. The local authority has planned to refurbish equipment and premises of the existing five heat substations and to build ten new heat substations. Also to extend the DH network by constructing a new 8.8 km district heating pipeline with 100-400 mm diameter.

37. Fuel Prices

249. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-22: Ulaangom – HOB Fuel Performance

Boilers	Rated Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
3xKVTS-10						
2xNR-54						
2xNR-54						
Total	14	5.588	135.2	28.1	29,770	837

Sources: Licensees, EA data & Consultants' data

38. Economic Benefits for Ulaangom

250. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

251. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities. Heat loss of apartment buildings constructed with pre-fabricated blocks is extremely high since this form of construction does not meet minimum standards.

252. Coal is usually transported from the "Khar Tarvagatain" coal mine lies 90 km from this Aimag center. A substantial reduction in coal transport costs will result if modern boilers are introduced.

253. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Ulaangom's heat supply system.

39. Ownership

254. The thermal plant and the section of network between thermal plant and consumers was privatized in 2003.

255. The owner of the TP owns the "Khar Tarvagatain" coal mine also. The TP do not produce profit, but coal some, thus the owner cross-subsidizes.

256. There are 6 entities such as airport, care center, etc. that have their own small HOBs of HP-18-27 type.

Table IX-23: Ulaangom - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2004	18.2	-	2.4	16.7	39.4%	191.4	12.0%	85.1	39.4%
2005	19.2	5.4%	2.4	17.0	9.9%	214.3	12.0%	93.5	9.9%
2006	18.5	-3.6%	2.5	17.2	10.1%	240.0	12.0%	103.0	10.1%
2007	17.6	-4.8%	2.5	17.5	10.2%	268.8	12.0%	113.5	10.2%
2008	18.3	3.9%	2.5	17.8	10.4%	301.1	12.0%	125.3	10.4%
2009	18.6	1.2%	2.6	18.0	10.5%	337.2	12.0%	138.5	10.5%
2010	17.2	-7.2%	2.6	18.4	10.7%	377.7	12.0%	153.3	10.7%
Average 2003 - 2010	-	-0.8%	-	-	14.5%	-	12.0%	-	14.5%
Forecast									
2011	17.1	-1.0%	2.7	18.7	1.9%	385.2	2.0%	156.3	1.9%
2012	16.9	-1.0%	2.7	19.0	1.9%	392.9	2.0%	159.3	1.9%
2013	16.7	-1.0%	2.8	19.3	1.9%	400.8	2.0%	162.4	1.9%
2014	16.6	-1.0%	2.8	19.5	1.9%	408.8	2.0%	165.5	1.9%
2015	16.4	-1.0%	2.8	19.8	1.9%	417.0	2.0%	168.8	1.9%
Average 2011 - 2015	-	-1.0%	2.8	-	1.9%	-	2.0%	-	1.9%
2015	16.4	0.1%	2.8	19.8	1.9%	417.0	2.0%	168.8	1.9%
2020	21.6	0.5%	3.0	21.4	7.7%	460.4	2.0%	185.8	1.9%
2025	-	-	-	23.0	7.7%	508.3	2.0%	204.5	1.9%

Table IX-24: Ulaangom Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption				------------------------------	Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,390	41,817	191,350	2,745	15,866	1,704	18,611	20,315	5.3	1.9
2005	2,426	42,454	214,312	2,780	17,770	1,730	20,549	22,280	5.9	2.0
2006	2,463	43,101	240,029	2,815	19,902	1,757	22,717	24,474	6.5	2.0
2007	2,500	43,757	268,833	2,850	22,290	1,783	25,141	26,924	7.2	2.0
2008	2,538	44,424	301,093	2,887	24,965	1,811	27,852	29,662	8.0	2.1
2009	2,577	45,100	337,224	2,923	27,961	1,838	30,884	32,722	8.9	2.1
2010	2,630	46,028	377,691	2,973	31,316	1,876	34,290	36,166	9.9	2.1
2011	2,670	46,718	385,245	3,010	31,943	1,904	34,953	36,857	10.0	2.2
2012	2,710	47,419	392,950	3,048	32,581	1,933	35,629	37,562	10.2	2.2
2013	2,750	48,130	400,809	3,086	33,233	1,962	36,319	38,281	10.4	2.2
2014	2,792	48,852	408,825	3,124	33,898	1,991	37,022	39,013	10.6	2.3
2015	2,833	49,585	417,001	3,164	34,576	2,021	37,739	39,760	10.8	2.3
2020	3,046	53,417	460,403	3,366	38,174	2,173	41,540	43,713	11.9	2.5

S. Khovd Aimag (Hovd)

257. Khovd Aimag is located in the central extreme west of Mongolia. The population is around 88,000.

258. Hovd, the urban centre has a population of around 27,000. Hovd is sited 1,401m above sea level, has an average annual temperature of 0.9 ˚C, with annual heating days of 229. The average annual precipitation is 128mm and average relative moisture is 438%. The nearest mountain is Ulaan uul and the nearest river Buyant.

40. Demand for Heat

259. The number of households taking heat supply is estimated at 1,900, around 12% of the Hovd population.

260. The Consultant has modelled the heat demand for Hovd based on supply of heating to apartments and public buildings, and hot tap water for domestic use.

Table IX-25: Hovd - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	26,518	1,686	147.4	1.5%	34,382	12.8
2005	26,888	1,709	149.6	1.5%	34,877	13.0
2006	27,100	1,734	151.8	1.5%	35,370	13.2
2007	25,198	1,763	154.2	1.6%	35,907	13.4
2008	24,303	1,789	156.5	1.5%	36,423	13.6
2009	24,828	1,814	158.8	1.5%	36,938	13.8
2010	16,898	1,843	161.2	1.5%	37,474	14.0
2011	16,718	1,897	166.0	3.0%	38,548	14.4
2012	16,538	1,954	171.0	3.0%	39,665	14.8
2013	16,360	2,014	176.2	3.0%	40,826	15.2
2014	16,182	2,074	181.4	3.0%	41,985	15.7
2015	16,006	2,137	186.9	3.0%	43,210	16.1
2020	22,009	2,437	217.0	3.2%	49,641	18.5

Sources: Licensees, EA data & Consultants' estimate

261. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-26: Hovd – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	9,771	68,400	287,280	0.037	0.100	0.029	39,665	4.1

Sources: Licensees, EA data & Consultants' estimate

41. Validation of Demand Forecast for Heat

262. The local authority reported that in 2012 the total heat production was 24.0 GCal/h which compares to the Consultant's end use forecast of 14.8 GCal/h indicating a 38% loss in the DH pipelines and at the consumer's premises.

263. The average heat consumption in Poland rural communes is 25GJ per person. In Hovd a consumption of 4.1 GCal per person equates to 17GJ per person. The average square meter per person of residential space heated in Poland is around 20 m2 compared to Hovd where it is 7 m^2.

264. Overall, the Consultant considers the forecast in Table IX-25 to be valid and within reasonable accuracy for heat planning purposes.

42. Existing Heat Supply

265. The town is supplied by HOB's and a DH network established in 1986. There are also thirteen individual heating systems. At the time that heating plants were put into operation, there were 16 small capacity HOBs, but today all except three are connected to the District Heating network.

266. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-27.

Table IX-27: Hovd - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
34.3	Y	N.A.	24.0	10.3	9.2	38%

Sources: Licensees, EA data

267. The heat plant currently comprises three steam boilers of KE-25-14E type.

268. There are nine heat substations. There is a 1.8 km main heat supply pipeline with 125-300 mm diameter. There is 7.6km of pipeline in total. Conductance of the pipeline is insufficient due to corrosion.

269. Domestic hot water is supplied through the heat substations. Seven of them once had pump mixing but now operate directly at rated 95/70°C temperature regime.

270. There are two pumps in the District heating system. If one pump works the pressure is not sufficient, if two operate, there is no longer back up pumping capacity in the event of failure.

271. Consumers of the Hovd town are more skilled at using an hydraulic adjustment washer

nozzle compared to consumers from the other Aimag centers for adjusting heat.

43. Fuel Prices

272. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-28: Hovd - HOB Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Hovd	24	6.3	151.2	33.57	12,910	433
Hovd	24	6.3	151.2	33.57	12,910	433

Sources: Licensees, EA data & Consultants' data

44. Economic Benefits for Hovd

273. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

274. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

275. There is no coal deposit in the territory of this province thus coal is transported by trucks from the “Mogoin Gol” coal mine of the Huvsgul province located in 140 km distance from the aimag center. The owner of the “Khar Tarvagatain” coal mine privatized Khovd heat plant in 2005 and has been using this coal since then.

276. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Hovd's heat supply system.

45. Ownership

277. Not reported

Table IX-29: Hovd - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	58.1	-	243.9	-	145.2	-
2004	26.5	-	8.4	59.0	1.5%	247.5	1.5%	147.4	1.5%
2005	26.9	1.4%	8.5	59.8	1.5%	251.4	1.6%	149.6	1.5%
2006	27.1	0.8%	8.7	60.7	1.5%	255.1	1.4%	151.8	1.5%
2007	25.2	-7.0%	8.8	61.7	1.6%	259.0	1.5%	154.2	1.6%
2008	24.3	-3.6%	8.9	62.6	1.5%	262.9	1.5%	156.5	1.5%
2009	24.8	2.2%	9.1	63.5	1.5%	266.8	1.5%	158.8	1.5%
2010	16.9	-31.9%	9.2	64.5	1.5%	270.8	1.5%	161.2	1.5%
Average 2003 - 2010	-	-6.4%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	16.7	-1.1%	9.5	66.4	3.0%	278.9	3.0%	166.0	3.0%
2012	16.5	-1.1%	9.8	68.4	3.0%	287.3	6.7%	171.0	3.0%
2013	16.4	-1.1%	10.1	70.5	3.0%	296.0	6.7%	176.2	3.0%
2014	16.2	-1.1%	10.4	72.6	3.0%	304.6	6.6%	181.4	3.0%
2015	16.0	-1.1%	10.7	74.8	3.0%	313.9	6.6%	186.9	3.0%
Average 2011 - 2015	-	-1.1%	10.1	-	3.0%	-	5.9%	-	3.0%
2015	16.0	0.1%	10.7	74.8	3.0%	313.9	6.6%	186.9	3.0%
2020	22.0	0.5%	12.2	85.9	14.8%	364.5	16.1%	217.0	3.0%
2025	-	-	-	98.6	14.8%	423.2	16.1%	252.0	3.0%

Table IX-30: Hovd Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	8,429	147,500	247,520	7,847	20,523	6,012	28,370	34,382	8.53	4.29
2005	8,543	149,500	251,440	7,936	20,848	6,093	28,784	34,877	8.65	4.35
2006	8,671	151,750	255,080	8,035	21,150	6,185	29,185	35,370	8.77	4.41
2007	8,814	154,250	259,000	8,145	21,475	6,287	29,620	35,907	8.90	4.49
2008	8,943	156,500	262,920	8,244	21,800	6,379	30,044	36,423	9.03	4.55
2009	9,071	158,750	266,840	8,343	22,125	6,470	30,468	36,938	9.16	4.62
2010	9,214	161,250	270,760	8,452	22,450	6,572	30,902	37,474	9.29	4.69
2011	9,486	166,000	278,880	8,659	23,123	6,766	31,782	38,548	9.55	4.83
2012	9,771	171,000	287,280	8,876	23,820	6,970	32,696	39,665	9.83	4.97
2013	10,071	176,250	295,960	9,102	24,540	7,184	33,642	40,826	10.11	5.13
2014	10,371	181,500	304,640	9,328	25,259	7,398	34,587	41,985	10.40	5.28
2015	10,686	187,000	313,880	9,563	26,025	7,622	35,588	43,210	10.70	5.44
2020	12,184	214,740	364,458	10,731	30,219	8,691	40,950	49,641	12.31	6.20

T. Govi – Altai Aimag (Altai)

278. Govi – Altai Aimag is located in the central south-west of Mongolia. The population is around 57,000.

279. Altai, the urban centre has a population of around 16,000. Altai is sited 2,181m above sea level, has an average annual temperature of 0.6 ˚C, with annual heating days of 210. The average annual precipitation is 157mm and average relative moisture is 53%. The nearest mountain is Hantaishir and the nearest river Zavhan.

46. Demand for Heat

280. The number of households taking heat supply is estimated at 2,000, or around 42% of the Altai population.

281. There are 27 apartment buildings supplied by heat from the above-mentioned small boiler houses, but these apartments have not yet been connected to the domestic hot water supply system.

282. Apartments and offices of Altai were supplied by heat from ten HOBs.

283. The Consultant has modelled the heat demand for Altai based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-31: Altai - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	11,942	692	74.7	11.5%	17,685	5.9
2005	11,674	737	77.6	3.9%	18,361	6.2
2006	11,599	1,042	100.8	29.9%	23,670	8.0
2007	11,126	1,055	102.5	1.6%	24,043	8.2
2008	10,621	1,250	107.6	5.0%	25,155	8.7
2009	10,515	1,431	113.1	5.2%	26,355	9.2
2010	8,473	1,774	126.7	12.0%	29,298	10.4
2011	8,283	2,024	133.5	5.4%	30,722	11.0
2012	8,096	2,274	140.4	5.1%	32,134	11.7
2013	7,911	2,524	147.2	4.9%	33,536	12.3
2014	7,728	2,899	157.1	6.7%	35,522	13.2
2015	7,547	3,274	167.0	6.3%	37,488	14.2
2020	14,151	4,128	226.5	7.1%	42,715	16.5

Sources: Licensees, EA data & Consultants' estimate

284. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-32: Altai – Heat Consumption (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	6,821	54,567	333,754	0.031	0.116	0.020	39,891	5.85

Sources: Licensees, EA data & Consultants' estimate

47. Validation of Demand Forecast for Heat

285. The local authority reported that in 2012 the total heat production was 20.1 GCal/h which compares to the Consultant's end use forecast of 14.0 GCal/h indicating a 30% loss in the DH pipelines and at the consumer's premises.

286. The average heat consumption in Poland rural communes is 25GJ per person. In Altai a consumption of 5.9 GCal per person equates to around 25GJ per person. The average square meter per person of residential space heated in Poland is around 20 m2 compared to Altai where it is only 8 m^2.

287. Overall, the Consultant considers the forecast in **Table IX-31** to be valid and within reasonable accuracy for heat planning purposes.

48. Existing Heat Supply

288. The town is supplied by small HOB's and a DH network.

289. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-33.

Table IX-33: Altai - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
30.4	N	N.A.	20.1	10.3	6.1	30%

Sources: Licensees, EA data

290. Ich-Altai" Co. has six boilers connected to the centralized water supply system (16 x BZUI-100, 8 x NR-18-54, 5 x CLRS-055 of types) installed by "Mandal-Altai" Co., Ltd., public shower house, foodstuff industry and "Mongol Bank" branch office.

291. The total length of the District Heating network is 12.7km.

49. Fuel Prices

292. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-34: Altai – Boiler Houses

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	**GCal / h**	**tons / h**	**tons / d**	**1000 ton p.a.**	**MNT / ton**	**million MNT p.a.**
Mandal-Golomt	29.3	4.3	104	22	28,000	616.0
Undram-Oyu	1.07	0.32	7.7	1.622	28,000	45.4
Udmyn-Undraa	0. 25	0.08	2.1	0.45	28,000	12.6
Total	30.37	4.7	113.8	24.1	28,000	674.0

Sources: Licensees, EA data & Consultants' data

50. Economic Benefits for Altai

293. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

294. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

295. Coal is transported by trucks from Zeegt (210 km), Huren gol (146 km), Hov Bulag (110 km) and Tsakhiurt (110 km) coal mines.

296. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Altai's heat supply system.

51. Ownership

297. Some organizations such as kindergarten, airport, agricultural organization, radio broadcasting station, oil supply agency, timber factor, etc. with transported water supply provide heat to their buildings by their own boilers of BZUI-100, NR-18-54 and CLRS-055 types.

298. Some small consumers e.g. pharmacy shop, care center, intelligence agent, household hospital, 4-person public shower house and commodity shops of the "Tulga-Altai".

Table IX-35: Altai - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	16.0	-	142.6	-	67.0	-
2004	11.9	-	0.7	16.6	11.5%	162.6	14.0%	74.7	11.5%
2005	11.7	-2.2%	0.7	17.7	3.9%	167.7	3.2%	77.6	3.9%
2006	11.6	-0.6%	1.0	25.0	29.9%	212.3	26.6%	100.8	29.9%
2007	11.1	-4.1%	1.1	25.3	1.6%	216.0	1.7%	102.5	1.6%
2008	10.6	-4.5%	1.2	30.0	5.0%	217.3	0.6%	107.6	5.0%
2009	10.5	-1.0%	1.4	34.3	5.2%	220.7	1.5%	113.1	5.2%
2010	8.5	-19.4%	1.8	42.6	12.0%	235.5	6.7%	126.7	12.0%
Average 2003 - 2010	-	-5.3%	-	-	9.9%	-	7.8%	-	9.9%
Forecast									
2011	8.3	-2.2%	2.0	48.6	5.4%	237.8	1.0%	133.5	5.4%
2012	8.1	-2.3%	2.3	54.6	5.1%	240.2	1.0%	140.4	5.1%
2013	7.9	-2.3%	2.5	60.6	4.9%	242.6	1.0%	147.2	4.9%
2014	7.7	-2.3%	2.9	69.6	6.7%	245.0	1.0%	157.1	6.7%
2015	7.5	-2.3%	3.3	78.6	6.3%	247.5	1.0%	167.0	6.3%
Average 2011 - 2015	-	-2.3%	2.6	-	5.7%	-	1.0%	-	5.7%
2015	7.5	0.1%	3.3	78.6	6.3%	247.5	1.0%	167.0	6.3%
2020	14.2	0.5%	4.1	101.3	29.0%	260.1	1.0%	226.5	5.7%
2025	-	-	-	130.7	29.0%	273.4	1.0%	307.2	5.7%

Table IX-36: Altai Heat Supply Model

	Hot Tap Water Driver	Heat Volumetric Drivers		------------------------------ Heat Consumption		------------------------------			Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,075	41,495	162,557	2,727	13,478	1,480	16,206	17,685	4.87	1.06
2005	2,211	44,213	167,745	2,875	13,909	1,577	16,784	18,361	5.05	1.12
2006	3,126	62,513	212,302	3,837	17,603	2,229	21,440	23,670	6.45	1.59
2007	3,166	63,313	215,967	3,878	17,907	2,258	21,785	24,043	6.55	1.61
2008	3,749	74,973	217,288	4,465	18,016	2,674	22,481	25,155	6.76	1.91
2009	4,292	85,848	220,651	4,998	18,295	3,062	23,294	26,355	7.00	2.18
2010	5,321	106,418	235,474	5,978	19,524	3,795	25,502	29,298	7.67	2.71
2011	6,071	121,418	237,829	6,672	19,720	4,330	26,392	30,722	7.93	3.09
2012	6,821	136,418	240,207	7,353	19,917	4,865	27,269	32,134	8.20	3.47
2013	7,571	151,418	242,610	8,020	20,116	5,400	28,136	33,536	8.46	3.85
2014	8,696	173,918	245,036	9,002	20,317	6,203	29,319	35,522	8.81	4.43
2015	9,821	196,418	247,486	9,962	20,520	7,005	30,483	37,488	9.16	5.00
2020	12,384	253,310	260,110	12,315	21,567	8,833	33,882	42,715	10.19	6.30

U. Uvurhangai (Arvaiheer)

299. Uvurhangai Aimag is located slightly South in the central of part of Mongolia, around 420km from Ulaanbaatar. The total population is around 120,000.

300. Arvaiheer, the urban centre, has a population of around 32,000. Arvaiheer is sited 1,800m above sea level, has an average annual temperature of 0.9 ˚C, with annual heating days of 212. The average annual precipitation is 237mm and average relative moisture is 53%. The nearest river is Ongy. Every year 1,113 inhabitants move in and 926 move out from Arvaiheer. The poverty ratio is 30.1%.

52. Demand for Heat

301. The number of households taking heat supply is estimated at 1,000, around 16% of the Arvaiheer population.

302. The Consultant has modelled the heat demand for Arvaiheer based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-37: Arvaiheer - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year		No.	sq km	%	GCal	GCal/h
2004	24,988	847	54.8	2.4%	12,573	5.0
2005	25,901	880	56.7	3.5%	12,983	5.2
2006	27,988	894	57.6	1.7%	13,188	5.3
2007	29,049	911	59.1	2.5%	13,496	5.4
2008	29,366	927	60.3	2.1%	13,762	5.5
2009	30,788	941	61.3	1.7%	13,983	5.6
2010	22,961	958	62.5	1.9%	14,232	5.7
2011	22,760	984	64.2	2.8%	14,603	5.8
2012	22,560	1,012	66.1	2.9%	15,002	6.0
2013	22,361	1,045	68.2	3.1%	15,440	6.2
2014	22,163	1,071	69.8	2.3%	15,776	6.3
2015	21,965	1,106	72.3	3.5%	16,299	6.5
2020	21,952	1,258	85.9	3.8%	20,253	7.9

Sources: Licensees, EA data & Consultants' estimate

303. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-38: Arvaiheer – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	5,059	43,000	64,700	0.025	0.022	0.015	15,002	2.97

Sources: Licensees, EA data & Consultants' estimate

53. Validation of Demand Forecast for Heat

304. The local authority reported that in 2012 the total heat production was 9.5 GCal/h which compares to the Consultant's end use forecast of 6.0 GCal/h indicating a 37% loss in the DH pipelines and at the consumer's premises.

305. The average heat consumption in Poland rural communes is 25GJ per person. In Arvaiheer a consumption of 3.0 GCal per person equates to 12.4GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Arvaiheer where it is 8.5 m^2.

306. The Consultant has modelled the heat demand for Arvaiheer based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

307. Table IX-37 to be valid and within reasonable accuracy for heat planning purposes.

54. Existing Heat Supply

308. The town is supplied by small HOB's and a DH network. There are 7 large scale HOBs, and some organizations have their own individual boilers within their premises. The total length of the DH network is 7.8km. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-39.

Table IX-39: Arvaiheer - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
13.5	N	0.0	9.5	4.0	3.5	37%

Sources: Licensees, EA data

309. The condition of the heating system is reported in Table IX-40.

Table IX-40: Arvaiheer – Heating System Condition (2012)

Boiler House	1	2	3	4	5	6	7
Boilers	Good	Good	Poor	Poor	Poor	Medium	Poor
Pipelines	Poor	Poor	Poor	Poor	Poor	Poor	Medium
Valves	Medium	Medium	Poor	Poor	Medium	Medium	Medium
Instrumentation	Medium	Medium	Poor	Poor	Poor	Poor	Poor

Sources: Licensees, EA data

55. Fuel Prices

310. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-41: Arvaiheer - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Arvaiheer	12.3	3.9	94.0	13.2	15,600	205
Total	12.3	3.9	94.0	13.2	15,600	205

Sources: Licensees, EA data & Consultants' data

56. Economic Benefits for Arvaiheer

311. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

312. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

313. Energy source is coal and it is transported by trucks from "Bayan-Teeg" coal mine located 130 km away from provincial center. Depending on the gasoline or transport cost, the price of heating increases.

314. The above economic benefits strongly support the case for refurbishment of Arvaiheer's heat supply system.

57. Ownership

315. Not reported.

Table IX-42: Arvaiheer - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	35.0	-	51.7	-	53.5	-
2004	25.0	-	4.2	36.0	2.4%	52.5	1.5%	54.8	2.4%
2005	25.9	3.65%	4.4	37.4	3.5%	54.0	2.9%	56.7	3.5%
2006	28.0	8.06%	4.5	38.0	1.7%	55.0	1.9%	57.6	1.7%
2007	29.0	3.79%	4.6	38.7	2.5%	57.0	3.6%	59.1	2.5%
2008	29.4	1.09%	4.6	39.4	2.1%	58.5	2.6%	60.3	2.1%
2009	30.8	4.84%	4.7	40.0	1.7%	59.7	2.1%	61.3	1.7%
2010	23.0	-25.42%	4.8	40.7	1.9%	61.0	2.2%	62.5	1.9%
Average 2003 - 2010	-	-0.66%	-	-	2.3%	-	2.4%	-	2.3%
Forecast									
2011	22.8	-0.9%	4.9	41.8	2.8%	62.8	7.9%	64.2	2.8%
2012	22.6	-0.9%	5.1	43.0	2.9%	64.7	7.8%	66.1	2.9%
2013	22.4	-0.9%	5.2	44.4	3.1%	66.6	7.8%	68.2	3.1%
2014	22.2	-0.9%	5.4	45.5	2.3%	68.0	7.7%	69.8	2.3%
2015	22.0	-0.9%	5.5	47.0	3.5%	70.7	7.7%	72.3	3.5%
Average 2011 - 2015	-	-0.9%	5.2	-	2.9%	-	7.8%	-	2.9%
2015	22.0	0.1%	5.5	47.0	3.5%	70.7	7.7%	72.3	3.5%
2020	22.0	0.50%	6.3	53.8	14.5%	102.5	7.8%	85.9	2.9%
2025	-	-	-	61.6	14.5%	148.6	7.8%	102.2	2.9%

Table IX-43: Arvaiheer Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	4,235	90,000	52,500	5,199	4,353	3,021	9,552	12,573	2.9	2.2
2005	4,400	93,500	54,000	5,367	4,477	3,138	9,844	12,983	3.0	2.2
2006	4,471	95,000	55,000	5,439	4,560	3,189	9,999	13,188	3.0	2.3
2007	4,553	96,750	57,000	5,522	4,726	3,247	10,248	13,496	3.1	2.3
2008	4,635	98,500	58,500	5,605	4,851	3,306	10,456	13,762	3.1	2.4
2009	4,706	100,000	59,700	5,676	4,950	3,357	10,626	13,983	3.2	2.4
2010	4,788	101,750	61,000	5,759	5,058	3,415	10,817	14,232	3.3	2.4
2011	4,918	104,500	62,800	5,888	5,207	3,508	11,095	14,603	3.3	2.5
2012	5,059	107,500	64,700	6,029	5,365	3,608	11,393	15,002	3.4	2.6
2013	5,224	111,000	66,600	6,192	5,522	3,726	11,714	15,440	3.5	2.7
2014	5,353	113,750	68,000	6,319	5,638	3,818	11,958	15,776	3.6	2.7
2015	5,529	117,500	70,700	6,492	5,862	3,944	12,355	16,299	3.7	2.8
2020	6,289	134,547	102,506	7,268	8,499	4,486	15,768	20,253	4.7	3.2

V. Suhbaatar (Baruun-Urt)

316. Suhbaatar Aimag is located in the central east of Mongolia. The population is around 100,000.

317. Baruun-Urt, the urban centre has a population of around 17,000. Baruun-Urt is sited 992m above sea level, has an average annual temperature of 0.8˚C, with annual heating days of 223. The average annual precipitation is 203mm and average relative moisture is 48%. No nearest mountain or river was reported.

58. Demand for Heat

318. The number of households taking heat supply is estimated at 900, or around 21% of the Baruun-Urt population.

319. The Consultant has modelled the heat demand for Baruun-Urt based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-44: Baruun-Urt - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year		No.	sq km	%	GCal	GCal/h
2004	6,567	773	123.7	1.48%	26,212	8.8
2005	6,429	784	125.6	1.54%	26,602	8.9
2006	6,801	797	127.5	1.51%	26,984	9.1
2007	6,831	809	129.4	1.49%	27,366	9.2
2008	7,264	820	131.3	1.47%	27,755	9.3
2009	7,714	833	133.3	1.52%	28,159	9.4
2010	6,630	845	135.3	1.50%	28,563	9.6
2011	6,575	870	139.3	2.96%	29,371	9.9
2012	6,520	897	143.5	3.02%	30,217	10.1
2013	6,465	923	147.8	3.00%	31,086	10.4
2014	6,410	952	152.3	3.04%	31,992	10.7
2015	6,355	980	156.8	2.95%	32,897	11.0
2020	12,489	1,116	181.4	3.13%	39,943	13.3

Sources: Licensees, EA data & Consultants' estimate

320. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-45: Baruun-Urt – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,588	57,400	241,080	0.032	0.084	0.011	30,217	8.4

Sources: Licensees, EA data & Consultants' estimate

59. Validation of Demand Forecast for Heat

321. The local authority reported that in 2012 the total heat production was 17.5 GCal/h which compares to the Consultant's end use forecast of 10.1 GCal/h indicating a 42% loss in the DH pipelines and at the consumer's premises.

322. The average heat consumption in Poland rural communes is 25GJ per person. In Baruun-Urt a consumption of 8.4 GCal per person equates to 35GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Baruun-Urt where it is 16 m^2.

323. Overall, the forecast in Table IX-44 is considered to be valid and within reasonable accuracy for heat planning purposes.

60. Existing Heat Supply

324. The town is supplied by small HOB's and a DH network.

325. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in **Table IX-46**.

Table IX-46: Baruun-Urt - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
25.0	N	5.6	17.5	10.3	7.4	42%

Sources: Licensees, EA data

326. When a Fodder factory was in operation until early 1991 its heating and industrial steam demand was supplied by boiler house equipped with 3 of KE-10-14 boilers, but the boiler house was closed with the factory. The water lines were not drained, no conservation measures were taken and equipment was removed. The apartment buildings previously served by the system are now served by small capacity boilers installed in 1992.

327. There are five boiler houses mainly equipped with domestically manufactured BZUI-100 and NR-18 boilers. In 2007 the ADB funded the replacement of the boilers with Chinese boilers of the DZL type.

328. The DH network has a length of 5.6km.

329. There are almost 100 consumers in the developed area of Baruun-Urt supplied with heating and hot water from the boiler houses. However the internal heating system of buildings are clogged and jammed due to the absence of periodic cleaning, which in turn reduces the quality of

the heating.

61. Fuel Prices

330. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-47: Baruun-Urt - HOB Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Baruun-Urt	17.5	5.6	134.4	30.0	14,400	14.40
Total	17.5	5.6	134.4	30.0	14,400	14.40

Sources: Licensees, EA data & Consultants' data

62. Economic Benefits for Baruun-Urt

331. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

332. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

333. The boilers burn coal transported by trucks from the Talbulag coal mine which is located 35 km from the town. Make-up water for the district heating networks is supplied from the centralized water supply system. Water is of high hardness which adversely affects their operational activity.

334. The above economic benefits strongly support the case for refurbishment of Baruun-Urt's heat supply system.

63. Ownership

335. Boiler houses together with the networks operated by the PUSO "Dorvolj" Co.

Table IX-48: Baruun-Urt - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	48.8	-	204.7	-	121.9	-
2004	6.6	-	3.1	49.5	1.5%	207.8	1.5%	123.7	1.5%
2005	6.4	-2.1%	3.1	50.2	1.5%	211.1	1.6%	125.6	1.5%
2006	6.8	5.8%	3.2	51.0	1.5%	214.2	1.5%	127.5	1.5%
2007	6.8	0.4%	3.2	51.8	1.5%	217.3	1.4%	129.4	1.5%
2008	7.3	6.3%	3.3	52.5	1.5%	220.6	1.5%	131.3	1.5%
2009	7.7	6.2%	3.3	53.3	1.5%	224.0	1.5%	133.3	1.5%
2010	6.6	-14.0%	3.4	54.1	1.5%	227.4	1.5%	135.3	1.5%
Average 2003 - 2010	-	0.4%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	6.6	-0.8%	3.5	55.7	3.0%	234.1	3.0%	139.3	3.0%
2012	6.5	-0.8%	3.6	57.4	3.0%	241.1	4.8%	143.5	3.0%
2013	6.5	-0.8%	3.7	59.1	3.0%	248.4	4.8%	147.8	3.0%
2014	6.4	-0.8%	3.8	60.9	3.0%	255.9	4.7%	152.3	3.0%
2015	6.4	-0.9%	3.9	62.7	3.0%	263.5	4.7%	156.8	3.0%
Average 2011 - 2015	-	-0.8%	3.7	-	3.0%	-	4.4%	-	3.0%
2015	6.4	0.1%	3.9	62.7	3.0%	263.5	4.7%	156.8	3.0%
2020	12.5	0.5%	4.5	71.9	14.7%	331.7	4.4%	181.4	3.0%
2025				82.5	14.7%	417.6	4.4%	209.8	3.0%

Table IX-49: Baruun-Urt Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	3,094	123,750	207,760	6,779	17,226	2,207	24,005	26,212	7.2	1.6
2005	3,138	125,500	211,120	6,859	17,505	2,238	24,364	26,602	7.3	1.6
2006	3,188	127,500	214,200	6,950	17,760	2,274	24,710	26,984	7.4	1.6
2007	3,238	129,500	217,280	7,041	18,016	2,309	25,056	27,366	7.5	1.6
2008	3,281	131,250	220,640	7,120	18,294	2,340	25,414	27,755	7.6	1.7
2009	3,331	133,250	224,000	7,210	18,573	2,376	25,783	28,159	7.8	1.7
2010	3,381	135,250	227,360	7,300	18,852	2,412	26,152	28,563	7.9	1.7
2011	3,481	139,250	234,080	7,480	19,409	2,483	26,888	29,371	8.1	1.8
2012	3,588	143,500	241,080	7,669	19,989	2,559	27,658	30,217	8.3	1.8
2013	3,694	147,750	248,360	7,858	20,593	2,635	28,451	31,086	8.6	1.9
2014	3,806	152,250	255,920	8,057	21,220	2,715	29,277	31,992	8.8	1.9
2015	3,919	156,750	263,480	8,255	21,846	2,795	30,101	32,897	9.0	2.0
2020	4,464	179,820	331,708	9,256	27,504	3,184	36,759	39,943	11.1	2.3

W. Bayankhongor (Bayankhongor)

336. Bayankhongor Aimag is located in the southern mid-west of Mongolia. The population is around 87,000.

337. Bayankhongor, the urban centre has a population of around 30,000. Bayankhongor is sited 1,860 above sea level, has an average annual temperature of -0.1˚C, with annual heating days of 232. The average annual precipitation is 200mm and average relative moisture is 47%. The nearest river is named Tuin.

64. Demand for Heat

338. The number of households taking heat supply is estimated at 810, or around 21% of the Bayankhongor population.

339. The Consultant has modelled the heat demand for Bayankhongor based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-50: Bayankhongor - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	21,067	721	144.2	1.5%	29,843	9.8
2005	20,198	743	147.2	2.1%	30,394	10.0
2006	20,716	754	149.4	1.5%	30,827	10.2
2007	22,120	765	151.7	1.5%	31,283	10.3
2008	24,245	771	153.5	1.2%	31,651	10.4
2009	23,922	776	155.3	1.2%	32,041	10.5
2010	18,758	789	157.7	1.5%	32,512	10.7
2011	18,573	797	159.3	1.0%	32,830	10.8
2012	18,389	805	160.9	1.0%	33,150	10.9
2013	18,206	813	162.6	1.0%	33,473	11.0
2014	18,023	821	164.2	1.0%	33,798	11.1
2015	17,842	830	165.9	1.0%	34,125	11.2
2020	23,649	872	174.4	1.0%	35,811	11.8

Sources: Licensees, EA data & Consultants' estimate

340. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-51: Bayankhongor – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,220	64,394	270,314	0.035	0.094	0.010	33,150	10.30

Sources: Licensees, EA data & Consultants' estimate

65. Validation of Demand Forecast for Heat

341. The local authority reported that in 2012 the total heat production was 13.4 GCal/h which compares to the Consultant's end use forecast of 11.0 GCal/h indicating an 18% loss in the DH pipelines and at the consumer's premises.

342. The average heat consumption in Poland rural communes is 25GJ per person. In Bayankhongor a consumption of 10.3 GCal per person equates to 43GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Bayankhongor where it is 20 m^2.

343. Overall, the Consultant considers the forecast in Table IX-52 to be valid and within reasonable accuracy for heat planning purposes.

66. Existing Heat Supply

344. The town is supplied by small HOB's and a DH network.

345. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-52.

Table IX-52: Bayankhongor - Heat Supply Capacity (2011)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
13.4	N	N.A.	13.4	0.0	2.4	18%

Sources: Licensees, EA data

346. The following boiler houses are operating in Bayankhongor:-

- Boiler house of the Dulaan Co., Ltd. with three BZUI-100 boilers.
- Boiler house of the Chandmani Co., Ltd. with one BZUI-100 and two NR-18-54 boilers.
- Hospital boiler house with three BZUI-100 boilers.
- 1st 10-year Secondary School boiler house with three BZUI-100 boilers.
- Academic Drama Theater boiler house with three BZUI-100 boilers.
- Social Insurance Department boiler with one BZUI-100 and one NR-18-54 boiler.
- 1st boiler house of the Nomgon Khairkhan Co., Ltd. with three BZUI-100 boilers.
- 2nd boiler house of the Nomgon Khairkhan Co., Ltd. with three BZUI-100 boilers.

347. Boilers used for heating have reached the end of their technical life, operating with low efficiency and high fuel consumption.

348. The District Heating network has a length of 7.4km. The network is severely corroded and thus unable to bear even lowest pressure. Pipe insulation is very poor; there is also considerable surface heat loss and leakage loss.

349. The condition of manholes and trenches is bad. Valves do not fully close, section valves in important places are missing; manhole covers and some metal parts of the valves have been stolen.

350. Consumers heating systems are worn out, heating facilities polluted and never cleaned or washed. Pipes in these internal systems are very old and cannot operate under pressure. As a result buildings have high heat loss. To exacerbate heat losses, buildings are not insulated and consumers siphon hot water from the heating system.

67. Fuel Prices

351. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-53: Bayankhongor - HOB Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	**GCal / h**	**tons / h**	**tons / d**	**1000 ton p.a.**	**MNT / ton**	**million MNT p.a.**
Bayanhongor	13.4	4.5	108.0	25.9	12,727	329.9
Total	13.4	4.5	108.0	25.9	12,727	329.9

Sources: Licensees, EA data & Consultants' data

68. Economic Benefits for Bayankhongor

352. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

353. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

354. Coal is transported by trucks from the "Taibulag" coal mine located 35km away from Bayankhongor. A reduction in coal transport costs will result if modern boilers are introduced.

355. The above economic benefits strongly support the case for refurbishment of Bayankhongor's heat supply system.

69. Ownership

356. All boiler houses except offices are privatized.

Table IX-54: Bayankhongor - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	56.8	-	238.6	-	142.0	-
2004	21.1	-	2.9	57.7	1.5%	242.2	1.5%	144.2	1.5%
2005	20.2	-4.1%	3.0	59.4	2.1%	245.8	1.5%	147.2	2.1%
2006	20.7	2.6%	3.0	60.3	1.5%	249.5	1.5%	149.4	1.5%
2007	22.1	6.8%	3.1	61.2	1.5%	253.4	1.6%	151.7	1.5%
2008	24.2	9.6%	3.1	61.7	1.2%	257.0	1.4%	153.5	1.2%
2009	23.9	-1.3%	3.1	62.1	1.2%	261.0	1.5%	155.3	1.2%
2010	18.8	-21.6%	3.2	63.1	1.5%	264.9	1.5%	157.7	1.5%
Average 2003 - 2010	-	-1.3%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	18.6	-1.0%	3.2	63.7	1.0%	267.6	1.0%	159.3	1.0%
2012	18.4	-1.0%	3.2	64.4	1.0%	270.3	1.0%	160.9	1.0%
2013	18.2	-1.0%	3.3	65.0	1.0%	273.1	1.0%	162.6	1.0%
2014	18.0	-1.0%	3.3	65.7	1.0%	275.8	1.0%	164.2	1.0%
2015	17.8	-1.0%	3.3	66.4	1.0%	278.6	1.0%	165.9	1.0%
Average 2011 - 2015	-	-1.0%	3.3	-	1.0%	-	1.0%	-	1.0%
2015	17.8	0.1%	3.3	66.4	1.0%	278.6	1.0%	165.9	1.0%
2020	23.6	0.5%	3.3	69.8	5.2%	293.1	1.0%	174.5	5.2%
2025	-	-	-	73.4	5.2%	308.3	1.0%	183.5	5.2%

Table IX-55: Bayankhongor Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		---------------------------- Heat Consumption ----------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,885	144,250	242,200	7,703	20,082	2,058	27,785	29,843	8.4	1.5
2005	2,970	148,500	245,840	7,891	20,384	2,118	28,275	30,394	8.5	1.5
2006	3,015	150,750	249,480	7,991	20,686	2,151	28,677	30,827	8.6	1.5
2007	3,060	153,000	253,400	8,090	21,011	2,183	29,101	31,283	8.7	1.6
2008	3,083	154,125	257,040	8,140	21,312	2,199	29,452	31,651	8.9	1.6
2009	3,105	155,250	260,960	8,189	21,638	2,215	29,827	32,041	9.0	1.6
2010	3,155	157,750	264,880	8,299	21,963	2,250	30,261	32,512	9.1	1.6
2011	3,187	159,362	267,586	8,369	22,187	2,273	30,556	32,830	9.2	1.6
2012	3,220	160,986	270,314	8,441	22,413	2,297	30,854	33,150	9.3	1.6
2013	3,252	162,623	273,062	8,512	22,641	2,320	31,153	33,473	9.4	1.7
2014	3,285	164,272	275,831	8,584	22,871	2,343	31,454	33,798	9.5	1.7
2015	3,319	165,934	278,622	8,656	23,102	2,367	31,758	34,125	9.5	1.7
2020	3,487	174,543	293,004	9,029	24,294	2,487	33,323	35,811	10.0	1.8

X. Bulgan (Bulgan)

357. Bulgan Aimag is located in the central region of Mongolia, just east of Ulan Baatar. The population is around 62,000.

358. Bulgan, the urban centre has a population of around 16,000. Bulgan is sited 1,310m above sea level, has an average annual temperature of -1.6 ˚C, with annual heating days of 240. The average annual precipitation is 304mm and average relative moisture is 63%. The nearest mountain is Bulgan Meej and the nearest river is Achuut Zuun Turuun.

70. Demand for Heat

359. The number of household taking heat supply is estimated at 650, or around 11% of the Bulgan population.

360. At present, about 60 customers are supplied with heat, but the internal heating system of the buildings is clogged due to the absence of periodic cleaning. The 280 apartment households do not have a proper hot water supply but tap hot water from the heating units; resulting in large network losses and reduced boiler performance.

361. There are 7 customers with internal hot water systems, but these systems require refurbishment.

362. The Consultant has modelled the heat demand for Bulgan based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-56: Bulgan - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	**No.**	**No.**	**sq km**	**%**	**GCal**	**GCal/h**
2005	9,185	600	93.8	-3.0%	22,779	6.7
2006	9,236	591	92.4	-1.4%	22,456	6.6
2007	9,517	595	93.1	0.7%	22,605	6.7
2008	9,425	597	93.4	0.3%	22,680	6.7
2009	9,897	606	94.8	1.5%	23,021	6.8
2010	7,370	615	96.2	1.5%	23,363	6.9
2011	7,235	609	95.3	-1.0%	23,131	6.8
2012	7,102	602	94.3	-1.0%	22,900	6.8
2013	6,970	596	93.3	-1.0%	22,669	6.7
2014	6,839	590	92.4	-1.0%	22,438	6.6
2015	6,709	584	91.4	-1.0%	22,208	6.6
2020	12,573	554	86.7	-1.0%	21,092	6.2

Sources: Licensees, EA data & Consultants' estimate

363. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-57: Bulgan – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	2,410	12,048	230,269	0.009	0.080	0.007	22,900	9.5

Sources: Licensees, EA data & Consultants' estimate

71. Validation of Demand Forecast for Heat

364. The local authority reported that in 2012 the total heat production was 13.4 GCal/h which compares to the Consultant's end use forecast of 9.5 GCal/h indicating a 47% loss in the DH pipelines and at the consumer's premises.

365. The average heat consumption in Poland rural communes is 25GJ per person. In Bulgan a consumption of 9.5 GCal per person equates to 40GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Bulgan where it is 5 m^2.

366. Overall, the Consultant considers the forecast in Table IX-57 to be valid and within reasonable accuracy for heat planning purposes.

72. Existing Heat Supply

367. The town is supplied by small HOB's and a DH network.

368. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-58.

Table IX-58: Bulgan - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
14.0	N	4.6	13.4	0.6	6.3	47%

Sources: Licensees, EA data

369. In 2007 the ADB funded replacement of under the ADB project, boiler houses #I, #2 and #4, pumps and District Heating pipelines were replaced. The consumers of boiler houses #3, #5, #6, and#7 were connected to these new boilers.

370. The new boilers were unsuitable for operating in local conditions and were destroyed; consumers were re-connected to the old boiler houses as before.

73. Fuel Prices

371. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-59: Bulgan - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Boiler house #1	3x0.7	37.24	744.72	105.43		
Boiler house #2	4x0.7	37.24	744.72	105.43		
Boiler house #3	3x0.7	37.24	744.72	105.43		
Boiler house #4	4x0.7	37.24	744.72	105.43		
Boiler house #5	3x0.7	37.24	744.72	105.43		
Boiler house #6	3x0.7	37.24	744.72	105.43		
Total	14	223.44	4468.32	632.58	26,500	16,763

Sources: Licensees, EA data & Consultants' data

372. The DH network has a length of 6.0km and a maximum diameter of 100.

74. Economic Benefits for Bulgan

373. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

374. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

375. Coal from Shivee-Ovoo coal mine of Dornogoby aimag is transported by railway 678 km to Erdenet and from Erdenet to Bulgan 80 km by trucks.

376. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Bulgan's heat supply system.

75. Ownership

377. The PUSO "Bulgan Meej" Co. is responsible for 7 heat only boiler houses together with the networks. These 7 boiler houses were equipped with domestically manufactured BZUI-100 and NR-18 water heating boilers with heat absorption areas of 100, 54 m2 as shown in below table.

Table IX-60: Bulgan - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	0.0	-	0.0	-	0.0	-
2004	9.4	-	2.5	12.4	0.0%	236.1	-	96.7	0.0%
2005	9.2	-1.8%	2.4	12.0	-3.0%	229.0	-3.1%	93.8	-3.0%
2006	9.2	0.5%	2.4	11.8	-1.4%	225.7	-1.5%	92.4	-1.4%
2007	9.5	3.0%	2.4	11.9	0.7%	227.2	0.7%	93.1	0.7%
2008	9.4	-1.0%	2.4	11.9	0.3%	228.0	0.3%	93.4	0.3%
2009	9.9	5.0%	2.4	12.1	1.5%	231.5	1.5%	94.8	1.5%
2010	7.4	-25.5%	2.5	12.3	1.5%	235.0	1.5%	96.2	1.5%
Average 2003 - 2010	-	-3.3%	-	-	-0.1%	-	-0.1%	-	-0.1%
Forecast									
2011	7.2	-1.8%	2.4	12.2	-1.0%	232.6	-1.0%	95.3	-1.0%
2012	7.1	-1.8%	2.4	12.0	-1.0%	230.3	-1.0%	94.3	-1.0%
2013	7.0	-1.9%	2.4	11.9	-1.0%	227.9	-1.0%	93.3	-1.0%
2014	6.8	-1.9%	2.4	11.8	-1.0%	225.6	-1.0%	92.4	-1.0%
2015	6.7	-1.9%	2.3	11.7	-1.0%	223.2	-1.0%	91.4	-1.0%
Average 2011 - 2015	-	-1.9%	2.4	-	-1.0%	-	-1.0%	-	-1.0%
2015	6.7	0.1%	2.3	11.7	-1.0%	223.2	-1.0%	91.4	-1.0%
2020	12.6	0.5%	2.2	11.1	-5.0%	211.8	-1.0%	86.7	-5.1%
2025	-	-	-	10.5	-5.0%	201.0	-1.0%	82.3	-5.1%

Table IX-61: Bulgan Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,475	30,932	236,083	2,135	19,575	1,765	21,710	23,475	5.7	1.3
2005	2,398	29,977	229,014	2,080	18,989	1,711	21,069	22,779	5.5	1.2
2006	2,363	29,540	225,722	2,055	18,716	1,686	20,770	22,456	5.4	1.2
2007	2,379	29,738	227,250	2,066	18,842	1,697	20,908	22,605	5.5	1.2
2008	2,387	29,837	228,008	2,072	18,905	1,703	20,977	22,680	5.5	1.2
2009	2,423	30,288	231,504	2,098	19,195	1,728	21,293	23,021	5.6	1.2
2010	2,459	30,738	235,000	2,124	19,485	1,754	21,609	23,363	5.6	1.3
2011	2,434	30,429	232,633	2,106	19,289	1,736	21,395	23,131	5.6	1.2
2012	2,410	30,119	230,269	2,088	19,093	1,719	21,181	22,900	5.5	1.2
2013	2,385	29,811	227,910	2,070	18,897	1,701	20,967	22,669	5.5	1.2
2014	2,360	29,503	225,555	2,052	18,702	1,683	20,754	22,438	5.4	1.2
2015	2,336	29,195	223,204	2,035	18,507	1,666	20,542	22,208	5.4	1.2
2020	2,216	27,730	211,812	1,949	17,562	1,581	19,512	21,092	5.1	1.1

Y. Tuv (Zuunmod)

378. Tuv Aimag is located in the central region of Mongolia, slightly south of Ulan Baatar. The population is around 90,000.

379. Zuunmod, the urban centre has a population of around 18,000. Zuunmod is sited 1,530m above sea level, has an average annual temperature of 1.6 ˚C, with annual heating days of 244. The average annual precipitation is 248mm and average relative moisture is 56%. The nearest mountain is Bogdhaan and the nearest river Zuunmod.

76. Demand for Heat

380. The number of households taking heat supply is estimated at 2,700, or around 53% of the Zuunmod population.

381. Today in this town there are 8 boiler houses under the District Heating Utility (DHU) and 6 boiler houses at different organizations such as the Meteorological Center, primary school, procurers office, road construction unit, water management utility and vocation school. All small HOBs, except vocational schools, have such a small capacity to supply only one building. All these small boilers belong to the local property ownership and operate under the control of DHU and organization it belongs to.

382. The heat demand of the Zuunmod town is very small. One boiler could cover almost 40% of the total demand. Therefore the heat plant is economically inefficient and fuel consumption will be increased a lot. The heat production cost is very high, but the selling price is very low and therefore the financial loss is high.

383. The Consultant has modelled the heat demand for Zuunmod based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-62: Zuunmod - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	15,095	1,144	203.3	0.9%	48,179	13.9
2005	15,125	1,206	205.1	0.9%	48,624	14.1
2006	14,333	1,271	207.0	0.9%	49,086	14.3
2007	11,659	1,400	219.7	6.1%	52,067	15.2
2008	14,842	1,757	233.1	6.1%	55,244	16.4
2009	15,586	1,824	241.1	3.4%	57,110	17.0
2010	13,245	2,200	250.4	3.9%	59,300	18.0
2011	12,989	2,440	259.4	3.6%	61,395	18.8
2012	12,736	2,705	269.0	3.7%	63,625	19.7
2013	12,485	3,000	279.3	3.8%	66,002	20.6
2014	12,236	3,327	290.4	4.0%	68,540	21.7
2015	11,990	3,689	302.3	4.1%	71,252	22.8
2020	14,280	5,370	369.5	4.4%	85,402	28.4

Sources: Licensees, EA data & Consultants' estimate

384. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-63: Zuunmod – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	9,469	56,812	594,194	0.032	0.206	0.028	63,625	6.72

Sources: Licensees, EA data & Consultants' estimate

77. Validation of Demand Forecast for Heat

385. The local authority reported that in 2012 the total heat production was 15.9 GCal/h which compares to the Consultant's end use forecast of 19.7 GCal/h indicating a -24% loss in the DH pipelines and at the consumer's premises.

386. The average heat consumption in Poland rural communes is 25GJ per person. In Bulgan a consumption of 6.7 GCal per person equates to 28GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Bulgan where it is 6 m^2.

387. Overall, the Consultant considers the forecast in **Table IX-63** to be valid and within reasonable accuracy for heat planning purposes.

78. Existing Heat Supply

388. The town is supplied by small HOB's and a DH network.

389. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-64.

Table IX-64: Zuunmod - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
25.8	Y	N.A.	15.9	10.0	-3.8	-24%

Sources: Licensees, EA data

390. The DH network has a length of 8.7km.

79. Fuel Prices

391. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-65: Zuunmod - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
#1	5x1.2	595	71.4	222	36,194	36.2
#2	5x1.2	595	71.4			
#3	5x1.2	595	48.8			
#4	3x1.2	376	18.1			
#5	3 x 0.7	376	27.07			
#6	2 x 0.7	376	18.1			
#7	1 x 0.7	376	9.02			
Total	25.8	3,326	1,009	222	36,194	36.2

Sources: Licensees, EA data & Consultants' data

80. Economic Benefits for Zuunmod

392. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

393. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

394. Coal needed for boiler houses is usually transported by trucks from Ulaanbaatar coal supply center and Nalaih coal mine which located in distance of 45 km.

395. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Zuunmod's heat supply system.

81. Ownership

396. Not reported

Table IX-66: Zuunmod - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	22.8	-	500.3	0.0	201.5	0.0
2004	15.1	-	4.0	24.0	0.9%	501.8	0.3%	203.3	0.9%
2005	15.1	0.2%	4.2	25.3	0.9%	503.3	0.3%	205.1	0.9%
2006	14.3	-5.2%	4.5	26.7	0.9%	504.8	0.3%	207.0	0.9%
2007	11.7	-18.7%	4.9	29.4	6.1%	532.8	5.5%	219.7	6.1%
2008	14.8	27.3%	6.2	36.9	6.1%	549.4	3.1%	233.1	6.1%
2009	15.6	5.0%	6.4	38.3	3.4%	567.8	3.4%	241.1	3.4%
2010	13.2	-15.0%	7.7	46.2	3.9%	571.8	0.7%	250.4	3.9%
Average 2003 - 2010	-	-1.1%	-	-	3.2%	-	1.9%	-	3.2%
Forecast									
2011	13.0	-1.9%	8.5	51.2	3.6%	582.9	1.9%	259.4	3.6%
2012	12.7	-2.0%	9.5	56.8	3.7%	594.2	2.1%	269.0	3.7%
2013	12.5	-2.0%	10.5	63.0	3.8%	605.7	2.1%	279.3	3.8%
2014	12.2	-2.0%	11.6	69.9	4.0%	617.5	2.1%	290.4	4.0%
2015	12.0	-2.0%	12.9	77.5	4.1%	629.5	2.1%	302.3	4.1%
Average 2011 - 2015	-	-2.0%	10.6	-	3.8%	-	2.1%	-	3.8%
2015	12.0	0.1%	12.9	77.5	4.1%	629.5	2.1%	302.3	4.1%
2020	14.3	0.5%	18.8	119.8	54.7%	697.5	2.1%	369.5	3.8%
2025	-	-		185.3	54.7%	772.9	2.1%	451.6	3.8%

Table IX-67: Zuunmod Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	4,006	60,086	501,825	3,713	41,609	2,857	45,322	48,179	11.8	2.0
2005	4,222	63,330	503,330	3,879	41,734	3,011	45,613	48,624	11.9	2.1
2006	4,450	66,750	504,840	4,053	41,859	3,174	45,912	49,086	12.0	2.3
2007	4,900	73,500	532,840	4,392	44,180	3,495	48,572	52,067	12.7	2.5
2008	6,150	92,250	549,360	5,307	45,550	4,387	50,857	55,244	13.3	3.1
2009	6,383	95,750	567,840	5,474	47,083	4,553	52,557	57,110	13.7	3.2
2010	7,700	115,500	571,760	6,400	47,408	5,492	53,808	59,300	14.1	3.9
2011	8,539	128,080	582,869	6,976	48,329	6,090	55,305	61,395	14.4	4.3
2012	9,469	142,030	594,194	7,604	49,268	6,754	56,871	63,625	14.9	4.8
2013	10,500	157,500	605,739	8,288	50,225	7,489	58,513	66,002	15.3	5.3
2014	11,644	174,655	617,509	9,034	51,201	8,305	60,234	68,540	15.7	5.9
2015	12,912	193,678	629,507	9,846	52,196	9,210	62,042	71,252	16.2	6.6
2020	18,796	299,553	697,513	14,161	57,834	13,406	71,996	85,402	18.8	9.6

Z. Dundgovy (Mandalgovi)

397. Dundgovy Aimag is located in the central south of Mongolia. The population is around 47,000.

398. Mandalgovi, the urban centre has a population of around 10,000. Mandalgovi is sited 1,715m above sea level, has an average annual temperature of 2.2˚C, with annual heating days of 212. The average annual precipitation ranges widely from 8.1 to 553.8mm and average relative moisture is 49%. The nearest mountain is Bor-Ovoo.

82. Demand for Heat

399. The number of households taking heat supply is estimated at 700, or around 40% of the Mandalgovi population.

400. Around 80 customers in the town centre are receiving heating, but the quality is poor because of clogging resulting from a failure to regularly clean the heating systems inside buildings. Although the apartment blocks were initially built with internal hot water fittings it is necessary to rehabilitate these because the system was never used. Because of the absence of a proper hot water service, many heating customers extract hot water from their radiators. This increases the water loss of the system and distorts the normal operation regime. It is preferable to establish a proper hot water supply system. Since neither the boiler houses nor customers have heat meters, the amount of heat distributed to customers can only be estimated.

401. The Consultant has modelled the heat demand for Mandalgovi based on the supply of heat to apartments and public buildings, and hot tap water for meal preparation.

Table IX-68: Mandalgovi - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	5,055	330	50.2	-	11,070	3.8
2005	6,938	334	50.7	0.8%	11,149	3.8
2006	6,778	334	50.8	0.2%	11,174	3.9
2007	5,001	334	53.5	5.5%	11,821	4.0
2008	4,972	411	59.6	11.4%	12,940	4.5
2009	4,869	424	60.5	1.5%	13,098	4.6
2010	3,084	653	92.1	52.1%	19,433	6.8
2011	3,009	671	93.4	1.4%	19,658	6.9
2012	2,936	687	94.5	1.2%	19,851	7.0
2013	2,863	697	95.2	0.7%	19,958	7.0
2014	2,792	707	95.9	0.8%	20,080	7.1
2015	2,721	716	96.5	0.6%	20,176	7.1
2020	7,010	778	99.5	0.6%	20,915	7.4

Sources: Licensees, EA data & Consultants' estimate

402. The Consultant's heat demand forecast is derived from a GCal per person estimate based

on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-69: Mandalgovi – Heat Consumption (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,437	48,116	130,000	0.028	0.045	0.010	19,851	5.8

Sources: Licensees, EA data & Consultants' estimate

83. Validation of Demand Forecast for Heat

403. The local authority reported that in 2012 the total heat production was 11.5 GCal/h which compares to the Consultant's end use forecast of 7.3 GCal/h indicating a 37% loss in the DH pipelines and at the consumer's premises.

404. The average heat consumption in Poland rural communes is 25GJ per person. In Mandalgovi a consumption of 5.9 GCal per person equates to 25GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Mandalgovi where it is 14 m^2.

405. Overall, the Consultant considers the forecast in **Table IX-68** to be valid and within reasonable accuracy for heat planning purposes.

84. Existing Heat Supply

406. The town is supplied heat by small HOB's and a DH network.

407. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-70.

Table IX-70: Mandalgovi - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
16.4	Y	N.A.	11.5	4.9	4.2	37%

Sources: Licensees, EA data

408. The heating supply to the town centre is provided by four boiler houses with a total of seven boilers of DHT-1.4 and NR-18 type which are locally produced and use solid fuel; there are three other boiler houses with a total of six imported boilers of RGJ type.

409. The previously used water boilers of BZUI-100, NR-18 type deteriorated quickly and had to be replaced every three years. The lifetime of the DTH-1.4 type boilers built in 2001 is uncertain. However, these Chinese boilers installed in 1998 were becoming slightly clogged in 2001, so they were opened for cleaning in 2001; the technicians consider that they should operate reliably for another three years.

410. Each boiler house has its own network, and cold water pipelines run together with heating in the same channel. The total length of the District Heating network is 12.8km.

411. The ADB funded installation of three Chinese boilers and replaced around 600 m of District Heating network in 2007. The boilers are reported not to have operated well under local conditions.

412. With the exception of the boiler houses of Gan-ilch Co.Ltd, the efficiency ratio of installed boilers are low (50%) and they are using large amount of coal.

413. Water is obtained from the town central water supply system. Although it contains a high proportion of solid particles, there is no water treatment equipment in boiler houses, which results in a significant reduction in boiler efficiency.

414. The route length of the water pipelines is 8.4km. The water pipelines are old and in poor condition with puncturing and large amount of water losses. The main lines should be replaced. The pumps of two boiler breakdown frequently due to their age, and 90/35 160/30 pumps should be replaced.

415. Pipelines in the distribution network and their insulation are in poor condition and suffer frequent punctures leading to significant heat loss. It is necessary to renovate and replace the pipelines. The existing network pumps have deteriorated and require replacement with modern pumps which use less electricity. Junction wells need repairing and fitting with covers.

416. The lack of measuring devices for measuring the amount of heat produced and distributed, no incentives for energy conservation, and the procedures for billing and payment are not well developed.

85. Fuel Prices

417. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-71: Mandalgovi - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	**GCal / h**	**tons / h**	**tons / d**	**1000 ton p.a.**	**MNT / ton**	**million MNT p.a.**
Dundgovy-Us	1.2	0.3	7.2	1,500	57,200	85,800
Gan Ilch	11.2	1.0	24.5	5,215	53,800	280,567
Tevshiin Govy	4.1	2.4	57.0	12,370	24,146	298,686
Total	16.5	3.7	88.7	19,085	135,146	665,053

Sources: Licensees, EA data & Consultants' data

86. Economic Benefits for Mandalgovi

418. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

419. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

420. Coals transported from Tevshiingovi mine (30 km) and Tavantolgoi mine (300 km) in Umnogovi aimag. Local people consider that Tevshiingovi coal does not fit into the Chinese boilers.

421. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Mandalgovi's heat supply system.

87. Ownership

422. All boiler houses except Dundgovi Water Service Company are privately-owned.

423. “Tevshiingovi” Shareholding Co.

424. “Mandalgovi impex” Shareholding Co.

Table IX-72: Mandalgovi - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	0.0	-	0.0	-	0.0	-
2004	5.1	-	1.7	23.1	0.0%	76.0	0.0%	50.2	0.0%
2005	6.9	37.3%	1.7	23.4	0.8%	76.3	0.0%	50.7	0.8%
2006	6.8	-2.3%	1.7	23.4	0.2%	76.6	0.0%	50.8	0.2%
2007	5.0	-26.2%	1.7	23.4	5.5%	84.4	271.4%	53.5	5.5%
2008	5.0	-0.6%	2.1	28.8	11.4%	86.3	18.3%	59.6	11.4%
2009	4.9	-2.1%	2.1	29.7	1.5%	86.3	0.0%	60.5	1.5%
2010	3.1	-36.7%	3.3	45.7	52.1%	129.8	0.0%	92.1	52.1%
Average 2003 - 2010	-	-5.1%	-	-	10.2%	-	0.0%	-	11.9%
Forecast									
2011	3.0	-2.4%	3.4	47.0	1.4%	130.0	0.2%	93.4	1.4%
2012	2.9	-2.4%	3.4	48.1	1.2%	130.0	0.0%	94.5	1.2%
2013	2.9	-2.5%	3.5	48.8	0.7%	130.0	0.0%	95.2	0.7%
2014	2.8	-2.5%	3.5	49.5	0.8%	130.0	0.0%	95.9	0.8%
2015	2.7	-2.5%	3.6	50.1	0.6%	130.0	0.0%	96.5	0.6%
Average 2011 - 2015	-	-2.5%	3.5	-	1.0%	-	0.0%	-	1.0%
2015	2.7	0.1%	3.6	50.1	0.6%	130.0	0.0%	96.5	0.6%
2020	7.0	0.5%	3.9	54.6	9.1%	130.0	0.0%	99.5	0.6%
2025	-	-	-	59.6	9.1%	130.0	0.0%	102.6	0.6%

Table IX-73: Mandalgovi Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	1,650	57,750	76,000	3,592	6,302	1,177	9,894	11,070	3.0	0.8
2005	1,671	58,500	76,300	3,631	6,326	1,192	9,957	11,149	3.0	0.9
2006	1,671	58,500	76,600	3,631	6,351	1,192	9,982	11,174	3.0	0.9
2007	1,671	58,500	84,400	3,631	6,998	1,192	10,629	11,821	3.2	0.9
2008	2,057	72,000	86,300	4,317	7,156	1,467	11,472	12,940	3.4	1.0
2009	2,121	74,250	86,300	4,429	7,156	1,513	11,584	13,098	3.5	1.1
2010	3,264	114,250	129,800	6,342	10,762	2,328	17,105	19,433	5.1	1.7
2011	3,354	117,382	130,000	6,487	10,779	2,392	17,266	19,658	5.2	1.7
2012	3,437	120,290	130,000	6,621	10,779	2,451	17,400	19,851	5.2	1.7
2013	3,483	121,905	130,000	6,695	10,779	2,484	17,474	19,958	5.3	1.8
2014	3,536	123,750	130,000	6,779	10,779	2,522	17,558	20,080	5.3	1.8
2015	3,578	125,214	130,000	6,846	10,779	2,552	17,625	20,176	5.3	1.8
2020	3,892	136,600	130,000	7,361	10,779	2,776	18,140	20,915	5.5	2.0

AA. Huvsgul (Muren)

425. Huvsgul Aimag is located in the north of Mongolia, slightly west of Ulan Baatar. The population is around 120,000.

426. Muren, the urban centre has a population of around 43,000. Muren is sited 1,500m above sea level, has an average annual temperature of -0.9 ˚C, with annual heating days of 242. The average annual precipitation is 217mm and average relative moisture is 59%. The nearest mountain is Dulaan uul and the nearest river Delgermuren.

88. Demand for Heat

427. The number of households taking heat supply is estimated at 813, or around 7.7% of the Muren population.

428. Muren is rather densely populated and construction goes intensively and probably continues in the future. Therefore, it is possible to have one TP integrating 6 separate small boiler houses establishing a centralized district heating system. In this case old boiler houses could be used as HSs.

429. The Consultant has modelled the heat demand for Muren based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-74: Muren - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	44,480	570	219.8	1.4%	51,710	14.2
2005	46,506	574	226.4	3.0%	53,246	14.7
2006	47,111	582	229.0	1.2%	53,860	14.8
2007	47,342	586	230.2	0.5%	54,138	14.9
2008	47,354	618	250.8	9.0%	58,945	16.2
2009	48,667	622	267.6	6.7%	62,834	17.2
2010	40,787	664	271.9	1.6%	63,848	17.5
2011	40,829	797	283.9	4.4%	66,697	18.5
2012	40,871	813	283.6	-0.1%	66,619	18.5
2013	40,913	829	283.2	-0.1%	66,544	18.5
2014	40,954	845	282.9	-0.1%	66,471	18.5
2015	40,996	862	282.6	-0.1%	66,400	18.5
2020	36,077	949	281.0	-0.1%	66,074	18.5

Sources: Licensees, EA data & Consultants' estimate

430. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-75: Muren – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,250	20,808	735,792	0.014	0.256	0.010	66,619	20.5

Sources: Licensees, EA data & Consultants' estimate

89. Validation of Demand Forecast for Heat

431. The local authority reported that in 2012 the total heat production was 26.2 GCal/h which compares to the Consultant's end use forecast of 18.7 GCal/h indicating a 29% loss in the DH pipelines and at the consumer's premises.

432. The average heat consumption in Poland rural communes is 25GJ per person. In Muren a consumption of 21GCal per person equates to 87GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Muren where it is 6.4 m^2.

433. Overall, the forecast in **Table IX-74** appears to be high and further validation is required.

90. Existing Heat Supply

434. The town is supplied by small HOB's and a DH network.

435. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-76.

Table IX-76: Muren - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
31.5	N	9.9	26.2	10.3	7.5	29%

Sources: Licensees, EA data

436. Heat supply of the town is provided from 6 independent centralized boiler houses forming 6 separate heat supply networks.

437. The Company rehabilitated its boilers in 1999-2006. These boilers were not automated yet, so they have manual starting and ash removal system. However MZ-1500 boiler is semi-automated. Coal bunker of this boiler is usually filled by hand. But the firing is controlled from the control board and regulated.

91. Fuel Prices

438. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-77: Muren - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	**GCal / h**	**tons / h**	**tons / d**	**1000 ton p.a.**	**MNT / ton**	**million MNT p.a.**
Muren	26.57	8.13	195.12	29,268	70,401	4,956,282

Sources: Licensees, EA data & Consultants' data

439. The District Heating network is 19.3km in length. The pipelines are worn out and deteriorated. No maintenance or repair has been carried out since the time of commissioning. Water loss is high as there are holes in the pipeline and consumers siphon hot water.

92. Economic Benefits for Muren

440. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

441. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

442. Coal required for heating is transported by trucks from Mogoin Gol, Jilchigbulag and Tomortein coal mines located 30, 54 and 217 km fom the aimag center respectively.

443. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Muren's heat supply system.

93. Ownership

444. These boilers belong to the ownership of the local government owned "Huvsgul Dulaan" Co., Ltd.

Table IX-78: Muren - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	14.4	-	566.4	-	216.7	-
2004	44.5	-	2.3	14.6	1.4%	574.5	1.4%	219.8	1.4%
2005	46.5	4.6%	2.3	14.7	3.0%	592.7	3.2%	226.4	3.0%
2006	47.1	1.3%	2.3	14.9	1.2%	599.5	1.1%	229.0	1.2%
2007	47.3	0.5%	2.3	15.0	0.5%	602.5	0.5%	230.2	0.5%
2008	47.4	0.0%	2.5	15.8	9.0%	658.0	9.2%	250.8	9.0%
2009	48.7	2.8%	2.5	15.9	6.7%	704.6	7.1%	267.6	6.7%
2010	40.8	-16.2%	2.7	17.0	1.6%	713.6	1.3%	271.9	1.6%
Average 2003 - 2010	-	-1.2%	-	-	3.3%	-	3.4%	-	3.3%
Forecast									
2011	40.8	0.1%	3.2	20.4	4.4%	737.9	3.4%	283.9	4.4%
2012	40.9	0.1%	3.3	20.8	-0.1%	735.8	-0.3%	283.6	-0.1%
2013	40.9	0.1%	3.3	21.2	-0.1%	733.7	-0.3%	283.2	-0.1%
2014	41.0	0.1%	3.4	21.6	-0.1%	731.5	-0.3%	282.9	-0.1%
2015	41.0	0.1%	3.4	22.1	-0.1%	729.4	-0.3%	282.6	-0.1%
Average 2011 - 2015	-	0.1%	3.3	-	0.8%	-	0.4%	-	0.8%
2015	41.0	0.1%	3.4	22.1	-0.1%	729.4	-0.3%	282.6	-0.1%
2020	36.1	0.5%	3.8	24.4	10.4%	718.9	0.4%	281.0	0.8%
2025	-	-	-	26.9	10.4%	708.6	0.4%	279.4	0.8%

Table IX-79: Muren Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,281	36,500	574,476	2,451	47,633	1,627	50,083	51,710	13.1	1.2
2005	2,296	36,750	592,696	2,465	49,143	1,638	51,608	53,246	13.5	1.2
2006	2,328	37,253	599,488	2,493	49,707	1,660	52,199	53,860	13.6	1.2
2007	2,343	37,503	602,543	2,507	49,960	1,671	52,467	54,138	13.7	1.2
2008	2,474	39,593	658,000	2,623	54,558	1,765	57,181	58,945	14.9	1.3
2009	2,490	39,845	704,595	2,636	58,422	1,776	61,058	62,834	16.0	1.3
2010	2,656	42,500	713,644	2,782	59,172	1,894	61,954	63,848	16.2	1.4
2011	3,187	51,000	737,929	3,239	61,185	2,273	64,424	66,697	16.8	1.6
2012	3,250	52,020	735,792	3,292	61,008	2,318	64,301	66,619	16.8	1.7
2013	3,315	53,060	733,662	3,347	60,832	2,365	64,179	66,544	16.8	1.7
2014	3,382	54,122	731,540	3,403	60,656	2,412	64,059	66,471	16.7	1.7
2015	3,449	55,204	729,425	3,460	60,480	2,460	63,940	66,400	16.7	1.8
2020	3,794	60,950	718,940	3,757	59,611	2,706	63,368	66,074	16.6	1.9

BB. Hentii (Ondorhaan)

445. Hentii Aimag is located in the central mid-east of Mongolia. The population is around 72,000.

446. Ondorhaan, the urban center has a population of around 28,400. Ondorhaan is sited 1,000m above sea level, with annual heating days of 244. The average annual precipitation is 264mm and average relative moisture is 59%. The nearest mountain is Undorhaan and the nearest river Herlen.

94. Demand for Heat

447. The number of households taking heat supply is estimated at 790, around 7.6% of the Ondorhaan population.

448. At present about 80 customers are supplied with heat, although the service suffers because the internal heating systems of the buildings are clogged due to the failure to carry out periodic cleaning. Only 7 customers are supplied with hot water. There are many consumers have no domestic hot water service, because of absence of internal hot water system.

449. There is no domestic hot water supply and apartment residents tap hot water from the heating units for their needs. 426 households live in 28 apartment buildings (3 of 36 households, 1 of 48, 4 of 24, 2 of 27, 2 of 12, 1 of 16 and 10 of 8 households). In order to address this issue hot water systems, with an appropriate tariff, should be installed at customers' premises. Existing hot water delivery systems should be refurbished and new ones should be installed at boiler houses which do not currently have this facility.

450. The Consultant has modelled the heat demand for Ondorhaan based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-80: Ondorhaan - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	20,057	723	73.9	-1.9%	18,022	7.6
2005	21,304	690	72.5	-1.9%	17,685	7.4
2006	21,676	658	71.2	-1.8%	17,358	7.2
2007	19,166	627	69.9	-1.8%	17,040	7.0
2008	20,013	598	68.7	-1.8%	16,732	6.9
2009	20,960	677	70.0	2.0%	17,092	7.2
2010	16,878	778	82.7	18.1%	20,087	8.4
2011	16,765	783	89.9	8.8%	21,777	9.0
2012	16,652	789	98.0	9.0%	23,653	9.6
2013	16,539	794	107.0	9.1%	25,735	10.3
2014	16,427	800	116.9	9.3%	28,045	11.1
2015	16,315	806	127.9	9.4%	30,610	11.9
2020	25,083	845	98.0	1.8%	27,514	11.0

Sources: Licensees, EA data & Consultants' estimate

451. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-81: Ondorhaan – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,156	18,934	221,420	0.013	0.077	0.009	23,653	7.50

Sources: Licensees, EA data & Consultants' estimate

95. Validation of Demand Forecast for Heat

452. The local authority reported that in 2012 the total heat production was 18.9 GCal/h which compares to the Consultant's end use forecast of 9.6 GCal/h indicating a 39% loss in the DH pipelines and at the consumer's premises.

453. The average heat consumption in Poland rural communes is 25GJ per person. In Ondorhaan a consumption of 7.5 GCal per person equates to 31GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Ondorhaan where it is 6 m^2.

454. Overall, the Consultant considers the forecast in **Table IX-80** to be valid and within reasonable accuracy for heat planning purposes.

96. Existing Heat Supply

455. The town is supplied by small HOB's and a DH network. The boilers are BZUI, NR, DTH, DZL types of which there are 30.

456. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-82.

Table IX-82: Ondorhaan - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
30.2	Y	N.A.	18.9	11.3	7.5	39%

Sources: Licensees, EA data

457. Each of the boiler houses has its own network to supply customers with heat; and operators are responsible for the network from the Boiler house to the first well from the customer's side. The DH network total length is 6.8 km, and maximum diameter is 150 mm. The PUSO and SUNO Co. systems provide hot water delivery. The heat distribution design temperature is 95/70°C, but it is not possible to comply with this during operation

458. In 2007, the ADB funded one Chinese DZL-0.7 boiler in boiler house No. 1, boilers in boiler house No. 2 were replaced by two boilers of type DZL-0.7 and one DZL-1.4, boilers in boiler house No. 1 were replaced by one boiler of type DZL-0.7 and one DZL-1.4. Pipeline and pump

replacement was also undertaken.

459. There are also number of small stand-alone boilers operated the private sector. The operational condition differs from boiler to boiler.

97. Fuel Prices

460. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-83: Ondorhaan - HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
KE-25-14E	7.55	1.4		10,000		
Hentii-Us #1	2.1					
Hentii-Us #2	2.8					
Hentii-Us #3	1.1					
Hentii-Us #4	0.35					
Hentii-Us #5	0.7					
Hentii-Us #6	0.11					
Hentii-Us #7	1.4					
Hentii-Us #8	0.4					
Och Manlai	1.4	0.5	12.3	2500		
Bayan-Erdes	2.5	0.9	22	4500		
Erooltugs	1.4	0.6	14.7	3000		
Suno Co.Ltd	1.4	0.6	14.7	3000		
Bayalag Hurah	0.78	0.2	5	1000		
Tsagaan Tsahit Uul	0. 25	0.15	3.5	700		
Total	24.0			24,700	23,742	586,427

Sources: Licensees, EA data & Consultants' data

461. Boiler efficiency is at about 50% and coal is consumed inefficiently. The design efficiency of DTH-1.5 boilers is not less 75%, but the boilers were commissioned in 2001 and the time since commissioning is not enough to prove the figure for normal operation conditions. The other existing boilers should be replaced with modern water boilers of at least 70% efficiency.

462. Clogging and corrosion due to the use of raw water adversely affects the operational life of boilers and networks. It is necessary to install water treatment devices appropriate for small capacity boilers.

463. The DH network is 6.8 km in length. The networks are in very poor condition with many failures which seriously impact on stability and reliability of heat supply. Replacement of the entire network for each of boiler houses is necessary.

98. Economic Benefits for Ondorhaan

464. The benefits of the refurbishment of the heating system are improved heat services for

residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

465. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

466. Coal transport costs and quality greatly affect boiler operation and efficiency. Although Chandgan tal coal mine is located relatively close but quality is very low and does not meet boiler requirements. The boiler houses mainly burn lignite from Chandgan tal coal mine located in Hentii aimag. A small quality of Hashaat coal is also used. Chandgan tal and Hashaat coal mines are respectively 59 km away and 110 km away from Ondorkhaan by truck transport. \

467. The above economic benefits strongly support the case for refurbishment of Ondorhaan's heat supply system.

99. Ownership

468. Some independent water heating boilers have been in operation since 1965 for the larger organizations such as the school and hospital. From the 1980s, they were transferred to the specialized public urban services sector and privatization began in 1998 for all those which were not operating with large financial losses.

469. Water and Household Authority (PUSO) is currently responsible for three boiler houses and one bathhouse. Other further five boiler houses fall under the responsibility of private companies.

Table IX-84: Ondorhaan - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	18.2	-	160.0	0.0	75.3	0.0
2004	20.1	-	2.9	17.4	-1.9%	158.3	-1.0%	73.9	-1.9%
2005	21.3	6.2%	2.8	16.5	-1.9%	156.8	-1.0%	72.5	-1.9%
2006	21.7	1.7%	2.6	15.8	-1.8%	155.2	-1.0%	71.2	-1.8%
2007	19.2	-11.6%	2.5	15.0	-1.8%	153.6	-1.0%	69.9	-1.8%
2008	20.0	4.4%	2.4	14.4	-1.8%	152.1	-1.0%	68.7	-1.8%
2009	21.0	4.7%	2.7	16.2	2.0%	150.6	19.0%	70.0	2.0%
2010	16.9	-19.5%	3.1	18.7	18.1%	179.2	11.2%	82.7	18.1%
Average 2003 - 2010	-	-2.3%	-	-	1.6%	-	3.6%	-	1.6%
Forecast									
2011	16.8	-0.7%	3.1	18.8	8.8%	182.8	2.0%	84.1	1.7%
2012	16.7	-0.7%	3.2	18.9	9.0%	186.5	6.0%	85.5	1.7%
2013	16.5	-0.7%	3.2	19.1	9.1%	190.2	6.0%	87.0	1.7%
2014	16.4	-0.7%	3.2	19.2	9.3%	194.0	5.9%	88.5	1.7%
2015	16.3	-0.7%	3.2	19.3	9.4%	197.9	5.9%	90.0	1.7%
Average 2011 - 2015	-	-0.7%	3.2	-	9.1%	-	5.2%	-	1.7%
2015	16.3	0.1%	3.2	19.3	9.4%	197.9	5.9%	90.0	1.7%
2020	25.1	0.5%	3.4	20.3	4.9%	263.9	5.2%	98.0	1.7%
2025	-	-	-	21.3	4.9%	352.0	5.2%	106.7	1.7%

Table IX-85: Ondorhaan Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption				------------------------------	Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	2,892	43,383	158,346	2,830	13,129	2,063	15,959	18,022	5.2	2.4
2005	2,758	41,370	156,757	2,720	12,998	1,967	15,718	17,685	5.2	2.2
2006	2,630	39,451	155,185	2,615	12,867	1,876	15,482	17,358	5.1	2.1
2007	2,508	37,620	153,627	2,513	12,738	1,789	15,251	17,040	5.0	2.0
2008	2,392	35,875	152,086	2,416	12,610	1,706	15,026	16,732	4.9	1.9
2009	2,707	40,600	150,560	2,678	12,484	1,931	15,162	17,092	5.0	2.2
2010	3,112	46,675	179,210	3,008	14,859	2,219	17,867	20,087	5.9	2.5
2011	3,134	47,004	182,794	3,026	15,156	2,235	18,182	20,417	6.0	2.6
2012	3,156	47,336	186,450	3,043	15,460	2,251	18,503	20,754	6.1	2.6
2013	3,178	47,669	190,179	3,061	15,769	2,267	18,830	21,097	6.2	2.6
2014	3,200	48,005	193,983	3,079	16,084	2,283	19,163	21,446	6.3	2.6
2015	3,223	48,344	197,862	3,097	16,406	2,299	19,503	21,802	6.4	2.6
2020	3,378	50,720	263,894	3,224	21,881	2,410	25,105	27,514	8.2	2.8

CC. Zavhan (Uliastai)

470. Zavhan Aimag is located in the central mid-west of Mongolia. The population is around 74,800.

471. Uliastai, the urban center has a population of around 15,700. Uliastai is sited 1,642m above sea level, has an average annual temperature of -2.3 ˚C, with annual heating days of 241. The average annual precipitation is 210mm and average relative moisture is 46%. The nearest river is Zavhan.

100. Demand for Heat

472. The number of households taking heat supply is estimated at 780, around 25% of the Uliastai population.

473. Uliastai is an industrial region with process steam needs for industries such as concrete factory, concrete slab workshop, automobile repair shop.

474. The Consultant has modelled the heat demand for Uliastai based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-86: Uliastai - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	13,937	670	150.7	1.5%	31,368	9.7
2005	12,832	680	152.9	1.5%	31,805	9.8
2006	13,188	690	155.2	1.5%	32,264	10.0
2007	13,418	700	157.5	1.5%	32,724	10.1
2008	13,437	710	159.8	1.5%	33,183	10.3
2009	13,332	721	162.3	1.6%	33,680	10.4
2010	9,363	732	164.7	1.5%	34,154	10.6
2011	8,972	754	169.7	3.0%	35,146	10.9
2012	8,588	777	174.7	2.9%	36,138	11.2
2013	8,214	800	180.0	3.0%	37,190	11.5
2014	7,847	824	185.4	3.0%	38,255	11.8
2015	7,489	849	190.9	3.0%	39,343	12.2
2020	11,319	913	200.6	1.0%	41,549	12.9

Sources: Licensees, EA data & Consultants' estimate

475. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-87: Uliastai – Heat Model (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	3,883	69,900	293,440	0.038	0.102	0.012	36,138	9.31

Sources: Licensees, EA data & Consultants' estimate

101. Validation of Demand Forecast for Heat

476. The local authority reported that in 2012 the total heat production was 13.4 GCal/h which compares to the Consultant's end use forecast of 11.2 GCal/h indicating a 17% loss in the DH pipelines and at the consumer's premises.

477. The average heat consumption in Poland rural communes is 25GJ per person. In Uliastai a consumption of 9.3 GCal per person equates to 39GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Uliastai where it is 18 m^2.

478. Overall, the Consultant considers the forecast in Table IX-86 to be valid and within reasonable accuracy for heat planning purposes.

102. Existing Heat Supply

479. The town is supplied by small HOB's and a DH network. There are 13 boiler houses with boilers 3 x Su-240, 20 x NR-18-54, 6 x NR-18-27 as well as other types. All boilers, except shower houses, are designed for heating purposes. The District Heating pipeline network is 14.1km in length.

480. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-89.

Table IX-88: Uliastai - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
18.1	N	N.A.	13.4	4.7	2.2	17%

Sources: Licensees, EA data

103. Fuel Prices

481. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-89: Uliastai – HOB Fuel Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Uliastai	18.1	6	144	34.7	24,400	847
Total	18.1	6	144	34.7	24,400	847

Sources: Licensees, EA data & Consultants' data

482. Because the District Heating network is old there are no valves or valves cannot be closed properly and leakage increases. It is one of the difficulties. The District Heating system cannot be hydraulically adjusted, so it becomes difficult to distribute heat evenly. To provide heat to the end users large pumps were used. Therefore, discharge of the network increases. By this way, boilers became unable to provide hot water over 60-70^{o}C temperature in the winter.

104. Economic Benefits for Uliastai

483. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

484. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

485. Because there is no any coal deposit in this province coal is transported by trucks from Mogoin Gol coal mine of Hovsgol province at a distance of 140km.

486. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Uliastai's heat supply system.

105. Ownership

487. All boiler houses have been privatized.

488. Four individual small boiler houses belong to the ownership of the consumers.

Table IX-90: Uliastai - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	59.4	-	249.2	-	148.4	-
2004	13.9	-	3.4	60.3	1.5%	253.1	1.6%	150.7	1.5%
2005	12.8	-7.9%	3.4	61.2	1.5%	256.8	1.4%	152.9	1.5%
2006	13.2	2.8%	3.5	62.1	1.5%	260.7	1.5%	155.2	1.5%
2007	13.4	1.7%	3.5	63.0	1.5%	264.6	1.5%	157.5	1.5%
2008	13.4	0.1%	3.6	63.9	1.5%	268.5	1.5%	159.8	1.5%
2009	13.3	-0.8%	3.6	64.9	1.6%	272.7	1.6%	162.3	1.6%
2010	9.4	-29.8%	3.7	65.9	1.5%	276.6	1.4%	164.7	1.5%
Average 2003 - 2010	-	-5.6%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	9.0	-4.2%	3.8	67.9	3.0%	285.0	1.0%	169.7	1.0%
2012	8.6	-4.3%	3.9	69.9	2.9%	293.4	1.0%	174.7	1.0%
2013	8.2	-4.4%	4.0	72.0	3.0%	302.4	1.0%	180.0	1.0%
2014	7.8	-4.5%	4.1	74.2	3.0%	311.4	1.0%	185.4	1.0%
2015	7.5	-4.6%	4.2	76.4	3.0%	320.6	1.0%	190.9	1.0%
Average 2011 - 2015	-	-4.4%	4.0	-	3.0%	-	1.0%	-	1.0%
2015	7.5	0.1%	4.2	76.4	3.0%	320.6	1.0%	190.9	1.0%
2020	11.3	0.5%	4.6	82.3	7.7%	337.0	1.0%	200.6	1.0%
2025	-	-	-	88.7	7.7%	354.1	1.0%	210.9	1.0%

Table IX-91: Uliastai Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	3,350	150,750	253,120	7,991	20,987	2,389	28,978	31,368	8.0	1.7
2005	3,400	153,000	256,760	8,090	21,289	2,425	29,379	31,805	8.1	1.7
2006	3,450	155,250	260,680	8,189	21,614	2,461	29,803	32,264	8.2	1.8
2007	3,500	157,500	264,600	8,288	21,939	2,496	30,227	32,724	8.3	1.8
2008	3,550	159,750	268,520	8,386	22,264	2,532	30,651	33,183	8.4	1.8
2009	3,606	162,250	272,720	8,496	22,613	2,572	31,108	33,680	8.6	1.8
2010	3,661	164,750	276,640	8,605	22,938	2,611	31,542	34,154	8.7	1.9
2011	3,772	169,750	285,040	8,822	23,634	2,691	32,456	35,146	8.9	1.9
2012	3,883	174,750	293,440	9,038	24,331	2,770	33,368	36,138	9.2	2.0
2013	4,000	180,000	302,400	9,263	25,074	2,853	34,337	37,190	9.5	2.0
2014	4,122	185,500	311,360	9,499	25,816	2,940	35,315	38,255	9.7	2.1
2015	4,244	191,000	320,600	9,733	26,583	3,027	36,315	39,343	10.0	2.2
2020	4,563	205,761	336,954	10,356	27,939	3,254	38,294	41,549	10.5	2.3

DD. Arhangai (Tsetserleg)

489. Arhangai Aimag is located in the central part of Mongolia. The population is around 88,000 in 2012.

490. Tsetserleg, the urban center has a population of around 25,500. Tsetserleg has an average annual temperature of -0.6 ˚C, with annual heating days of 250. The average annual precipitation is 340mm and average relative moisture is 50%. The nearest mountain is Bulgan and the nearest river Tamir.

106. Demand for Heat

491. The number of households taking heat supply is estimated at 900, or around 18% of the population of Tsetserleg.

492. At present the Ilch-Arhangai Co. supplies heat to 45 consumers of which 17 are apartment buildings. Twelve consumers previously connected to the heating network have built their own stand-alone boilers of small capacity.

493. The Consultant has modelled the heat demand for Tsetserleg based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-92: Tsetserleg - Heat Demand Forecast

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	17,292	782	102.1	1.5%	22,092	7.0
2005	17,157	793	103.7	1.5%	22,415	7.1
2006	17,236	805	105.3	1.5%	22,738	7.2
2007	17,482	817	106.8	1.5%	23,060	7.3
2008	17,284	830	108.5	1.6%	23,400	7.5
2009	17,027	842	110.1	1.4%	23,722	7.6
2010	14,054	855	111.7	1.5%	24,061	7.7
2011	13,847	862	112.6	0.8%	24,236	7.7
2012	13,641	868	113.4	0.8%	24,412	7.8
2013	13,437	875	114.3	0.8%	24,588	7.8
2014	13,235	881	115.2	0.8%	24,764	7.9
2015	13,034	888	116.0	0.7%	24,939	7.9
2020	15,526	921	120.4	0.8%	25,840	8.2

Sources: Licensees, EA data & Consultants' estimate

494. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-93: Tsetserleg – Heat Model (Per Annum)

	HH's	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	868	52,088	171,779	0.030	0.060	0.013	24,412	5.6

Sources: Licensees, EA data & Consultants' estimate

107. Validation of Demand Forecast for Heat

495. The local authority reported that in 2012 the total heat production was 10.6 GCal/h which compares to the Consultant's end use forecast of 8.1 GCal/h indicating a 23% loss in the DH pipelines and at the consumer's premises.

496. The average heat consumption in Poland rural communes is 25GJ per person. In Tsetserleg a consumption of 5.6 GCal per person equates to 24GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Tsetserleg where it is 12 m^2.

497. Overall, the Consultant considers the forecast in **Table IX-92** to be valid and within reasonable accuracy for heat planning purposes.

108. Existing Heat Supply

498. The town is supplied by small HOB's and a DH network. All of Tsetserleg's boiler houses are BZUI-100 and NR-18-54 boilers of which there are twelve. The boilers commenced operation from 1980-1983.

499. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-94.

Table IX-94: Tsetserleg - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
14.4	N	N.A.	10.6	3.8	2.5	23%

Sources: Licensees, EA data

500. Each boiler has its own district heating network. The DH pipeline route length is 4.5 km and maximum diameter is 150 mm.

501. The heating network supply temperature is in range of 60-70^{0}C at the outlet of the boiler houses, which is insufficient to provide adequate heating of buildings at the desired temperature.

109. Fuel Prices

502. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-95: Tsetserleg - HOB Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
Arhangai	12.3	3.8	91.2	21.9	35,000	766
Total	12.3	3.8	91.2	21.9	35,000	766

Sources: Licensees, EA data & Consultants' data

110. Economic Benefits for Tsetlerleg

503. The benefits of the refurbishment of the heating system are improved heat services for residents, efficient use of water, reduced coal consumption and coal trucking (and associated dust) and the reduction in noxious emissions.

504. Improved heating services will contribute to the economic well-being of the town and act to lessen the rate of migration of the townspeople to larger cities.

505. The boiler houses burn coal from Bayanteeg coal mine located in Bayanhongor Aimag, some 402 km from Tsetserleg. A small amount of coal is also transported from Bayantsagaan coal mine located just 45 km away, but the mining capacity is very low, less than 100 ton per year, because coal there is mined manually.

506. The above economic benefits, including reduction of emissions, strongly support the case for refurbishment of Tsetserleg's heat supply system.

111. Ownership

507. Tsetserleg is heated by 8 independent small district heating systems each with its own heating source. The boiler houses were privatized in September 1999; and today the Ilch-Arhangai Co. operates the boiler houses with 68 percent of the shares, the rest of the shares, and the networks being State-owned.

Table IX-96: Tsetserleg - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	46.2	-	152.5	-	100.7	-
2004	17.3	-	3.9	46.9	1.5%	154.7	1.4%	102.1	1.5%
2005	17.2	-0.8%	4.0	47.6	1.5%	157.1	1.6%	103.7	1.5%
2006	17.2	0.5%	4.0	48.3	1.5%	159.5	1.5%	105.3	1.5%
2007	17.5	1.4%	4.1	49.0	1.5%	161.9	1.5%	106.8	1.5%
2008	17.3	-1.1%	4.2	49.8	1.6%	164.3	1.5%	108.5	1.6%
2009	17.0	-1.5%	4.2	50.5	1.4%	166.8	1.5%	110.1	1.4%
2010	14.1	-17.5%	4.3	51.3	1.5%	169.2	1.5%	111.7	1.5%
Average 2003 - 2010	-	-3.2%	-	-	1.5%	-	1.5%	-	1.5%
Forecast									
2011	13.8	-1.5%	4.3	51.7	0.8%	170.5	0.8%	112.6	0.8%
2012	13.6	-1.5%	4.3	52.1	0.8%	171.8	0.8%	113.4	0.8%
2013	13.4	-1.5%	4.4	52.5	0.8%	173.1	0.8%	114.3	0.8%
2014	13.2	-1.5%	4.4	52.9	0.8%	174.4	0.8%	115.2	0.8%
2015	13.0	-1.5%	4.4	53.3	0.7%	175.7	0.7%	116.0	0.7%
Average 2011 - 2015	-	-1.5%	4.4	-	0.8%	-	0.8%	-	0.8%
2015	13.0	0.1%	4.4	53.3	0.7%	175.7	0.7%	116.0	0.7%
2020	15.5	0.5%	4.6	55.3	3.8%	182.3	0.8%	120.4	0.8%
2025	-	-	-	57.4	3.8%	189.2	0.8%	125.0	0.8%

Table IX-97: Tsetserleg Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption ------------------------------					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	3,908	117,250	154,660	6,481	12,824	2,788	19,305	22,092	5.0	2.0
2005	3,967	119,000	157,080	6,561	13,024	2,829	19,586	22,415	5.1	2.0
2006	4,025	120,750	159,500	6,642	13,225	2,871	19,867	22,738	5.2	2.0
2007	4,083	122,500	161,920	6,722	13,426	2,913	20,148	23,060	5.3	2.1
2008	4,150	124,500	164,340	6,813	13,626	2,960	20,440	23,400	5.3	2.1
2009	4,208	126,250	166,760	6,893	13,827	3,002	20,720	23,722	5.4	2.1
2010	4,275	128,250	169,180	6,984	14,028	3,049	21,011	24,061	5.5	2.2
2011	4,308	129,235	170,479	7,028	14,135	3,073	21,164	24,236	5.5	2.2
2012	4,341	130,220	171,779	7,073	14,243	3,096	21,316	24,412	5.6	2.2
2013	4,374	131,206	173,079	7,118	14,351	3,119	21,469	24,588	5.6	2.2
2014	4,406	132,191	174,379	7,162	14,459	3,143	21,621	24,764	5.6	2.2
2015	4,439	133,176	175,679	7,207	14,566	3,166	21,773	24,939	5.7	2.3
2020	4,607	138,292	182,324	7,437	15,117	3,286	22,554	25,840	5.9	2.3

EE. Govy-Sumber (Choir)

508. Govy-Sumber Aimag is located to the Central East of Mongolia. The total population of the Aimag is small at around 14,000.

509. Choir, the urban center has a population of around 9,000. Choir is sited 1,430m above sea level, has an average annual temperature of 0.36 ˚C, with annual heating days of 2232. The average annual precipitation is 194mm and average relative moisture is 48%. The nearest mountain is named Choir; there is no river in the Aimag.

112. Demand for Heat

510. The number of households taking heat supply is estimated at 1,050 or around 59% of the Choir population.

511. The Gobi-Sumber Aimag center was established in the middle of 50s together with facilities of the Choir station the railway and engineering networks. During a long utilization boiler and district heating network became old and deteriorated.

512. Starting from 1970s apartments, public service facilities, thermal plant, a complete engineering network for Russian military unit were built in the Khonkhor, but since 1990 due to withdrawal of Russian troops these buildings and facilities left with no utilization, and district heating network remained without use. Therefore this network technically deteriorated very much, heat loss increased and its safety operation was being jeopardized and became impossible to use in the future.

513. By 2020 Choir town will be one of the “Free Economic Zone’s with rapid development expected. Accordingly the city has planned new apartment blocks, cultural facilities and public service centers. To support this development plan, it is intended to develop a centralized district heating system.

514. The Consultant has modelled the heat demand for Choir based on the supply of heat to apartments and public buildings, and hot tap water demand for meal preparation.

Table IX-98: Choir - Heat Demand Forecast

	Urban Pop’n	HH’s with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2004	902	905	60.3	1.7%	14,046	7.1
2005	887	918	61.2	1.5%	14,243	7.2
2006	927	930	62.0	1.3%	14,417	7.3
2007	960	945	63.0	1.6%	14,635	7.4
2008	1,013	960	64.0	1.6%	14,853	7.5
2009	1,091	973	64.9	1.4%	15,050	7.6
2010	1,042	988	65.9	1.5%	15,268	7.7
2011	1,064	1,018	67.9	3.0%	15,702	7.9
2012	1,086	1,048	69.9	2.9%	16,136	8.2
2013	1,108	1,080	72.0	3.0%	16,590	8.4
2014	1,131	1,113	74.2	3.1%	17,066	8.7

	Urban Pop'n	HH's with heat	District Heat Area	Growth Rate	Annual Heat Consumption	Maximum Demand
Year	No.	No.	sq km	%	GCal	GCal/h
2015	1,153	1,145	76.4	3.0%	17,542	8.9
2020	8,880	1,306	88.4	3.1%	19,933	10.1

Sources: Licensees, EA data & Consultants' estimate

515. The Consultant's heat demand forecast is derived from a GCal per person estimate based on empirical formulae. The GCal per person is an end-use consumption and does not include heat losses.

Table IX-99: Choir – Heat Consumption (Per Annum)

	DH Consumers	Apartments	Public Buildings	Residential Space Heat	Public Buildings Heat	Residential Hot Tap Water	Total	Per person
Year		m^2	m^3	PJ	PJ	PJ	GCal	GCal
2012	5,238	41,900	78,400	0.025	0.027	0.016	16,136	3.1

Sources: Licensees, EA data & Consultants' estimate

113. Validation of Demand Forecast for Heat

516. The local authority reported that in 2012 the total heat production was 3.1 GCal/h which compares to the Consultant's end use forecast of 8.2 GCal/h indicating a 29% loss in the DH pipelines and at the consumer's premises.

517. The average heat consumption in Poland rural communes is 25GJ per person. In Choir a consumption of 3.1 GCal per person equates to 13GJ per person. The average square meter per person of residential space heated in Poland is around 20 m^2 compared to Choir where it is 8 m^2.

518. Overall, the Consultant considers the forecast in Table IX-98 to be valid and within reasonable accuracy for heat planning purposes.

114. Existing Heat Supply

519. The town is supplied by small HOB's and a DH network. All of Choir's boiler houses are BZUI-100 and NR-18 boilers. There are twelve boilers in total. There are also thirteen individual heating systems. The district heating network route length is 4.7 km.

520. The rated capacity, reported production capacity, spare capacity and capacity loss is shown in Table IX-100.

Table IX-100: Choir - Heat Supply Capacity (2012)

Rated Capacity	Hot Tap Water	Steam	Production Capacity	Spare Capacity	Downstream Capacity Loss	
GCal / h	Y / N	ton / h	GCal / h	GCal / h	GCal / h	% of Production
13.5	Y	N.A.	11.6	1.9	3.4	29%

Sources: Licensees, EA data

521. The district heating network route length is approximately 4.7 km.

115. Fuel Prices

522. Coal is transported by railway from Shivee-Ovoo coal mine.

523. The licensees reported fuel prices and fuel consumption at rated output.

Table IX-101: Choir - HOB Performance

Boiler	Capacity	Hourly coal consumption	Daily coal consumption	Annual coal consumption	Average Price Coal	Total Coal Purchases[7]
Type	GCal / h	tons / h	tons / d	1000 ton p.a.	MNT / ton	million MNT p.a.
BZUI, NR	13.5	3.1	74.4	16.5	13,960	241.9
Total	13.5	3.1	74.4	16.5	13,960	241.9

Sources: Licensees, EA data & Consultants' data

116. Ownership

524. Not reported.

[7] Including 5% handling charge

Table IX-102: Choir - Statistics

Year	Aimag Centre Population		DH Consumers	Residential Apartments		Public Buildings		Total	
	thous.	Growth		thous. m^2	Growth	thous. m^3	Growth	thous. m^2	Growth
Historical									
2003	-	-	-	35.6	-	66.4	-	59.3	-
2004	0.9	-	4.5	36.2	1.7%	67.5	1.7%	60.3	1.7%
2005	0.9	-1.6%	4.6	36.7	1.5%	68.6	1.7%	61.2	1.5%
2006	0.9	4.5%	4.7	37.2	1.3%	69.4	1.2%	62.0	1.3%
2007	1.0	3.6%	4.7	37.8	1.6%	70.6	1.6%	63.0	1.6%
2008	1.0	5.5%	4.8	38.4	1.6%	71.7	1.6%	64.0	1.6%
2009	1.1	7.7%	4.9	38.9	1.4%	72.8	1.6%	64.9	1.4%
2010	1.0	-4.5%	4.9	39.5	1.5%	73.9	1.5%	65.9	1.5%
Average 2003 - 2010	-	2.5%	-	-	1.5%	-	1.6%	-	1.5%
Forecast									
2011	1.1	2.1%	5.1	40.7	3.0%	76.2	3.0%	67.9	3.0%
2012	1.1	2.1%	5.2	41.9	2.9%	78.4	1.3%	69.9	2.9%
2013	1.1	2.0%	5.4	43.2	3.0%	80.6	1.3%	72.0	3.0%
2014	1.1	2.0%	5.6	44.5	3.1%	83.2	1.4%	74.2	3.1%
2015	1.2	2.0%	5.7	45.8	3.0%	85.7	1.4%	76.4	3.0%
Average 2011 - 2015	-	2.0%	5.4	-	3.0%	-	1.7%	-	3.0%
2015	1.2	0.1%	5.7	45.8	3.0%	85.7	1.4%	76.4	3.0%
2020	8.9	0.5%	6.5	52.6	14.9%	91.7	1.7%	88.4	3.0%
2025	-	-	-	60.5	14.9%	98.2	1.7%	102.3	3.0%

Table IX-103: Choir Heat Supply Model

	Hot Tap Water Driver	Space Heat Drivers		------------------------------ Heat Consumption					Heat Demand	
	DH Consumers	Apartments	Public Buildings	Residential Heating	Public Building Heating	Residential Hot Tap Water	Total Space Heat	Total incl. Hot Tap Water	Space Heat	Heat & Hot Tap Water
Year		m^3	m^3	GCal	GCal	GCal	Gcal	Gcal	Gcal/h	Gcal/h
2004	4,525	90,500	67,480	5,223	5,595	3,228	10,818	14,046	3.4	3.7
2005	4,588	91,750	68,600	5,283	5,688	3,272	10,971	14,243	3.5	3.7
2006	4,650	93,000	69,440	5,343	5,758	3,317	11,101	14,417	3.5	3.8
2007	4,725	94,500	70,560	5,415	5,850	3,370	11,265	14,635	3.5	3.8
2008	4,800	96,000	71,680	5,486	5,943	3,424	11,430	14,853	3.6	3.9
2009	4,863	97,250	72,800	5,546	6,036	3,468	11,582	15,050	3.6	4.0
2010	4,938	98,750	73,920	5,617	6,129	3,522	11,746	15,268	3.7	4.0
2011	5,088	101,750	76,160	5,759	6,315	3,629	12,074	15,702	3.8	4.1
2012	5,238	104,750	78,400	5,900	6,501	3,736	12,400	16,136	3.9	4.3
2013	5,400	108,000	80,640	6,052	6,686	3,852	12,738	16,590	4.0	4.4
2014	5,563	111,250	83,160	6,203	6,895	3,968	13,099	17,066	4.1	4.5
2015	5,725	114,500	85,680	6,354	7,104	4,083	13,458	17,542	4.2	4.7
2020	6,531	131,544	98,191	7,133	8,142	4,658	15,275	19,933	4.8	5.3

APPENDIX A
UB MUNICIPAL GOVERNMENT HEAT DRIVER FORECASTS

Additions to 2015 – Total DHC customers = 449,320

		Connected Households	Population	Gcal/hr
1	Buyant-Uhaa	3,545	14,888	26.6
2	Bayangol	4,000	16,800	30
3	City new centre	560	2,351	4.2
4	Sunshine	2,507	10,528	18.8
5	Yarmag-1	3,507	14,728	26.3
6	Future sub district	1,507	6,328	11.3
7	Japan town	1,507	6,328	11.3
8	Marshal	998	4,490	7.5
9	XIV sub district	5,000	21,000	37.5
10	East Selbe sub district	3,142	13,196	23.6
11	VII sub district	6,600	27,720	49.5
12	TV centre surroundings sub district	2,000	8,400	15
13	Military town	999	4,198	7.5
14	Wall material surroundings	1,000	4,200	7.5
15	Gandan temple sub district	304	2,039	2.3
16	Hill 1000 subdistrict	999	4,195	7.5
17	Golden	2,987	12,544	22.5
18	Rainbow apartment sub district	2,000	8,400	15
19	Chingis avenue, XIX sub district	1,508	6,787	11.3
20	Middle river around sub district	1,000	4,200	7.5
	Total	45,668	193,320	343

Additions to 2020 – Total DHC customers = 812,536

		Connected Households	Population	Gcal/hr
1	Buyant-Uhaa	12,500	52,500	93.8
2	Bayangol	18,000	75,600	135
3	City new centre	12,500	52,500	93.8
11	Sunshine	10,000	42,000	75
4	Yarmag-1	5,000	21,000	37.5
12	Future sub district	13,000	54,600	97.5
17	Japan town	4,000	16,800	30
13	XIV sub district	12,000	50,400	90
10	East Selbe sub district			
5	VII sub district	10,000	42,000	75
6	TV centre surroundings sub district	4,200	17,640	31.5
18	Military town	5,930	24,906	44.5
7	Wall material surroundings	11,600	48,720	87
8	Gandan temple sub district	582	3,900	4.4
9	Hill 1000 subdistrict	6,100	25,620	45.8
14	Rainbow apartment sub district	2,000	8,400	15
10	Middle river around sub district	1,000	4,200	7.5
15	Olympic town	2,000	8,400	15
16	Weave factory around sub district	1,750	7,350	13.1
	Total	132,162	556,536	991

Additions to 2030 – Total DHC customers = 1,155,189

	Consumer Name	Connected Households	Population	Gcal/hr
1	Buyant-Uhaa	12,500	52,500	93.8
2	Bayangol	18,000	75,600	135
3	City new centre	12,500	52,500	93.8
4	Sunshine	10,000	42,000	75
5	Yarmag-1	5,000	21,000	37.5
6	Future sub district	13,000	54,600	97.5
7	Japan town	4,000	16,800	30
8	Marshal town	2,195	9,878	16.5
9	XIV sub district	12,000	50,400	90
10	East Selbe sub district	4,500	18,900	33.8
11	VII sub district	10,000	42,000	75
12	TV centre surroundings sub district	4,200	17,640	31.5
13	Military town	5,930	24,906	44.5
14	Wall material surroundings	11,600	48,720	87
15	Gandan temple sub district	582	3,900	4.4
16	Hill 1000 subdistrict	6,100	25,620	45.8
17	Golden park	1,500	6,300	11.3
18	Rainbow apartment sub district	2,000	8,400	15
19	Chingis avenue, XIX sub district	4,151	18,679.5	31.1
20	Middle river around sub district	1,000	4,200	7.5
21	Rotation-32	10,000	42,000	75
22	Olympic town	2,000	8,400	15
23	Onor sub district part-B	2,640	11,088	19.8
24	Moscow sub district part II	3,150	13,230	23.6
25	Dar-Eh private apartments II stage	256	1,075	1.9
26	Dar-Eh sub district private apartments	4,044	16,985	30.3
27	Mamba temple	2,100	8,820	15.8
28	Yellow stone	7240	28,960	54.3
29	US-15	2,310	9,702	17.3
30	Uliastai	5,600	23,520	42
31	Altan-Ulgii surroundings	9,000	36,000	67.5
32	Amgalan	16,000	71,960	120
33	III-IV (or III-VII?)	1,979	8,906	14.8
34	Modern Mongolia sub district	700	3,150	5.3
35	West-South industrial area	3,000	13,500	22.5
36	Weave factory around sub district	1,750	7,350	13.1
	Total	212,527	899,189	1,594

APPENDIX B
BOTTOM-UP HEAT FORECASTING MODEL
(SPREADSHEET)